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CONTENTS

Page

J. ISSAAS Vol. 18, No. 1:1-5 (2012)

CONTINUITY AND CHANGE IN FOOD SECURITY, AN ASSESSMENT OF ISSUES

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Ladies and Gentlemen, Colleagues,

It is always a pleasure to be invited to speak about one's passion – to avoid the word hobby, which carries a rather frivolous connotation. Of course I use the word passion here in the sense of a long term academic interest. In this presentation I would like to re-examine the general food policy in the 1970s, by co-incidence not only the formative years of food security in Indonesia but also my own, and compare this to the current policies and current general situation. Many things have changed since the 1970s. We can learn from the differences, and maybe even more from the things that stay the same. In my address I will single out one element that deserves much more recognition and attention than it currently gets, namely the fact that agriculture is business, and the role of small and medium family enterprises in the sector.

I will refer where I can to ASEAN countries in my talk, but I will largely focus on Indonesia, because over the years Indonesia's agriculture sector has shown tremendous dynamism. Of course, I am also most familiar with Indonesia, so it is easier for me to derive lessons from looking at Indonesia than at other countries.

First, however, a quick enumeration of the current and hot issues in South East Asia. There are many.

First, the importance of price stability has come repeatedly to the forefront, especially so since the price jumps of 1997 and 1998. Second, food security is still considered as a major challenge, and some organizations even say that the food security systems have failed. I am not sure I agree with that. Third, food sovereignty sometimes still surfaces in the meaning that any given country has the freedom to set policy is it deems fit, but not so frequently anymore. Fourth, climate change and global warming front often as a long term process with negative consequences for food security, Fifth, genetic modification is now generally seen as offering growth potential although it is still heavily debated. Although many doubt GM seed would help small farmers; the need for high yielding varieties especially of the major food crops is widely recognized.

There are of course many more angles and aspects of food security, but the foregoing are the main current issues.

Now, with this in the back of our mind, let us take a look at the 1970s. In some ways it was possibly an easier time than the current period, but we will let the historians decide about that. In the 1970s many South East Asian economies were still very much top down, or "command" economies, with accompanying political systems. Policy formulation was very much a centrally instigated work. The implementation was a different story, more about that in a while.

The ingredients of what was called the Green Revolution are well known and analyzed: irrigation, development and distribution of appropriate varieties and production and distribution of fertilizer. Irrigation was done by central and local planning; the rice varieties came from IRRI – while the original parent material was a cross between an Indonesian variety and material from Taiwan. Gas

rich South Asian countries had little problems setting up some state owned and state ran fertilizer factories. Those three were the ingredients, and the cooks were the tens of thousands of extension officers, initially also accompanied by students, spreading the new technology in the villages, in Indonesia initially on Java and later Off Java. Over the medium term the interventions were a great success, labor productivity went up, income and food availability increased and provided a broad medium term push towards rural development.

All this could happen against the backdrop of price stability – in Indonesia this was brought about by a system of state managed rice local rice purchases and imports and subsequent releases in areas with a shortage of rice and high prices. Of importance was the national level policy of recognizing rice "plus" and "minus" areas. If an area was "minus" the bupati and the relevant departments got money, and if they did not succeed, the careers of the civil servants was on the line.

This whole configuration of policies has been termed food policy – whatever the term, it is totally clear that the whole set of policies was multi-sectoral and pro-poor, and in Indonesia involved the presidential office, as well as the ministries of agriculture, public works, home affairs, and specialized agencies, such BULOG and DOLOG. The late 1960s and the 1970s was a period of grand problems and grand solutions. The whole process was driven by strong political will, of course by the late president Soeharto, someone who understood agriculture and rural people very well. Mistakes were made – for example the massive application of organophosphates, resulting in huge losses because of pests and diseases, but these were corrected.

So, at the end of the 1970s we saw a food sector in Indonesia with myriads of small farmers, primarily on Java, and transmigrants off Java, massive government departments and a number of state ran enterprises, and a careful subsector of local rice traders and storage companies. Two basic trends were clearly visible in those years, a down going trend of international rice prices and a continuing fragmentation of rice land holdings on Java, and actually also in the traditional rice production centers off Java.

But perhaps the most important observation is that even though Indonesia's policies focused very much on rice, the fact remains that rice never occupied more than 50 % of food intake, and that over 50% of food and income for small farmers was provided by non-rice food and feed crops, maize, soybean, cassava, vegetables, fish, small livestock and many crops and fruits. This already pointed at a natural process of diversification in the 1970s. I believe this process was broadly the case in South East Asia.

Right now we are in 2011, and the issues of price stability and food security are still with us, poverty also, though substantially reduced. New issues have come over the horizon, such as climate change and global warming. The nature of government and governance has also changed.

Let us first look at the current back drop, the international and domestic trade situation, and the domestic policy theater in Indonesia. In South East Asia, Thailand has remained the major rice supplier, and is now accompanied by Vietnam. One can expect Myanmar to join the region's rice exporters the moment the country can manage the necessary reform. But the Asia Region also hosts two giant consumers and producers, India and China of course. A small fraction of their rice stocks looms as very large in South East Asia. Imagine what would happen if these two countries enjoy a bumper harvest in the same year and would export their surpluses – prices would go way down, or inversely, as has happened in 2007; if they have a reduced harvest, and put a ban on exports...Prices would go sky high... No wonder the major rice consuming countries try to grow their own consumption in-country.

The result is that rice as a commodity remains a "rest" trade, meaning that only around 6 % of global production is traded internationally. No real change there. We also see no real change in Indonesia in the impact of bad harvests, the impact of the 1997 El Nino was 1.8 %, this year we cope with an impact of 1.5 %. This points at a need for some imports. Indonesia has to increase productivity substantially.

We see a big and structural change in the long term trend of international rice prices. Since the early 2000s rice prices are on the increase, signifying an end to a century old trend of down going prices. Rice is becoming slowly slightly scarcer in the world, relative to other commodities. This trend, in combination with the fact that only some 6% of rice is internationally traded, may partly cause disruptions in the rice market to be more severe than before. The events of 2007/8 seem to bear out this notion. Some bad harvests, combined with a rather ill contemplated purchasing by some importing countries, accompanying bans on exports by an exporting country, resulted in a huge swing upwards of rice prices in 2007/2008. This sort of thing did not happen in the 1970s.

ASEAN and Indonesia have come a long way since the 1970s. ASEAN is the undisputed world leader in palm oil production, and Indonesia is now the leading producer. With Vietnam, Indonesia has developed its coffee industry dynamically, also in cocoa Indonesia has made huge progress. With the huge increases in rubber prices, Indonesia has moved up, together with Thailand, with other ASEAN countries taking advantage as well. Malaysia divested away from rubber into palm oil. The soybean industry in Indonesia expands continually, cashew nut production (as in Vietnam) is growing, and vegetable production is now supplying cold stores supplying urban consumption centers throughout the archipelago. Indonesia exports flower plantlets, and the country now has dozens of tissue culture labs supplying the growers with homogenous planting material. Fresh water fisheries is continually expanding as well, dairy development against expectations of some is also continuing. The meat industry in Indonesia remains something of a dark horse with some foreign investment, but relatively little domestic investment.

All these sub-sectors have one key characteristic in common. They are host to the hard core of any country's agriculture sector, namely the small and medium size family enterprises, a rural based middle class. Even the palm oil sub-sector, though dominated by a number of huge conglomerates, cannot do without the medium size enterprises. The rice sub-sector is somewhat absent as a generator of a rural middle class. Only maybe in Thailand and the Philippines the rice sector on the production spawned some limited middle class farming and small and medium enterprises, but not really so in the other ASEAN countries. The dynamic developments show that agriculture is business, and also show that things can happen as a result of private initiative.

Rice productivity has gone up tremendously over the last decades with Indonesia as the area productivity leader in ASEAN, while Thailand leads in labour productivity. In Indonesia, and I believe elsewhere, the basic characteristics of this sub-sector have not really changed, the fertilizer industries are still state managed, while the private sector contribution to seed is still limited. Perhaps this will change with a new generation of hybrids coming on the market.

A very important characteristic in Indonesia is the structure of rice land holdings. In virtually all production centres these are are minimal at around 2000 m and often much smaller than that. This may explain why rice production has not generated a rural middle class. It seems though that in Indonesia the trend of continuing fragmentation has come to a standstill. This matter needs researching, because it seems that this trend is related to two phenomena, namely the increasing reliance of the Javanese rural population on increasing income from annual or seasonal migration, and the related change in land use towards built up land, or land for housing. But this remark is merely to

the side of the main issues addressed in this presentation. But in view of future land availability it seems important enough for checking though.

It is time for an interim observation. Food security policy has succeeded very well on the production side in rice, but it did not really lead to long term capital formation among the rural population, whereas those commodities more outside food policy scope went through dynamic development and did result in a strong expansion of a rural middle class of farmers.

What can we say about the policy theater of 2011 vis a vis the 1970s? I would say that of the ASEAN countries Indonesia and Vietnam have possibly changed most. In Indonesia I would be tempted to say we changed from a command economy towards a highly intricate voting economy. Political parties and local party alliances play a primary role at all levels, sometimes for the common benefit but not automatically so. In ASEAN countries I do not think rice based food policy has changed really. In Indonesia we count one additional policy, the rice for the poor. Pro poor policy has changed towards location specific targeting and consumer level interventions. With the huge increase in international labour migration from rural areas in Indonesia and many other countries in ASEAN and elsewhere, there is a case to be made for pro poor policy through migration policy and policy on financial transfers to back home.

Many recent studies, among which the authoritative World Bank study of 2007, show that in Indonesia, with a per capita income of around 3600 US$ income, and a poverty incidence of around 22 %, productivity expansion in agriculture remains still the best poverty alleviation instrument. This is absolutely the case in the most impoverished areas where well over 60 percent of the population is totally dependent on agriculture. I believe the same holds true in all ASEAN countries.

Since the introduction of local autonomy in Indonesia surely many districts try their best to deal with their local poverty through local programmes and locally devised support systems. I know for a fact that many districts try their level best, but in many cases these districts, especially the newly created ones, simply lack the know how to undertake improvement in earnest. In this regard the role of the many universities in the region is essential – however, many suffer from a great demand for education, but little means to provide it. So maybe we can say that since the 1970s the time of the big results (and some big mistakes), is over, and that we can now speak of a period many attempts, well intended but not necessarily well guided. Maybe there are many mistakes, but that does not matter, as long as we learn. And as long as we are brave enough to improve decisions and actions.

The times of a centrally managed learning system, as we devised in agriculture in the 1980s and onwards may be over. In Indonesia we decentralized it in the 1990s, but it still remained frought with a centralist philosophy, simply through the centering of know how in one institution. In this regard we may draw a very important conclusion from the simple fact that most sub-sectors which have shown continuous growth over the last decades are dominated by small and medium size enterprises, mostly family based. The people who own and run these companies will learn, otherwise they lose their income, and may even go bankrupt.

Before we move on to conclusions, I will end my observations with a remark on Global Warming and Climate Change. These notions have spawned a whole new industry of projects in Official Development Assistance. In Forestry we are still witnessing the slow and uneasy birth of REDD – meaning Reducing Emissions from Deforestation and Forest Degradation. It is totally obvious and in fact very good that the international development community is very stern in applying all the criteria to make projects that really satisfy the goals of the REDD and CC programmes. Even, if I may say so, when the progress is slow and uncertain... The key notions concern primarily the forestry and the energy sectors, but to a more limited extent they also affect agriculture in its many

forms. In agriculture economics the concepts of risk and uncertainty have played a major role in just about all development work. Risk as you all know, refers to a quantifiable possibility, always based on statistics and expectations, while uncertainty refers to possible events which are not quantifiable through observations and statistics. Business deals with risk – and good business reduces uncertainty to risk through the clever use of observations and science. And this is exactly what good agriculture development does, identify risk, quantify it, and reduce uncertainty through technology development and application. This is really where all the disciplines in agriculture come in.

So, I sincerely hope that the new nodes of thought, if I may call Climate Change and related ideas such, will yield a fruitful contribution to the development of the business element in agriculture and that it will contribute to local livelihoods and family income. My hope is that it will result in forward looking projects and ideas.

It is time to sum up conclusions.

First. The need for price stability of international and domestic rice prices has increased, or is at least as strong as ever. Lasting solutions would need to involve, aside from the ASEAN countries, the two giant producers and consumers in the region.

Second. I know for a fact that because of the need for price stability and food security Indonesia cannot do without the current rice policy. But the success of the last decades was only possible because of expanded production though the application of improved technology in the field, not so much through the introduction of new varieties. The yield increases of the last decade are almost entirely based on this long term process of increasing production efficiency. Every discipline plays a vital role in this process.

Conclusion number Three concerns the growing institutional complexity of food policy systems. Food policy is actually spread out over many different actors, the Ministries of Agriculture, Local Government, rice Procurement and distribution systems, Presidential Office, Public Works. This was the case in the 1970s, and this continues to be the case against changed political backdrops in the region, and is actually expanded with more importance of local government and also NGO's as participants. This puts strain on the system as such if it is to remain responsive and innovative. Conclusion Four. Food security does not happen though government intervention alone. Local income increase and expanded depends increasingly on private initiative. Agriculture is business, even if it is small scale.

Conclusion number Five is about the need for a focus on new development partnerships. In the future policies I would advocate to make the existence and dominance of the small and medium size enterprises a center fold. Let local government, local universities, backstopped by more advanced ones if necessary, together with S&E identify options, risks and investments and try them out. We all talk about and maybe use multi-stakeholder platforms locally, but I would advocate to for Private Public Partnerships off the ground locally. Not big ones such as in infrastructure, but small ones. I firmly believe this is really part of the way ahead.

I sincerely hope I have satisfied at least some your expectations in this presentation. Our duty at this time in South East Asia is to devise ways and means to bring about progress in rural areas and to secure a sufficiency of food at affordable prices. This duty will not change in the foreseeable future.

I thank you for your kind listening and wish you all fruitful discussions, Thank you!

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FRESHWATER AQUACULTURE'S CONTRIBUTION TO FOOD SECURITY IN VIETNAM: A case study of freshwater tilapia aquaculture in Hai Duong province

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ABSTRACT

Vietnam has become the second largest rice exporter in the world. However, the food security is still a local urgent necessity for the farmers in several parts of the country, particularly, in area where most of arable land used to low paddies have been transferred to uncertain crops causing many difficulties to farmers on their food need. The current and potential contributions of aquaculture to food security have been well depicted under aspects of food availability (quantity and quality), food access (affordability), food utilization (nutrition, food preparation and sanitation knowledge, dietary habits, health conditions) . This paper presents the findings of the study on 70 freshwater tilapia fish and 35 none-fish farms in Tu Ky district, Hai Duong province on their production and marketing activities. It is found out that freshwater tilapia aquaculture play an important roles to the food security of local rural poor because of its provision of high-quality food, generation of cash incomes, available food supply to local markets, especially, in the context of inadequate supply of livestock protein sources due to burning issues of epidemics such as bird flu, blue ear and foot and mouth diseases. The remaining problems of local tilapia fish farms are also known as efficient resource utilization, and enhancement of farm sustainability through infrastructure construction and (farming) technology innovations.

Key words: freshwater aquaculture, tilapia, food security, aquaculture's contribution

INTRODUCTION

Aquaculture contributes to the livelihoods of the poor through improved food supply, employment and income opportunities. The Fisheries and Aquaculture Department (FAO) has defined the role of fish aquaculture which contributes to national food self-sufficiency through direct consumption and through trade and exports.

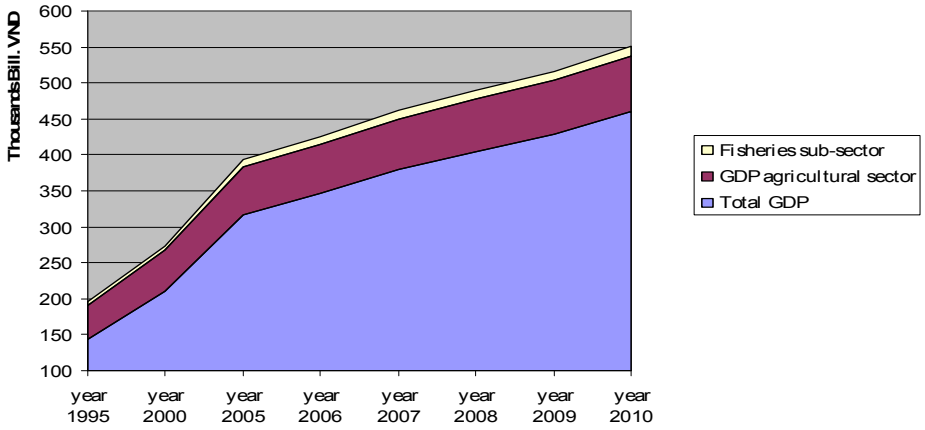
Supposed to be not a major solution for food security, current aquaculture does contribute to overall food supply by increasing the production of popular fish, thus reducing prices and by broadening the opportunities for income and food access (McKinsey, 1998; Sverdrup-Jensen, 1999). Thus aquaculture is indicated to be an important system for local food security through reduced vulnerability to unpredictable natural crashes in aquatic production, improved food availability, improved access to food and more effective food utilization (FAO, 2003a). Furthermore, the role of aquaculture can be assessed by looking at its impact on a variety of different aspects of food security base on core indicators: stability of food supply, availability of food, access for all to supplies and effective biological utilization of food.

The stability of food supply gives people access to adequate food at all times. Comparative trends in traditional agricultural food production with those from aquaculture under different environmental conditions. Quantifying the revenues generated from the aquaculture in comparison with traditional farming methods reveals the its significance to food security thank to the vulnerable

reduction to natural catastrophes (Williams, 1999). In addition, the percentage of fish farmer's total income received from aquaculture could also be an important measurement of its role in alleviating hunger and poverty. Besides, aquaculture products are used primarily for foods then one could imply that aquaculture is important not only in food provision during the most critical periods, but also in providing cheap and accessible food to those most in need (Ali and Delisle, 1999; Maxwell et al., 1999). In reality, the amount of land and water resources required for a quantity of food produced in aquaculture could also be compared to that achieved on land, although species diversity, levels of intensification and the range of products produced may make this evaluation hard. Increasing the supply of fisheries products is not sufficient to improve food security without the assurance of economic, physical and social access to adequate and nutritious food (Kent, 1997; FSIEWS, 2001).

From other perspectives, economic access to food occurs when households generate sufficient income to buy food and nations generate foreign exchange to pay for food imports (Sigot, 1998; Williams, 1999). Moreover, consumption of fish, often a non-staple food, rises rapidly with income on a percentage basis (Bouis, 2000). Alternatively, the distribution of poverty could be compared with that of aquaculture over time in order to determine whether the extent of poverty decreases in the presence of aquaculture. Aquaculture may provide a primary source of income to many farmers thus ensuring economic access to food (Williams, 1999; Ahmed and Lorica, 2002). Particularly, individuals must be able to get to food supplies and so increasing the physical access of the poor to productive resources may be a more reliable guarantee of food security than increasing purchasing power (Ahmed, 1999). In reality, social access to food requires supplies to be equitably available to people of all cultures and beliefs. Thus studies on the attitude towards aquaculture would be useful to assess the acceptability of the technology by different classes and religions (Pérez-Sánchez and Muir, 2003).

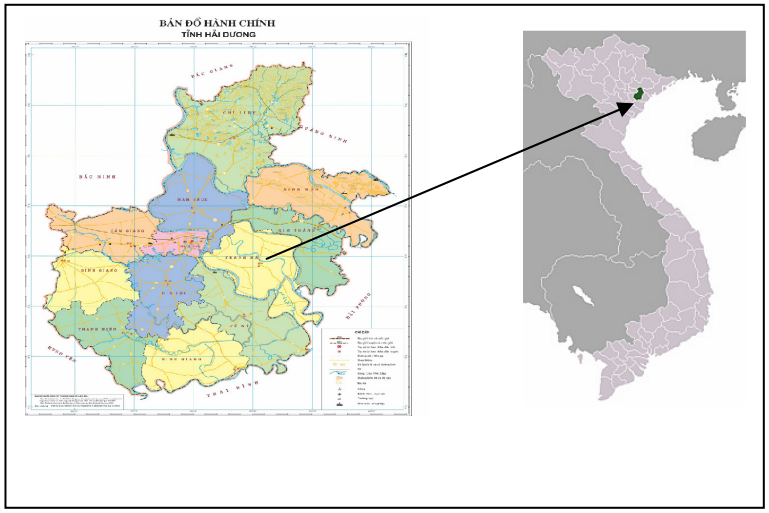
In Vietnam, aquaculture has a major proportion to fisheries sub-sector which gives a considerable contribution to its agricultural GDP and total GDP (see figure 1). Annual growth in this sub-sector recorded at 7.2%, smaller than the total GDP (7.7%) but larger than agricultural GDP (4.1%) during 1995-2010. Therefore, aquaculture has been projected to develop for high demand of exported markets and domestic consumption. As a result, tilapia was selected to key farmed fish and introduced for a long history. Although repeatedly introduced many new tilapia species unsuccessfully, thank to a government program of tilapia development (1999 – 2001), the GIFT tilapia was created and attracted to authorities and farmers' special attention to culture and develop in many areas in the country. The tilapia farming has undoubtedly contributed to food security and livelihood for farmers and the poor in Hai Duong province.



Source: General statistical office, 2010

Fig. 1. Fisheries' value contribution to Agricultural GDP and the country's GDP

Located in the Red River Delta, Hai Duong is a agricultural province base on many favorable aquatic resources with about 10,000 ha of aquaculture area. Consequently, tilapia farming movement in Hai Duong had taken place strongly since creation of GIFT tilapia which improved the quality of tilapia strains in 2000. In freshwater aquaculture, tilapia is considered a low-cost operation with good financial returns which have incentives for poor farmers in rural areas to culture these fishes in small seasonal ponds, ditches, particularly low paddy-field which are of little benefits. Tilapia farming are supposed to utilize properly and seasonally, which creates an economic source of food fish and additional income in many rural areas (Abdel-Fattah M. El-Sayed., 2006). In addition, tilapia farming is a self-sufficiency fish harvest initiative specifically designed to enhance food production, produce a nutritional source of food to reduce malnutrition, and encourage economic sustainability with a viable and marketable product (Food for the poor website). This study was designed to investigate the fish aquaculture contribution to food security on assessing the tilapia farming households' efforts to ensure their food stability, availability, access and utilization.



(Source: Vietnam department of survey and mapping 2010)

RESEARCH METHODS

Both secondary data and primary data were gathered for this study. The secondary data on general information of Hai Duong province, the basis information related to tilapia farming were gathered from the statistical yearbook of Hai Duong and General statistical office. In addition, 03 focus group discussions with tilapia producers in Hai Duong were held to get their evaluations on the weaknesses and strengths of the tilapia production, and their suggestions for better developing the tilapia farming movement. Furthermore, the direct interviews of 70 and 35 tilapia and none-tilapia households, farms in the preventative conditions and situations of tilapia culture using the questionnaire were implemented in January to March, 2010 to collect the necessary data and information to assess the contribution of aquaculture to food security in Hai Duong province. These data and information include the profile of the households, farms, their agricultural practices, the current income related to their activities and services, the comparative advantages and disadvantages to tilapia production in terms of home consumption, employment opportunity, aquaculture revenues, income generated analyzed on stocking density and/or intensification level, achievements, and farmer perception of profitability and feasibility on tilapia farming. The study mainly used methods of descriptive statistics and comparative analysis.

RESULTS AND DISCUSSION

Hai Duong is located in the center of North Vietnam. It has one city under province and 11 districts with natural area of 165 thousand ha, of which agricultural land accounts for 53.5% or around 88,400 ha. It has a total population of 1,708,000 persons, of which rural population accounts for 80.9% in 2009. The majority of its labor forces (approximately 70%) still engages in agricultural sector despite recent reduction. In recent years, Hai Duong has pushed up developing agriculture and industrial production in the direction of economic and industrialization and modernization. Thus, its GDP growth reached at 11.5% a year in the period of 2006 – 2010 and its agricultural GDP growth recorded at 4.5% (Hai Duong Statistical office, 2010) while the whole of Vietnam, these figures were around 6.7% and 3.3% respectively (General Statistical office, 2010).

Characteristics of survey households

In recent years, Hai Duong has oriented to develop the aquaculture as one of its development strategy which utilized properly its comparative advantages of natural resources. Initial establishment, many households has transformed their low paddy-fields to aquaculture production base on local authorities' orientation and master planning. This creates a new type of farmer – tilapia farmers who culture the tilapia fish. These tilapia households own many attributes that differed with the traditional farming households characteristics presented in Table 1. Tilapia farmers are more active, educated, younger and less experienced than non-tilapia farmers. Except for attributes of household size, around 4.5 persons, and landholdings, approximately 0.34 ha per farm. Almost tilapia farmers completed their secondary school level (9 years), while none-tilapia spent 7.1 years in education. Non-tilapia households had several advantaged characteristics such as longer experience in occupation, availability of land for the rent in and the rent out. In addition, about 90% of tilapia farmers engaged in rice production as their major occupation. On the other hand, most respondents (85%) were born in their villages.

Table 1. Characteristics of surveyed households

Indicators	Unit	Average	
		Tilapia households (N=70)	Non-Tilapia households (N=35)
Age of household head	Years	45.3	51.2
Education of household head	Years	8.8	7.1
Household size	People	4.58	4.57
Experience in present occupation	Years	6.5	-
Experience in previous occupation	Years	20.9	29.7
Land ownership	Ha	0.359	0.335
Fishpond area	Ha	0.270	-
Rent in	m^2	416	264
Rent out	m^2	10	198

Source: Survey data, 2010

Furthermore, analytical results of agricultural land show that the amount of land owned by both surveyed groups seems not to be differentiated; except high demanding for rent in 416 m^2 in tilapia households for developing their tilapia production. This also explained a result of the land reform in two recent decades in northern Vietnam, then gardening areas and farmlands, in most cases, were distributed proportionally to individual farms base on their size of family members. However, the allocated land in these surveyed households had particular distinctions which suggested the

farmers' knowledge, experience and skills in their production. Thus, land was diversified used for many agricultural practices such as: cultivation (rice produce, perennial-fruit crops, vegetable and fish aquaculture, while most land (9 Sao or 3,252 m^2) was employed for rice production in non-tilapia households. Only average 2 Sao(1 sao = 360m^2) for rice production was investigated in tilapia households.

Fish aquaculture contribution to food security

Fish and all other aquatic products contribute to food security directly as notorious human food providing protein, essential amino acids not found in the stables, calcium, iodine and several vitamins, minerals. In Hai Duong, fish aquaculture assists food security by providing income for fish farmers and livelihood for workers in aquaculture, traded supply and services industries such as feeds, extension, hatcheries, and so forth. Three dimensions of food security - sustainable supply, access to food, and nutritional adequacy – are now each addressed in following paragraphs.

Sustainable food supply

The provision of inland aquatic resources to food supply is deteriorating as increasing the gap between supply of and demand for. Supply is static at best, while demand continues to grow. To prevent such a situation from deteriorating further, the resource employed for aquaculture production must be kept in healthy, functioning order, even more expansion in under-exploited traditional regions. To be food secure, a population, household, or individual must have access to adequate food at all times. Thus food should be accessible all year round, irrespective of the political or economic situation. Particularly, aquaculture has reduced the vulnerable level of environmental shocks such as droughts and floods. The trend on land transformation in traditional agricultural food production to aquaculture production has taken place in the whole country and particular strongly in Hai Duong province. The results reveal the facts that most aquaculture areas employed economically have been conversed to be those from low-paddy fields which is susceptible to environment shocks, especially during the flooding season (Table 2). Annually, the planted area of paddy has been reduced at 1.62% in the period 2002 - 2009. In contrast, the aquaculture area had an upward trend, 4% a year through the period. This phenomenon can be considered a positive evidence for aquaculture contribution to food security in term of availability of food fish; stability of food supply as well as generating more income for sustainable aquaculture farmers in Vietnam.

Table 2. Aquaculture land transformation from traditional agriculture (rice) production.

(Unit: thousand hectare)

Land types	2002	2004	2006	2008	2009	Annual growth (%)
A. Planted Area of paddy						
Whole country	7504.3	7445.3	7324.8	7400.2	7440.1	-0.12
Red River delta	142.4	1210.0	1171.2	1153.2	1155.4	34.86
Hai Duong	142.4	135.9	130.9	126.9	127.0	-1.62
B. Aquaculture Area						
Whole country	797.7	920.1	976.5	1052.6	1044.7	3.93
Red River delta	92.2	102	113.1	121.2	124.9	4.43
Hai Duong	7.6	8.3	8.8	9.9	10	4.00

Source: General statistics office, 2010

Access to food

Many studies have shown that aquaculture give direct access to the household food supply in those low-income households that begin to grow their own fish and depending on proximity to markets and quantities of fish produced, and also contributes to improve their income and/or barter trade.

From findings of the study, tilapia farmers partially harvest for your home consumption during your fish production cycle. In theory, animal protein from fish sources is an extremely vital role for low-income farmers who grow fish that is eaten regularly at home. In Hai Duong, 97% of respondents reported that fish produced was consumed in the household (3.9% of total production or 533 kg per year) which gives a great contribution to their daily diet in improving the micro micro-nutrients, the rest being sold at farm gate or at the local market. Aquaculture thereby improved not only access to food by direct growing of fish for food security but also generating income to purchase foods and other needs such as housing, education, and medical services thereby reducing poverty (Table 3).

Table 3. Annual productivity, revenues, costs and profitability for tilapia production in Hai Duong

	Tilapia			
Factors\ production	**Extensive**	**Semi-intensive**	**Intensive**	**All**
Labor input (L – man per day)	312	237	278	257
Gross Output (Q - kg)	6,364	14,529	20,638	13,798
Total cost (1000 VND)	68,303	231,200	344,944	215,572
Feeds (1000 VND)	53,523	180,443	279,288	171,842
Fingerlings (1000 VND)	7,232	30,182	42,212	27,845
Fertilizer, chemicals (1000 VND)	1,414	4,744	7,120	4,491
Other (1000 VND)	6,134	12,629	16,324	12,055
Revenue (1000 VND)	127,280	322,470	452,760	302,972
Net farm income (1000 VND)	58,977	91,270	107,816	87,400
Home consumption (kg)	447	538	626	533
Products for sale (kg)	5,917	13,991	20,012	13,265

Source: General statistics office, 2010

Almost all tilapia farmers agreed that tilapia aquaculture increased fish consumption from 0.5 kg per person per month to 1.5 kg per person per month as a result of growing fish; and their economic situation improved by 40% from the sales. Analytically, tilapia is a kind of fish with short production cycles, which require low inputs and therefore little capital investment. That is suitable to both self-sufficient farming and commercial systems. Therefore, tilapia production has increased dramatically over the last decade in Hai Duong. However, the increasing availability of seed and the rising price of fish could cause its larger scale and more intensive cultivation in commercial production.

Fish production may bring additional benefits if it enables households to rise above subsistence farming level and into more commercial scales of operation. Tilapia households income (VND[1] 87 million) is 1.4 times as much as non-tilapia households (Table 4). The figure was analyzed in generating income from households' activities on their practices. Obviously, aquaculture value gives the greatest contribution to their total income at the tilapia group (75.5%), while in non-tilapia family the income generated from cultivation accounted for 50% of the total. Moreover, off-farm activities have a significant importance in money creation in the family without tilapia production.

Table 4. The structure of income at the surveyed households

Household Types per year	Tilapia households		Non-tilapia households	
	Amount (VND)	(%)	Amount (VND)	(%)
Cultivation	12,935,200	14.8%	30,057,402	50.2%
Livestock	4,457,400	5.1%	15,148,451	25.3%
Aquaculture	65,987,000	75.5%	-	0.0%
Other	4,020,400	4.6%	14,669,449	24.5%
Total	87,400,000	100.0%	59,875,302	100.0%

Source: Survey data, 2010

Aquaculture production seems to lead definitely to greater direct access to food, including fish for home consumption by poor people and for outcomes of food security when the income generated from aquaculture are examined by household classification (Table 5). Fish production usually requires high capital inputs, technical know-how, and ownership of or access to land/water resources. Basically, the richer tilapia farms are, the more significant fish income is. In Vietnam, the survey results show that fish aquaculture have benefited to the middle (VND 52 million, more than 2 times against the poor group) and large-scale (rich) commercial farmers (more than 4 times from the middle group). Although the total income in the poor group had the smallest amount, the figure is still higher above the Vietnamese national poverty line[2] and clearly aquaculture contributed to a considerable significance to their living, 51%. Most of them are happy and find fish aquaculture as a crucial instrument for poverty reduction and current economic improvement.

Table 5. The structure of tilapia households' income by household classification

Income sources	Poor		Medium		Better off	
	Amount ('000VND)	%	Amount ('000VND)	%	Amount ('000VND)	%
Cultivation	8,289,837	32.8	11,721,813	22.5	20,503,470	9.5
Livestock	1,216,927	4.8	2,972,641	5.7	10,791,300	5.0
Aquaculture	12,893,616	51.0	31,303,612	60.0	81,293,840	84.0
Other	2,881,220	11.4	6,153,534	11.8	3,237,390	1.5
Total	25,281,600	100	52,151,600	100	215,826,000	100

Source: Survey data, 2010.

[1] 1 USD = 18,500 VND

[2] The food poverty line is calculated as the expenditure required, given Vietnamese food consumption patterns. The poverty lines estimated for the 2006 -2010 are
- VND 200 000 per month in rural areas (VND 2.4 million per year); and
- VND 260 000 per month in urban areas (VND 3.12 million per year)

Aquaculture also can improve access to food by those who labor for wages on larger enterprises and in ancillary activities and who thereby gain income. The employment estimated base on man-day per ha per year are presented in Table 6. The estimation of job creation in rice production recorded at 168 man-day per ha per year, while tilapia farming can provide more opportunities of jobs, 257 man-day per ha per year, which gives a meaningful contribution to the employment strategy in rural areas in Vietnam. Hai Duong annual report on socio-economic implementation indicated that the seasonal unemployment rate of rural labors reached at approximately 30%. The study shows that most tilapia households (70%) reported to self-employed their own family labors. Furthermore, in larger-scale (commercial) farms, 60% respondents stated that hired labors were used for their tilapia production. The monthly salary for fish workers was from VND 3 to 3.5 million.

Table 6. Job creation in tilapia households by production intensification

(Unit: man-day per ha per year)

Household types	Extensive	Semi-intensive	Intensive	Grand-Average
Grand-Average	**312**	**237**	**278**	**257**
Poor HH	348	258	318	***284***
Medium HH	297	230	275	***249***
Better off	262	214	241	***225***

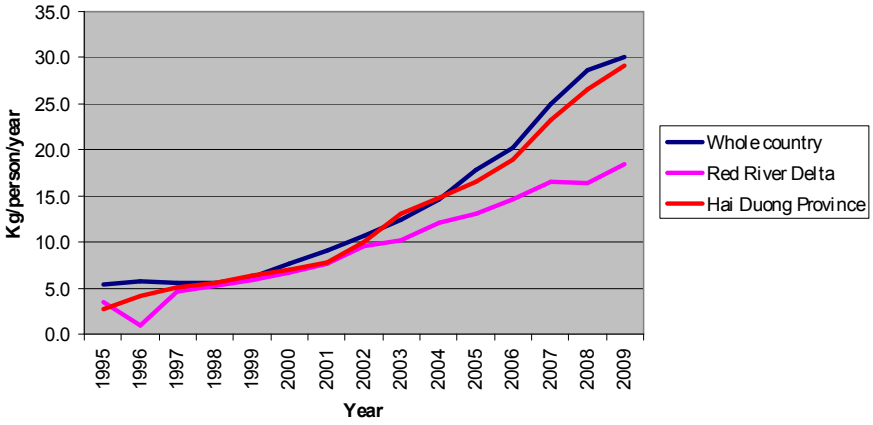
Source: Survey data, 2010.

Nutritional adequacy

The nutritional adequacy of food supply relies on fish production changing in parallel with the human population density in Hai Duong, whereas aquaculture production per caput increases and maintains food availability. Particularly, statistical data in Vietnam indicates the significant progress in raising food consumption of aqua cultural products per person in the period 1995 – 2009 (see Figure 2). Aquaculture consumption have increased to 30 kg per person per year in 2009 from 5.4 kg per person per year in 1995 in the whole country, and to 29.04 kg per person per year from 2.7 kg per person per year in Hai Duong, respectively. The World Fish Center analysis estimates demand responses to changes in fish price and income.

Fish consumption also shows the variation in term of type and price according to a rural/urban divide. The annual fish consumption per capita is generally higher in rural than in urban (Dey et al.2005). Among rural consumers, fish producers consume more than non-producers. Tilapia has priorities in consumer choice of a particular species since freshwater fish often have lower prices than marine fish, even in cultured fish such as common carp, grass carp… From the Poor's demand for fish and its availability to them, it is apparent that it is affected not just by availability of, and preferences for fish. Where fish stocks are in decline and demand is high, the price of fish, particularly wild fish, has increased to the extent that the poor can no longer afford to eat what they caught. In such cases, they may eat cultured fish (tilapia) or not eat fish at all, substituting it with other foodstuffs e.g. pork, beef, chicken … The availability of nutritious alternatives to fish then become a vital consideration.

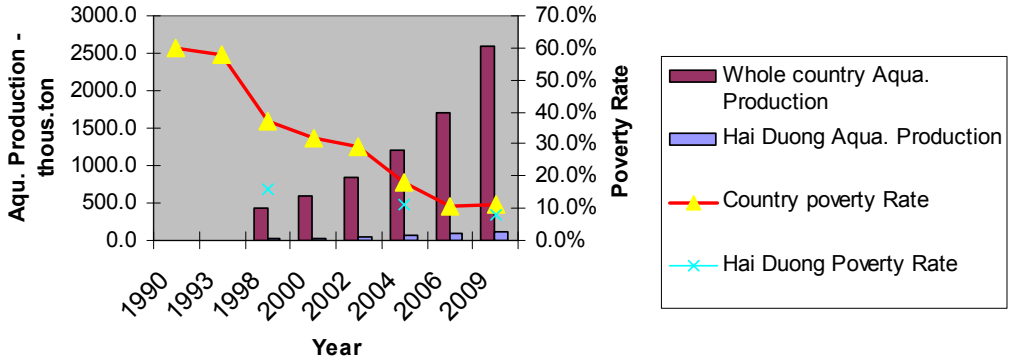
On the other hand, increased supply of fish from aquaculture has led to decrease in price of farmed fish in local and neighboring markets. This tilapia fish culture increases the supply of affordable fish, thereby reducing the cost and increasing the availability of fish to poorer households. The average price paid for fish also increases as income increases. Not surprisingly, poorer households consume lower value fish than the rich. However, despite the lower cost of the fish they purchase, the share of fish expenditure of total animal protein is still higher for poorer households. This indicates the importance of fish in diets of poor people, primarily due to the higher cost of other sources of protein.



Source: General statistics office, 2010

Fig. 2. Aquaculture production per caput in Vietnam 1995 – 2009.

The study results show that annual growth of aquaculture production per caput in Hai Duong rising close to the extent of whole country and more rapidly than the Red river delta region. This also suggests the importance of food fish in people's daily intake as well as the nutrient adequacy in the food security. It is suggested that deeper understanding of the fish utilization and its share of micro-nutrients and animal protein in farmers' daily meals.

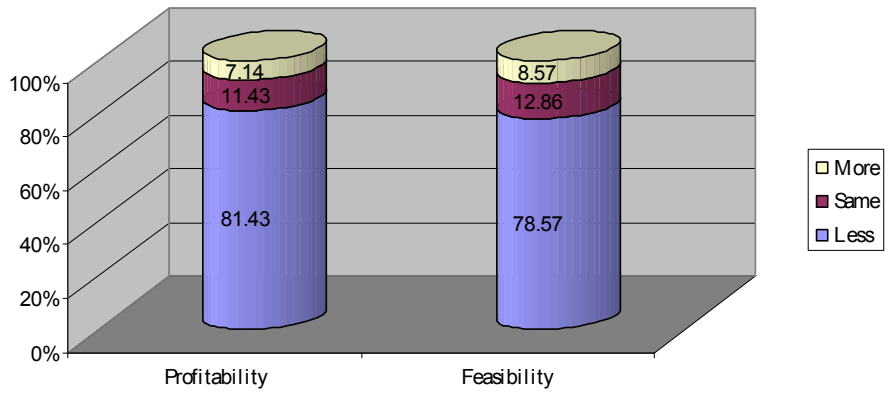


Source: Estimates based on annual Hai Duong economic report and Wikipedia Vietnam - Human Poverty Index, 2010

Fig. 3. Relationship between poverty and presence of aquaculture production in Hai Duong 1990 - 2009

The effective utilization of food is an important aspect of food security and relies on sufficient energy consumption and a varied diet to provide required micronutrients. Therefore, the energetic contribution of aquaculture products could be assessed in terms of calorific importance. Several studies proved that aquaculture has improved life expectancy, growth, fertility in the poor households under aspects of nutrient adequacy. Nonetheless, the aquaculture contribution to food security can be evaluated by examining the decreasing poverty rate to the presence or absence of aquaculture. Figure 3 shows the downtrend in poverty rate in the years 1990 – 2009 in parallel with rapidly rising aquaculture production. The national poverty rate fell to 11% in 2009 from 60% in 1990. In Hai Duong, the poverty rate decreased by 4.5% from 1998 to 2004 and recorded at under

approximately 8% in 2009. The surveyed results also reported the coincidental answer in the profitability and feasibility in tilapia aquaculture (Fig. 4)



Source: Survey data, 2010

Fig. 4. Farmer perception on the profitability and feasibility of tilapia farming in Hai Duong (percentage of farms)

The performance perception of tilapia farming in relation to other sources of income varied amongst farmers. Figure 4 shows how it was perceived as more profitable and feasible (viable for tilapia production in relation to knowledge, effort and time demanded and market opportunities) for the majority of the farmers (81.43% claimed to be more profitable, and 78.57% claimed to be more feasible); however, more farmers claimed tilapia farming was less feasible (8.6%) compared to the other sources of income, while only 7% claimed it was less profitable.

CONCLUSION

In Vietnam, the strong movement of inland fish aquaculture development has been taken widespread to ensure availability of food fish (30 kg/person/year in 2009) with annual fish consumption growth recorded at 13.05% (1995-2009). Similarly, Hai Duong has an aquaculture area of 10.000 ha, 4% increasing in annual area growth in 2009. This has annually created remarkable value contribution to its agricultural GDP (2,140 VND billion, occupying for 24.3% of total GDP).

Like Hai Duong, in many other provinces, has favorable conditions to develop the tilapia farming. These help Hai Duong farmers to utilize better the resources to improve their living standards. Tilapia culture could get high yield about 14 tons/ha, equivalent to a revenue of 300 VND million, generating net farm income about 87 VND million (4,724 USD) per ha a year, much more efficient than traditional rice production (only 66 VND million). The tilapia farmers' economic and food conditions has been improved. However, the increasing availability of seeds (fingerlings), the appropriate control of inputs, and access to capital investment (ownership, loans) would be highly appreciated for enhancing the aquaculture contribution to the poor farmers' income and food security.

Freshwater aquaculture plays an important role in stabilizing the fish food regarding to scarcity of fish capture. Aquaculture production per caput has increased from 2.7 to 29 kg per person per year (1995-2009). It is also an effective solution for poverty reduction and hunger elimination in Vietnam. The aquaculture production increased as the poverty rate deceased, correspondingly.

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THE ROLE OF PHILIPPINE STATE COLLEGES AND UNIVERSITIES IN ENHANCING FOOD SECURITY

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ABSTRACT

Aside from their prime mandate of providing Instruction, Research, and Extension to the publics, state colleges and universities (SUCs) in the Philippines are also an indispensable instrumentality in helping address local and global issues such as food security. It is the intent of this paper to share what SUCs in the Philippines are doing towards enhancing food security. It specifically ventilates some of the significant experiences and best practices of Philippine SUCs, which are seen to bring about a significant dent in helping realize the World Food Summit Plan of Action. In coming up with this paper, documentary analyses, interview with key informants, review of related literature, and personal accounts on relevant University experiences were employed.

INTRODUCTION

Food security is a global issue. In the Philippines, it has been reported that for more than 800 million people who do not get enough regular, healthy food, ill health and a shorter life expectancy are real risks. Children, and especially very young children, who suffer from food insecurity will be less developed than children of the same age who have had sufficient food. They will most likely be shorter and weigh less, and be less able physically and intellectually, because of poor nutrition.

Putting food on the table is a daily struggle for most Filipino families. Results of a national food consumption survey showed the difficulty of obtaining a nutritionally-adequate diet. Even households with incomes in the highest quartile failed to have diets adequate in energy, vitamins and minerals. Are Filipino households eating enough? In answer to its own question, the Food and Nutrition Research Institute concluded that in 2003, "the typical one-day dietary pattern of Filipino households remained to be a combination cereals-vegetable-fish, as they contributed the largest share in the total intake," as was the case also in 1978, 1982, 1987 and 1993.

The above scenarios illustrate the extent of food security problem in the Philippines. The country's food and nutrition problem has become more complex, and the resources needed to address it effectively have increased enormously, making broad networking a necessity. There is now a large cast of characters. In addition to the people themselves and national and local governments, other players are the food business and industry, mass media, agencies of the United Nations, transnational food corporations, non-governmental organizations, international funding agency, etc. (Gopalan, 2005).

The academic institutions, such as state universities and colleges (SUCs), also form part of this large cast of characters. They, therefore, play a crucial role towards enhancing food security.

Modalities/Strategies Employed by SUCs in Addressing Food Security

How do SUCs respond to the challenge of enhancing food security?

Following are some of the modalities/strategies employed by SUCs in helping address the issue of food security:

A. Production as a Mandate of SUCs

State Universities and Colleges in the Philippines are mandated to perform a trilogy of functions: instruction, research and extension. However, considering that majority of SUCs control vast resources such as land, manpower, technology, infrastructure and other facilities that could be utilized for economic activities, the Philippine government added production or income generation as a fourth function.

As one of the legal bases in establishing income-generating projects, Republic Act No. 8292, otherwise known as the Higher Education Modernization Act of 1997, legitimizes efforts of state universities and colleges in agribusiness program implementation. A provision allows SUCs to enter joint venture with business and industry for the profitable development and management of the economic assets of the institutions, the proceeds to be used for the development and strengthening of the college or university.

All SUCs in the Philippines engage in income generating projects (IGPs) with the initial intention of enriching their main trilogy functions. They are one in the philosophy that the ultimate measure of the effectiveness of any institution is its contribution to and impact on the educational, economic, social, cultural and political well-being of the students, faculty and employees and the community they serve. These are all geared toward development of quality human resources and technologies supportive to people empowerment, global competitiveness and sustainable development. Through its production function, SUCs embark on various activities that aim to help address food production and security. These include special projects related to the massive conduct or implementation of agricultural, agroforestry, fishery and other related commodities. The Don Mariano Marcos Memorial State University (DMMMSU), for instance, which is one of the leading agricultural universities in northern Philippines, has initiated a good number of food production projects both in the University and in its various Extension service areas. One of its flagship commodities, apiculture or beekeeping, has penetrated to various provinces in the country, and had consequently triggered massive adoption by a good number of rural clientele.

B. Research & Development Symposia: A Marketplace for Generated Technologies

A very good repository and marketplace for generated technologies, which could be a springboard for triggering technology adoption and eventual massive food production/entrepreneurship, is the yearly conduct of Regional Symposium on R&D Highlights throughout the country. Each region in the country has an agricultural resources research and development consortium, whose membership includes institutions that implement R&D projects, that mounts the yearly gathering of topnotch researchers to present the highlights of their respective generated technologies. SUCs have been the forefront players in this R&D endeavor.

Table 1 Number of researches and posters presented, ILARRDEC Regional R&D Symposia (2006-2011)

Year	No. of researches presented	No. of posters presented	Total
2011	35	22	57
2010	31	15	46
2009	39	22	61
2008	34	19	53
2007	35	-	35
2006	35	-	35
Total	**209**	**78**	**287**

This year, in Region 1, the Ilocos Agriculture Resources Research and Development Consortium (ILARRDEC) had come up with very good technologies as can be gleaned in the last staging of its R&D symposium. Most of the commodities usually presented in the ILARRDEC symposia are along high-value fruit crops and vegetables, cereals, commercial and plantation crops, livestock, poultry, forestry, apiculture, sericulture, among others. Table 1 shows the prolificacy of generated technologies by ILARRDEC.

C. Education Economic Zones for State Universities

Recently, the Commission on Higher Education launched the *Education Economic Zones for State Universities* in the country. Here, series of national fora on SUCs-private partnership on economic zones are held to discuss projects which are of help to SUCs in generating financial resources so they can continuously deliver quality higher education to meet the standard of the industry that their graduates hope to serve.

The series of national fora also provide an avenue for sharing existing best practices on SUC-Private partnership relative to the following sub-themes: enterprise development; intellectual property management/technology business incubation/ technology commercialization; asset, management and development; business process-outsourcing; among others. They also aim to explore the future potential SUCs-private partnership.

D. SUC Alliance for Income Generating Projects

In response to the call of Philippine President Benigno C. Aquino, III in modernizing agriculture, the Commission on Higher Education is set to launch the formation of a SUC Alliance where research results of selected higher education institutions will be subjected to technology business incubation.

SUCs which are strong in a particular R&D commodity shall take the lead role in fast tracking the dissemination, diffusion, adoption and commercialization of that particular commodity, in partnership with other SUCs. The DMMMSU, for instance, whose commodity strength is beekeeping, shall be the lead institution of a national network for apiculture.

E. Partnership with R&D Institutions

Forging linkages and networks with R&D institutions is also an effective modality by which SUCs can help address food security.

The DMMMSU, for instance, had recently inked a memorandum of agreement with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India regarding the implementation of the "Strengthening Rainfed Agriculture Research Development and Extension in the Philippines." ICRISAT is a non-profit, non-political, international organization for science-based agricultural development that helps developing countries mobilize science to increase dryland agricultural crop productivity and *food security*, reduce poverty, and protect the environment.

DMMMSU and ICRISAT shall engage in collaborative rainfed agriculture RD&E projects. Being a SUC, DMMMSU stands to benefit much from this partnership as it shall be adopting and commercializing cutting edge rainfed agriculture technologies provided by ICRISAT through the Philippine agricultural R&D network.

CONCLUDING STATEMENT

The World Food Summit Plan of Action said that food security exists "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

Academic institutions, such as SUCs, can do no less in doing its part in helping enhance food security in the country. Aside from their primordial role of empowering and educating the people, they are an effective instrumentality in coming up with practical, feasible and viable options and modalities towards realizing the World Food Summit Plan of Action.

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FOOD DIVERSIFICATION IN JAPAN: RECENT DEVELOPMENTS IN FUNCTIONAL FOODS

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BACKGROUND

According to the World Health Organization (WHO), food security is built on the following 3 pillars:

a. Food availability: sufficient quantities of food available on a consistent basis.
b. Food access: having sufficient resources to obtain appropriate foods for a nutritious diet.
c. Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

In many countries, health problems related to dietary excess are an ever increasing threat, and malnutrition and food-borne diarrhea are becoming additional burden.

Regarding the situation in Japanese specifically, the food self-sufficiency rate (SSR) is low, for example, 80% of the ingredients for “Tempura-soba (Japanese noodles made from buckwheat flour)” are imported from abroad. Food patterns have changed in Japan with SSR decreasing from 70% in 1965 to 40% in recent years. In particular, rice consumption has reduced and oil consumption has increased in recent years (Fig. 1). Since diets have been westernized, energy intake has become excessive because of an increasing fat to energy ratio; in contrast, the carbohydrate to energy ratio has reduced.

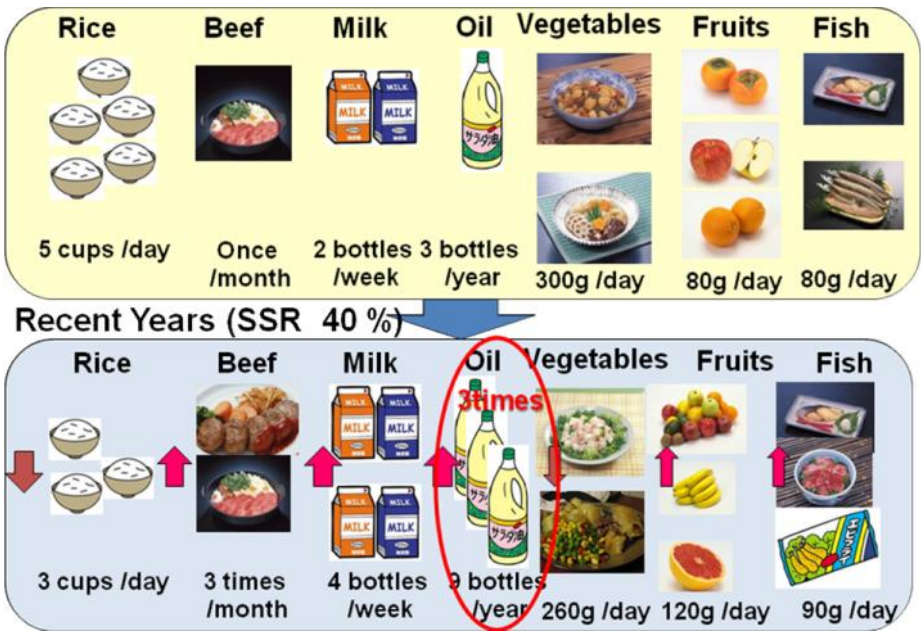


Fig. 1. Changes in the food consumption pattern in Japan

Recently, production of rice flour has increased for bread production, but the cost of using this product in bread is higher than that for wheat flour. Reduced rice consumption has also led to increased meat and fat intake, reduced vitamin and mineral intake, and reduced exercise levels. This has led to an increased prevalence of lifestyle-related diseases such as dyslipidemia, diabetes, cardiovascular diseases, hypertension, osteoporosis, and cancer in Japan. It is also important to consider the economic effects (primary care and self-medication cost) of lifestyle-related diseases. For example, increase in the prevalence of diabetes would necessitate considerable resources for adequate management (Fig. 2). Therefore, improvement of food quality is an important issue, although increase in food quantity (security) is also required.

In Case of Diabetes

~Medical Expenses~

Treatment for Glycophilia (Nutrition Education & Exercise Prescription)

15 dollars/month

Treatment for Prevention of Diabetic Complication

1750 dollars/month

Dialysis for Diabetic Nephropathy

8750 dollars/month

Fig. 2. Economic effects of primary care and self medication in Japan

Development of Functional Food Science in Japan

The term "physiologically functional food", which first appeared in the Nature journal in 1993 with the headline "Japan explores the boundary between food and medicine" has had a strong international impact. Functional food, is defined as those that have the potential to reduce the risk of lifestyle-related diseases and associated abnormal modalities, have garnered global interest since the 1980s when the systematic research had humble beginnings as a national project in Japan. In 1991, the project led to the launch of the national food for specified health uses (FOSHU) policy; almost 1000 FOSHU products with 8 categories of health claims have been approved up to the present (Tables 1 and 2).

Many FOSHU products claim improvement of gastrointestinal (GI) conditions. The effective component is usually a carbohydrate, which can be divided into oligosaccharides, dietary fiber, and lactic acid bacteria. Approved products containing these components can, for instance, claim that they help to increase intestinal bifidobacteria and thus help to maintain a healthful GI condition.

Other products have been approved for uses concerning blood cholesterol, triacylglycerol, body fat, blood pressure, bone, teeth, and blood glucose (Table 1). The details are as follows:

a. Blood cholesterol: Effective components include soy protein, chitosan, low-molecular-weight sodium alginate, and phytosterols. Approved products that contain these components can claim that they help to decrease blood cholesterol levels.
b. Blood neutral fat: Medium-chain fatty acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and digested globin are believed to decrease blood neutral fat levels after meal consumption. Approved products that contain these constituents claim that they help to reduce postprandial blood triglyceride levels.
c. Body fat: Oolong tea polyphenols are thought to help reduce body fat gain. Approved products that contain these constituents claim that they help to reduce body fat gain.
d. Blood pressure: Effective components that are believed to reduce blood pressure include

lactotripeptide from fermented milk, dodecapeptide from casein, a group of peptides from sardine, dried bonito, seaweed, and γ-aminobutyric acid. Approved products containing these components can claim that they are suitable for people with moderately high blood pressure.

e. Bone health. Vitamin K-2 and soy isoflavone are regarded as promoters of bone calcification. Approved products containing these components can claim such effects.
f. Absorption of minerals: Fructooligosaccharides in the colon and casein phosphopeptide in the small intestine are thought to improve calcium absorption. Approved products containing these components can claim that they help in improved absorption of calcium.
g. Dental health: Some sugar alcohols such as xylitol, maltitol, erythritol, and palatinose are considered to be hypocariogenic, whereas green tea polyphenol is regarded as noncariogenic. Approved products contain these sugar alcohols can claim that these products are low or noncariogenic. In addition, some FOSHU-approved products can claim that these aid in maintaining strong and healthy teeth.
h. Blood glucose: Effective components include indigestible dextrin, wheat albumin, and L-arabinose. Approved products that contain these components can claim that these materials are helpful for those who are concerned about their blood glucose level.

Table 1. Approved Health Claims on FOSHU **(**as of 2011/04/01)

Health Uses	**Food category**	**Ingredients (Example)**	**Model Claim, statements**	**Number approved**
GI function	Table sugar	Oligosaccharides	• Helps maintain good GI condition • Helps improve bowel movement	350
Cholesterol level	Powdered beverage Oil Refined oil	Soy protein, Chitosan, Phytosterol, Medium-chain fatty acids, DHA, EPA	• Helps lower cholesterol level • Helps resist body fat gain	142 70
Triacyglycerol Body Fat				
	Oolong tea	Polyphenol	• For those concerned about	

Health Uses	Food category	Ingredients (Example)	Model Claim, statements	Number approved
			body fat	
Blood pressure	Instant powder soup, candy	Peptides	• For those with high blood pressure	120
Mineral absorption Bone health	Table sugar Beverage	Oligosaccharides Casein pospho-peptide	• Promotes calcium absorption	53
		Soy isoflavone	• Supports bone health	
Dental health	Chewing gum	Mixture of Xylitol, Calcium Phosphate and Fukuronori extract	• Helps maintain strong and healthy teeth	79
Blood glucose level	Beverage Instant Miso soup	Indigestible dextrin	• For those concerned about blood glucose level	141

To reduce disease risk there are additional approved FOSHU health claims (Table 2).

Table 2. Additional approved FOSHU health claim for reduction of disease risk

Functional ingredients	Health claim approved	Precautions in ingestion
Calcium Daily intake of calcium from the FOSHU products should be between 300 and 700 mg.	This product contains adequate calcium. Intake of a proper amount of calcium contained in healthy meals with appropriate exercise may support healthy bones of young women and reduce the risk of osteoporosis when aged.	Diseases are generally caused by various factors. Excessive ingestion of calcium will not eliminate the risk of developing osteoporosis.
Folic acid	This product contains adequate folic acid.	Diseases are generally

Daily intake of folic acid from the FOSHU products should be between 400 and 1000 mg.	Healthy meals containing an appropriate amount of folic acid may support healthy fetal development in pregnant women and allow them to bear healthy babies by reducing the risk of neural tube defects such as spina bifida.	caused by various factors. Excessive ingestion of folic acid will not eliminate the risk of giving birth to a child with a neural tube defect.

Since 1991, food functionalities have been extensively researched, and novel functional food genomics based on nutrigenomics have also been introduced. The availability of these functional foods is evaluated by using the "omics" techniques to cyclopedically analyze how gene expression fluctuates in each intravital tissue after consuming a functional food or its component.

Safety Evaluation of Soybean Isoflavones

Since the availability of functional foods has been adequately assessed, the focus has now turned to the evaluation of safety and the necessity of risk assessment.

The Food Safety Commission of the Cabinet Office assesses the risk and safety of foods, including the so-called "health foods" and FOSHU. Soybean isoflavone was approved in 2001 as the principle ingredient in FOSHU, as targeted to individuals concerned about bone health. After the shapes of the tablets and capsules were finalized and brought into effect by the health-promoting food system in April 2001, the assessment of safety was specifically emphasized. As an initiative, the Food Safety Commission of the Cabinet conducted a safety evaluation of soy isoflavones.

Soybean isoflavones are structurally similar to estrogen; have the ability to bind to the estrogen receptor, exhibit weak estrogen activity; and have anti-oxidative and anti-inflammatory efficacies relevant to prevention of chronic diseases, including lifestyle-relate diseases such as cancer, cardiovascular disease, diabetes, and osteoporosis (Fig. 3).

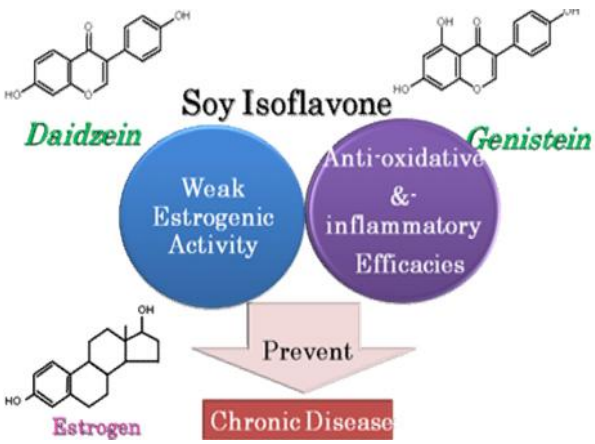


Fig. 3. Chemical structures of soy isoflavones and estrogen

In 2001, soybean isoflavone was approved as the principle ingredient in FOSHU targeted to individuals concerned about bone health. There are tea, soymilk and soft drink products that contain 40 mg of isoflavone conjugate, which is equivalent to 25 mg of the aglycone form. In 2004, applications for a tablet containing soy isoflavone aglycones as its principal ingredient, and a fermented food containing isoflavone aglycone in amounts exceeding the usual amounts in FOSHU were filed for approval. Foods with fortified or condensed isoflavones have not been consumed before, and there is a possibility that the tablets and capsules would be excessively consumed. Thus, the Food Safety Commission issued a Notice, "Basic approaches to evaluating the safety of FOSHU containing soy isoflavones" in 2006. According to this evaluation, the maximum recommended level for safe isoflavone aglycone intake in the daily diet was set at 70 to 75 mg/day. Table 3 shows quantities of foods containing around 75 mg of isoflavone. These indicate that it will be easy to exceed 75 mg of isoflavones in a standard Japanese daily diet.

Table 3. Food equivalents of 75 mg of isoflavone

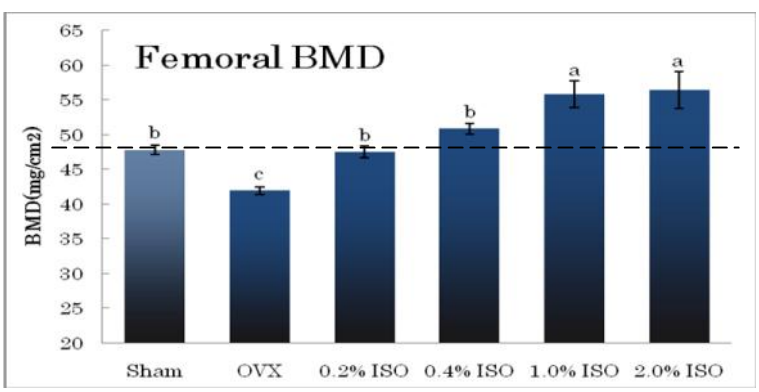
Commodity	**Equivalencies**
Natto fermented soybeans (46 g/package)	2 packages ＝ 71 mg
Tofu	1 piece (300g) ＝ 80 mg
Soy milk, 200 g/ package	2 packages＝ 82 mg

Soy flour, 6 g/ spoon	8 spoons = 77 mg

In the USA, The Food and Drug Administration (FDA) indicated that, “25 grams of soy protein daily in a diet low in saturated fatty acid and cholesterol may reduce a risk of heart disease.”. This amount of soy protein (25 g) daily is very likely to equate to more than 75 mg of isoflavone. Which should we then choose, reducing the risk of heart disease or consuming a safe level of isoflavone? It appears that maximum recommended safe levels of safe isoflavone intake are not easy to evaluate and 75 mg of isoflavones may be low when considering daily diets in Japan.

RiskJbenefit Analysis of Functional Foods: The Case of Soy Isoflavones

We conducted an animal experiment to examine the dose–response relationship between isoflavone supplementation and bone and uterine weights in ovariectomized (OVX) mice, a model for postmenopausal osteoporosis. The results indicated that administration of 0.2% isoflavone prevented bone loss and inhibited uterine hypertrophy, a risk factor for uterine cancer, in the OVX mice The results suggest that the appropriate dose of isoflavones to prevent uterine hypertrophy might be less than 0. 2%. (Fig. 4).



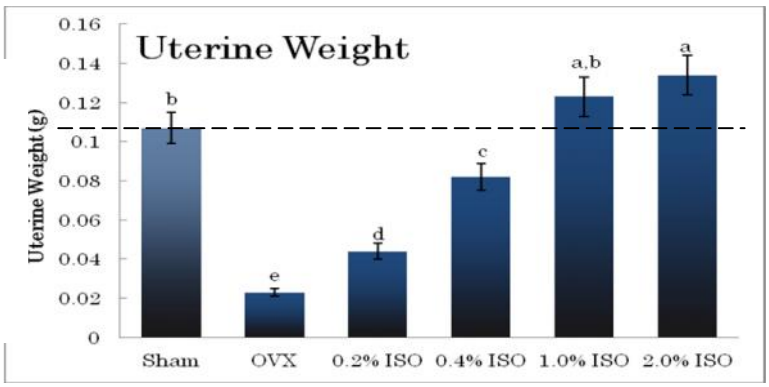


Fig. 4. Dose –response relationship between isoflavone supplementation and bone-mineral density (BMD) or uterine weight in ovariectomized (OVX) mice.

It is thought that the clinical effectiveness of isoflavones might be attributable to their ability to produce equol, a metabolite of daidzein (a major isoflavone), in the gut , although only 50% of Asians can produce equol from daidzein (Fig. 5).

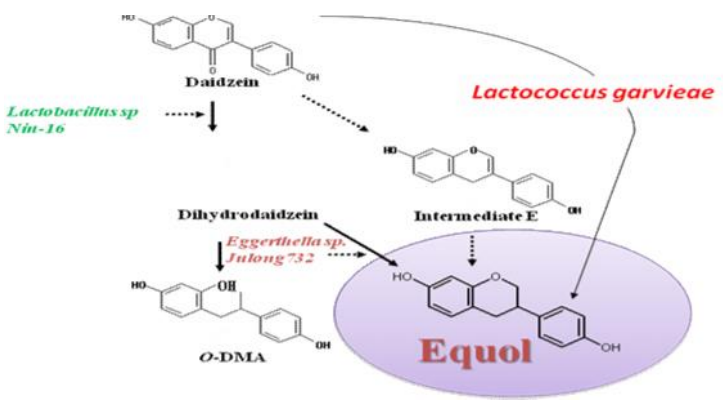
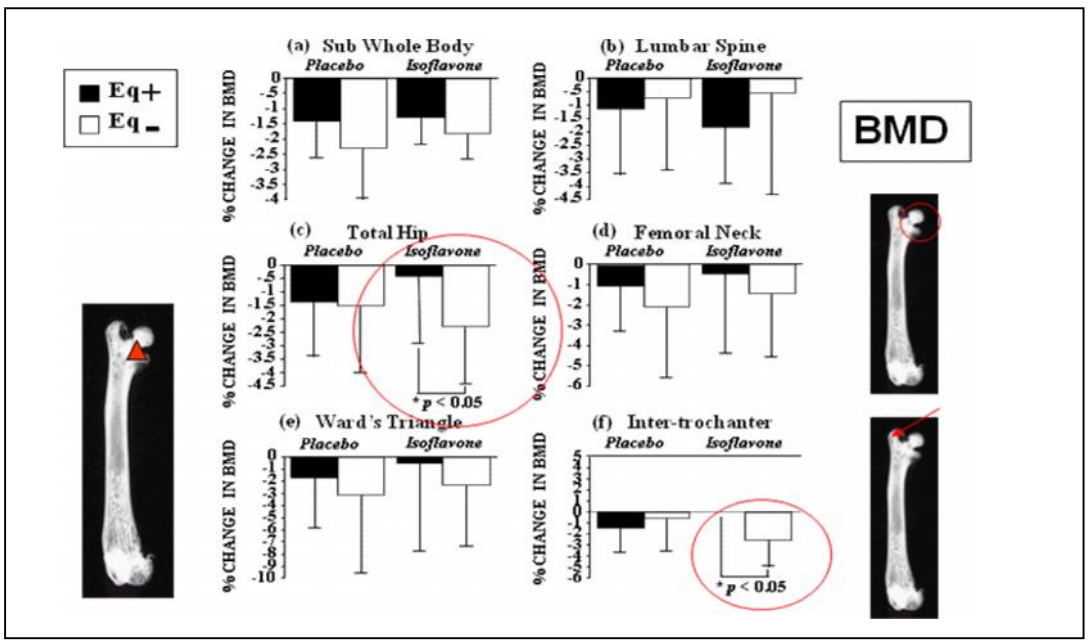


Fig. 5. Daidzein metabolism and candidate microflora for producing equol

Among postmenopausal Japanese women, individuals who are able to produce equol experience beneficial effects on bone loss (Fig. 6). Effects of 1 year isoflavone conjugate intake (47mg aglycone equivalent) in addition to the normal diet (average: 28 mg/day) on changes in bone mineral density (BMD) in postmenopausal Japanese women stratified according to their equol status. Mean (SD) percentage changed in the BMD of the sub-whole body, lumbar spine, total hip, femoral neck, Ward's triangle, and inter-trochanteric region after the 1-year intervention in the study groups.



The subjects were stratified by their equol status in both the study groups and were referred to as equol producers (■) and nonproducers (□). Significant differences were observed in the total hip and inter-trochanteric BMD between the equol producers and nonproducers in the isoflavone group (Student's t test *p = 0.05).

Fig. 6. Effects of 1 year isoflavone conjugate intake (47mg aglycone equivalent) in addition to the normal diet (average: 28 mg/day) on changes in bone mineral density (BMD) in postmenopausal Japanese women stratified according to their equol status.

To examine the effects of isoflavone intake on hormone levels in the postmenopausal women in the same intervention study, we measured serum concentrations of estrogen, FSH, LH, progesterone, and thyroid hormones. The results indicated that, in equol producers, around 75 mg of daily isoflavone intake shows beneficial effects on the bones after 1 year without any harmful effect (risk) on the level of sex and thyroid hormones.

Table 4. Effects of 1 year isoflavone conjugate intake (47mg aglycone equivalent) in addition to the normal diet (average: 28 mg/day) on serum sex- and thyroid- hormone concentrations in postmenopausal Japanese women.

		Placebo (n = 29)	Isoflavone (n = 25)	Placebo vs Iso
Estradiol (pg/ mL)	Baseline	12.66(4.03)	12.32(3.34)	NS
	After 1 year	12.98(7.31)	11.98(2.94)	NS
	% change	6.09(57.71)	1.20(23.80)	NS
FSH (U/L)	Baseline	70.36(26.02)	68.19(18.66)	NS
	After 1 year	60.00(19.83) *	58.12(17.86) *	NS
	% change	-12.36(8.40)	-14.05(9.01)	NS
LH (U/L)	Baseline	26.68(13.87)	27.70(9.32)	NS
	After 1 year	22.43(11.12) *	22.33(7.90) *	NS
	% change	-12.16(15.98)	-19.10(14.44)	NS
Progesterone (ng/mL)	Baseline	0.27(0.11)	0.29(0.16)	NS
	After 1 year	0.21(0.10) *	0.24(0.12) *	NS
	% change	-24.54 (29.47)	-14.07(18.08)	NS
T3 (ng/mL)	Baseline	1.13 (0.16)	1.08 (0.13)	NS
	After 1 year	1.10 (0.16)	1.03 (0.16)	NS
	% change	-1.60 (6011)	-3.92 (7.96)	NS
T4 (μg/dL)	Baseline	8.57 (1.12)	8.19 (1.28)	NS
	After 1 year	8.46 (1.13)	7.54 (1.42) *	NS
	% change	-1.85 (7.46)	-4.48 (6.23)	NS
TSH (mU/L)	Baseline	2.34 (1.10)	2.30 (0.74)	NS
	After 1 year	2.75 (2.81)	2.25 (1.10)	NS
	% change	12.71 (69.59)	-9.22 (32.74)	NS

* Significantly different from baseline by paired *t*-test, $p < 0.05$

CONCLUSIONS

Although it is necessary to have food in sufficient quantity, improvement of food quality is also important. Functional foods and FOSHU have been developed in Japan for improving the health status of individuals and preventing lifestyle-related diseases.

The maximum recommended safe level for isoflavone intake is not easy to evaluate and 75mg daily may be too low an amount in the for daily diets.

During the past few years, only the validity, that is the benefits, of FOSHU were evaluated. More recently, risk evaluation has been promoted in Japan. Risks and benefits posed by functional foods should be collaterally evaluated in the near future, and risk–benefit analyses should be performed to investigate the correlation between these two factors.

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LAND TENURE AND TENANCY CONDITIONS IN RELATION TO RICE PRODUCTION IN THREE VILLAGES IN THE RED RIVER DELTA, VIETNAM

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ABSTRACT

Red River Delta is one of the main rice producing regions in Vietnam. With large variations in natural conditions, the Red River Delta is suitable for development of different types of crops and animals. In recent years, the importance of fisheries, aquaculture and fruit trees have been increasing. With the average farming area per household in Red River Delta being 0.28 ha (2005), land is a limiting factor in generating sufficient income. Most farmers resort to diversifying their farming to high value crops such as vegetables, fruit trees, and livestock for urban markets, or engaging in non-farm activities. The result of this trend is the emergence of tenancy among farmers. This paper attempts to clarify the determination and function of rice land tenancy within the context of the economic structure in three villages in the North of Vietnam. A series of questionnaire surveys were conducted in 2010- 2011 in the villages of Hung Yen (A), Bac Ninh (B), and Hai Phong (C) Provinces which are located in the Red River Delta. The main findings of the research are as follows. There is an increasing area of non-rice production with the appearance of different kinds of tenurial status in different villages. The tenurial status changes with the age of the farmers, indicating the influence of life-cycle on farmers' economic behavior. There is also heavy dependence upon kinship ties in landlord-tenant relations. The production function analysis revealed that the increased use of land, labor, seed and fertilizer could lead to a higher rice production. The average rental under the predominant form of tenancy appeared to be equal to the marginal product of land, but under the contracts established between relatives, the average rental was much lower than the marginal product.

Key words: landlord-tenant relation, fragmentation, rent function, rice farming, production function, marginal product

INTRODUCTION

Land policy is an essential component of economic development measures in all countries and especially in the developing country of Vietnam (Deininger, 2003). Land tenure in Vietnam is complicated because of political, social, economic and natural conditions. Farmers do not own agricultural land, instead land is owned by the state. Based on the Resolution No.10 of Land Law in 1988, former communal farms were first broadly divided into a number of blocks according to land and water conditions, each of which was then equally divided among the commune members with

land use rights (Sally, MacAulay and Pham, 2006). The allocation was intended to provide an egalitarian land distribution, and each household was allocated land according to the number of family members in the household. Therefore, each household came to possess a number of plots under severe fragmentation, resulting in difficulties in farm management. It was estimated that there were 70-100 million plots of land (World Bank, 2005), with around 10% of these plots having an area of only 100 m^2 or less.

Since the 1993 Land Law was introduced, farmers have had greater freedom to choose which crop to grow. The local governments (provinces) had control over a change of land use, mainly for changes from annual crop to perennial crop lands. However, with high economic and population growth, dietary patterns in the developing countries are rapidly changing, and the demand for food is diversifying in favor of livestock, fruit and vegetables (World Bank, 2005). Land reform has affected land use patterns in districts close to towns and cities in that high value crops are becoming increasingly common in some communes (Cho and Yagi, 2001). There is a clear trend among farmers to reduce rice cultivation and increase the planting of fruit and vegetables (Fujimoto and Vu, 2003). As a result, changes in land use have undoubtedly begun to occur (World Bank, 2005).

Red River Delta (RRD) is one of the two main agricultural producing regions in Vietnam. This delta is smaller but more intensely developed and more densely populated than the Mekong River Delta (MRD). In the RRD, farmers do not sell land, and for those farmers who intend to expand their farms, it is necessary to acquire farmlands by renting-in from other farmers. In fact, land tenancy was occurring both before and after the 1993 Land Law (Do, 2003; Deininger, 2003; World Bank, 2005). Most of the rice production studies were conducted in MRD, where the average size of farms was considerably larger and less fragmented than those in RRD. Economic analysis of land fragmentation has been conducted in RRD (Hung, 2006), but less attention has been paid to the relation between land tenure systems and production (Fujimoto and Kitajima, 2003).

Land tenure situation refers to the ownership and use of land, which is one of the basic production factors in agriculture, and thus represents not only arrangements concerning the land factor in the production process but also an indicator of the socio-economic system of the agricultural village. For further agricultural development, it is necessary to have a better understanding of the present land tenure situation, especially in relation to rice land. This could allow progress to the goal of more efficient use of resources and improved incomes among farmers.

METHODOLOGY

This paper aims to analyze the current situation of land tenure systems, including the pattern of land holding and the existing tenancy contracts of farm respondents. More precisely, this paper attempts to clarify the effect of the land tenure system and tenancy conditions in relation to rental level and rice production in three villages in RRD.

Primary data were obtained from a questionnaire survey of farm households, conducted in 2010. The following considerations were taken into account in the selection of the subject villages: (1) the villages represented different economic conditions in RRD, the main rice growing area, (2) one village should be close to the development center and others less influenced by the center, (3) there were distinctive features in land tenure situation, labor arrangement and practice of farm management. Thus, three study villages were chosen: Village A in Hung Yen province representing a suburban village, Village B in Bac Ninh province as a purely agricultural village, and Village C in Hai Phong province as an agricultural village in a coastal region.

For the purpose of this research, a “farm household” was defined on the basis of three

criteria: household members shared the same fund or budget, household members ate meals together, and household members were related by blood or marriage. The studied households were chosen because they had a typical farm size in the village and the same land and irrigation conditions. The total number of farm households studied accounted for 71, 51, and 42 in villages A, B, and C, respectively.

Econometric and statistical analyses were used in this paper. Descriptive analysis was conducted in order to investigate the differences in land tenure status. To identify quantitatively the factors affecting rental level, a multiple regression analysis was conducted.

In addition to the conventional indicator of land fragmentation (the number of blocks), the Simpson index (SI) of land fragmentation was utilized in this paper. This index is defined as $\left(1 - \frac{\sum_i a_i^2}{A^2}\right)$, where a_i is the area of the i^{th} plot, A is the rice land area and $A = \sum a_i$, and thus a value must be between zero and one. A value of zero means that the farm household has only one parcel of rice land, while a value close to one means the household has a number of blocks and so is more fragmented (Scott, 1987).

Cobb-Douglas production function analysis was conducted in order to examine the input-output relationship of production under different conditions in the three villages. This form of production function was preferred because of its advantages: the estimated regression coefficients are equivalent to output elasticity with respect to inputs used in the estimation, indicating the relative importance or the magnitude of contribution of the input variables to the production; and marginal products of the inputs can easily be estimated from the estimated regression coefficients (Heady and Dillon, 1961).

CHARACTERISTICS OF THE STUDY AREAS AND FARMERS STUDIED

The RRD, located in the coastal region of Northern Vietnam, covers 11 provinces. The delta is a flat, triangular region of 1.67 million ha. Some (48%) of the 802,600 ha of the total land area of the Delta is used as agricultural land. It is an agriculturally rich area, where most of the land is devoted to rice cultivation. In recent years, fisheries, aquaculture and fruit trees have been growing in importance. Land is a limiting factor (the average farm land area per household in RRD was 0.28 ha in 2005), so farmers tend to diversify more into high value crops for urban markets or seek non-farm income. Most land in the RRD is fertile, irrigated and suitable for development of different types of crops and animals. Typical cropping systems at the farm level in the RRD are as follows (Fujimoto and Vu, 2003): (1) Two rice crops, (2) One rice crop and two vegetable crops, (3) Two rice crops and one vegetable crop, (4) Four vegetables crops, and (5) All year fruit trees.

The Villages Studied

Hung Yen province is located at the eastern gateway, situated 10km from Hanoi and consisting of 10 districts (Table 1). This province has the typical feature of a delta: flat topography without hills or mountains. There were 54,600 ha of agricultural land, of which 91% were for the cultivation of annual crops, and the rest for perennial crops, fish farming, and other purposes. Of the more than 253,000 households, 62% belonged to the agricultural sector, while 87% of the total population of 1.13 million were engaged in agriculture at the time of study.

Bac Ninh Province, the smallest province of Vietnam, is situated partly on the lowland and hills of RRD, 30 km to the east of the capital city and consists of 7 districts. The total land area was

82,000 ha, of which agricultural land occupied 53.1 %. Agricultural households constituted 48% of the total households with more than 784,000 people working in agriculture. This province has not developed industry as other provinces have but is very famous for its handicraft and cultural heritage.

Hai Phong, the third most populous city in Vietnam, is located in the center of RRD, approximately 120 km from Hanoi. It serves as the primary seaport for the northern region of Vietnam. It is also a popular tourist destination. This province of 14 districts comprises the largest total land area (152,000 ha) of the three study provinces. Although only 33% of total land area was used for agriculture, the number of agricultural households constituted 52% of total households with one million agricultural workers.

Table 1. Basic information of study provinces.

	Hung Yen - A		**Bac Ninh- B**		**Hai Phong - C**	
Distance to Hanoi capital (km)	10		30		120	
Total number of districts	10		7		14	
Total land area (thousand ha)	92.3		82.3		152.2	
Agricultural land (thousand ha)	54.6	(59.2)	43.7	(53.1)	51.2	(33.6)
Rice land (thousand ha)	*41.3*	*(75.6)*	*37.2*	*(85.1)*	*41.7*	*(81.4)*
Total households (thousand)	253.4		213.7		269.3	
Agricultural households (thousand)	157.8	(62.3)	103.8	(48.6)	141.9	(52.7)
Total population (thousand people)	1,131.2		1,026.7		1,841.7	
Agricultural population (thousand people)	988.8	(87.4)	784.4	(76.4)	1,049.0	(57.0)

Note: Figures in parentheses are percentages.
Source: Vietnam General Statistic Office, 2010

The Farmers Studied

A questionnaire survey was conducted in 2010 in the three villages, covering a total of 164 farmers with a population of 737 people: 71 farmers in Village A, 51 farmers in Village B and 42 farmers in Village C. Table 2 provides a general description of farmers interviewed. The average age of household heads was around 52, but their ages ranged from 30 to 81 years. It was found that most of the farmers had finished secondary school. Some of them, mostly young farmers, had been educated up to high school.

Most of the household heads worked on their individual farms as the main occupation, while some worked as members of farming cooperatives and workers. The average family size was 4.3 persons, and the number of family members who assisted in farming activities was 2.5 persons. Through the investigation, it was found that, in the farm households near the capital, Village A, young people soon separated from their parents after marriage to become individual families, mostly engaged in non-agricultural sectors for higher income. In the other villages, however, they still lived together and formed a larger farm household.

Table 2. General description of households studied in the three study villages.

Items	A	B	C	Overall
Total population (people)	284	246	207	737
No. of households	71	51	42	164
Average age of the heads (years)	52.7	51.4	49.8	51.6
Education				
Elementary school	13	7	5	25
High school	15	13	7	35
Main occupation				
Farmer	55	44	34	133
Cooperative members	6	5	7	18
Workers	3	2	1	6
Handicraft	1	0	0	1
Other	6	0	0	6
Average family size (persons)				
Total members	4.0	4.8	4.3	4.3
Agricultural workers	2.2	2.6	3.0	2.5

Source: Our survey 2010-2011.

LAND TENURE SITUATION

There were different systems of land tenure, but in each area one system was typically common. In this section, characteristics of land tenure situation in the study villages are clarified. Because of the fact that land is owned by the state and farmers were allocated with land use rights, the term "owned land" in this paper refers to the land allocated to the farmers.

Land Resources

Under the 1993 Land Law, farmers were allocated with land for long-term and stable use and granted five rights of land use: the rights of transfer, exchange, lease, inheritance and mortgage. Thus, land operated by studied farmers was acquired through allocation, inheritance or tenancy. Most owned land was acquired by allocation, while young farmers inherited from their parents. The three study villages were located in the main rice growing area, and therefore land holdings were largely limited to rice land. **Table 3** shows the type and area of land owned and operated at the time of study. The unit of area is the sao, which is a traditional measure of area in Vietnam; one sao is equivalent to 360m^2. While rice land area was predominant, farmers also owned other kinds of land as well. In addition to upland, which was an important land resource in all three villages, fruit land area was increasing in Village A. The farmers who operated rice land accounted for 71%, 92% and 100% in Villages A, B, and C respectively. It is important to note that the operated area has increased through tenancy contracts by about 4% in Village C, 12% in Village B and as much as 27% in Village A, showing the demand for expanding cultivated area. There was a significant expansion of all kinds of land in Villages A and B for agricultural diversification in response to the expanding market of Hanoi, but not so much in Village C.

Table 3. Land resources in the three study villages, 2010.

	Owned			Operated			
	No. of HH	**Total area (sao)**	**%**	**No. of HH**	**%**	**Total area (sao)**	**%**
A							
Rice land	51	215.15	56.2	50	71.4	273.15	52.2
Upland	47	139.09	36.4	46	65.7	212.49	40.6
Fruit land	14	28.30	7.4	15	21.4	38.08	7.3
Total	71	382.54	100	70		523.72	100
B							
Rice land	49	139.25	64.8	47	92.2	162.00	66.0
Upland	40	75.70	35.2	38	74.5	83.35	34.0
Total	51	214.95	100	51		245.35	100
C							
Rice land	42	168.25	72.9	42	100	178.60	74.4
Upland	36	62.65	27.1	37	88.1	61.35	25.6
Total	42	230.90	100	42		239.95	100
Overall							
Rice land	142	522.65	63.1	139	85.3	613.75	60.8
Upland	123	277.44	33.5	121	74.2	357.19	35.4
Fruit land	14	28.30	3.4	15	9.2	38.08	3.8
Total	164	828.39	100	163		1,009.02	100

Source: Our survey 2010-2011.

Tenurial Status

The details of operated land area by tenurial status are shown in Table 4. Owner-tenant farmers appeared generally to operate the largest area of land, averaging 8.2 sao per farm. In Village A, they operated 9.6 sao per farm household and in Villages B and C, 6.3 and 7.5 sao, respectively.

Tenurial status seemed to change in relation to the age of farmers, indicating the life-cycle nature of farmers' economic behavior. In all three villages, owner farmers, who acquired land through inheritance from their parents, were the youngest. As they accumulated farming experience and capital, they started to rent-in land and became owner-tenant farmers with a larger cultivated area. As they grew older, their children also grew up and as a result of smaller family need, they rented-out their land to their children and became landlord-owner-tenant farmers. In some cases, because of the fragmentation of land, when farmers had good relations with others, they adjusted the location of operated land by rent-in and rent-out contracts at the same time to reduce labor cost and become landlord-owner-tenant farmers. As farmers grew even older, they stopped renting-in and increasingly rented-out their land, with their cultivated area becoming smaller, to become landlord-owner farmers. Eventually, farmers retired as pure landlords by renting out all of their owned land.

It is interesting to note that this life-cycle in RRD appeared to be different from other Southeast Asia countries. For instance, in Thailand and Malaysia, farmers began their lives as tenant farmers, renting in some land from such close relatives as parents. As they grew older, they were likely to receive some land through inheritance from their parents and became owner-tenant farmers. Eventually they stopped renting in land as they came to own sufficient land for the family need**,** thus

becoming owner farmers. Meantime, as their children grew older and married, they started helping their children by renting out part of their land holding and so became landlord-owner-farmers. They then retired from farming to become landlords, letting their children cultivate all the land (Fujimoto, 1983; Matsuda and Fujimoto, 1998).

Thus, it is clear that in RRD farmers started their life as owner farmers, while in other countries, they started as tenant farmers and tenancy commonly appeared to function as a means of adjusting production capacity to meet the family needs.

Table 4. Number of households and land area according to tenurial status in the three study villages.

	No.	Total area owned (sao)	%	Average area operated (sao)	Ave. age of the head (years)
A					
Landlord	1	4.00	1.0	0	76.0
Landlord-owner farmers	10	63.93	16.7	4.13	63.3
Landlord-owner-tenants	9	50.32	13.2	8.22	57.7
Owner farmers	20	110.97	29.0	5.55	44.3
Owner-tenants	31	153.32	40.1	9.60	52.5
Sub total	71	382.54	100	7.38	52.7
B					
Landlord-owner farmers	12	58.40	25.7	2.93	60.2
Landlord-owner-tenants	7	47.15	26.1	6.72	57.4
Owner farmers	13	43.25	20.0	3.33	42.8
Owner-tenants	19	66.15	28.1	6.31	49.8
Sub total	51	214.95	100	4.21	51.4
C					
Landlord-owner farmers	10	63.05	27.3	4.96	60.0
Landlord-owner-tenants	2	11.00	4.8	5.35	56.0
Owner farmers	19	97.00	42.0	5.11	43.7
Owner-tenants	11	59.85	25.9	7.51	49.8
Sub total	42	230.9	100	5.71	49.8
Overall					
Landlord	1	4.00	0.5	0	76.0
Landlord-owner farmers	32	185.38	22.4	3.94	61.1
Landlord-owner-tenants	18	108.47	13.1	7.32	57.4
Owner farmers	52	251.22	30.3	4.83	43.7
Owner-tenants	61	279.32	33.7	8.20	51.2
Total	164	828.39	100.0	5.97	51.6

Source: Our survey 2010-2011.

Two of the five stages in the farmers' life-cycle (landlord-owner-tenants and owner-tenants) corresponded to 50% of all farmers, indicating the importance of tenancy relations in analyzing land tenure systems in RRD in recent years. It was seen that a large area of rice land was rented-out but an even larger area was rented-in in all of the three villages. In other words, tenancy was a common phenomenon in these areas, especially in Village A. This probably reflected the increasingly stronger demand for farm land expansion.

Fragmentation

Fragmentation, the division of a farm into separate blocks of land, is a characteristic of agriculture throughout the world. It is not unique to any one region, culture or farming system and it is estimated that 80% of the world's farmland is fragmented (Scott, 1987). In Vietnam, based on the Resolution No.10 of the Land Law in 1988, land was distributed on the principle of fairness, taking into account soil and socio-demographic characteristics of the region. In this way, true equality was pursued in land distribution with respect not only to the extent of land area but also the quality of land. Therefore, each household was allocated with a number of plots of different locations and extent under severe fragmentation. There are advantages and disadvantages to land fragmentation. By cultivating plots in different geographical areas, variation in output can be less because the risks caused by drought, flood and diseases can also be spread (Blarel, 1992). However, fragmentation causes difficulties in the application of new technology, mechanization, irrigation and access to the fields. Labor requirement is certainly greater under severe fragmentation. Therefore, land fragmentation may result in lower crop yield and reduce the positive impact of expanded farm size on productivity (Wan and Cheng, 2001).

With more than 70% of farm households cultivating rice, the detailed analysis of land tenure is focused on rice land in this paper. Two main measures of fragmentation were used: the number of blocks per farm household, and Simpson's diversification index. Table 5 shows the degree of fragmentation by farm size in study villages. Land fragmentation varied between villages. Village A had the largest average rice land area with 5.47 sao, and an average of 2.7 blocks per farm household. In Villages B and C, the average number of blocks of rice land per farm household was larger (2.9) but the average rice land area was smaller, 3.45 sao and 4.25 sao respectively. This result showed that the average area of each block in Village A was larger than in Villages B and C.

When the degree of fragmentation was measured by the number of blocks of land per farm household, Village A's farms were the least fragmented and Villages B and C were at the same level. When the degree of fragmentation was measured by Simpson's index, it was 0.48 for farms in Village A, 0.55 for Village B and 0.58 for Village C on the average, meaning that rice land in Village C was most fragmented, and Village A the least fragmented. For each village, farmers with a larger rice land area had more fragmented holdings, indicating that increase in cultivated area was accompanied by an increase in the number of blocks of land. However, for the same farm size group, rice land in Village A was least and Village C most fragmented, because of the prevailing land tenancy contracts in the villages.

Tenancy Contracts and Landlord-Tenant Relations

The Land Law of 1993 gave security of tenure over allocated land, with land use rights granted for 20 years for annual crop and 50 years for perennial crop land. Land ceilings were imposed at 2-3ha for annual crop land and 10 ha for perennial crop land in communes in the delta area. Land use rights can be transferred, exchanged, leased, inherited, and mortgaged (Sally, MacAulay and Pham, 2006). Following this law, land transfers are occurring, but many are in fact illegal. The main reason for these illegal transactions is the high cost associated with registering land transfers. Most households were issued with only one land use certificate for all of their allocated plots. If a household wishes to dispose of or exchange any one of their plots, they must surrender their land certificate and have it reissued. There are high transaction costs involved in doing this, so that land use rights transactions are normally carried out with no official registration.

Among the total of 71, 51 and 42 farm households in Villages A, B, and C, there were 53, 54 and 26 rice land contracts, respectively. The farm households studied reported fewer rent-out than rent-in contracts and they showed varying trends over time. Table 6 shows the number, form and

rental level of tenancy contracts by landlord-tenant relation. There were four main forms of tenancy contracts: rent-free, fixed rent in cash, fixed rent in kind and fixed rent in cash equivalent. First, rent-free contract was practiced only in two cases in Villages A and B. This form of tenancy was common among very close relatives, usually between parents and their children. It became clear that retired parents allowed their children, who also have their own land, to work on their land without payment in order to maintain the land use right. Under the current policy, if farmers cannot cultivate their land, their land would be collected and distributed to other farmers.

Table 5. Rice land fragmentation indices by farm size in the three study villages.

Farm size (sao)	No. of HH	%	Ave.area per HH (sao)	Ave. No. of block	Ave. SI
A					
Under 3	10	20.0	2.30	2.1	0.33
3- under 6	27	54.0	4.48	2.5	0.46
6- under 9	6	12.0	7.07	3.3	0.56
More than 9	7	14.0	12.41	3.9	0.65
Sub Total	50	100	5.47	2.7	0.48
B					
Under 3	24	51.1	1.92	2.4	0.47
3- under 6	17	36.2	3.80	3.2	0.61
6- under 9	4	8.5	7.73	3.8	0.68
More than 9	2	4.3	10.15	4.0	0.68
Sub Total	47	100	3.45	2.9	0.55
C					
Under 3	14	33.3	2.34	2.1	0.46
3- under 6	21	50.0	4.19	3.0	0.61
6- under 9	6	14.3	8.02	4.3	0.74
More than 9	1	2.4	9.85	5.0	0.71
Sub Total	42	100	4.25	2.9	0.58
Overall					
Under 3	48	34.5	2.12	2.23	0.44
3- under 6	65	46.8	4.21	2.85	0.55
6- under 9	16	11.5	7.59	3.81	0.65
More than 9	10	7.2	11.71	4.00	0.66
Total	139	100	4.42	2.83	0.53

Source: Our survey 2010-2011.

Second, fixed rent in cash refers to a contract where the rental was paid in cash at fixed level. Rent was generally paid after harvest and it was a common practice for tenants to bring the cash rent to the landlord's house, rather than landlords coming to collect it from their tenants. This tenancy form constituted 20% of all contracts in Village A, but was seldom practiced in other villages. The average rental was around 290,000 VND per sao per year.

Third, fixed rent in kind was a contract where a fixed amount of unhusked rice (paddy) was paid as rent after harvesting. This form of contract was usually adopted according to the request of the landlords for their own consumption of rice at home. Thus, it constituted 20%, 35% and 54% of the rice land tenancy contracts in Villages A, B and C respectively. The amount of rental did not greatly

differ among the three villages, being around 62 kg paddy per sao per year for rice land.

Fourth, the common form of tenancy contract was fixed rent in cash equivalent. Rent was paid in cash, equivalent to the specified amount of paddy rent as sold after harvesting. The calculated price was the on-going price of paddy in the province or region, and it was 4,300 VND per kg at the end of 2010. Since the average rental was around 96 kg of paddy per sao per year, it amounted to about 414,000 VND.

It is noted that the overall average rental was 348,000 VND per sao per year for various forms of tenancy contract. However, for the predominant form of tenancy contract (fixed rent in cash equivalent), a clear difference existed in the average rental for two types of landlord-tenant relations, relatives and non-relatives. The overall rental was only 314,200 VND per sao per year for those contracts established between relatives, while it was 451,300 VND between non-relatives. This difference seemed to support the argument that the landlords were willing to give a lower rental to their relatives.

As mentioned earlier, larger farms tended to be more fragmented but fragmentation level could be decreased through tenancy. The reasons for landlord and tenant to rent-out and rent-in, shown in Tables 7 and 8, could explain how fragmentation may be reduced through tenancy. There was a total of 91 rent-in and 42 rent-out contracts in the three villages. Rent-in and rent-out contracts refer to those lands rented in and rented out respectively by farmers under study. While “expanding block size” was the main reason for renting in land (34%), as much as 23% of rent-out transactions were caused by “too small” plots of cultivated land. This change in the increased size of block or the decreased number of blocks certainly lowered the magnitude of Simpson’s index of land fragmentation. The most frequently mentioned reason for renting out was “land located far away” (32%), while 19% of rent-in contracts were chosen for being “land located near.”

The land allocation policy has caused the fragmentation of farms cultivated by farmers. Recently, in order to reduce fragmentation and cost of production, renting out small and far plots and renting in nearby plots to expand cultivated area has emerged as an important trend. Because of the frequency of kinship ties involved in tenancy relations, it is not at all surprising to see the reason; “landlord (usually a relative) does not cultivate” for renting in (37%) and to “help relatives” (to expand their block size and cultivation area) for renting out (30%).

In short, fixed-rent tenancy assumed risks to be borne solely by the tenant, who paid a fixed amount of rent, regardless of the quantity of harvest; but the tenants could make their own decisions and reduce risks through irrigation facilities, better seeds, improved pest control and better farming techniques. Thus, fixed-rent tenancy, especially fixed-rent in cash equivalent, was found to be common and becoming more popular.

Table 6. Tenancy forms and rental rate by landlord-tenant relation in the three study villages.

	Relatives		Ave. Rental	Non relatives		Ave. Rental	Total		Ave. Rental	Cash equivalent
	No.	%	/sao/year	No.	%	/sao/year	No.	%	/sao/year	(1,000 VND)
A										
Rent free	1	2.7		0	0		1	1.9	0	
Fixed rent-in cash (1,000 VND)	9	24.3	253.3	2	12.5	450.0	11	20.8	289.1	
Fixed rent-in kind (kg paddy)	11	29.7	69.1	0	0	0	11	20.8	69.1	297.1
Fixed rent-in cash equivalent (kg paddy)	16	43.2	89.4	14	87.5	106.4	30	56.6	97.3	418.5
Sub total	37	100		16	100		53	100		358.5
%	66.0			34.0			100			
B										
Rent free	1	2.6		0	0		1	1.9	0	
Fixed rent-in cash (1,000 VND)	1	2.6	270.0	0	0	0	1	1.9	270.0	
Fixed rent-in kind (kg paddy)	19	48.7	58.7	0	0	0	19	35.2	61.3	263.6
Fixed rent-in cash equivalent (kg paddy)	18	46.2	88.6	15	100	102.1	33	61.1	95.8	411.9
Sub total	39	100		15	100		54	100		349.5*
%	66.7			33.3			100			
C										
Fixed rent-in cash (1,000 VND)	1	5.0	280.0	0	0	0	1	3.8	280.0	
Fixed rent-in kind (kg paddy)	14	70.0	60.0	0	0	0	14	53.8	60.7	261.1
Fixed rent-in cash equivalent (kg paddy)	5	25.0	86.0	6	100	111.7	11	42.3	94.5	406.5
Sub total	20	100		6	100		26			323.3*
%	61.5			38.5			100			
Overall										
Rent free	2	2.1		0	0		2	1.5	0	
Fixed rent-in cash (1,000 VND)	11	11.5	257.2	2	5.4	450.0	13	9.8	286.9	
Fixed rent-in kind (kg paddy)	44	45.8	61.7	0	0.0	0	44	33.1	63.1	271.2
Fixed rent-in cash equivalent (kg paddy)	39	40.6	88.6	35	94.6	105.5	74	55.6	96.2	413.8
Total	96	100	314.2*	37	100	451.3*	133	100		348.0*
%	65.4			34.6			100			

Source: Our survey 2010-2011. Note: * Overall average rental in cash equivalent

Table 7. Reasons for renting-in rice land given by tenants in the three study villages.

	A	B	C	Total	%
Expand block size	12	16	3	31	(34.1)
Landlord does not cultivate	12	13	9	34	(37.4)
Land located near	8	8	1	17	(18.7)
Increasing income	8	5	4	17	(18.7)
Having time	4	3	2	9	(9.9)
No. of contract	39	36	16	91	

(Multiple answers)
Source: Our survey 2010-2011.

Table 8. Reasons for renting-out rice land given by landlords in the three study villages.

	A	B	C	Total	%
Land located far away	7	4	4	15	(31.9)
Help relatives	3	6	5	14	(29.8)
Too small	3	6	2	11	(23.4)
Excess over family need	3	4	1	8	(17.0)
Old age/ Retired	2	3	0	5	(10.6)
No. of contract	14	18	10	42	

(Multiple answers)
Source: Our survey 2010-2011.

ECONOMIC ANALYSIS RELATED TO RICE PRODUCTION

There were a number of economic studies dealing with rice farming in Vietnam but most of them were concerned with the MRD. Very little attention has been given to the effects of land tenure systems on rice production. This section discusses the results of the economic analysis of land tenure systems in relation to rice production in the three villages studied in the RRD.

Rent Function

With the expansion of the tenancy market, one important issue is the determination of rental levels. Analysis of rental determination will provide another view of the nature of landlord-tenant relations among the farmers. Excluding rent-free contracts, there were 89 rent-in and 42 rent-out contracts for rice land, and rent functions were estimated for both groups of tenancy contracts.

The model used for the estimation of rent function is as follow:

$$R = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where,
R is the average rent per sao per year for rice land tenancy contract, expressed in thousand VND.
X_1 refers to the area of rented land (sao),
X_2 refers to physical quantity of rice production value (kg/sao/year),
X_3 refers to total years so far rented (years),

X_4 is a dummy variable for the existence of kinship ties in landlord-tenant relations; 0 for relatives (including distant relatives) and 1 for non-relatives, and

X_5 is a dummy variable of tenant residence, 0 for tenant living inside the village and 1 for outside the village

With generally small farm size, there is a strong demand for the expansion of farm land area (X_1) through tenancy. In order to obtain a larger land area, the tenants probably accepted a higher rental level. Physical quantity of rice production (X_2) is an economic variable in determining rental level, and it can be expected that the higher the level of production, the higher will be the rental level.

Total years so far rented (X_3) is considered as a factor in rental determination. The rental is paid either per season or per year, and the rental level can be raised easily when the contract is renewed. Therefore, the longer the years rented, the cheaper would be the rental level.

Regarding social considerations in rental determination, it is possible that kinship (X_4) based tenants may be in a better position than those tenants renting in from non-relatives. The landlord who was a tenant's relative was expected to make the rental cheaper than for non-relatives. Beside the kinship ties in landlord-tenant relations, tenant residence (X_5) was also important in deciding the rental level. Because of close social relations of farmers in a village, tenants living in the same village with their landlords may have expected a lower rental level than those contracts with landlords living in other villages.

Results of the estimation are presented in Table 9. The coefficient of determination (R^2) was 65% and 69% for rent-in and rent-out contracts respectively, indicating that two-thirds of rental variations were explained by the variables included in the model. The regression coefficient for the area of rented-out land (X_1) is statistically significant at the 5% probability level. This means that the larger the land area rented out per contract, the higher the rental level per sao, as expected. The results suggest that if the land area under contract was larger by one sao, the rental would increase by roughly 28,535 VND per sao, with other things being constant. It should be clearly noted that this variable is statistically significant only for rent-out function. It seemed that the landlord tended to rent-out a larger area with higher rental level, while most of the tenants rented-in land to expand cultivated area and were prepared to pay a high rent even for a small piece of land.

The regression coefficient for the physical quantity of rice production (X_2) is statistically significant at the 1% probability level and has the expected sign. If the output per one sao of land under contract increased by 1,000 VND per year, the rental level would increase by 770 VND per sao per year.

The regression coefficient for the total years rented (X_3) is also statistically significant for both rent-in and rent-out functions. The longer the period rented, the lower the rental level per sao. The contract period ranged from 2 to 20 years with an average of 5 years. Recently, landlords wanted to rent-out on a short contract for the purpose of easily changing the rental level under the market price. Within the contract period, the rental could not be raised, therefore the longer period meant the older contract with a lower rental level. This factor showed a contrasting result in the determination of rental for fruit land (Phan and Fujimoto, 2010). In the case of fruit land, longer periods of rental contract commanded higher levels of rental per sao, because fruit production needed a certain period of cultivation to attain economic efficiency. So the tenants wanted to rent-in land on a long-term contract and were willing to accede to a higher rental level for their fruit production.

The regression coefficient for kinship ties is also statistically significant at the 1% level for rent-in and rent-out functions. Kinship appeared to lower the level of rental. The magnitude of the

regression coefficient suggests that the existence of kinship ties reduced the rental by 36,550 VND and 112,460 VND for rent-in and rent-out respectively, from the mean rental of 346,600 VND per sao on the average.

The regression coefficient for the place of tenant residence is statistically significant at the 5% level for the rent-in as well as rent-out functions. Tenants living outside the village seemed to have a higher rental level compared with tenants living inside the village as expected, because farmers in the same village usually have close relations.

The result of this analysis was quite consistent with the situation described in the preceding section. As tenancy relations were flexible, the process of rental determination was clearly affected by social factors such as kinship ties and place of residence.

Table 9. Rent function estimates for rice land tenancy in the three study villages.

	Rent-in			**Rent-out**		
	Reg. coff.		**t value**	**Reg. coff.**		**t value**
Constant	141.76		1.35	311.41		7.87
Area of rented land (sao)	8.45		1.07	28.53	*	1.85
Production (1,000 VND/sao)	0.77	***	2.85			
Total years rented (years)	-18.13	***	-7.99	-9.13	**	-2.06
Kinship (dummy)	36.55	***	2.7	112.46	***	4.99
Tenant residence (dummy)	30.03	**	2.21	39.34	**	2.02
N	89			42		
R square	0.65			0.69		
F value	56.60			58.80		

* Significant at the 10% probability level.

** Significant at the 5% probability level.

***Significant at the 1% probability level.

Source: Our survey 2010-2011.

Production Function

In view of different land and water conditions, it is possible for different villages to have different input-output relationships. Therefore, Cobb-Douglas production function is used to examine the factors of production which affect the level of rice production in each village. Data obtained from farmers were dealt with on a per-season basis. Since the farmers planted two rice crops in a year (spring rice and summer rice), the number of the sample was actually doubled. The form of the function is written as follows:

$$Y=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}$$

Where,

Y refers to gross rice production in each season per farm as measured in kg.

X_1: the area of rice land planted to rice (sao) in each season. This refers to cultivated area including owned and rented land under operation. The relationship of land area and rice production is expected to be positive in that the increase in operated land will increase rice production.

X_2: Total labor input (man-days), including not only family but also hired labor. It is expected that the increased use of labor will increase rice production.

X_3: Total value of seed, measured in 1,000 VND. There were different kinds of rice seed and the better

quality seed was generally more expensive. Thus, it is expected that production will increase with the higher value of seeds.

X_4: The amount of pesticides, including herbicide, measured in 1,000 VND. Although modern varieties were improved to become pest and disease resistant, farmers generally applied pesticide and herbicide in order to overcome pest and disease attack. Through the better cure of pest and disease problems, rice production may increase.

X_5: Total amount of chemical fertilizer (NPK) expressed in kg.

X_6: Education level of farmer, 1 for primary school, 2 for secondary school and 3 for high school. It is hoped that this variable will correspond to basic training which is essential in good and efficient farm management. A positive sign is expected for the regression coefficient of education.

Table 10 shows the estimates of Cobb-Douglas production functions in rice farming of different villages in 2010. The coefficients of determination (R^2) indicate that the model explained more than 92% of the total variations of rice production among the farmers of different villages.

Most of the six independent variables had significant coefficients in all villages. The magnitude of the regression coefficient for total labor (X_2) is the largest for all villages and it is significant at the 1 to 5% level. The increased use of labor by 10% will probably result in increased output by 5.6 to 7.1%. In Village A, the regression coefficient for land area (X_1) is statically significant, indicating that a 10% increase in area would result in a higher production by 3.1%. However, it is important to note that the land area was not a significant factor in Villages B and C, where severe fragmentation was observed. It is probable that positive effects of larger planted area were offset by the increased fragmentation, resulting in insignificant contribution of land area to increased rice production.

The value of seed (X_3) was also an important variable, significant at the 1% level for all famers. Production could be increased by around 1% by investing 10% more in better seeds. Increase in fertilizer (X_5) by 10% could also increase production by 0.6 to 1.3%. But in the case of pesticide (X_4), the regression coefficient has a negative sign, indicating that a larger use of pesticide would not result in a higher production. It can be explained by the fact that the farmers used pesticide only when pest and disease actually damaged the crop, and they would tend to apply more pesticide if they observed a high incidence of pests and diseases. The incidence of pest and diseases was correlated with low productivity. Thus, the more pesticide used, the more disease probably appeared and production decreased. The magnitude of the contribution of education (X_6) for all farmers is high, pointing to the importance of management skill.

In short, the production function analysis revealed that both labor input and land area were important determinants of rice income. The contribution of other factors appeared to be rather small. With the limited land area available and rapid increase in population in Vietnam, improving rice production clearly depended on agricultural labor.

Based on the production function estimates, the marginal products of some production factors can be estimated and the efficiency of resource use examined. The marginal value product (MVP) of land was estimated to be 218,260 VND per sao per season, or 436,520 VND per sao per year. The marginal factor cost (MFC) of land, the overall average rental per sao per year, was 348,000 VND. However, under the contract of fixed rent in cash equivalent, which was the predominant form in the study villages, the average rental was as high as 413,800 VND. Especially, it was 451,300 VND for the contracts established between non-relatives, and the MVP/MFC ratio is 0.97, indicating that the average rental was almost equal to the marginal product of land. However, in the case of the contracts established between relatives, the average rental was 314,200 VND, making the MVP/MFC ratio to be 1.39. This indicates that the rental level was somehow kept lower than the marginal product of land under the contracts between non-relatives.

Table 10. Rice production function estimates in the three study villages.

	A			B			C			Over all		
	Reg. coff.		**t value**	**Reg. coff.**		**t value**	**Reg. coff.**		**t value**	**Reg. coff.**		**t value**
Constant	3.98		10.64	3.63		7.19	3.38		5.79	3.78		14.32
Area (sao)	0.31	*	1.66	0.21		0.79	0.05		0.15	0.24	*	1.76
Labor (man days)	0.56	***	2.94	0.57	**	2.11	0.71	**	2.14	0.59	***	4.17
Seed (1,000 VND)	0.12	***	4.04	0.13	***	2.70	0.14	***	3.33	0.09	***	4.80
Pesticide (1,000 VND)	-0.08	***	-5.20	-0.04	*	-1.97	-0.04	**	-2.21	-0.05	***	-5.42
Fertilizer (kg)	0.06	**	2.18	0.13	***	3.13	0.12	***	2.92	0.11	***	5.14
Education (level)	0.14	***	7.25	0.03		0.90	0.07	**	2.21	0.09	***	6.58
N	100			94			84			278		
Sum of coefficients	1.11			1.01			1.04			1.08		
R square	0.97			0.95			0.92			0.97		
F value	1,074.60			912.57			646.23			2,571.58		

* Significant at the 10% probability level.

** Significant at the 5% probability level.

***Significant at the 1% probability level.

Source: Our survey 2010-2011.

CONCLUSION

Based on the detailed data collected from a series of questionnaire surveys in three rice growing villages (A, B, and C) in the Red River Delta, this paper presented an analysis of land tenure system and tenancy conditions in relation to rental level and rice production. It became clear that farm size varied greatly among the households in the same village and also in different villages, due to the emergence of tenancy contracts. Expanded farm size was generally accompanied by a higher degree of fragmentation, but in some cases tenancy eased the level of fragmentation. Village A, located near Hanoi, had the largest average operated area, with the largest number of land transactions and the highest rental level. There was a general trend of increasing non-rice cultivation in all the three villages.

Five kinds of land tenure status were observed: landlord, landlord-owner farmer, landlord-owner-tenant farmer, owner farmer and owner-tenant farmer. The tenurial status changed with the age of farmers, supporting the life-cycle of farmers' economic behavior. The great majority of tenancy contracts were also found to be between relatives. There existed a considerable variation in the actual rental levels among fixed-rent tenancy agreements even in the same village because the rental variation seemed to reflect mutual aid between kin-based relatives in landlord-tenant relations. The estimation of rent functions confirmed social considerations in the process of rental determination. The Cobb-Douglas production function analysis revealed that land, labor, seed, fertilizer, and education are important for increasing rice production. However, pesticide appeared to be overused.

It is also important that the average rental level of rice land appeared to be equal to the marginal product of land in rice farming, pointing to the economic rationality in the tenancy market. However, the rental level appeared to be much lower than the marginal product of land under those contracts established between relatives, confirming the influence of social considerations in tenancy conditions. Therefore, it can be concluded that the current land tenure systems and tenancy conditions clearly reflected social considerations of the farmers. It is economically rational to enlarge farm size through tenancy contracts, as farm size contributes positively to the improvement in farm efficiency and income. Land policy should aim to ease the level of farm fragmentation, while promoting farm size expansion.

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LAND TENURE AND TENANCY CONDITIONS IN RELATION TO RICE PRODUCTION IN THREE VILLAGES IN THE RED RIVER DELTA, VIETNAM

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ABSTRACT

Red River Delta is one of the main rice producing regions in Vietnam. With large variations in natural conditions, the Red River Delta is suitable for development of different types of crops and animals. In recent years, the importance of fisheries, aquaculture and fruit trees have been increasing. With the average farming area per household in Red River Delta being 0.28 ha (2005), land is a limiting factor in generating sufficient income. Most farmers resort to diversifying their farming to high value crops such as vegetables, fruit trees, and livestock for urban markets, or engaging in non-farm activities. The result of this trend is the emergence of tenancy among farmers. This paper attempts to clarify the determination and function of rice land tenancy within the context of the economic structure in three villages in the North of Vietnam. A series of questionnaire surveys were conducted in 2010- 2011 in the villages of Hung Yen (A), Bac Ninh (B), and Hai Phong (C) Provinces which are located in the Red River Delta. The main findings of the research are as follows. There is an increasing area of non-rice production with the appearance of different kinds of tenurial status in different villages. The tenurial status changes with the age of the farmers, indicating the influence of life-cycle on farmers' economic behavior. There is also heavy dependence upon kinship ties in landlord-tenant relations. The production function analysis revealed that the increased use of land, labor, seed and fertilizer could lead to a higher rice production. The average rental under the predominant form of tenancy appeared to be equal to the marginal product of land, but under the contracts established between relatives, the average rental was much lower than the marginal product.

Key words: landlord-tenant relation, fragmentation, rent function, rice farming, production function, marginal product

INTRODUCTION

Land policy is an essential component of economic development measures in all countries and especially in the developing country of Vietnam (Deininger, 2003). Land tenure in Vietnam is complicated because of political, social, economic and natural conditions. Farmers do not own agricultural land, instead land is owned by the state. Based on the Resolution No.10 of Land Law in 1988, former communal farms were first broadly divided into a number of blocks according to land and water conditions, each of which was then equally divided among the commune members with

land use rights (Sally, MacAulay and Pham, 2006). The allocation was intended to provide an egalitarian land distribution, and each household was allocated land according to the number of family members in the household. Therefore, each household came to possess a number of plots under severe fragmentation, resulting in difficulties in farm management. It was estimated that there were 70-100 million plots of land (World Bank, 2005), with around 10% of these plots having an area of only 100 m^2 or less.

Since the 1993 Land Law was introduced, farmers have had greater freedom to choose which crop to grow. The local governments (provinces) had control over a change of land use, mainly for changes from annual crop to perennial crop lands. However, with high economic and population growth, dietary patterns in the developing countries are rapidly changing, and the demand for food is diversifying in favor of livestock, fruit and vegetables (World Bank, 2005). Land reform has affected land use patterns in districts close to towns and cities in that high value crops are becoming increasingly common in some communes (Cho and Yagi, 2001). There is a clear trend among farmers to reduce rice cultivation and increase the planting of fruit and vegetables (Fujimoto and Vu, 2003). As a result, changes in land use have undoubtedly begun to occur (World Bank, 2005).

Red River Delta (RRD) is one of the two main agricultural producing regions in Vietnam. This delta is smaller but more intensely developed and more densely populated than the Mekong River Delta (MRD). In the RRD, farmers do not sell land, and for those farmers who intend to expand their farms, it is necessary to acquire farmlands by renting-in from other farmers. In fact, land tenancy was occurring both before and after the 1993 Land Law (Do, 2003; Deininger, 2003; World Bank, 2005). Most of the rice production studies were conducted in MRD, where the average size of farms was considerably larger and less fragmented than those in RRD. Economic analysis of land fragmentation has been conducted in RRD (Hung, 2006), but less attention has been paid to the relation between land tenure systems and production (Fujimoto and Kitajima, 2003).

Land tenure situation refers to the ownership and use of land, which is one of the basic production factors in agriculture, and thus represents not only arrangements concerning the land factor in the production process but also an indicator of the socio-economic system of the agricultural village. For further agricultural development, it is necessary to have a better understanding of the present land tenure situation, especially in relation to rice land. This could allow progress to the goal of more efficient use of resources and improved incomes among farmers.

METHODOLOGY

This paper aims to analyze the current situation of land tenure systems, including the pattern of land holding and the existing tenancy contracts of farm respondents. More precisely, this paper attempts to clarify the effect of the land tenure system and tenancy conditions in relation to rental level and rice production in three villages in RRD.

Primary data were obtained from a questionnaire survey of farm households, conducted in 2010. The following considerations were taken into account in the selection of the subject villages: (1) the villages represented different economic conditions in RRD, the main rice growing area, (2) one village should be close to the development center and others less influenced by the center, (3) there were distinctive features in land tenure situation, labor arrangement and practice of farm management. Thus, three study villages were chosen: Village A in Hung Yen province representing a suburban village, Village B in Bac Ninh province as a purely agricultural village, and Village C in Hai Phong province as an agricultural village in a coastal region.

For the purpose of this research, a “farm household” was defined on the basis of three

criteria: household members shared the same fund or budget, household members ate meals together, and household members were related by blood or marriage. The studied households were chosen because they had a typical farm size in the village and the same land and irrigation conditions. The total number of farm households studied accounted for 71, 51, and 42 in villages A, B, and C, respectively.

Econometric and statistical analyses were used in this paper. Descriptive analysis was conducted in order to investigate the differences in land tenure status. To identify quantitatively the factors affecting rental level, a multiple regression analysis was conducted.

In addition to the conventional indicator of land fragmentation (the number of blocks), the Simpson index (SI) of land fragmentation was utilized in this paper. This index is defined as $\left(1 - \frac{\sum_i a_i^2}{A^2}\right)$, where a_i is the area of the i^{th} plot, A is the rice land area and $A = \sum a_i$, and thus a value must be between zero and one. A value of zero means that the farm household has only one parcel of rice land, while a value close to one means the household has a number of blocks and so is more fragmented (Scott, 1987).

Cobb-Douglas production function analysis was conducted in order to examine the input-output relationship of production under different conditions in the three villages. This form of production function was preferred because of its advantages: the estimated regression coefficients are equivalent to output elasticity with respect to inputs used in the estimation, indicating the relative importance or the magnitude of contribution of the input variables to the production; and marginal products of the inputs can easily be estimated from the estimated regression coefficients (Heady and Dillon, 1961).

CHARACTERISTICS OF THE STUDY AREAS AND FARMERS STUDIED

The RRD, located in the coastal region of Northern Vietnam, covers 11 provinces. The delta is a flat, triangular region of 1.67 million ha. Some (48%) of the 802,600 ha of the total land area of the Delta is used as agricultural land. It is an agriculturally rich area, where most of the land is devoted to rice cultivation. In recent years, fisheries, aquaculture and fruit trees have been growing in importance. Land is a limiting factor (the average farm land area per household in RRD was 0.28 ha in 2005), so farmers tend to diversify more into high value crops for urban markets or seek non-farm income. Most land in the RRD is fertile, irrigated and suitable for development of different types of crops and animals. Typical cropping systems at the farm level in the RRD are as follows (Fujimoto and Vu, 2003): (1) Two rice crops, (2) One rice crop and two vegetable crops, (3) Two rice crops and one vegetable crop, (4) Four vegetables crops, and (5) All year fruit trees.

The Villages Studied

Hung Yen province is located at the eastern gateway, situated 10km from Hanoi and consisting of 10 districts (Table 1). This province has the typical feature of a delta: flat topography without hills or mountains. There were 54,600 ha of agricultural land, of which 91% were for the cultivation of annual crops, and the rest for perennial crops, fish farming, and other purposes. Of the more than 253,000 households, 62% belonged to the agricultural sector, while 87% of the total population of 1.13 million were engaged in agriculture at the time of study.

Bac Ninh Province, the smallest province of Vietnam, is situated partly on the lowland and hills of RRD, 30 km to the east of the capital city and consists of 7 districts. The total land area was

82,000 ha, of which agricultural land occupied 53.1 %. Agricultural households constituted 48% of the total households with more than 784,000 people working in agriculture. This province has not developed industry as other provinces have but is very famous for its handicraft and cultural heritage.

Hai Phong, the third most populous city in Vietnam, is located in the center of RRD, approximately 120 km from Hanoi. It serves as the primary seaport for the northern region of Vietnam. It is also a popular tourist destination. This province of 14 districts comprises the largest total land area (152,000 ha) of the three study provinces. Although only 33% of total land area was used for agriculture, the number of agricultural households constituted 52% of total households with one million agricultural workers.

Table 1. Basic information of study provinces.

	Hung Yen - A		**Bac Ninh- B**		**Hai Phong - C**	
Distance to Hanoi capital (km)	10		30		120	
Total number of districts	10		7		14	
Total land area (thousand ha)	92.3		82.3		152.2	
Agricultural land (thousand ha)	54.6	(59.2)	43.7	(53.1)	51.2	(33.6)
Rice land (thousand ha)	*41.3*	*(75.6)*	*37.2*	*(85.1)*	*41.7*	*(81.4)*
Total households (thousand)	253.4		213.7		269.3	
Agricultural households (thousand)	157.8	(62.3)	103.8	(48.6)	141.9	(52.7)
Total population (thousand people)	1,131.2		1,026.7		1,841.7	
Agricultural population (thousand people)	988.8	(87.4)	784.4	(76.4)	1,049.0	(57.0)

Note: Figures in parentheses are percentages.
Source: Vietnam General Statistic Office, 2010

The Farmers Studied

A questionnaire survey was conducted in 2010 in the three villages, covering a total of 164 farmers with a population of 737 people: 71 farmers in Village A, 51 farmers in Village B and 42 farmers in Village C. Table 2 provides a general description of farmers interviewed. The average age of household heads was around 52, but their ages ranged from 30 to 81 years. It was found that most of the farmers had finished secondary school. Some of them, mostly young farmers, had been educated up to high school.

Most of the household heads worked on their individual farms as the main occupation, while some worked as members of farming cooperatives and workers. The average family size was 4.3 persons, and the number of family members who assisted in farming activities was 2.5 persons. Through the investigation, it was found that, in the farm households near the capital, Village A, young people soon separated from their parents after marriage to become individual families, mostly engaged in non-agricultural sectors for higher income. In the other villages, however, they still lived together and formed a larger farm household.

Table 2. General description of households studied in the three study villages.

Items	A	B	C	Overall
Total population (people)	284	246	207	737
No. of households	71	51	42	164
Average age of the heads (years)	52.7	51.4	49.8	51.6
Education				
Elementary school	13	7	5	25
High school	15	13	7	35
Main occupation				
Farmer	55	44	34	133
Cooperative members	6	5	7	18
Workers	3	2	1	6
Handicraft	1	0	0	1
Other	6	0	0	6
Average family size (persons)				
Total members	4.0	4.8	4.3	4.3
Agricultural workers	2.2	2.6	3.0	2.5

Source: Our survey 2010-2011.

LAND TENURE SITUATION

There were different systems of land tenure, but in each area one system was typically common. In this section, characteristics of land tenure situation in the study villages are clarified. Because of the fact that land is owned by the state and farmers were allocated with land use rights, the term "owned land" in this paper refers to the land allocated to the farmers.

Land Resources

Under the 1993 Land Law, farmers were allocated with land for long-term and stable use and granted five rights of land use: the rights of transfer, exchange, lease, inheritance and mortgage. Thus, land operated by studied farmers was acquired through allocation, inheritance or tenancy. Most owned land was acquired by allocation, while young farmers inherited from their parents. The three study villages were located in the main rice growing area, and therefore land holdings were largely limited to rice land. **Table 3** shows the type and area of land owned and operated at the time of study. The unit of area is the sao, which is a traditional measure of area in Vietnam; one sao is equivalent to 360m^2. While rice land area was predominant, farmers also owned other kinds of land as well. In addition to upland, which was an important land resource in all three villages, fruit land area was increasing in Village A. The farmers who operated rice land accounted for 71%, 92% and 100% in Villages A, B, and C respectively. It is important to note that the operated area has increased through tenancy contracts by about 4% in Village C, 12% in Village B and as much as 27% in Village A, showing the demand for expanding cultivated area. There was a significant expansion of all kinds of land in Villages A and B for agricultural diversification in response to the expanding market of Hanoi, but not so much in Village C.

Table 3. Land resources in the three study villages, 2010.

	Owned			Operated			
	No. of HH	**Total area (sao)**	**%**	**No. of HH**	**%**	**Total area (sao)**	**%**
A							
Rice land	51	215.15	56.2	50	71.4	273.15	52.2
Upland	47	139.09	36.4	46	65.7	212.49	40.6
Fruit land	14	28.30	7.4	15	21.4	38.08	7.3
Total	71	382.54	100	70		523.72	100
B							
Rice land	49	139.25	64.8	47	92.2	162.00	66.0
Upland	40	75.70	35.2	38	74.5	83.35	34.0
Total	51	214.95	100	51		245.35	100
C							
Rice land	42	168.25	72.9	42	100	178.60	74.4
Upland	36	62.65	27.1	37	88.1	61.35	25.6
Total	42	230.90	100	42		239.95	100
Overall							
Rice land	142	522.65	63.1	139	85.3	613.75	60.8
Upland	123	277.44	33.5	121	74.2	357.19	35.4
Fruit land	14	28.30	3.4	15	9.2	38.08	3.8
Total	164	828.39	100	163		1,009.02	100

Source: Our survey 2010-2011.

Tenurial Status

The details of operated land area by tenurial status are shown in Table 4. Owner-tenant farmers appeared generally to operate the largest area of land, averaging 8.2 sao per farm. In Village A, they operated 9.6 sao per farm household and in Villages B and C, 6.3 and 7.5 sao, respectively.

Tenurial status seemed to change in relation to the age of farmers, indicating the life-cycle nature of farmers' economic behavior. In all three villages, owner farmers, who acquired land through inheritance from their parents, were the youngest. As they accumulated farming experience and capital, they started to rent-in land and became owner-tenant farmers with a larger cultivated area. As they grew older, their children also grew up and as a result of smaller family need, they rented-out their land to their children and became landlord-owner-tenant farmers. In some cases, because of the fragmentation of land, when farmers had good relations with others, they adjusted the location of operated land by rent-in and rent-out contracts at the same time to reduce labor cost and become landlord-owner-tenant farmers. As farmers grew even older, they stopped renting-in and increasingly rented-out their land, with their cultivated area becoming smaller, to become landlord-owner farmers. Eventually, farmers retired as pure landlords by renting out all of their owned land.

It is interesting to note that this life-cycle in RRD appeared to be different from other Southeast Asia countries. For instance, in Thailand and Malaysia, farmers began their lives as tenant farmers, renting in some land from such close relatives as parents. As they grew older, they were likely to receive some land through inheritance from their parents and became owner-tenant farmers. Eventually they stopped renting in land as they came to own sufficient land for the family need**,** thus

becoming owner farmers. Meantime, as their children grew older and married, they started helping their children by renting out part of their land holding and so became landlord-owner-farmers. They then retired from farming to become landlords, letting their children cultivate all the land (Fujimoto, 1983; Matsuda and Fujimoto, 1998).

Thus, it is clear that in RRD farmers started their life as owner farmers, while in other countries, they started as tenant farmers and tenancy commonly appeared to function as a means of adjusting production capacity to meet the family needs.

Table 4. Number of households and land area according to tenurial status in the three study villages.

	No.	Total area owned (sao)	%	Average area operated (sao)	Ave. age of the head (years)
A					
Landlord	1	4.00	1.0	0	76.0
Landlord-owner farmers	10	63.93	16.7	4.13	63.3
Landlord-owner-tenants	9	50.32	13.2	8.22	57.7
Owner farmers	20	110.97	29.0	5.55	44.3
Owner-tenants	31	153.32	40.1	9.60	52.5
Sub total	71	382.54	100	7.38	52.7
B					
Landlord-owner farmers	12	58.40	25.7	2.93	60.2
Landlord-owner-tenants	7	47.15	26.1	6.72	57.4
Owner farmers	13	43.25	20.0	3.33	42.8
Owner-tenants	19	66.15	28.1	6.31	49.8
Sub total	51	214.95	100	4.21	51.4
C					
Landlord-owner farmers	10	63.05	27.3	4.96	60.0
Landlord-owner-tenants	2	11.00	4.8	5.35	56.0
Owner farmers	19	97.00	42.0	5.11	43.7
Owner-tenants	11	59.85	25.9	7.51	49.8
Sub total	42	230.9	100	5.71	49.8
Overall					
Landlord	1	4.00	0.5	0	76.0
Landlord-owner farmers	32	185.38	22.4	3.94	61.1
Landlord-owner-tenants	18	108.47	13.1	7.32	57.4
Owner farmers	52	251.22	30.3	4.83	43.7
Owner-tenants	61	279.32	33.7	8.20	51.2
Total	164	828.39	100.0	5.97	51.6

Source: Our survey 2010-2011.

Two of the five stages in the farmers' life-cycle (landlord-owner-tenants and owner-tenants) corresponded to 50% of all farmers, indicating the importance of tenancy relations in analyzing land tenure systems in RRD in recent years. It was seen that a large area of rice land was rented-out but an even larger area was rented-in in all of the three villages. In other words, tenancy was a common phenomenon in these areas, especially in Village A. This probably reflected the increasingly stronger demand for farm land expansion.

Fragmentation

Fragmentation, the division of a farm into separate blocks of land, is a characteristic of agriculture throughout the world. It is not unique to any one region, culture or farming system and it is estimated that 80% of the world's farmland is fragmented (Scott, 1987). In Vietnam, based on the Resolution No.10 of the Land Law in 1988, land was distributed on the principle of fairness, taking into account soil and socio-demographic characteristics of the region. In this way, true equality was pursued in land distribution with respect not only to the extent of land area but also the quality of land. Therefore, each household was allocated with a number of plots of different locations and extent under severe fragmentation. There are advantages and disadvantages to land fragmentation. By cultivating plots in different geographical areas, variation in output can be less because the risks caused by drought, flood and diseases can also be spread (Blarel, 1992). However, fragmentation causes difficulties in the application of new technology, mechanization, irrigation and access to the fields. Labor requirement is certainly greater under severe fragmentation. Therefore, land fragmentation may result in lower crop yield and reduce the positive impact of expanded farm size on productivity (Wan and Cheng, 2001).

With more than 70% of farm households cultivating rice, the detailed analysis of land tenure is focused on rice land in this paper. Two main measures of fragmentation were used: the number of blocks per farm household, and Simpson's diversification index. Table 5 shows the degree of fragmentation by farm size in study villages. Land fragmentation varied between villages. Village A had the largest average rice land area with 5.47 sao, and an average of 2.7 blocks per farm household. In Villages B and C, the average number of blocks of rice land per farm household was larger (2.9) but the average rice land area was smaller, 3.45 sao and 4.25 sao respectively. This result showed that the average area of each block in Village A was larger than in Villages B and C.

When the degree of fragmentation was measured by the number of blocks of land per farm household, Village A's farms were the least fragmented and Villages B and C were at the same level. When the degree of fragmentation was measured by Simpson's index, it was 0.48 for farms in Village A, 0.55 for Village B and 0.58 for Village C on the average, meaning that rice land in Village C was most fragmented, and Village A the least fragmented. For each village, farmers with a larger rice land area had more fragmented holdings, indicating that increase in cultivated area was accompanied by an increase in the number of blocks of land. However, for the same farm size group, rice land in Village A was least and Village C most fragmented, because of the prevailing land tenancy contracts in the villages.

Tenancy Contracts and Landlord-Tenant Relations

The Land Law of 1993 gave security of tenure over allocated land, with land use rights granted for 20 years for annual crop and 50 years for perennial crop land. Land ceilings were imposed at 2-3ha for annual crop land and 10 ha for perennial crop land in communes in the delta area. Land use rights can be transferred, exchanged, leased, inherited, and mortgaged (Sally, MacAulay and Pham, 2006). Following this law, land transfers are occurring, but many are in fact illegal. The main reason for these illegal transactions is the high cost associated with registering land transfers. Most households were issued with only one land use certificate for all of their allocated plots. If a household wishes to dispose of or exchange any one of their plots, they must surrender their land certificate and have it reissued. There are high transaction costs involved in doing this, so that land use rights transactions are normally carried out with no official registration.

Among the total of 71, 51 and 42 farm households in Villages A, B, and C, there were 53, 54 and 26 rice land contracts, respectively. The farm households studied reported fewer rent-out than rent-in contracts and they showed varying trends over time. Table 6 shows the number, form and

rental level of tenancy contracts by landlord-tenant relation. There were four main forms of tenancy contracts: rent-free, fixed rent in cash, fixed rent in kind and fixed rent in cash equivalent. First, rent-free contract was practiced only in two cases in Villages A and B. This form of tenancy was common among very close relatives, usually between parents and their children. It became clear that retired parents allowed their children, who also have their own land, to work on their land without payment in order to maintain the land use right. Under the current policy, if farmers cannot cultivate their land, their land would be collected and distributed to other farmers.

Table 5. Rice land fragmentation indices by farm size in the three study villages.

Farm size (sao)	No. of HH	%	Ave.area per HH (sao)	Ave. No. of block	Ave. SI
A					
Under 3	10	20.0	2.30	2.1	0.33
3- under 6	27	54.0	4.48	2.5	0.46
6- under 9	6	12.0	7.07	3.3	0.56
More than 9	7	14.0	12.41	3.9	0.65
Sub Total	50	100	5.47	2.7	0.48
B					
Under 3	24	51.1	1.92	2.4	0.47
3- under 6	17	36.2	3.80	3.2	0.61
6- under 9	4	8.5	7.73	3.8	0.68
More than 9	2	4.3	10.15	4.0	0.68
Sub Total	47	100	3.45	2.9	0.55
C					
Under 3	14	33.3	2.34	2.1	0.46
3- under 6	21	50.0	4.19	3.0	0.61
6- under 9	6	14.3	8.02	4.3	0.74
More than 9	1	2.4	9.85	5.0	0.71
Sub Total	42	100	4.25	2.9	0.58
Overall					
Under 3	48	34.5	2.12	2.23	0.44
3- under 6	65	46.8	4.21	2.85	0.55
6- under 9	16	11.5	7.59	3.81	0.65
More than 9	10	7.2	11.71	4.00	0.66
Total	139	100	4.42	2.83	0.53

Source: Our survey 2010-2011.

Second, fixed rent in cash refers to a contract where the rental was paid in cash at fixed level. Rent was generally paid after harvest and it was a common practice for tenants to bring the cash rent to the landlord's house, rather than landlords coming to collect it from their tenants. This tenancy form constituted 20% of all contracts in Village A, but was seldom practiced in other villages. The average rental was around 290,000 VND per sao per year.

Third, fixed rent in kind was a contract where a fixed amount of unhusked rice (paddy) was paid as rent after harvesting. This form of contract was usually adopted according to the request of the landlords for their own consumption of rice at home. Thus, it constituted 20%, 35% and 54% of the rice land tenancy contracts in Villages A, B and C respectively. The amount of rental did not greatly

differ among the three villages, being around 62 kg paddy per sao per year for rice land.

Fourth, the common form of tenancy contract was fixed rent in cash equivalent. Rent was paid in cash, equivalent to the specified amount of paddy rent as sold after harvesting. The calculated price was the on-going price of paddy in the province or region, and it was 4,300 VND per kg at the end of 2010. Since the average rental was around 96 kg of paddy per sao per year, it amounted to about 414,000 VND.

It is noted that the overall average rental was 348,000 VND per sao per year for various forms of tenancy contract. However, for the predominant form of tenancy contract (fixed rent in cash equivalent), a clear difference existed in the average rental for two types of landlord-tenant relations, relatives and non-relatives. The overall rental was only 314,200 VND per sao per year for those contracts established between relatives, while it was 451,300 VND between non-relatives. This difference seemed to support the argument that the landlords were willing to give a lower rental to their relatives.

As mentioned earlier, larger farms tended to be more fragmented but fragmentation level could be decreased through tenancy. The reasons for landlord and tenant to rent-out and rent-in, shown in Tables 7 and 8, could explain how fragmentation may be reduced through tenancy. There was a total of 91 rent-in and 42 rent-out contracts in the three villages. Rent-in and rent-out contracts refer to those lands rented in and rented out respectively by farmers under study. While “expanding block size” was the main reason for renting in land (34%), as much as 23% of rent-out transactions were caused by “too small” plots of cultivated land. This change in the increased size of block or the decreased number of blocks certainly lowered the magnitude of Simpson’s index of land fragmentation. The most frequently mentioned reason for renting out was “land located far away” (32%), while 19% of rent-in contracts were chosen for being “land located near.”

The land allocation policy has caused the fragmentation of farms cultivated by farmers. Recently, in order to reduce fragmentation and cost of production, renting out small and far plots and renting in nearby plots to expand cultivated area has emerged as an important trend. Because of the frequency of kinship ties involved in tenancy relations, it is not at all surprising to see the reason; “landlord (usually a relative) does not cultivate” for renting in (37%) and to “help relatives” (to expand their block size and cultivation area) for renting out (30%).

In short, fixed-rent tenancy assumed risks to be borne solely by the tenant, who paid a fixed amount of rent, regardless of the quantity of harvest; but the tenants could make their own decisions and reduce risks through irrigation facilities, better seeds, improved pest control and better farming techniques. Thus, fixed-rent tenancy, especially fixed-rent in cash equivalent, was found to be common and becoming more popular.

Table 6. Tenancy forms and rental rate by landlord-tenant relation in the three study villages.

	Relatives		Ave. Rental	Non relatives		Ave. Rental	Total		Ave. Rental	Cash equivalent
	No.	%	/sao/year	No.	%	/sao/year	No.	%	/sao/year	(1,000 VND)
A										
Rent free	1	2.7		0	0		1	1.9	0	
Fixed rent-in cash (1,000 VND)	9	24.3	253.3	2	12.5	450.0	11	20.8	289.1	
Fixed rent-in kind (kg paddy)	11	29.7	69.1	0	0	0	11	20.8	69.1	297.1
Fixed rent-in cash equivalent (kg paddy)	16	43.2	89.4	14	87.5	106.4	30	56.6	97.3	418.5
Sub total	37	100		16	100		53	100		358.5
%	66.0			34.0			100			
B										
Rent free	1	2.6		0	0		1	1.9	0	
Fixed rent-in cash (1,000 VND)	1	2.6	270.0	0	0	0	1	1.9	270.0	
Fixed rent-in kind (kg paddy)	19	48.7	58.7	0	0	0	19	35.2	61.3	263.6
Fixed rent-in cash equivalent (kg paddy)	18	46.2	88.6	15	100	102.1	33	61.1	95.8	411.9
Sub total	39	100		15	100		54	100		349.5*
%	66.7			33.3			100			
C										
Fixed rent-in cash (1,000 VND)	1	5.0	280.0	0	0	0	1	3.8	280.0	
Fixed rent-in kind (kg paddy)	14	70.0	60.0	0	0	0	14	53.8	60.7	261.1
Fixed rent-in cash equivalent (kg paddy)	5	25.0	86.0	6	100	111.7	11	42.3	94.5	406.5
Sub total	20	100		6	100		26			323.3*
%	61.5			38.5			100			
Overall										
Rent free	2	2.1		0	0		2	1.5	0	
Fixed rent-in cash (1,000 VND)	11	11.5	257.2	2	5.4	450.0	13	9.8	286.9	
Fixed rent-in kind (kg paddy)	44	45.8	61.7	0	0.0	0	44	33.1	63.1	271.2
Fixed rent-in cash equivalent (kg paddy)	39	40.6	88.6	35	94.6	105.5	74	55.6	96.2	413.8
Total	96	100	314.2*	37	100	451.3*	133	100		348.0*
%	65.4			34.6			100			

Source: Our survey 2010-2011. Note: * Overall average rental in cash equivalent

Table 7. Reasons for renting-in rice land given by tenants in the three study villages.

	A	B	C	Total	%
Expand block size	12	16	3	31	(34.1)
Landlord does not cultivate	12	13	9	34	(37.4)
Land located near	8	8	1	17	(18.7)
Increasing income	8	5	4	17	(18.7)
Having time	4	3	2	9	(9.9)
No. of contract	39	36	16	91	

(Multiple answers)
Source: Our survey 2010-2011.

Table 8. Reasons for renting-out rice land given by landlords in the three study villages.

	A	B	C	Total	%
Land located far away	7	4	4	15	(31.9)
Help relatives	3	6	5	14	(29.8)
Too small	3	6	2	11	(23.4)
Excess over family need	3	4	1	8	(17.0)
Old age/ Retired	2	3	0	5	(10.6)
No. of contract	14	18	10	42	

(Multiple answers)
Source: Our survey 2010-2011.

ECONOMIC ANALYSIS RELATED TO RICE PRODUCTION

There were a number of economic studies dealing with rice farming in Vietnam but most of them were concerned with the MRD. Very little attention has been given to the effects of land tenure systems on rice production. This section discusses the results of the economic analysis of land tenure systems in relation to rice production in the three villages studied in the RRD.

Rent Function

With the expansion of the tenancy market, one important issue is the determination of rental levels. Analysis of rental determination will provide another view of the nature of landlord-tenant relations among the farmers. Excluding rent-free contracts, there were 89 rent-in and 42 rent-out contracts for rice land, and rent functions were estimated for both groups of tenancy contracts.

The model used for the estimation of rent function is as follow:

$$R = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where,
R is the average rent per sao per year for rice land tenancy contract, expressed in thousand VND.
X_1 refers to the area of rented land (sao),
X_2 refers to physical quantity of rice production value (kg/sao/year),
X_3 refers to total years so far rented (years),

X_4 is a dummy variable for the existence of kinship ties in landlord-tenant relations; 0 for relatives (including distant relatives) and 1 for non-relatives, and

X_5 is a dummy variable of tenant residence, 0 for tenant living inside the village and 1 for outside the village

With generally small farm size, there is a strong demand for the expansion of farm land area (X_1) through tenancy. In order to obtain a larger land area, the tenants probably accepted a higher rental level. Physical quantity of rice production (X_2) is an economic variable in determining rental level, and it can be expected that the higher the level of production, the higher will be the rental level.

Total years so far rented (X_3) is considered as a factor in rental determination. The rental is paid either per season or per year, and the rental level can be raised easily when the contract is renewed. Therefore, the longer the years rented, the cheaper would be the rental level.

Regarding social considerations in rental determination, it is possible that kinship (X_4) based tenants may be in a better position than those tenants renting in from non-relatives. The landlord who was a tenant's relative was expected to make the rental cheaper than for non-relatives. Beside the kinship ties in landlord-tenant relations, tenant residence (X_5) was also important in deciding the rental level. Because of close social relations of farmers in a village, tenants living in the same village with their landlords may have expected a lower rental level than those contracts with landlords living in other villages.

Results of the estimation are presented in Table 9. The coefficient of determination (R^2) was 65% and 69% for rent-in and rent-out contracts respectively, indicating that two-thirds of rental variations were explained by the variables included in the model. The regression coefficient for the area of rented-out land (X_1) is statistically significant at the 5% probability level. This means that the larger the land area rented out per contract, the higher the rental level per sao, as expected. The results suggest that if the land area under contract was larger by one sao, the rental would increase by roughly 28,535 VND per sao, with other things being constant. It should be clearly noted that this variable is statistically significant only for rent-out function. It seemed that the landlord tended to rent-out a larger area with higher rental level, while most of the tenants rented-in land to expand cultivated area and were prepared to pay a high rent even for a small piece of land.

The regression coefficient for the physical quantity of rice production (X_2) is statistically significant at the 1% probability level and has the expected sign. If the output per one sao of land under contract increased by 1,000 VND per year, the rental level would increase by 770 VND per sao per year.

The regression coefficient for the total years rented (X_3) is also statistically significant for both rent-in and rent-out functions. The longer the period rented, the lower the rental level per sao. The contract period ranged from 2 to 20 years with an average of 5 years. Recently, landlords wanted to rent-out on a short contract for the purpose of easily changing the rental level under the market price. Within the contract period, the rental could not be raised, therefore the longer period meant the older contract with a lower rental level. This factor showed a contrasting result in the determination of rental for fruit land (Phan and Fujimoto, 2010). In the case of fruit land, longer periods of rental contract commanded higher levels of rental per sao, because fruit production needed a certain period of cultivation to attain economic efficiency. So the tenants wanted to rent-in land on a long-term contract and were willing to accede to a higher rental level for their fruit production.

The regression coefficient for kinship ties is also statistically significant at the 1% level for rent-in and rent-out functions. Kinship appeared to lower the level of rental. The magnitude of the

regression coefficient suggests that the existence of kinship ties reduced the rental by 36,550 VND and 112,460 VND for rent-in and rent-out respectively, from the mean rental of 346,600 VND per sao on the average.

The regression coefficient for the place of tenant residence is statistically significant at the 5% level for the rent-in as well as rent-out functions. Tenants living outside the village seemed to have a higher rental level compared with tenants living inside the village as expected, because farmers in the same village usually have close relations.

The result of this analysis was quite consistent with the situation described in the preceding section. As tenancy relations were flexible, the process of rental determination was clearly affected by social factors such as kinship ties and place of residence.

Table 9. Rent function estimates for rice land tenancy in the three study villages.

	Rent-in			**Rent-out**		
	Reg. coff.		**t value**	**Reg. coff.**		**t value**
Constant	141.76		1.35	311.41		7.87
Area of rented land (sao)	8.45		1.07	28.53	*	1.85
Production (1,000 VND/sao)	0.77	***	2.85			
Total years rented (years)	-18.13	***	-7.99	-9.13	**	-2.06
Kinship (dummy)	36.55	***	2.7	112.46	***	4.99
Tenant residence (dummy)	30.03	**	2.21	39.34	**	2.02
N	89			42		
R square	0.65			0.69		
F value	56.60			58.80		

* Significant at the 10% probability level.

** Significant at the 5% probability level.

***Significant at the 1% probability level.

Source: Our survey 2010-2011.

Production Function

In view of different land and water conditions, it is possible for different villages to have different input-output relationships. Therefore, Cobb-Douglas production function is used to examine the factors of production which affect the level of rice production in each village. Data obtained from farmers were dealt with on a per-season basis. Since the farmers planted two rice crops in a year (spring rice and summer rice), the number of the sample was actually doubled. The form of the function is written as follows:

$$Y=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}$$

Where,

Y refers to gross rice production in each season per farm as measured in kg.

X_1: the area of rice land planted to rice (sao) in each season. This refers to cultivated area including owned and rented land under operation. The relationship of land area and rice production is expected to be positive in that the increase in operated land will increase rice production.

X_2: Total labor input (man-days), including not only family but also hired labor. It is expected that the increased use of labor will increase rice production.

X_3: Total value of seed, measured in 1,000 VND. There were different kinds of rice seed and the better

quality seed was generally more expensive. Thus, it is expected that production will increase with the higher value of seeds.

X_4: The amount of pesticides, including herbicide, measured in 1,000 VND. Although modern varieties were improved to become pest and disease resistant, farmers generally applied pesticide and herbicide in order to overcome pest and disease attack. Through the better cure of pest and disease problems, rice production may increase.

X_5: Total amount of chemical fertilizer (NPK) expressed in kg.

X_6: Education level of farmer, 1 for primary school, 2 for secondary school and 3 for high school. It is hoped that this variable will correspond to basic training which is essential in good and efficient farm management. A positive sign is expected for the regression coefficient of education.

Table 10 shows the estimates of Cobb-Douglas production functions in rice farming of different villages in 2010. The coefficients of determination (R^2) indicate that the model explained more than 92% of the total variations of rice production among the farmers of different villages.

Most of the six independent variables had significant coefficients in all villages. The magnitude of the regression coefficient for total labor (X_2) is the largest for all villages and it is significant at the 1 to 5% level. The increased use of labor by 10% will probably result in increased output by 5.6 to 7.1%. In Village A, the regression coefficient for land area (X_1) is statically significant, indicating that a 10% increase in area would result in a higher production by 3.1%. However, it is important to note that the land area was not a significant factor in Villages B and C, where severe fragmentation was observed. It is probable that positive effects of larger planted area were offset by the increased fragmentation, resulting in insignificant contribution of land area to increased rice production.

The value of seed (X_3) was also an important variable, significant at the 1% level for all famers. Production could be increased by around 1% by investing 10% more in better seeds. Increase in fertilizer (X_5) by 10% could also increase production by 0.6 to 1.3%. But in the case of pesticide (X_4), the regression coefficient has a negative sign, indicating that a larger use of pesticide would not result in a higher production. It can be explained by the fact that the farmers used pesticide only when pest and disease actually damaged the crop, and they would tend to apply more pesticide if they observed a high incidence of pests and diseases. The incidence of pest and diseases was correlated with low productivity. Thus, the more pesticide used, the more disease probably appeared and production decreased. The magnitude of the contribution of education (X_6) for all farmers is high, pointing to the importance of management skill.

In short, the production function analysis revealed that both labor input and land area were important determinants of rice income. The contribution of other factors appeared to be rather small. With the limited land area available and rapid increase in population in Vietnam, improving rice production clearly depended on agricultural labor.

Based on the production function estimates, the marginal products of some production factors can be estimated and the efficiency of resource use examined. The marginal value product (MVP) of land was estimated to be 218,260 VND per sao per season, or 436,520 VND per sao per year. The marginal factor cost (MFC) of land, the overall average rental per sao per year, was 348,000 VND. However, under the contract of fixed rent in cash equivalent, which was the predominant form in the study villages, the average rental was as high as 413,800 VND. Especially, it was 451,300 VND for the contracts established between non-relatives, and the MVP/MFC ratio is 0.97, indicating that the average rental was almost equal to the marginal product of land. However, in the case of the contracts established between relatives, the average rental was 314,200 VND, making the MVP/MFC ratio to be 1.39. This indicates that the rental level was somehow kept lower than the marginal product of land under the contracts between non-relatives.

Table 10. Rice production function estimates in the three study villages.

	A			B			C			Over all		
	Reg. coff.		**t value**	**Reg. coff.**		**t value**	**Reg. coff.**		**t value**	**Reg. coff.**		**t value**
Constant	3.98		10.64	3.63		7.19	3.38		5.79	3.78		14.32
Area (sao)	0.31	*	1.66	0.21		0.79	0.05		0.15	0.24	*	1.76
Labor (man days)	0.56	***	2.94	0.57	**	2.11	0.71	**	2.14	0.59	***	4.17
Seed (1,000 VND)	0.12	***	4.04	0.13	***	2.70	0.14	***	3.33	0.09	***	4.80
Pesticide (1,000 VND)	-0.08	***	-5.20	-0.04	*	-1.97	-0.04	**	-2.21	-0.05	***	-5.42
Fertilizer (kg)	0.06	**	2.18	0.13	***	3.13	0.12	***	2.92	0.11	***	5.14
Education (level)	0.14	***	7.25	0.03		0.90	0.07	**	2.21	0.09	***	6.58
N	100			94			84			278		
Sum of coefficients	1.11			1.01			1.04			1.08		
R square	0.97			0.95			0.92			0.97		
F value	1,074.60			912.57			646.23			2,571.58		

* Significant at the 10% probability level.

** Significant at the 5% probability level.

***Significant at the 1% probability level.

Source: Our survey 2010-2011.

CONCLUSION

Based on the detailed data collected from a series of questionnaire surveys in three rice growing villages (A, B, and C) in the Red River Delta, this paper presented an analysis of land tenure system and tenancy conditions in relation to rental level and rice production. It became clear that farm size varied greatly among the households in the same village and also in different villages, due to the emergence of tenancy contracts. Expanded farm size was generally accompanied by a higher degree of fragmentation, but in some cases tenancy eased the level of fragmentation. Village A, located near Hanoi, had the largest average operated area, with the largest number of land transactions and the highest rental level. There was a general trend of increasing non-rice cultivation in all the three villages.

Five kinds of land tenure status were observed: landlord, landlord-owner farmer, landlord-owner-tenant farmer, owner farmer and owner-tenant farmer. The tenurial status changed with the age of farmers, supporting the life-cycle of farmers' economic behavior. The great majority of tenancy contracts were also found to be between relatives. There existed a considerable variation in the actual rental levels among fixed-rent tenancy agreements even in the same village because the rental variation seemed to reflect mutual aid between kin-based relatives in landlord-tenant relations. The estimation of rent functions confirmed social considerations in the process of rental determination. The Cobb-Douglas production function analysis revealed that land, labor, seed, fertilizer, and education are important for increasing rice production. However, pesticide appeared to be overused.

It is also important that the average rental level of rice land appeared to be equal to the marginal product of land in rice farming, pointing to the economic rationality in the tenancy market. However, the rental level appeared to be much lower than the marginal product of land under those contracts established between relatives, confirming the influence of social considerations in tenancy conditions. Therefore, it can be concluded that the current land tenure systems and tenancy conditions clearly reflected social considerations of the farmers. It is economically rational to enlarge farm size through tenancy contracts, as farm size contributes positively to the improvement in farm efficiency and income. Land policy should aim to ease the level of farm fragmentation, while promoting farm size expansion.

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FARM SIZE AND ITS EFFECT ON THE PRODUCTIVE EFFICIENCY OF SUGAR CANE FARMS IN CENTRAL NEGROS, THE PHILIPPINES

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ABSTRACT

This paper examines the productive efficiency of sugar cane production across farm size in the Philippines. Non-parametric Data Envelopment Analysis was used to determine the productive efficiency levels from a 1997-98 cross-sectional survey 1 of 24 sugar cane farms in Central Negros area. Results indicate that the small farm group appears to be not as economically efficient as the larger ones. Medium and large farm groups appear to be equally economically efficient. Therefore, from an agricultural policy point of view, the trend towards larger farm sizes could have a beneficial impact on the efficiency of the Philippine sugar industry as a whole. However, this countervails the trend set by the land reform law (CARL) which pursues social equity. Inefficiency differences among farm size groups appear to be related with the physical input used and cost. The higher input usage by the large farms tends to increase the quantity produced and, with the low price of inputs, generates a larger profit per hectare. The higher input prices faced by the small farmers tends to reduce the amount of input used thus giving a lower profit. Part of the allocative efficiency differences between the farm size groups may be attributed to the differences in the input price. Thus, government cooperative programs that provide farmers access to cheaper farm inputs through bulk purchasing may actually lead to increased productive efficiency.

Key words: Technical efficiency, scale efficiency, allocative efficiency, economic efficiency, input use, sugar cane production, data envelopment analysis

INTRODUCTION

In June 10 1988, sugar cane lands were placed under the Comprehensive Agrarian Reform Program (CARP). Agrarian reform in this context refers to the redistribution of land to the tillers of the soil (*i.e.,* small farmers, tenants and farm workers). The law covered both private and public agricultural lands regardless of tenurial arrangements and crops produced. Under the law, a landowner may retain an area of not more than 5 hectares and 3 hectares may be awarded to each child (15 years of age and above).The intention is to establish owner cultivatorship of economic sized farms that would ultimately improve productivity and lodge equity among planters, tenants and farm workers in the sugar industry. However, since its official introduction, it has created various controversial issues.

It was argued that the effect of further fragmentation of land into small farm sizes countervails economic and efficient sugar cane production. Putzel and Cunnington (1989) in their study on the Philippine agrarian reform noted that large farms are more productive and efficient as they perform better because there is the opportunity for the optimal utilisation of resources. The use of modern machines like tractors and harvesters is considered to be more appropriate and economically efficient in large farms.

Currently, the average productivity level of the small sugar cane farms remains the same, being the lowest *vis-à-vis* medium and large farms. This low farm production and productivity has always been blamed on the inefficiency of small farms, although big farms own and control around 65% of the country's total sugar land. They are also the more favoured in terms of technology and access to information and extension services. This means, much of the blame lies with them.

Modernization of farm practices can improve productive efficiency, however this is difficult to achieve at present due to the limited financial capability of the farmers. However, it is imperative for farmers to be competitive in order to survive the 5% tariff to be imposed on sugar under the ASEAN Free Trade Agreement in 2015.

Under such circumstances, it is appropriate to verify whether sugarcane farms in the Philippines are efficient or not. This is because efficient utilization of economic resources can reduce the cost of production and thus make the industry more competitive. Efficiency studies show the possibility of raising productivity by improving efficiency without increasing the resource base or developing new technology. It also helps determine the under (over) utilization of factor inputs. Okoye *et al.* (2009) found a strong inverse technical efficiency-size relationship on cassava production in Ideato North LGA of Imo state. They observed that land utilization is much higher on smaller farms and further concluded that the country's land redistribution program be supported by technical and financial assistance for farmers to increase productivity, efficiency and growth in agriculture. A different result was obtained by Helfand and Levine (2004) for farms in the Center-West Brazil. The preferential access by large farms to institutions and services, as well as more intensive use of the technologies and inputs, caused the positive efficiency-size relationship.

Therefore, the main objective of this paper is to investigate the effect of farm size on the productive efficiency of sugar cane production. Specifically, the study seeks to establish the relationship between farm size and technical, allocative and economic efficiency. It also investigates whether sugar cane farmers are efficient in their input use and attempts to determine the factors influencing such inefficiencies. Knowledge on the relative importance of the different types of inefficiency and their impact on farm productive efficiency will help craft interventions to make sugar cane farmers more efficient and competitive.

Essentially, herein data were used when the implementation of the CARP in relation to farm size-efficiency was assessed by Fabella (2009) and Briones (2008, APPC Sub-Study #3).

METHODOLOGY

Theoretical framework. The measurements of efficiency were researched extensively after Farrell's (1957) seminal work. He distinguished the efficiency of a firm into two components: technical efficiency (TE) measures the ability of a firm to produce maximal potential output from a given input. While allocative efficiency (AE) measures the ability of a firm to utilize the inputs in optimal proportions, given their respective prices and available technology. The combination of these two measures is the level of economic efficiency (EE) [Coelli, 1996].

Further studies on efficiency measurement decomposed technical efficiency into purely technical (PTE) and scale efficiency (SE). SE measures the optimality of the firm's size (Forsund *et al.*, 1980). A firm displaying increasing returns to scale (IRS) is too small for its scale of operation. In contrast, a firm with decreasing returns to scale (DRS) is too large for the volume of activities that it conducts.

Concept of Data Envelopment Analysis (DEA). This is a technique based on the non-parametric mathematical programming approach to frontier estimation. It measures the efficiency of a decision-making unit (DMU), or in this case a farm, relative to the efficiency of all other farms. The DEA methodology was formally developed and named by Charnes *et al*. (1978), where efficiency was defined as the weighted sum of outputs over a weighted sum of inputs, where the weight structure is calculated by the means of mathematical programming and constant returns to scale (CRS) were assumed. Banker *et al*. (1984) extended the model to include variable returns to scale (VRS) which allowed for optimisation of farms based on size.

Efficiency can be examined from an input-orientation or from an output-orientation. Input-orientated technical efficiency means a farm minimises the quantity of inputs, while holding output constant. An output-orientation implies a farm maximizes output, given the current quantity of inputs which remain fixed. The two measures provide the same technical efficiency scores when constant returns to scale (CRS) technology applies, but are unequal when variable returns to scale (VRS) is assumed (Färe *et. al.*, 1994).

This paper assumes a VRS technology and selected an output orientation because the concern is to maximize output from a given set of inputs, rather than the converse.

An output-oriented LP model, developed by Charnes *et al.* (1978) is defined as

$$\max_{-,\,a,\,s_i^-,\,s_i^+} \quad z_k = {}^{-}_{k} + \pounds \cdot \bar{1} s^+ + \pounds \cdot \bar{1}\, s^-$$

$$\begin{aligned} subject\ \ to: \quad & {}^{-}_{k} Y_k - Y^a + s^+ = 0 \\ & X^a + s^- = X_k \\ & {}^{a}_{ji},\ s^-_{ki},\ s^+_{mi} \geq 0 \end{aligned}$$

where Y denotes an $s \times n$ matrix of output measures; X denotes an $m \times n$ matrix of input measures; $X_k = \{x_{ik}\}$ denotes inputs ($i = 1, 2, \ldots, m$) employed by farm k ($k = 1, 2, \ldots, n$); $Y_k = \{y_{rk}\}$ denotes outputs ($r = 1, 2, \ldots, s$) produced by farm k; $s+$ and $s-$ are slack variables; λ is an intensity (weight) vector; ε is a non-Archimedean (infinitesimal) constant; $\bar{1}$ are row unit vectors of dimension $1 \times s$ (outputs) and $1 \times m$ inputs; and θ is a scalar defining the proportional augmentation applied to all outputs of farm k.

Non-zero elements of the optimal λ- identify the set of dominating farms on the production frontier, against which farm k is evaluated. Dominating farms are on the frontier and define the reference point (peers) for the DMU k. The presence of the non- Archimedean (infinitesimal) constant in the objective function allows the maximization over θ to preempt the minimization involving slack variables, *e.g.*, regardless of the values of $s+$ and $s-$, their multiplication by ε will not allow them to have any impact on θ. The optimization is computed in a two-stage process. First, maximum augmentation of outputs is achieved by obtaining the optimal value of θ^*. In a second

stage, the DMU is moved onto the efficient frontier via slack variables s^{+*} and s^{-*} (Charnes *et al.*, 1997).

The above LP is solved N times – once for each farm in the sample. Each LP produces a θ - parameter and a λ- vector. The θ - parameter provides information on the technical efficiency score for the *k-th* farm and the λ- vector provides information on the peers of the (inefficient) *k-th* farm. The peers of the *k-th* farm are those efficient farms that define the facet of the frontier against which the (inefficient) k-th farm is projected. The optimal solution to each problem, θ*, which satisfies $1 \leq \theta^* \leq \infty$, measures the maximal proportional increase in output levels for the k-th farm with inputs held constant. Hence, $1/\theta^*$ measures technical efficiency of the *k-th* farm, where the technical efficiency score will lie between zero (inefficient) and one (efficient). If $\theta = 1$, no increase in outputs is possible, which means the farm lies on the frontier and is thus technically efficient under Farrell's definition.

The output-oriented VRS model is obtained from the CRS model by adding a convexity constraint $\bar{1}\lambda=1$ to the CCR model. The measure of technical efficiency obtained in this model is also named "pure technical efficiency" (PTE) as it is free of scale effects. Therefore the scale efficiency values for each analyzed farm can be obtained by the ratio between the scores for technical efficiency with constant and variable returns. Thus: $SE = TE_{CRS} / TE_{VRS}$. Production is scale efficient if SE=1.0, or if the $TE_{CRS} = TE_{VRS}$.

In identifying the AE of the sample farms, this paper assumes a VRS technology and selected an input-orientation on the premise that constraints on inputs compel farmers to strive to minimize costs on inputs while maintaining output at the same level. Cost efficient farms are identified by solving:

$$\min_{x_1,\ldots,x_n,\ \alpha_1 \alpha_k} \sum_{n=1}^{t} w_n^0 x_n$$

$$\text{subject to}: \quad \sum_{k=1}^{K} y^k \alpha^k \geq y$$

$$\sum_{k=1}^{K} x_n^k \alpha^k \leq x_n \quad \text{for} \quad 1 \leq n \leq t$$

$$\sum_{k=1}^{K} x_n^k \alpha^k \leq x_n^0 \quad \text{for} \quad n > t$$

$$\sum_{k=1}^{K} \alpha^k = 1$$

$$\alpha^k \geq 0$$

where w_n^0 is the cost of the *n* (*n=1,...,t*) input faced by the farms whose efficiency is being tested, λ^k is the weight given to farm *k* in forming a convex combination of the output or input vectors, x_n denotes the optimal amount of input n (*n=1,...,t*), y^k denotes the output of farm *k (k=1,...,K)*, λ^k is the weight given to farm *k*, x_n^k denotes the level of input n for farm k, and x_n^0 is the amount of fixed

input *n* on the farm whose efficiency is being tested.

The cost efficiency index is calculated as the ratio between the optimal cost ($w_n^0 x_n$) and the observed cost on the k^{th} farm being tested ($w_n^0 x_n^k$). Cost efficient farms are those with a cost efficiency index equal to one.

Source of data. The data is obtained from the database used in the study on the "Technical efficiency in the production of sugar cane in Central Negros area: An application of data envelopment analysis" (Padilla-Fernandez and Nuthall, 2009). The 127 respondents were categorized and treated according to farm size group in response to the objectives set in this paper. In the Philippines, farms with less than 10 hectares are considered small; less than 50 hectares, medium; and above 50 hectares, large for sugar cane production. This farm size classification was followed in the study.

Using a stratified random sampling method, the data collection used a structured questionnaire on farmer's production activities in terms of inputs, output, and socio-economic characteristics for crop year 1997-98. The investigation was conducted in the central portion of Negros Island, the "sugar bowl" of the Philippines. This was chosen as it has relatively homogeneous farm samples in terms of geographic characteristics, market conditions and farming practices. The sugar cane planter (or farmer) as a sampling unit was limited to the head of the farming household who is an owner-operator and/or leasee-operator, except for a farm manager.

Treatment of data for technical efficiency measurements. One output and five inputs were used in measuring the technical efficiency levels of individual farms. For the output, the farmers' share of raw sugar, measured in 50 kilo per bag (LKg), was the output considered.

While for the input factors, all operations that used animal power (expressed as person-animal days) were combined as well as the operations that used machines (expressed as person-tractor days). Likewise, all of the operations that used hand power were combined into one factor and expressed in person-days. While all of the operations that are carried out by person-animal power and/or by person-machine combinations, were combined into the number of hours of power used. Based from the survey data on person-animal days and person-machine days, the conversion factor derived for sugar cane cultivation was 1 hour of animal work = 0.13587 hour of machine work. Hence, the inputs used include cropped area (hectares); seeds and planting materials (*lacsa*= 10,000 cane points or stools); an aggregated NPK fertilizer input (kilograms); power (hours) and an aggregated labor input (person-days). The output and the inputs of the two types of crop culture (i.e., ratoon and plant crops) were aggregated.

Treatment of data for allocative efficiency measurements. The only output here is the value of sugar. Generally, the domestic and export sugar is sold in the local farmers' associations thus they face similar transaction costs and/or market imperfections. Hence, the average composite price of sugar in Central Negros was used.

The input costs were obtained from the farmers. Four variable inputs were considered. Seed, replanting materials and fertilizer expenses were aggregated into one variable. The labor expense variable was calculated as the sum of hired labor and management cost. Operating and maintenance (OM) expenses included the cost of fuels and oils, supplies, interest on operating expenses, the machines, land and buildings maintenance and depreciation costs. The latter (fixed cost) however was combined with the variable cost (OM) so as not to increase the number of variables thus increasing

the discriminatory power of the DEA method. However, the land rental was disaggregated to form one factor cost (for comparability, it was assumed all land was leased and the average land rental gathered for the year was used.

After the input-output variables were organized, the comprehensive samples were grouped into farm size categories. To ensure comparability of the group efficiency scores, an hypothetical farm was created and included in all groups as a base.

The productive efficiency of each farm were solved using DEA linear programming models with the aid of the Warwick DEA computer software package developed by Thanassoulis and Emrouznejad (1996).

RESULTS AND DISCUSSIONS

Efficiency measures. The average PTE, SE and OTE for small, medium and large farms are shown in Table 1. All efficiency scores for larger farms are, on average, higher than for smaller farms. Decomposition of technical inefficiency between scale inefficiency (inappropriate scale) and pure technical inefficiency shows that the mean PTE scores across farm sizes are lower than the SEs which means that the major source of overall technical inefficiency appears to be technical, as against scale inefficiency. This suggests that inefficiencies are mostly due to inefficient management practices. The PTE scores suggest that gains from improving technical efficiency exist and appear to be much higher on small than on medium and large farms. Similar results were obtained by Rios and Shively (2005) for coffee farms in Dak Lak province, Vietnam and Yusuf and Malomo (2007) for poultry farms in Ogun state, Nigeria.

Table 1. Pure technical (PTE), scale (SE) and overall technical efficiency (OTE) measurements by farm size (Sub-sample with a reference farm).

Efficiency	**Small farms *n* = 54**			**Medium farms *n* =40**			**Large farms *n* =33**		
Score	**PTE**	**SE**	**OTE**	**PTE**	**SE**	**OTE**	**PTE**	**SE**	**OTE**
% efficient farms	20	19	11	23	20	15	27	24	15
Mean	0.757	0.949	0.710	0.823	0.974	0.783	0.834	0.966	0.812
Median	0.761	0.982	0.707	0.845	0.989	0.788	0.855	0.997	0.796

Turning to the scale efficiency, more farms operate above the optimal scale than farms below the optimal scale (Table 2). Across farm sizes, it shows that the highest share of scale efficient farms is in the group under large and small farm size. Detailed analysis shows that majority of large and medium farms operate above the optimal scale while majority of small farms operate below the optimal scale.

Table 2. Comparison of the number and per cent of farms with various returns to scale.

	Small		**Medium**		**Large**		**All farms**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Scale efficient farms (CRS)	6	11	2	5	4	12	12	0
Farms under IRS	35	65	16	37	1	3	51	40
Farms under DRS	13	24	22	58	28	85	64	50

This suggest that larger farms can reduce their input congestion by reallocating some of the over utilized resources to other enterprises where they can be fully utilized or for small farms, reduce costs further by increasing their scale of operation to increase efficiency.

For the purpose of determining the most productive scale size for each farm size groups, all input-output data of all farms exhibiting CRS were consolidated and averaged (Table 3). The optimum sizes obtained are around 5, 16 and 108 hectares for small, medium and large farms. If farm size is to be restricted by social policy, then this size should be as large as possible up to around 41 hectares. However, smaller size inefficiency must be weighed against the social advantages.

The average optimum land size is around 41 hectares, which is lower than the optimum size (50 hectares) stated in the report of the Presidential Task Force on the Sugar Industry (1997 p.2C). If block farming among small farmers is advised in any technology innovation program, an optimum size of around 40 hectares is desirable. Block farming in this context is the cultivation of farmers' fields as a group and synchronizing their farm operations to reduce overall costs (especially on tractor services, harvesting and hauling).

Table 3. Comparison of average input-output data: Constant returns to scale farms.

Input-output	Constant returns to scale farms			
	Small	**Medium**	**Large**	**All farms**
Yield (tons cane ha)	47.58	43.81	70.65	54.63
Area (ha)	4.88	16.25	107.57	41.01
Seeds (10,000 ha)	2.37	2.46	5.25	3.34
NPK fertilizer (kgs ha)	381.33	387.80	779.50	515.13
Power (hours ha)	17.17	19.38	23.07	19.50
Labor (person-day ha)	82.02	121.87	114.80	98.50

AE, OTE and EE indices for small, medium and large farms are shown in Table 4. Data shows that in majority of the sample farms, there are fewer technically efficient farms than there are allocatively efficient ones. Also, the AE scores are higher than the PTE scores. The latter implies that technical inefficiency rather than allocative is the primary source of economic inefficiency.

Looking at the median AE, OTE and EE levels, the small farms obtained the lowest while the medium farms, the highest (although in terms of mean efficiency, the large farms obtained the highest).

Table 4. Allocative (AE), pure technical (PTE) and economic efficiency (EE) measurements by farm size (Sub-sample with a reference farm).

Efficiency Score	Small farms n = 54			Medium farms n =40			Large farms n =33		
	AE	**PTE**	**EE**	**AE**	**PTE**	**EE**	**AE**	**PTE**	**EE**
% efficient farms	22	20	7	33	23	15	27	27	12
Mean	0.804	0.757	0.620	0.845	0.823	0.711	0.859	0.834	0.727
Median	0.803	0.761	0.616	0.900	0.854	0.727	0.878	0.855	0.694

Efficiency differences between two farm sizes shows interesting results for OTE and EE (Table 5). Mann-Whitney statistical test shows that the variation between the median OTE of small and large farm groups revealed significant result at α=0.05 level while α=0.10 level in small and

medium farm groups. The EE differences between small and medium and between small and large farm groups also revealed highly significant results. This implies that the small farms appear to be not as economically efficient as the larger ones, while medium and large farms appear to be equally economically efficient.

Table 5. The Mann-Whitney statistical test: Efficiency measurement by farm size.

Type of efficiency measurement	A standard Z-value	Significance level 2-Tailed p
Allocative		
1. Small and Medium	-1.2932	0.1960
2. Small and Large	-1.5460	0.1221
3. Medium and Large	-0.1134	0.9097
Overall technical		
1. Small and Medium	-1.8279	0.0676**
2. Small and Large	-2.2886	0.0221*
3. Medium and Large	-0.6703	0.5027
Economic		
1. Small and Medium	-2.0673	0.0387*
2. Small and Large	-2.2892	0.0221*
3. Medium and Large	-0.1400	0.8887

Note: ** and * denote significance at 10 and 5 percent, respectively

Kruskal –Wallis test for efficiency differences between the three farm sizes shows that only in the economic efficiency assessment is the difference significant (Table 6). This provides an efficiency argument against land reform whether small farms demonstrate greater overall economic efficiency and not only productivity *i.e*., yield per hectare.

Table 6. Kruskal –Wallis test: Allocative, overall technical and economic efficiency measurements by farm size.

Type of efficiency assessment	No. of Farm Size Group	Value of K-W statistics	Level of probability
Allocative (AE)	3	2.8868	0.2361
Overall Technical (OTE)	3	4.1778	0.1238
Economic (EE)	3	6.7602	0.0340

These results may be linked to the level of physical input used and cost as EE does not mean to reach a high productivity level, but to pursue the highest possible profit at a given productivity level. The high amount of input used by the large farms tends to increase their relative output and with the low price of inputs thus generating a larger profit (Table 7). T-test for equality of means show that between small and large farms, the difference in all of the input prices (per unit) are highly significant ($p = 0.01$ level). Between small and medium farms, the difference in labor input price is highly significant. Between medium and large farms, the differences in all of the input prices are significant at 5 per cent.

There is considerable evidence that large farms have comparative advantage in obtaining a lower price for their inputs thus the use of more inputs. For example, for labor, the large farmers can bargain for a lower wage because of the longer contract they can offer to the workers.

The low cost of seeds incurred by the large farmers is reasonable since a large hectareage can produce sufficient cane tops and planting material thus minimising the cost of seeds. The small farmers have to buy seeds from neighbouring farms. In the case of power, small farmers usually hire tractors and since the scope of work is on a per hectare basis, the cost is high, whereas those large farms with tractors can maximize their use although they pay more overheads, fuel and repair and depreciation costs. It is clear that part of allocative efficiency differences between the small and large farms can be attributed to the differences in the input prices.

Table 7. Comparison of average input-output data.

Input-output	Farm sizes			All
	Small	Medium	Large	Farms
Average area	4.08	26.04	104.01	36.96
Tons sugar ha^{-1}	40.91	51.47	61.47	49.58
Physical inputs ha				
Seeds (lacsa)	5.01	5.89	5.89	5.52
Fertilizer (kgs.)	557.25	735.62	835.39	685.70
Power (hours)	20.08	22.62	26.88	22.65
Labor (person-day)	93.53	111.73	118.85	105.84
Total cost ha^{-1} Php	24,571.17	28,621.00	32,392.65	27,879.06
Input cost/unit				
Seeds (lacsa)	273.93	191.31	155.62	213.92
Fertilizer (kgs)	7.05	6.77	6.53	6.82
Power (hours)	106.77	110.46	101.91	106.67
Labor (person-day)	97.98	86.86	89.46	92.26

Note: Independent sample test was applied to test mean differences.

Input use and slacks. Because inefficient use of a particular input may vary with farm size, we examine whether any distinct pattern exists across the three farm groups with respect to excessive use of land, labor and other variable inputs. This is achieved by analyzing the slack and surplus variables in the DEA estimation obtained from the analysis of PTE.

A slack value indicates the amount by which a DEA model constraint is not satisfied, and therefore represents the amount by which an input is overused relative to how the most efficient farms utilize the input. Thus, technically efficient farms do not have excess inputs while technically inefficient farms have one or more excess inputs.

Seed input appears to be in surplus across farm size; followed by NPK fertilizer except in the large farm group which has land as its next excess input to seed (Table 8). Land is also a surplus in medium farm group. This means, medium and large farms are underutilizing their land and also not optimizing their outputs. In the case of excessive seed input, this is sensible as the seeds (cane tops) can be taken from the other farms and are sometimes free of charge. These cane tops are not included in the processing of sugar cane as they contain less sugar. Excesses in NPK usage can be attributed to improper fertilization. Thus, for large farm groups, technically inefficient farms can reduce their input use by around 13, 18, 28, 43 and 11 per cent of land, seeds, NPK fertilizer, power and labor,

respectively and still achieve, on average, around 35 per cent increase in production. The same interpretation applies to small and medium farm groups.

DEA also determines those variables that effectively constrain production, and hence efficiency. Thus for all farms, power (*i.e.*, animal and machines) is the main constraint. This may infer the non-accessibility of working animals and hired tractors in their area. Labor is also a limiting factor especially for small farm groups. This is possible especially when the opportunity cost of labor is too high and farmers, as well as workers, do have opportunities other than farming. In addition, labor shortage, especially during the time of harvesting, is a serious problem as it can delay the operation which leads to high sugar-yield losses. As expected, land is the least input slack for the small farm group. This may infer that land is most effectively utilized by the small farmers.

Table 8. Analysis of slack inputs and adjustments to inputs and outputs: All technically inefficient farms.

			Per cent of input and output adjustments to give 100% efficiency			
Input and output	**TIE farms**	**% of total**	**Mean**	**Min**	**Max**	**Std Dev**
Small farms	41					
Output- LKG			48.63%	0.30%	130.10%	33.81%
Inputs	*					
AREA	8	20%	20.2%	0.1%	54.0%	17.5%
SEED	33	80%	31.1%	2.1%	87.8%	22.6%
Fertilizer	28	68%	30.1%	0.3%	72.3%	17.3%
POWER	16	39%	34.5%	5.5%	72.1%	19.0%
LABOR	11	27%	23.4%	0.1%	57.3%	17.9%
Medium farms	27					
Output- LKG			32.1%	0.6%	80.4%	24.3%
Inputs	*					
AREA	14	52%	13.7%	0.3%	43.2%	11.0%
SEED	18	67%	18.8%	2.1%	38.1%	13.5%
Fertilizer	15	56%	18.7%	1.3%	49.5%	11.8%
POWER	8	30%	34.9%	10.0%	58.7%	14.9%
LABOR	12	44%	11.8%	2.3%	24.7%	7.1%
Large farms	24					
Output- LKG			34.9%	1.3%	74.4%	21.3%
Inputs	*					
AREA	14	58.3%	13.2%	0.1%	31.7%	8.8%
SEED	15	62.5%	18.0%	0.8%	44.4%	12.7%
Fertilizer	13	54.2%	27.6%	3.6%	51.5%	15.4%
POWER	6	25.0%	43.2%	19.9%	66.2%	17.5%
LABOR	11	45.8%	11.1%	0.9%	23.0%	7.5%
Total farms	92					

			Per cent of input and output adjustments to give 100% efficiency			
Input and output	**TIE farms**	**% of total**	**Mean**	**Min**	**Max**	**Std Dev**
Output- LKG			38.54%	0.73%	94.97%	26.46%
Inputs	*					
AREA	36	39.1%	15.7%	0.2%	43.0%	12.4%
SEED	66	71.7%	22.6%	1.7%	56.8%	16.3%
Fertilizer	56	60.9%	25.5%	1.7%	57.8%	14.9%
POWER	30	32.6%	37.5%	11.8%	65.7%	17.1%
LABOR	34	37.0%	15.4%	1.1%	35.0%	10.9%

*Number of TIE farms with the stated input as slack.

CONCLUSION AND POLICY IMPLICATIONS

The major source of overall technical inefficiency appears to be technical rather than scale inefficiency. Improving technical efficiency appears to be much higher on small (24%) than on medium (18%) and large farms (17%). On the average, the small, medium and large farms can reduce their input use proportionately by 19 %, 12% and 9%, respectively, and still produce the same level of output, assuming no other constraining factors. This would cut down the average cost of production and improve the competitiveness of the sugarcane farms in Central Negros.

While scale analysis shows the majority of large and medium farms operate at decreasing returns to scale, while the majority of small farms operate increasing returns to scale. This suggests that larger farms can reduce their input congestion by reallocating some of the over utilized resources to other enterprises where they can be fully utilized; or for small farms, reduce costs further by increasing their scale of operation to increase efficiency.

Results also showed that technical, rather than allocative, inefficiency is the major source of economic inefficiency across farm sizes. Small farms appeared to be not as economically efficient as the large ones while medium and large farms appeared to be equally economically efficient. Therefore, from an agricultural policy point of view, the trend towards larger farm sizes could have a beneficial impact on the efficiency of the Philippine sugar industry as a whole. This, however, runs against the trend set by the land reform law (CARL) which pursues social equity.

Inefficiency differences among farm size groups appears to be related with the physical input used and cost. The higher input usage by the large farms tends to increase the quantity produced and, with the low price of inputs, generates a larger profit per hectare. The higher input prices faced by the small farmers tends to reduce the amount of input used thus giving a lower profit. Part of the allocative efficiency differences between the farm size groups may be attributed to the differences in the input price. Thus, government cooperative programs that provide farmers access to cheaper farm inputs through bulk purchasing may actually lead to increased productive efficiency.

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ANTIFUNGAL ACTIVITY OF TEAK (*TECTONA GRANDIS* L.F) LEAF EXTRACT AGAINST *ARTHRINIUM PHAEOSPERMUM* (CORDA) M.B. ELLIS, THE CAUSE OF WOOD DECAY ON *ALBIZIA FALCATARIA* (L.) FOSBERG

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ABSTRACT

Arthrinium phaeospermum (Corda) M.B. Ellis is one of the fungi which causes decay on *Albizia falcataria* (L.) Fosberg wood. Synthetic fungicides are commonly applied to reduce wood decay, however, its improper use may cause environmental and health problems. The extract of higher tropical plants were proven by previous workers to possess antimicrobial activities against plant pathogenic fungi. In this study, the antifungal activity of teak leaf extract was tested against *A. phaeospermum,* the cause of wood decay in *A. falcataria* . The air-dried leaves of teak, *Tectona grandis* were extracted with methanol and evaporated in a rotary evaporator. Antifungal activity of the leaf extract was tested based on well diffusion method on potato dextrose agar (PDA). Leaf extracts, 0.5 %, 1 %, 2 % and 4 % (w/v) were tested in this study. Sterile distilled water containing 0.2% Tween-80 was used as solvent and control. The results of this study showed that the teak leaf extract at a concentration as low as 0.5% (w/v) suppressed significantly the growth of *A. phaeospermum* by 81.4%, with minimum inhibitory concentration (MIC) of 0.4 % (w/v). The leaf extract inhibited significantly the fungal radial growth, total biomass and sporulation.

Key words : antimicrobial activity, tropical plants, pathogenic fungi.

INTRODUCTION

Albizia falcataria is one of the important wood trees that is used for many purposes. In Bali, the wood of this tree is widely used for furniture and wood carvings, particularly for modern art. However, this wood is susceptible to fungal wood decay. Several types of fungi have been reported to be associated with the wood decay such as *Serpula lacrymans*, *Coniophora puteana*, *Amyloporia xantha*, *Chaetomium globosum*, *Cladosporium* spp, *Penicillium* spp., *Monilia* sp. and *Arthrinium phaeospermum* (Astiti, 1998; Novianto, 2009; Singh, 2010).

Arthrinium phaeospermum is one of the causal agent of wood decay of *A. falcataria.* The infection by this fungus reduces the durability and quality of wood (Novianto, 2009). Synthetic chemical fungicides has been used as preservatives to control this wood decay however, an increase in the awareness on the negative impacts of these chemicals particularly on human health and environment has made this preservative unsuitable. Many chemical wood preservatives have been prohibited for use on wood (Priadi, 2005). Exploration of the higher plants to produce wood preservative agents that are environmentally friendly and safe to the human health is necessary.

Higher tropical plants can produce diverse anti-microbe and anti-insect substances (Downum et al., 1993; Lis-Balchin et al., 1996; Nakamura et al., 1996). Substances such as flavonoids, alkaloids, terpenoids are the secondary metabolites produced by the plants as chemical defense against pests and diseases attacks. It is estimated only 10% of these tropical plants have been investigated for their pesticidal activity. Teak is one of these plants which produces secondary metabolic products containing phenolic compounds.

Manoharachary and Gourinath (1988) determined the efficacy of some tropical plant extracts against four pathogenic fungi, i.e. *Curvularia lunata*, *Cylindrocarpon lichenicola*, *Fusarium solani* and *Myrothecium leuchotrichum*. The plants tested were *Calatropis*, *Datura*, *Ocimum*, *Ricinus* and *Thidax*. Among the plant parts tested, extracts of roots and flowers were found to be effective in inhibiting sporulation and growth of fungi. Bandara and Wijayagunasekeya (1988) evaluated three rhizomatous herbs, i.e. *Acorus calamus* (Araceae), *Zingiber zerumbet* and *Curcuma longa* (Zingiberaceae) for their antifungal activity against *Cladosporium* sp., *Btryodiplodia theobromae*, *Fusarium solani*, *Phytophthora infestans*, *Pythium* sp., and *Pyricularia oryzae*. Their results revealed that extracts of *A. calamus* and *Z. zerumbet* had profound effect on growth of all fungi tested.

Fifteen plant species of different families were evaluated for antifungal acitivity by Suprapta et al. (2001) to control *Ceratocystis* fruit rot on snake fruit (*Salacca edulis*). Their findings revealed that root extract of *Alpinia galanga* and the leaf extract of *Carica papaya* significantly inhibited the growth of *Ceratocystis* sp. both on PDA medium and on snake fruit. The leaf extract of *Pometia pinnata* was found to contain antifungal activity against *Phytophthora infestans*, the causal agent of late blight of potato (Suprapta et al., 2002). The application of the leaf extracts of *Piper betle* and root extract of *Alpinia galanga* controlled significantly the wilt disease of banana caused by *Fusarium oxysporum* and *Pseudomonas solanacearum* under field conditions (Arya et al., 2001)

Appropriate technological improvement, which result in more effective use of natural resources is required to preserve the wood particularly against the attack of fungi. Astiti (1998) found that the water extract of teak leaf obviously inhibited the growth of *Monilia* sp., the cause of wood decay. The methanol crude extract of the leaf of *Tectona grandis* at concentration 5 mg ml^{-1} inhibited the sporulation of *Alternaria cajani* and *Helminthosporium* sp. by 86.8% and 90.0%, respectively (Shalini and Srivastava, 2008). This study was conducted to evaluate the antifungal potential of teak leaf extracts particularly against *A.phaeospermum*, the cause of wood decay on *A. falcataria.*

MATERIALS AND METHODS

Sample Collection and Extraction

Mature *Tectona grandis* leaves were collected from Bukit, Jimbaran Denpasar Bali, Indonesia. The leaves were washed in tap water, and cut into small pieces of about 2 mm x 2 mm in size and air dried for three days under room temperature (28 ± 2^{o} C). The leaves were ground using a blender to powder form and extracted with methanol (PA grade) by soaking for 48 h in the dark under room temperature (28 ± 2^{o} C). The extract was then filtered through two layers of cheese cloth and followed by Whatman No.1 filter paper. The filtrates were evaporated in a rotary evaporator (Iwaki, Tokyo Japan) and the crude extract was used for antifungal testing against *A. phaeospermum.*

Determination of Minimum Inhibitory Concentration

The fungus, *A. phaeospermum* was isolated from rotten wood and maintained in the Laboratory of Microbiology, Faculty of Science Udayana University. The fungus was re-cultured on PDA medium to allow it to produce mycelia and spores. The propagules (spores and mycelia) were harvested in sterile distilled water. Propagule suspension (200 µl) were spread on melted PDA

medium in a laminar flow. After the medium become solid, a diffusion well was made in the center of PDA using cork borer (5 mm diam.). Into the well, 20 µl crude extract of teak leaf was applied using a micro pipette at concentrations 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 1%, 2% and 4% (w/v). For control, 20 µl sterile distilled water containing 0.2% Tween-80 was used. Five Petri dishes were prepared for each concentration. The cultures were then incubated for 48 h in the dark under room temperature. The formation of inhibition zone around the diffusion well was observed and was used to determine the antifungal activity. The lowest concentration in which the leaf extract of teak leaf produced inhibition zone is known as minimum inhibitory concentration (MIC).

Effect of Extract on Radial Growth

The teak leaf extract at various concentrations (0.5%, 1%, 2% and 4%, w/v) were applied on Petri dishes and 10 ml melted PDA medium was added. The sterile distilled water containing 0.2% Tween-80 was used as control. The Petri dishes were shaken gently to allow the extract to distribute evenly. After the medium solidified, a mycelial plug (5 mm diam.) of *A. phaeospermum,* taken from the edge of a 3-day old culture was put in the center of the PDA. Five Petri dishes were prepared for each concentration. The cultures were incubated for 7 days in the dark under room temperature. The diameter of fungal colony was measured daily. The inhibitory activity to the radial growth (IR) was determined according to the following formula (Pinto *et al*., 1998):

$$IR\ (\%) = \frac{dc - dt}{Dc} \times 100$$

where: IR = inhibitory activity to the radial growth
dc = average increase in mycelia growth in control plates
dt = average increase in mycelia growth in treated plates.

Effect of Extract on Sporulation

Spores were harvested in sterile distilled water from a culture maintained in slant PDA. The suspension was passed through a filter paper (Whatman No.2) to separate the spore and mycelia or hypae. A 200 µl spore suspension (2×10^5 spores/ml^{-1}) was added into 10 ml potato dextrose broth in a test tube containing various concentrations of teak leaf extract, i.e. 0%, 0.5%, 1%, 2% and 4% (w/v). The cultures were incubated in the dark under room temperature for five days. The number of spores were counted using haemocytometer under light microscope. The inhibitory activity to the spore formation (IS) was calculated according to the following formula :

$$IS\ (\%) = \frac{dc - dt}{dc} \times 100$$

where:
IS = inhibitory activity to the sporulation
dc = spore's density on control (without extract treatment)
dt = spore's density with extract treatment.

Effect of Extract on Fungal Biomass

The determination of the effect of teak leaf extract on fungal biomass was done in 100 ml potato-dextrose broth (PDB) medium that was placed in a 200-ml Erlenmeyer flask. The teak leaf extract was added into the flask at concentration varied from 0%, 0.5%, 1%, 2% and 4% (w/v). The medium was then inoculated with 1 ml of spore suspension (the spore density was 2×10^5 spores/ml). The final volume of the culture was 100 ml with five flasks for each concentration. The cultures were incubated in the dark for 8 days under room temperature. The biomass was harvested

through centrifugation at 5,000 rpm for 5 minutes. The pellet (biomass) was taken and placed on glass filter paper and dried in an oven at 60^{o}C until constant weight.

The inhibitory activity against the fungal biomass (IB) was calculated according to the formula :

$$IB\ (\%) = \frac{WC - WT}{W} \times 100$$

Where: IB = inhibitory activity to the fungal biomass
WC = dry weight of biomass on control (without extract treatment)
WT = dry weight of biomass with extract treatment.

RESULTS AND DISCUSSION

The teak leaf extract suppressed significantly the growth of *A. phaeospermum* with a minimum inhibitory concentration (MIC) of 0.4 % (not shown). This extract inhibited significantly ($P<0.05$) the radial growth of this fungus on PDA medium. Treatment with 0.5% teak extract resulted in 81.44 % inhibitory activity against fungal radial growth. Results of this study showed that the higher the teak extract concentration, the higher the inhibitory activity. No fungal growth was observed on plates treated with teak leaf extract at concentration 4 % (w/v) (Table 1).

Table 1. Inhibitory activity of teak leaf extract against the radial growth of *Arthrinium phaeospermum*

Extract concentration (%, w/v)	Diameter of fungal colony (mm)	Percent inhibition
0	90 a*	-
0.5	16.6 b	81.44
1	11.8 c	86.89
2	10.2 d	88.67
4	0 e	100

* Values followed by the same letters in the same column are not significantly different according to the Duncan's Multiple Range Test at *P<5%.*

The treatment with teak leaf extract containing as much as 2% (w/v) suppressed significantly ($P<0.05$) the spore formation of *A. phaeospermum* on PDB medium when compared to all treatments except with 4% extract , where there was insignificant difference in spore formation ($P>0.05$) was observed (Table 2). Likewise, the treatment with teak leaf extract significantly ($P<0.05$) inhibited the biomass formation of *A. phaeospermum* on PDB medium. An extract concentration as low as 1% (w/v) can suppress the biomass formation of *A. phaeospermum* by 65.55% (Table 3).

Table 2. Inhibitory activity of teak leaf extract against the formation of of *Arthrinium phaeospermum* spores.

Extract concentration (%, w/v)	Spore's density ml^{-1} (x 10^{5} spores)	Percent inhibition
0	104.5 a*	-
0.5	65 b	37.80
1	36 c	65.55
2	9 d	91.39
4	1.5 d	98.56

* Values followed by the same letter in the same column are not significantly different according to the Duncan's Multiple Range Test at *P* < 5%.

Table 3. Inhibitory activity of teak leaf extract against the biomass of *Arthrinium phaeospermum.*

Extract concentration (%, w/v)	Dry weight of biomass (mg)	Percent inhibition
0	304.2 a*	-
0.5	204.6 b	32.74
1	90.4 c	70.28
2	41.4 d	86.39
4	9 e	97.04

*Values followed by the same letter in the same column are not significantly different according to the Duncan's Multiple Range Test at $P < 5\%$.

Reddy et al. (2009) tested the antifungal activity of phyto-extracts and plant oils of several plant species such as *Azadirachta indica*, *Allium cepa*, *Allium sativum*. *Tegetes erecta*, *Aloe barbadensis*, *Eucalyptus globulus* against the growth of *Cercospora moricola* Cooke, the causal agent of leaf spot of Mulberry (*Morus alba* L.). Highest mycelial growth inhibition (72.59%) was recorded in *Eucalyptus globulus* at 10% concentration. Plant oils viz., *Madhuca indica* oil (3%), *Cymbopogon citratus* oil (0.05%) and neem oil (3%) also inhibited the mycelial growth of the fungus with 75.73%, 73.22% and 24.44% inhibition respectively, when compared to control. The antifungal activity of aqueous, petroleum ether, benzene, chloroform, methanol and ethanol extracts and alkaloid extract of *Prosopis juliflora* (Sw.) DC. leaves (Mimosaceae) was evaluated for antifungal activity by poisoned agar technique against *Alternaria alternata* a causal organism of brown spot of tobacco. Aqueous extract recorded highly significant antifungal activity at 24% concentration. Among different solvent extracts tested, methanol and ethanol extract recorded highly significant antifungal activity. Methanol extract was further subjected to fractionation guided by antifungal activity leading to the isolation of alkaloid extract, which was also recorded highly significant antifungal activity against the test fungus and the minimum inhibitory activity was recorded at 1000 ppm. The antifungal activity of alkaloid extract was compared with synthetic fungicides viz., copper oxychloride, captan, mancozeb and thiram at their recommended dosage of 2000 ppm, indicating that the alkaloid extract was highly effective, even at the dosage lower than for the synthetic fungicides (Raghavendra et al., 2009)).

Extracts from several plants have been studied for their antifungal activities against plant pathogenic fungi. *Piper betle* (Family : Piperaceae), *Alpinia galanga* (Family Zingiberaceae), *Eugenia aromatica* (Family Myrtaceae), *Pometia pinnata* (Family Sapindaceae), *Sphaeranthus indicus* (Family Compositae) and *Carica papaya* (Family Caricaceae) were proven to possess antifungal activities against several pathogenic fungi. Methanol extracts of *A. galanga* rhizome and *C. papaya* leaf obviously inhibited the radial growth of *Ceratocystis* sp., the causal agent of fruit rot disease on snake fruits (*Sallaca edulis*) on PDA medium. Treatment with 0.5% (w/v) extracts of *A. galanga* or *C. papaya* inhibited the radial growth of *Ceratocystis* sp. by 92.5% and 73.3%, respectively (Suprapta et al., 2001). The *P. betle* crude extract reduced spore formation of *Fusarium oxysporum* f.sp. *vanillae* in potato dextrose (PD) broth medium. The spore formation was inhibited by the *P. betle* crude extracts as low as 0.1% (w/v) with inhibitory activity of 84.41%. Minimum inhibitory concentration (MIC) of this extract was 0.15% (w/v). The spore as well as the radial growth of *F. oxysporum* f.sp. *vanillae* were completely inhibited when 0.3% to 0.5% *P. betle* crude extract was added to PDA medium. The inhibitory activity increased with increasing concentrations of this extract within the tested concentration (Suprapta and Ohsawa, 2007).

Five plant species, namely *E. aromatica*, *A. galanga*, *Pometia pinnata*, *Sphaeranthus indicus* and *P. betle* exhibited antifungal activity against *Phytophthora palmivora*, the causal agent of cocoa black pod disease. The crude extract of these plant species showed inhibitory activity against the radial growth of *P. palmivora* of more than 50% at a concentration of 0.5% (w/v) on PDA medium (Suprapta et al., 2008). The leaf extract of *Pometia pinnata* exhibited antifungal activity against

Phytophthora infestans, the causal agent of potato late blight disease. Treatment with 0.5% (w/v) crude extract of *P. pinnata* on PDA medium inhibited 85% of the radial growth of *P. infestans* (Suprapta et al., 2002).

Bandara et al. (1989) tested the crude extract of *Acorus calamus* (Araceae) and *Zingiber zerumbet* (Zingiberaceae) rhizomes against the growth and spore formation of several pathogenic fungi. These plant extracts inhibited significantly the growth of *Cladosporium* sp., *Btryodiplodia theobromae*, *Fusarium solani*, *Phythophthora infestans*, *Phythium* sp., and *Pyricularia oryzae*. The inhibiting activity of the extract of *A. calamus* against the growth of *F. solani* was better that of carbendazim, a synthetic fungicide.

Although plant extracts with antifungal potential in *in vitro* tests are not always effective under field conditions, several works showed the effectiveness of plant extracts in controlling plant diseases in the field. Arya et al. (2001) showed that treatment with the water extracts of *Piper betle* and *Carica papaya* reduced significantly the disease incidence of banana wilt disease under field conditions. The application of *Alpinia galanga* root extract and *C. papaya* leaf extract effectively suppressed the development of *Ceratocystis* fruit rot of *Salacca edulis* (Suprapta et al., 2001). An extract formulation containing flower extract of *Eugenia aromatica* and leaf extract of *Piper betle* at concentration 0.5% (w/v) significantly reduced the incidence of cocoa black pod disease under field condition (Suprapta et al., 2008). This formulation has also been proven to be effectively controlled the stem rot disease on vanilla seedling (Suprapta and Khalimi, 2009).

The present study revealed that the methanolic extract of the teak leaf obviously inhibited the growth, spore formation and biomass formation of *A. phaeospermum*. These results suggest that the teak leaf extract contained antifungal substances against *A. phaeospermum*, one of the important causal fungi of wood decay on *A. falcataria*. The purified components may have even have more potency with respect to antifungal activities against *A. phaeospermum*. Further work on the types of substances and purification of individual groups of bioactive components can reveal the exact potential of teak leaf to inhibit *A. phaeospermum*. Considering the results of the present study, it is possible to use the leaf extract of teak to control the wood decay under natural conditions. For this purpose, it is necessary to develop the extract formulation and delivery system that can maintain the antifungal activities of the extracts under natural conditions.

CONCLUSION

The methanol extract of teak leaf significantly inhibited the fungal radial growth, total biomass and sporulation of *A. phaeospermum*, the causal agent of wood decay of *A. falcataria*. This extract can be considered as one of the alternatives to chemical wood preservatives for controlling the wood decay on *A. falcataria*. A further study is needed to isolate and identify the active compounds that are responsible for antifungal activity against *A. phaeospermum.*

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COMPARATIVE STUDY ON SAMPLE PREPARATION METHODS FOR THE HPLC QUANTIFICATION OF ITURIN FROM CULTURE SUPERNATANT OF AN ANTAGONISTIC *BACILLUS* STRAIN

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ABSTRACT

Iturin is one of the antimicrobial cyclic lipopeptides produced by antagonistic strains of *Bacillus* spp. This study evaluated sample preparation methods for high-performance liquid chromatography (HPLC) quantification of iturin from culture supernatant of an iturin-producing *Bacillus* strain. The acid precipitation and methanol extraction (APME) method showed a lower efficiency than the butanol extraction and methanol substitution (BEMS) method. Direct application of culture supernatant to HPLC analysis showed the lowest efficiency. The BEMS method was the most effective method for quantifying the amount of iturin from culture supernatant based on the percent recovery and the time required to perform the analysis.

Key words: lipopeptides, biosurfactant, antifungal, biological control

INTRODUCTION

The antagonistic strains of *Bacillus* spp. are recognized as biological control agents against several kinds of plant diseases, and are expected to use in countries of Southeast Asia region. *Bacillus* spp. show highly tolerance against high temperature, dryness and storage, because of its endospore forming. Furthermore, in the Southeast Asia region, it has been thought that there are many of biological resources which are effective *Bacillus* strains as biological control agents.

Iturin is a circular lipopeptide produced by antagonistic strains of *Bacillus* spp. (Hiradate *et al*., 2002). Iturin consists of a heptapeptide circularized with a β-amino fatty acid, which has homologous variants of different lengths, and the fatty acid chains have differing isometry (Fig. 1) (Hiradate *et al*., 2002). Lipopeptides with antifungal activity have been identified in a broad range of host strains (Phae and Shoda, 1991), and many *Bacillus* spp. that produce iturin have been employed as biological control agents against several plant diseases; e.g., mulberry anthracnose caused by *Colletotrichum dematium* (Yoshida *et al*., 2001). A dose-dependent effect on disease suppression when iturin was applied to soil against tomato damping-off caused by *Rhizoctonia solani* (Mizumoto *et al*. 2007). Therefore, the evaluation of iturin production by antagonistic *Bacillus* strains is one of the critical factors in screening for effective strains to act as antagonists.

Several chemical properties of iturin have been reported so far. Besson *et al*. (1976), reported that iturin in the culture supernatant of *B. subtilis* is precipitated by acidification to pH 3.0 by using HCl and can be extracted from the precipitates using organic solvents.

Two major sample preparations for high-performance liquid chromatography (HPLC)-based quantification of cyclic lipopeptides have previously been reported (Phae and Shoda. 1991; Yazgan *et al*., 2001). The acid precipitation and methanol extraction (APME) method was developed by Phae and Shoda (1991) and widely used for the quantification of iturin (Hsieh *et al*., 2008; Grover *et al*., 2010). The other method, the 1-butanol extraction and methanol substitution (BEMS) method was developed by Yazgan *et al*. (2001) and widely used for quantification of antimicrobial lipopeptide in culture supernatants (Romero *et al*. 2007). This present study evaluated these sample preparation methods for the quantification of iturin in culture supernatant.

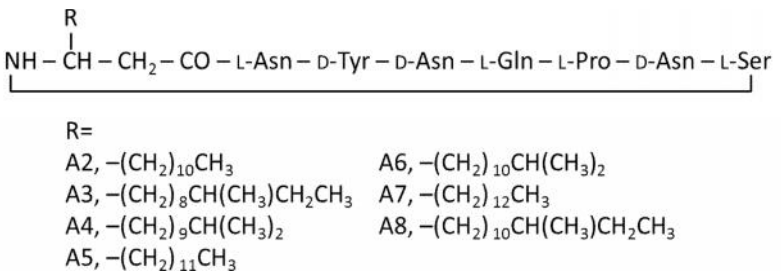

Fig. 1. Chemical structure of iturin.

MATERIALS AND METHODS

Strain and culture conditions

Bacillus subtilis ATCC 21556 was used as an iturin-producing bacterium. No.3S medium containing 1% Polypepton S (Nihon Pharmaceutical, Tokyo Japan), 1% glucose, 0.1% K_2HPO_4, and 0.05% $MgSO_4 \cdot 7H_2O$ was used as the culture medium. (Tsuge *et al*., 2001). A culture shaken for 2 days at 25°C was used for the quantification of iturin.

Partial purification of iturin from solid-state culture

Partially purified iturin was obtained from a solid-state culture of *B. subtilis* ATCC 21556 for the recovery test. Soybean curd residue (Soyaflour, The Nisshin OilliO Group, Ltd., Tokyo, Japan) was used as a solid-state medium. One hundred grams of solid-state medium (60% water content) was placed in a 500-mL plastic case and autoclaved at 121°C for 30 min. A *B. subtilis* ATCC 21556 culture shaken for 2 days was inoculated onto the solid-state medium at an initial concentration of 10^7 cells g^{-1} fresh weight (FW) and incubated for 5 days at 25°C. The solid-state culture (100g) was extracted using 300 mL of 1-butanol and shaking for 10 min at room temperature. The butanol fraction was collected by centrifugation at 5000 × g for 5 min at 20°C, washed with distilled water, and dried using a rotary evaporator. The residue was dissolved in 200 mL of methanol, and 10 g of ODS resin (Wakosil, Wako Pure Chemical Industries, Ltd., Osaka, Japan) was added to the methanol extraction. Distilled water was added to the ODS mixture (up to 30% of methanol concentration). The ODS resin was washed using 30% methanol and applied to the column. Iturin was eluted from the column using 100% methanol.

Preparation procedures

Culture supernatants were collected by centrifugation at 8000 × g for 5 min at 4°C and divided for further preparation.

APME

This method was developed by Phae and Shoda (1991). Forty milliliters of culture supernatant was acidified to a pH of 2.0 using 12 M HCl and then incubated for 18 h at 4°C. Precipitates were collected by centrifugation at 8000 × g for 10 min at 4°C and then extracted with 4 mL of methanol for 30 min by shaking. The methanol extract was collected by centrifugation at 8000 × g for 10 min at 4°C.

BEMS

This method was according to Yazgan *et al*. (2001) with some modifications. Four milliliters of culture supernatant was extracted using 1 mL of 1-butanol by vortex mixing for 20 s. After centrifugation at 10000 × g for 2 min at 20°C, the organic (upper) layer was collected by a pipette. The remaining aqueous layer was extracted twice using 300 μL of 1-butanol. The organic fractions were combined and evaporated by centrifugal evaporator (VC-36S, Tietech Co., Ltd., Nagoya, Japan), and the dried sample was dissolved using 300 μL of methanol.

Direct method

The direct method was carried out by direct application of a culture supernatant for HPLC analysis. All samples were filtered using a 0.45-μm PTFE membrane (ADVANTEC, Advantec MFS, Inc., Dublin, CA USA) prior to HPLC analysis. The precision of the APME and BEMS methods was defined as percent column volume (CV) based on 10 replications of each method.

Recovery test

The recovery test of iturin from culture supernatant was carried out by adding partially purified iturin to a culture supernatant of *B. subtilis* ATCC 21556. Ten milliliters of partially purified iturin methanol solution (1.8 mg mL^{-1}) was added to 600 mL of culture supernatant and then divided for further preparation.

HPLC analysis

HPLC analysis was performed using a Shimadzu LC-10 HPLC system at 205 nm with an LC-10Av UV-VIS spectrophotometer (Shimadzu, Kyoto, Japan); the column was a Mightysil RP-18 GP containing ODS (5 μm, 250 mm × 4.6 mm ID; Kanto Chemical Co., Tokyo, Japan). The column conditions for iturin analysis were 65% methanol (mobile phase), 1 mL/min, 45°C. Injection volume was 10 μL. Data collection was performed using a Chromato-PRO data integrator (Run Time Co., Kanagawa, Japan). Iturin standard was purchased from Sigma-Aldrich (St. Louis, MO, USA). The lower limit of detection was 0.57 μg mL^{-1} by HPLC analysis for each iturin homologs (data not shown).

RESULTS AND DISCUSSION

The antimicrobial lipopeptide iturin has homologous variants of fatty acid moieties; 7 homologs (A2 to A8) have been identified so far (Fig. 1). This study detected 5 homologs of iturin, A2 to A6, from an iturin standard purchased from Sigma-Aldrich. A chromatograph of iturin homologs A2 to A6 in the culture supernatant of *B. subtilis* ATCC21556 is shown in Fig. 2. Each peak of iturin was collected and confirmed by MALDI-TOF-MS (Shimadzu, Kyoto, Japan).

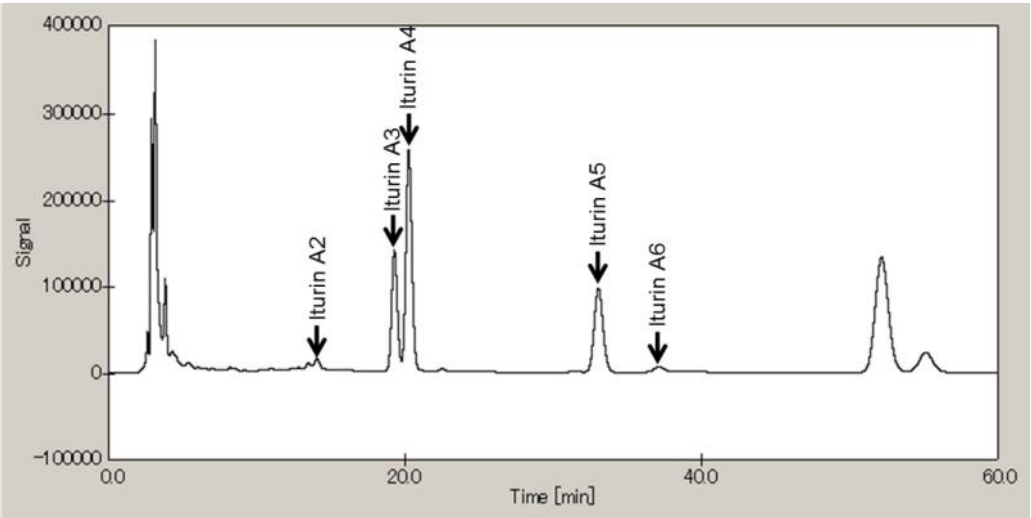

Fig. 2. Chromatogram of iturin homolog extract using the BEMS method and culture supernatant of *Bacillus subtilis* ATCC 21556.

Iturin concentrations in the culture supernatant of *B. subtilis* ATCC21556 prepared using the APME, BEMS, and direct methods are shown in Table 1. With the BEMS method, each homolog of iturin was detected at concentrations greater than 3 times those found using the APME method. The BEMS method also had lower CV values for each homolog compared to the APME method. The ratio of each homolog (iturin A2 to A5) was approximately the same between the APME and BEMS methods. The direct method had the lowest efficiency for iturin quantification. Percent recovery values of each iturin homolog are shown in Table 2. The BEMS method had the highest percent recovery among the 3 preparation methods. For the BEMS method, all homologs were almost completely recovered. In contrast, the APME method recovered less than 15% of the total iturin. However, the recovery of iturin A2 was much lower than A6 recovery by APME in this study. This suggests that the acid precipitation step in the APME method might cause the low efficiency of recovery.

Bie *et al*. (2004) reported a related study on sample preparation method for HPLC quantification of iturin. They screened the main factors affecting extraction of iturin from the precipitates which were collected by centrifugation followed by acidified of the culture supernatant in APME method of this study. They observed that methanol or ethanol showed higher efficiency than propanol or 1-butanol, which was used as the organic solvent for extraction of iturin. The reason for the low efficiency associated with the APME method remains unclear.

For the BEMS method, we modified the ratio of culture supernatant and 1-butanol for extraction from the original Yazgan's method (Yazgan *et al*., 2001). In the original method, they extracted by one-fourth volume of 1-butanol against culture supernatant for 3-times; whereas this study used one-fourth volume of 1-butanol once, and further extraction by 3/40-times volume of 1-butanol twice. There was no significantly difference in the recoveries of iturin from culture supernatant between the original and modified method (data not shown).

The direct method showed the lowest percent recovery for all iturin homologs. No iturin homologs were recovered other than iturin A2. Thimon *et al*. (1992) reported that the critical micelle concentration of iturin in 0.1 M $NaHCO_3$ solution is 43 μM at 25°C. The concentration of

total iturin in the culture supernatant of *B. subtilis* ATCC21556 determined by the BEMS method was approximately 700 μM. Therefore, it is likely that the low recovery efficiency for the direct method was caused by the formation of micelles of iturin in the culture supernatant.

Table 1. Effect of sample preparations for iturin quantification.

Preparation	Iturin (mg mL^{-1})[a]						CV[b]					
	A2	A3	A4	A5	A6	Total	A2	A3	A4	A5	A6	Total
APME[c]	14.2	25.5	82.8	67.5	5.4	195.4	0.088	0.086	0.082	0.107	0.117	0.089
BEMS[d]	46.3	101.5	296.1	251.2	37.8	732.8	0.064	0.071	0.070	0.070	0.065	0.069
Direct	1.2	0.2	0.6	n.d[e]	n.d	2.0	n.t[f]	n.t	n.t	n.t	n.t	n.t

Table 2. Percent recovery of iturin homologs by preparation method

Preparation	**Recovery of iturin (%)[a]**					
	A2	**A3**	**A4**	**A5**	**A6**	**Total**
APME[b]	3.7	20.5	14.2	11.9	58.1	14.1
BEMS[c]	97.0	98.5	99.2	100.6	98.6	99.6
Direct	11.5	-2.0	-0.3	0	0	0.5

[a]Mean value of 10 replications
[b]Acid precipitation and methanol extraction
[c]Butanol extraction and methanol substitution

CONCLUSIONS

In this study, we evaluated the sample preparation methods for antifungal lipopeptide iturin in culture supernatant for HPLC analysis. Based on percent recovery and method precision, we conclude that the BEMS method is the most effective sample preparation method for iturin quantification in the culture supernatant of antagonistic *Bacillus* strains.

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THE ECONOMIC EFFECTS OF THE COMPREHENSIVE AGRARIAN REFORM PROGRAM IN THE PHILIPPINES

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ABSTRACT

One of the major interventions to effect rural development in the Philippines is the Comprehensive Agrarian Reform Program, which was instituted in 1988 and its implementation is extended until 2014. Using a panel data from a series of surveys (1990, 2000, and 2006), the economic impacts of the Program were evaluated. Using income, expressed in real terms, as the main economic indicator, the analyses showed that there have been significant positive changes to the economic well being of the beneficiaries of the Program using the first difference between the intervention and the control group. The first difference was also significant across time or on the before and after the program comparison. However, the double difference approach, which compared the control group before and the intervention group after revealed that the changes in economic benefits were no longer significant. One could argue that the changes on the economic attributes of the respondents are not necessarily attributable to CARP as an intervention. However, the Program needs to be given the benefit of the doubt. Hence, there is the need to look at further refining analytical techniques to isolate the effects of the intervention and to develop analytical tools based on a more systematic study design. Further, the paper also examined the effect of the program using alternative indicators, such as the value of assets as well as level of expenditures. The results did not deviate from the findings with income as the main indicator, which indicate that these alternate indicators can also be explored in similar studies.

Key words: impact evaluation, double difference analysis, panel data analysis, qualitative response models, rural development

INTRODUCTION

In response to the peasants' demand for equitable access to land, which is the main productive resource in the rural areas of the country, the Philippine constitution enshrined that the government shall undertake an agrarian reform program founded in the right of farmers and regular farm workers who are landless to own directly or collectively the lands they till, or, in the case of farm workers, to receive a just share of the fruits (Article XIII, Section 4). This intent was operationalized by the implementation of the Comprehensive Agrarian Reform Program (CARP) under the legal framework of Republic Act 6657.CARP was designed not only to mitigate social unrest through redistribution of land but also to enhance household incomes and promote rural development through the provision of support services such as credit, capacity building, rural infrastructures, technology promotions and agribusiness development.

Most of the studies done so far in the economic assessment of CARP were focused on income and poverty and are limited to the comparative analysis across time or between the beneficiaries of the program vis-à-vis the non-beneficiaries. This paper introduced other economic variables like assets and expenditures as well as provided an extended the methodological approach to double difference models.

CARP Scope and Components

CARP covers alienable and disposable lands of the public domain devoted to or suitable for agriculture, lands of the public domain in excess to the specific limits, lands owned by the Government devoted to or suitable for agriculture; and private lands devoted to or suitable for agriculture regardless of the tenurial arrangements and agricultural crops raised or that can be raised. The operationalization of CARP's vision to promote an equitable society and a progressive countryside was done through three program components, namely: land tenure improvement, program beneficiaries' development, and delivery of agrarian justice.

Land tenure improvement (LTI) includes both land transfer and non-land transfer schemes. Under the land transfer category is land acquisition and distribution (LAD) which involves the major processes of land survey, identification of qualified Agrarian Reform Beneficiaries (ARBs), processing of claim folders for landowners' compensation, land valuation and compensation, registration of the awarded lands with the LRA, and issuance of certificates of land ownership award (CLOAs) to ARBs. The modalities under LAD are: 1) Operation Land Transfer (OLT); 2) compulsory acquisition (CA); 3) voluntary offer to sell (VOS) scheme; 4) voluntary land transfer scheme (VLT).

Lands classified under OLT are lands that were supposed to be covered under Presidential Decree (P.D.) 27, which covers tenanted rice and corn lands. Under CARP, landowners are provided incentives if they voluntarily offer their lands for coverage (R.A. 6657). Landowners are also allowed to directly transfer land covered under the Program to qualified beneficiaries as defined in the Law. Under the non-land transfer scheme are leasehold operation (LHO), stock distribution option (SDO), and production and profit sharing (PPS). Leasehold operation applies to lands that are within the retention limit of landowners or have not yet been acquired for distribution.

Program Beneficiaries Development (PBD) includes wide range of interventions. The goals are to provide farmers access to the necessary support services that would make their lands more productive and enhance their economic welfare. The Department of Agrarian Reform (DAR) provides general support services by carrying out the provision of the following services to farmer beneficiaries: 1) irrigation facilities; 2) infrastructure development and public works projects in agrarian reform areas and settlements; 3) credit support; 4) promote, develop and provide financial assistance to small and medium scale industries in agrarian areas; and 5) research, development and information dissemination.

Legal assistance and exercise of quasi-judicial function are the key components of the agrarian justice support to the ARBs. For legal assistance, the DAR represents the ARBs in any legal concern within the framework of CARP implementation. In the exercise of the quasi-judicial function, the DAR adjudicates and resolves cases concerning the implementation of CARP.

CARP Assessments

The scope of CARP was estimated at about 8 Million hectares (Garilao, 1997) covering both the areas to be covered by DENR. The Department of Agrarian Reform is responsible for land distribution of private and government-owned lands and settlement areas while the Department of Environment and Natural Resources (DENR) is involved in land distribution of public lands and stewardship contracts in forestry areas. As a lead implementing agency, DAR provides and coordinates the delivery of support services to farmer-beneficiaries and promotes the development of viable agrarian reform communities. Under DAR's coverage, the estimated scope was roughly 5.163 million hectares. As of 2010, DAR has distributed an estimated 4.166 million hectares to 2.4 million ARBs under the various modalities of tenurial improvements (Gordoncillo and Quicoy, 2011). Since the implementation of the program, the government has already spent about PhP145 billion

(Gordoncillo, 2009). It is in this context that an assessment of the economic impacts of the Program is in order.

Studies have already established that there have been significant impacts of CARP on the economic well-being of the farmer beneficiaries (Reyes, 2002; Lim, 2007; and Gordoncillo, 2003). However, the methodological approaches used so far in the determination of the effects of CARP had been limited to the comparison of the economic indicators in terms of the treatment effect or comparative analysis between two periods.

Data and Sources

The data used in the analysis for this paper is the panel data established for CARP in a series of surveys in 1990 (Cornista, 1990) and the two surveys in 2000, and 2006 (Gordoncillo, 2003 and 2009). In 1990, the then Institute of Agrarian Studies of the College of Economics and Management, UPLB, was commissioned by DAR to conduct a Benchmark Study for CARP. In said study, a total of 9,870 farmer respondents from 43 provinces across the country were surveyed for the baseline data. These provinces were identified to be the Strategic Operating Provinces because they constitute the considerable proportion of the total estimated scope for CARP. In 2000, DAR with the financial support from ADB and FAO, again commissioned the Institute of Agrarian Studies to do an impact assessment using the 1990 survey as the benchmark; hence, a resurvey was conducted and from the original 1990 respondents a total of 1,854 farmers were resurveyed consisting of 873 ARBs and 981 non-ARBs. In 2006, another round of survey was conducted covering those who were already covered in the 2000 survey. In the third round of survey, 1,623 respondents were surveyed, which was lesser than the number of respondents in the 2000 survey due to attrition problems. Of the total respondents in the 2006 survey, 771 are ARBs and the remaining 852 respondents were non-ARBs.

METHODOLOGY

Conceptually, most of the researches relating tenure and farmers' productivity and income drew theoretical foundations from the Marshallian inefficiency argument attributed to Alfred Marshall, who in the 19th century advocated that restructuring property rights through land reform could lead to increases in farmers income by eliminating the inefficiencies in tenancy relations (Gathak and Ingersent, 1984). These arguments have been widely accepted as shown in the logical framework of most rural development interventions supported by multi-lateral donor-agencies. Generally, the indicators include farm income as the main verifiable economic indicator.

Studies on the economic effects of rural development interventions like CARP were already done in the past (Reyes, 2002 and Gordoncillo, 2003). However, these previous attempts to measure the economic effects of CARP were limited to either before-after comparison or with-without comparative analysis. Consequently, some of the limitations in terms of the bias in the estimations were not eliminated. To estimate the economic effects of CARP, there is the need to know what would have been the effect without the Program.

Following the arguments outlined by Baker (2000) and if we let Pi as the intervention variable, where $P_i = 1$ if the respondent is a CARP beneficiary or an ARB and 0 otherwise or a Non-ARB, then the change in income (Y_i) between the baseline and the fallow-up surveys can be expressed as:

$$Y_{di} = Y_{fi} - Y_{bi} \left| P_i = 1 \right.$$

Where Y_{di} is the income difference, Y_{fi} is the income at the follow-up survey and Y_{bi} is the income level at the baseline survey given that $P_i = 1$ or that the respondent is an ARB. The average difference in income is simply the mean of all the difference for the non ARBs.

The expected value of Y*di* the can be written as

$$Y = E(Y_{fi} - Y_{bi}) \big| P_i = 1$$

This difference is what has been referred to as the treatment effect on the ARBs. However, the difference in the treatment effect to the ARBs is not exactly the same as the income effect of CARP. To estimate the true effect of the program there is the need to estimate the "counterfactual" expected value (Baker, 2000). If the income of an ARB increased in the follow-up survey compared to the baseline, it is possible that the income would have increased anyway even if the respondent had not been a beneficiary under CARP due to other unobserved effects.

In experimental studies, eliminating the bias would have been fairly straightforward. One only needs to randomly select the intervention and the control groups. Unfortunately, in rural development interventions like CARP, the beneficiaries are not selected in a random manner. Beneficiaries are chosen on the basis of a pre-determined set of criteria such as being a tenant or a landless farm worker. Being poor and landless prior to CARP could influence the ARBs capacity to enhance his level of income rendering bias in the estimates of income changes. Without correcting this bias, the true effect of CARP on income could not be efficiently estimated.

Since the data available covers the baseline survey in 1990 and the two subsequent surveys in 2000 and 2006 for both ARBs and Non-ARBs, the bias attributable to the unobservables can be eliminated by taking the difference of difference or the double difference. Conceptually, the estimation of the double difference can be examined in the matrix in Table 1.

Table 1. Matrix of the double difference in income across time and across groups

Survey	**Intervention**	**Control**	**Difference by Time**
Baseline	Y_{ib}	Y_{cb}	$Y_{ib} - Y_{cb}$
Endline	Y_{ie}	Y_{ce}	$Y_{ie} - Y_{ce}$
Difference by group	$Y_{ib} - Y_{ie}$	$Y_{cb} - Y_{ce}$	$(Y_{ie} - Y_{ce}) - (Y_{ib} - Y_{cb})$

Y_{ib} and Y_{cb} are the income levels at the baseline survey for the intervention group and the control group, respectively. Y_{ie} and Y_{ce} represent the income level at the endline survey for the intervention group and control group, respectively. The double difference is given by the expression: $(Y_{ie} - Y_{ce}) - (Y_{ib} - Y_{cb})$.

In its simplest form, the double difference is the impact of the program. Studies have used this simple difference to estimate the impact of rural development interventions (Ahmed, et al, 2009). However, this simple double difference analysis assumes that the impact of the intervention is the same for all the recipients. This assumption may not necessarily be valid in the case of the ARBs of CARP. Among farmers, the level of education differentiates farmers' productivity and therefore, differentiates their incomes. Hence, it is better to use the intervention and time variables as estimators of the outcome variable. Other control variables such as the level of education may have compounding effects to the outcome variable. In a regression model, control variables can be readily incorporated.

Using the level of income Y_i, then the double difference regression model can be expressed as:

$$Y_i = \alpha_0 + \alpha_1 P_i + \alpha_2 T_i + \alpha_3 P_i T_i + \varepsilon_i$$

Where

Y_i	-	the level of income
P_i	-	the program effect: Pi = 1 with intervention; 0 otherwise
T_i	-	is the time effect: Ti = 1 if endline; 0 otherwise
P_iT_i	-	is the interaction effect or the DD effect.

To verify if the parameters in the regression are the same as the double difference estimators in Table 1, one can take the expected value of the parameters:

$$E(Y_i | P_i = 0, T_i = 0) = \alpha 0$$

$$E(Y_i | P_i = 1, T_i = 0) = \alpha 0 + \alpha_1$$

$$E(Y_i | P_i = 0, T_i = 1) = \alpha 0 + \alpha_2$$

$$E(Y_i | P_i = 1, T_i = 1) = \alpha 0 + \alpha_1 + \alpha_2 + \alpha_3$$

Therefore, it can be verified that the first difference takes out the treatment effect α_1, and the double difference takes out the time effect α_2, leaving the double difference effect as α_3 or simply, the parameter estimate of the interaction variable P_iT_i.

Finally, to allow for some covariates or other intervening variables, the regression model can be expanded as

$$Y_i = \alpha_0 + \alpha_1 P_i + \alpha_2 T_i + \alpha_3 P_i T_i + \sum_1^n \beta_i X_i + \varepsilon_i$$

Where β_i are the parameters and X_i are the covariates.

RESULTS AND DISCUSSIONS

Nominal Income

Across the three survey periods, nominal income has consistently increased from about PhP33,000 in 1990 to PhP84,000 in 2000 and roughly PhP90,000 in 2006 (Table 2). Total income was derived as the sum of farm, off-farm and non-farm income. Notably, the income levels of ARBs are consistently shown to be higher than that of the Non-ARBs in all the survey periods. This pattern is also true for both farm and off-farm sources of income. However, for non-farm income, the trend has been in the opposite direction for the 2000 and 2006 surveys: the non-farm income levels were lower for ARBs compared to non-ARBs. It is also worth noting that while the respondents are generally farmers, income derived from non-farm sources were almost equal to incomes derived from farming. This composition of total family income will have critical implications on how poverty alleviation measures will have to be designed.

Table 2. Nominal income (PhP) of the respondents by period and by source.

Year	Type of Respondent	Farm Income	Off-Farm Income	Non-Farm Income	Total Income
1990	ARB	25,619	7,566	29,133	38,464
	Non-ARB	19,546	6,485	20,624	29,061
	Total	22,528	6,930	24,380	33,507
2000	ARB	69,721	6,964	49,613	95,985
	Non-ARB	47,121	6,344	51,002	73,681
	Total	58,918	6,618	50,370	84,194
2006	ARB	69,165	11,453	47,523	101,573
	Non-ARB	52,754	10,312	54,259	80,472
	Total	61,814	10,795	51,340	90,497
Total	ARB	52,870	8,279	43,612	77,877
	Non-ARB	36,933	7,383	43,641	60,355
	Total	45,186	7,765	43,628	68,643

Table 3. Respondents' income (PhP) in real terms (2000 prices) by period and by source.

Year	Type of Respondent	Farm Income	Off-Farm Income	Non-Farm Income	Total Income
1990	ARB	53,798	20,162	61,643	56,104
	Non-ARB	38,841	17,380	43,429	46,311
	Total	46,450	18,536	51,684	50,828
2000	ARB	69,721	6,964	49,613	95,985
	Non-ARB	47,121	6,344	51,002	73,681
	Total	58,918	6,618	50,370	84,194
2006	ARB	50,537	11,870	35,361	57,119
	Non-ARB	39,594	10,279	40,533	47,935
	Total	45,713	10,943	38,286	52,274
Total	ARB	57,917	16,307	51,007	61,062
	Non-ARB	42,798	14,489	47,069	50,475
	Total	50,799	15,266	48,838	55,413

Expenditures

The conventional approach to measure the economic effects of rural development interventions has been to use income as the main indicator. However, income as an economic indicator has been subjected to serious criticisms on two grounds. First is the difficulty in generating an accurate measurement of income. In most income surveys, the information is generally solicited through recall and there is the natural tendency not to divulge income information. The other problem is associated with the sensitivity of income to the price levels, particularly in rural households where a considerable proportion of income is derived from selling agricultural outputs to the market.

Hence, recent attempts to measure economic effects of rural development intervention have included expenditure patterns as alternative measure of economic well being. Parallel with the income pattern, the expenditure levels among ARBs is consistently higher compared to Non-ARBs for all the survey periods. This pattern applies to both the nominal expenditures and real expenditures.

Table 4. Family expenditures (PhP) in nominal and real terms (2000 prices) by type of respondents.

Year	Type of Respondent	Nominal Expenditures	Real Expenditures
1990	ARB	20,200	42,608
	Non-ARB	16,811	35,440
	Total	18,407	38,815
2000	ARB	56,404	56,404
	Non-ARB	51,220	51,220
	Total	53,661	53,661
2006	ARB	66,581	45,468
	Non-ARB	59,255	40,540
	Total	62,735	42,884
Total	ARB	46,965	48,316
	Non-ARB	41,657	42,594
	Total	44,163	45,299

Assets

While expenditure is a better alternative to income, it still has some serious limitations because expenditures do not account for household savings. Also, soliciting from the respondents the information on household's savings would be more problematic than asking for the level of income. Further, in a rural setting, a considerable proportion of household consumption is from subsistence production, which is not necessarily valued and is therefore not considered in the calculation of household expenditures. The measure that is argued to be reflective of the true long term economic position of the household is the estimated market value of assets.

Unfortunately, the 1990 data capture instrument did not include a module on assets. The module on estimated value of assets was only included in the 2000 and 2006 surveys. The advantage of asset value as an indicator of economic well being is that it can be accurately measured, and it is not sensitive to price fluctuations.

The average value of assets also reflects the same pattern as with income and expenditures (Table 5). ARBs consistently exhibited higher value of assets compared to Non-ARBs in both survey periods and in both farm and household assets. In terms of the total value of assets in 2000, ARBs have an estimated value of about PhP66, 379 compared to roughly PhP54, 085 for Non-ARBs. In 2006, the estimated value increased to PhP72, 350 and PhP64, 791 for ARB and Non-ARB, respectively.

For both survey periods, the value of farm assets is about a quarter to the value of household assets. In 2000, farm assets were estimated at PhP29, 691 while household assets were at PhP95, 547. The 2006 survey reflected similar proportion. The estimate for farm asses in 2000 was about PhP37, 307 and PhP131, 091, in 2006.

Table 5. Estimated value of assets (PhP) by period and by type of respondents.

Year	Type of Respondent	Total Farm Assets	Total Household Assets	Total Assets
2000	ARB	30,808	101,693	66,379
	Non-ARB	28,070	90,078	54,085
	Total	29,691	95,547	59,865
2006	ARB	38,947	139,562	72,350
	Non-ARB	34,924	123,426	64,791
	Total	37,307	131,091	68,213
Total	ARB	33,954	119,453	69,041
	Non-ARB	30,716	105,578	59,045
	Total	32,633	112,138	63,665

Double Difference Regression

The estimated double difference regression equation **is** of the form:

$$Y_i = \beta_0 + \beta_1 C_i + \beta_2 T_{1i} + \beta_3 T_{2i} + \beta_4 C_i T_{1i} + \beta_5 C_i T_{2i} + \beta_6 HHS + \beta_7 Age + \beta_8 LS$$

Where

Yi = the outcome measures

Ci = CARP (Program) dummy: Ci = 1 if ARB; 0 otherwise

T1 = Time Dummy: T1 = 1 if year is 2000; 0 otherwise
T2 = Time Dummy: T2 = 1 if year is 2006; 0 otherwise
HHS = Household size
Age = Age of respondent
LS = Average size of landholdings

Table 6 shows the parameter estimates of the double difference regression models for total income, farm income, expenditures and estimated value of assets with the following determinants; household size, age of respondents, size of landholding, the intervention variables and the time trend variables. The parameter estimates for household size were consistently significant for all the models except for the farm income model and are in conformity to a priori expectations in terms of the relationships. As the household size increases total family income and other economic outcome measures also increased, A larger household is expected to have more income contributors. Similarly, land size was expected to be directly associated with the level of farm production and therefore income. Parameter estimates for the age variable, which were expected to be directly associated with the economic outcome measures were only highly significant in the total income and asset models. The estimates were only slightly significant for the expenditures model (p-value = 0.1004) and insignificant in the farm income model. For the model where the dependent variable is total income, the treatment variable C and the time dummy for 2000 were significant, which means that the income of the ARBs is significantly higher than that of the Non-ARBs and the income levels of those surveyed in 2000 were significantly higher than those surveyed in 1990. However, the parameter estimates for the time dummy for 2006 and both the double difference for the 2000 and 2006 surveys were not significant.

Table 6. Parameter estimates of the various logistic regression models

Model	**Total Income**		**Farm Income**		**Expenditures**		**Total Assets**	
	β	**Sig.**	**β**	**Sig.**	**β**	**Sig.**	**β**	**Sig.**
Constant	21,150	0.0000	14,842	0.0048	5,479	0.0599	34,312	0.0000
C	7,313	0.0012	14,314	0.0000	4,323	0.0183	10,603	0.0000
T1	11,777	0.0000	13,007	0.0001	18,275	0.0000		
T2	3,340	0.1494	3,629	0.3216	9,847	0.0000	10,222	0.0001
CT1	2,701	0.3957	2,301	0.6148	(684)	0.7914		
CT2	(193)	0.9524	(5,899)	0.2202	(411)	0.8772	(4,490)	0.2362
HH Size	2,035	0.0000	395	0.3416	4,207	0.0000	807	0.0438
Age	188	0.0004	118	0.1376	70	0.1040	260	0.0009
Land Size	2,584	0.0000	6,717	0.0000	1,395	0.0000	1,200	0.0116

Similar pattern was exhibited for the model where the dependent variable is farm income. The CARP dummy and the time dummy for 2000 were significant. However, the 2006 time dummy was not significant and the double difference estimators for both 2000 ($C*T_1$) and 2006 ($C*T_2$) were not significant.

The model where the dependent variable was expenditures showed a slightly different pattern of parameter estimates. The program dummy and the 2000 time dummy variable were still significant. In addition, the 2006 time dummy variable was also significant. However, the double difference parameter estimates were still not significant.

The model where the dependent variable was the estimated value of assets only reflected estimates for the 2006 time dummy because the 1990 survey did not include a module on value of assets. In this alternative model, the program effect as reflected in the CARP dummy variable was significant and the time dummy variable differentiating the 2000 and the 2006 respondents was also significant, which implies that the value of assets among the 2006 respondents was higher than those surveyed in 2000. However, the interaction variable which measures the double difference effect between 2000 and 2006 was still not significant.

What has been consistently shown conforms to the findings in previous studies establishing that, in terms of income, the ARBs earned more than the Non-ARBs and that the income of the respondents surveyed in 2000 were higher than those who were surveyed in 1990. While there was no significant difference between those surveyed in 2000 and 2006 in the model where the dependent variable was total income or farm income, the parameter estimate for the time effect in 2006 was significant in the models where the dependent variables were either expenditures or value of assets. However, these significant estimates only showed the significant differences but these differences cannot be attributed to the program because the double difference parameter estimates were not significant.

CONCLUSIONS

The descriptive part of these analyses provided the indicative trend that in terms of all the economic outcome variables, the ARBs tend to have more compared to Non-ARBs and that the economic outcome measures were greater for those who were surveyed in 2000 and 2006 compared to those surveyed in 1990. This pattern was also validated in the inferential models. However, in terms of the double difference analyses, the model showed that the estimated parameters were not statistically significant.

The expected conclusion is to argue that CARP did not have any significant effect on the economic well being of the beneficiaries. However, these findings could be attributed to the inherent limitation of the panel data. To be able to have more robust counter factual analyses, there must be a representative treatment and control group. The panel data established by the Department of Agrarian reform has some serious limitations in so far as the treatment and the control groups are concerned. The 1990 baseline was conducted across 43 provinces nationwide. Because of logistical constraints, the 2000 survey was done by overlaying the 1990 respondents with the ARB master list of DAR and the treatment group were identified as those included in the 1990 survey who eventually became ARBs of CARP and the control group in the 2000 survey were selected only from the 1990 sample within the communities where the identified ARBs were located, What could have been done to have a better treatment and control group was to use the entire population of ARBs as the sampling frame for the surveys. The 1990 baseline survey was done too soon.

The analysis also provided alternative indictors of economic well being that program benefit monitoring should consider. While the paper provided some conceptual basis for the use of alternative economic outcome measures, the results is unable to provide conclusive statistical basis to prescribe the advantage of using said alternative economic outcome variables. Other indicators like assets may provide a more accurate and appropriate measures of economic well being because it reflects the true economic position of the households and is not sensitive to price changes. However,

more rigorous statistical works would be needed to verify the argument that these alternative economic measures are better in capturing the true economic position of the farmers.

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INDUCTION OF PUTATIVE RESISTANT LINES OF ABACA (*MUSA TEXTILIS* NEE) TO *BANANA BUNCHY TOP VIRUS* AND *BANANA BRACT MOSAIC VIRUS* THROUGH *IN VITRO* MUTAGENESIS

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ABSTRACT

Gamma rays using Cobalt 60 (^{60}Co) irradiation method was conducted to determine the sensitivity doses and response of *in vitro* propagated abaca to *Banana bunchy top* (BBT) and *Banana bract mosaic* (BBrM) diseases. Abaca cultivars (cvs) Tinawagan Pula (TP) and Tangongon (TG) were studied. Both cvs. had similar biological/physiological reactions to gamma rays resulting to high mortality and low shoot proliferation at higher dosage. The LD_{30} for shoot proliferation was established at 10 to 15 Gy. Cultivar response (shoot growth per sub-culture cycle) on post-irradiation showed that cv. TG had higher tolerance to gamma ray than cv. TP. A total of 3,210 and 3,765 irradiated abaca including the non-irradiated control were aphid- and mechanically-inoculated with *Banana bunchy top virus* (BBTV) and *Banana bract mosaic virus* (BBrMV), respectively. Three months after inoculation, the initial PCR-based diagnosis on putative resistant (PR) materials showed 43 TP (0.6%) and 9 TG (0.9%) selected abaca lines were consistently found negative to BBTV and 36 TP (1.6%) and 15 TG (0.9%) were initially uninfected with BBrMV. Although field trial of these lines and yield components are necessary for final selection, this study showed the bench mark and possibility of mutation breeding to produce virus resistant abaca. As gamma irradiation dose (LD_{30}) coupled with *in vitro* propagation was established in abaca, screening and generating PR lines against viruses infecting abaca can be easily achieved over the conventional breeding works.

Key words: Gamma irradiation, *Pentalonia nigronervosa*, mechanical inoculation, PCR

INTRODUCTION

Abaca (*Musa textilis* Nee) or also known as the 'Manila hemp' is indigenous to the Philippines and a source of premier traditional rope fiber of the world. It continues to boost the country as the top exporter of raw fiber with an estimated value of 6,933 tons, contributing 85% of the total world abaca fiber production (FAOSTAT, 2007 and PCARRD, 2008). Abaca fiber as the country's longstanding export commodity, also serves as basic material for clothing and footwear, pulp and paper industries (teabags, currency notes, filter paper, *etc.*) and even in non-traditional uses like the non-woven, disposable and fiber composites for the automotive industry. Likewise, the abaca industry supports the livelihood of around 140,000 abaca farmers and strippers, whereas the fiber craft industry provides livelihood to rural women and out-of-school youths.

Despite of being the prime export commodity, abaca experiences a decline in the production. Constraints that bring to the industry's declining productivity include poor technology adoption of farmers, low input production practices, lack of clean, high-yielding planting materials and the prevalence of diseases. Virus diseases are the ultimate biological threats to the industry due to difficulties on quick detection methods, elimination of infected plants under field condition, rapid spread of the disease/virus inocula and production of virus-free planting materials. Three known genera of viruses have been identified attacking abaca in the country. These include the *Banana bunchy top virus* (BBTV) of the genus *Babuvirus*, *Banana bract mosaic virus* (BBrMV) and *Abaca mosaic virus* (AMV) of the genus *Potyvirus*, and *Cucumber mosaic virus* (CMV) of the genus *Cucumovirus* (Bajet and Magnaye, 2002; Furuya *et al.,* 2006; Pietersen and Thomas, 2001; Pinili *et al.,* 2011;Sharman *et al.,* 2000a and 2000b).

Bunchy top disease of abaca in particular showing similar symptom as the banana bunchy top disease (BBTD) is prevalent and restricted to the Philippines. The disease is caused by BBTV and is transmitted persistently by banana aphid, *Pentalonia nigronervosa* Coq. Until now, BBTD and its causal virus are considered the most important biological constraints in abaca production contributing economic yield loss and had wiped out some abaca plantations in the country (Calinisan, 1939; Raymundo and Bajet, 2000). BBTV consists of at least 6 multi-component css DNA (DNA-R,-U3,-S,-M,-C and –N) of 1 kb in size and satellite DNAs (Burns *et al.,* 1995; Harding *et al.,* 1991 and 1993) sharing common genome organization; all have a conserved major region (CR-M) and stem-loop (CR-SL), a potential TATA box 3' virion sense and polyA signal (Burns *et al.*, 1995). However, according to researchers the virus causing bunchy top disease on abaca is closely related to BBTV which created confusion on the real identity of the virus. The major gene of BBTV DNA-R also contains small integral gene aside from the main open reading frame (ORF) which encodes the 'master' viral Rep. However the function of this small integral gene is still unknown as the gene product of DNA-U3 (Horser *et al.,* 2001;Wanitchakorn *et al.*, 2000). In the case of the newly described member of the genus *Babuvirus*, the *Abaca bunchy top virus* (ABTV) DNA-R only consist of single ORF which same encodes the 'master' Rep protein and lacks the integral ORF (Sharman *et al.,* 2008). This novel virus was found in selected abaca in the Philippines and banana from Sarawak, Malaysia sharing only 79-81% and 54-76% amino acid and nucleotide sequence identities, respectively to BBTV. In this paper, we refer the bunchy top-causing virus in abaca as BBTV since the virus shows high homology with those previously described BBTV infecting banana.

BBrMV on the other hand, has been reported first only in bananas in the Philippines (Bajet and Magnaye, 2002) on banana-growing areas with recorded 40% yield reduction (Magnaye and Espino, 1990). The virus has been classified as a distinct member of the family *Potyviridae* having flexuous rods measuring 725 nm with 38 kDa coat protein (Thomas *et al.*, 1997). However, recently BBrMV was isolated from abaca plants naturally infected in Albay, Philippines (Sharman *et al.,* 2000a) and other regions sometimes with mix infection by BBTV(Pinili *et al.,* unpublished data).

Yield reductions caused by these viruses are due to stunting, leaf malformation, and ultimately death of the infected plant. Thus, effective disease management options are still being explored and evaluated. Such options include optimization of diagnostic protocol for more reliable and effective, early detection of the virus that can be used in large number of samples, production of virus-free planting materials through *in vitro* propagation and mutation breeding.

Mutation breeding using mutagenic agents such as radiation and certain chemical are being used to generate and select desired mutant for disease resistance (Novak and Brunner, 1992). Induced mutation through gamma radiation for instance was successfully applied and found to confer some

diseases of banana and other crops (Damasco *et al.*, 2005 and 2006; Phadvibulya *et al.*, 2004; Reddy, 2000), tolerance to *Fusarium oxysporum* f. sp. *cubense* (Bhagwat and Duncan, 1998); Black Sigatoka caused by *Mycosphaerella fijiensis* (Reyes-Borja *et al.*, 2007) and even resistance to salinity (Miri, *et al.*, 2009). In the Philippines, mutation breeding in tissue-cultured banana has been evaluated (Damasco *et al.*, 2006). The use of induced mutation in banana has been conducted and found effective in selecting mutant lines resistant to BBTV. However, in the case of abaca, the screening for BBTV and BBrMV resistance is another task to be done. Thus, this study was undertaken to (i) initially determine the optimum lethal dose (LD_{30}) of abaca to gamma irradiation using Cobalt 60 (^{60}Co) for high shoot proliferation and plant vigor and (ii) screen the regenerated plants for resistance to BBTV and/or BBrMV using artificial aphid transmission and mechanical inoculation, respectively under greenhouse condition.

MATERIALS AND METHODS

Plant material and radiosensitivity test

Two abaca cultivars (cvs) namely; Tinawagan Pula (TP) and Tangongon (TG) were micropropagated using the standard *in vitro* culture protocol (Murashige and Skoog, 1962). Proliferating cultures or multiple shoots (clump of 2-3 shoots with all leaves cut almost at the base of the shoot explants to expose the growing point or meristem) of abaca cvs. were subjected to varying doses (0, 5, 10, 15, 20, 30, 40, 60, 80 and 100 Gy) of gamma irradiation from ^{60}Co source at the Philippine Nuclear Research Institute (PNRI). Irradiating multiple shoots would give high to moderate percentage of chimeras; hence we sub-cultured irradiated shoots every 4 weeks for 4-5 cycles (M_1V_4-M_1V_5) similar to banana. In radiosensitivity response and post-radiation recovery, 6 replications with 5 shoot tip clusters (2-3 shoots per cluster) per replication were used. The irradiated shoot cultures were assessed measuring the survival growth after 45 days. To determine the radiation effect on shoot proliferation, single shoots were separated and sub-cultured up to 3 cycles (M_1V_0-M_1V_3) (Novak and Brunner, 1992) into fresh medium, immediately after irradiation.

For gamma ray optimization (LD_{30}), tissue cultured abaca were scored at various traits including shoot survival (proportion of shoots resuming growth upon gamma irradiation, %) and growth response (number of shoots from 0 to100 Gy doses) 45 days after irradiation (M_1V_2). Based on the survival and shoot multiplication rate, the LD_{30} was estimated.

After determining the optimum dose (LD_{30} – 10 to15 Gy), several bulk irradiations were conducted using the optimum dose. Irradiated shoot-tip multiples were sub-cultured every 4 weeks for 4-5 cycles (M_1V_4 or M_1V_5) on the same proliferation medium. Upon adequate sub-culturing the individual shoots were separated and transferred for rooting. The rooted plantlets were maintained in coir dust: sand: soil medium at 0.5:1:1 ratio, covered with plastic cups to avoid drying under greenhouse condition for 1 month prior to virus inoculation.

Screening for putative resistant lines

Irradiated (M_1V_4-M_1V_5) and non-irradiated abaca plants were inoculated with BBTV from infected abaca using aphids. Aphids, *P. nigronervosa* were starved for 30 min and allowed to feed onto BBTV-infected cut leaf with 24 h acquisition feeding period (AFP). Ten (10) aphids (adults and nymphs) were then inoculated to a 1 month-old healthy abaca. For BBrMV, sap from infected bract of the male bud of inflorescence macerated with Phosphate Buffer Saline with Tween20 (PBS-T) was used as inoculum source. Mechanical inoculation was done with the aid of abrasive Celite or

carborundum. All plants were observed for symptom development for 3 months under greenhouse condition.

A total of 3,210 and 3,765 irradiated (M_1V_4-M_1V_5) abaca including the non-irradiated control were aphid- and mechanically-inoculated with BBTV and BBrMV, respectively. Uninoculated irradiated and non-irradiated abaca plants were also maintained as negative control plants.

Samples showing distinct BBT and BBrM symptoms were immediately removed, only those showing no symptoms were selected for virus detection. All plants that were found negative to these viruses were micropropagated again (M_1V_5) as described above for re-inoculation test in preparation for field evaluation. Regenerants and rooted plants were maintained under same greenhouse condition and then diagnosed again for the presence of viruses.

All abaca materials and aphids were obtained from the Crop Science Cluster- Institute of Plant Breeding, University of the Philippines Los Baños (CSC-IPB, UPLB). Inoculation and plant maintenance were conducted in the same institute prior to diagnoses. Selected samples were brought fresh and maintained on FTA card (Whatman, USA) based upon the manufacturer's instruction and kept at -30°C until processed. All samples were brought to the Laboratory of Tropical Plant Protection, Tokyo University of Agriculture, Japan through Import Permit (No. 21Y625 and 22Y927) from the Ministry of Agriculture, Forestry and Fisheries, Japan.

Enzyme-linked immunosorbent assay

Double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) was performed with monoclonal antibodies (Agdia, Elkhart, IN, USA) against BBTV and BBrMV following the manufacturer's protocol. Color developing time followed at 50 min. The A_{405nm} value of each well was measured using microplate reader (BIO-RAD Model 680, Dynatech VA, USA). Values of three times or higher than the negative control were regarded as positive (+).

BBTV nucleic acid extraction, primers and PCR conditions

Nucleic acid was extracted from 0.1g leaf tissue using PhytoPure DNA extraction kit (GE®Amersham Biosciences, Little Chalfant, UK). PCR reaction was carried out in 25 µl mix using primer pairs; D11 Forward (5'- GGAAGAAGCCTCTCATCTGCTTCAGACARC- 3') and D12 Reverse (5' – TTCCCAGGCGCACACCTTGAGAAACGAAAG – 3') by Karan *et al.* (1994). Takara Ex Taq (TAKARA, Kyoto, Japan) was used as the DNA polymerase and 0.2% skimmed milk was added to the PCR cocktail (De Boer *et al.*, 1995) to avoid possible latex interference during PCR detection. PCR conditions (94°C denaturation for 4 min; 29 cycles of 94°C for 1 min, annealing temperature of 61°C for 1 min and 72°C 2 min; and 72°C for 10 min extension) were used to amplify the complete BBTV-DNA-R. To further confirm whether the BT inoculum source was BBTV or ABTV, another primer pairs the 1108C3A (5'- GGATWACATATCATGTATAAAC – 3') and 1108C3B2 (5'- TTCTTGGGATACCTCGCCAT – 3') by Sharman *et al.* (2008) were used. This amplifies the DNA-S with no cross-reaction to BBTV. The thermal cycler conditions for ABTV primer were the same as BBTV except that the annealing temperature was reduced to 55°C. Reactions were carried out in DNA Thermal Cycler (Gene Amp PCR system 9600, Perkin Elmer, Norwalk, CT, USA).

BBrMV IC-RT-PCR

Immunocapture reverse transcriptase polymerase chain reaction (IC-RT-PCR) assay was carried out in abaca leaf samples following Dassanayake (2001) with modification to compare the

sensitivity of DAS-ELISA for BBrMV. Tubes were coated with anti-BBrMV capture antibody (Agdia, Elkhart, IN, USA) at 1:200 with coating buffer and incubated at room temperature for 3 h. Tubes were then washed with PBS-T three times at 3 min interval. Samples (0.1g) were homogenized in 0.5ml general extract buffer (pH 7.4) and centrifuge for 5 min at 14000 rpm. Fifty (50) µl of plant extract was added in pre-washed tubes and incubated overnight at 4°C. After incubation, tubes were washed again 3 times with PBS-T and air-dried at room temperature for 5 min, centrifuge at 3000 rpm for 3 min. One (1) µl of Oligo dT primer (0.5g/µl) (ReverTra Ace, Toyobo, Japan) and 23µl of RNAse free water were added. Tubes were heated at 80°C for 10 min chilled on ice for 5 min and spun down briefly. The following mixture was added: 5x 1st strand buffer - 8µl; 0.1M DTT - 4µl; reverse transcriptase (ReverTra Ace, Toyobo,, Japan) - 1µl; dNTPs (10mM) - 2µl and RNAse inhibitor - 1µl. Tubes were incubated at 42°C for 1 hr, 75°C for min and chilled on ice for 10 min For cDNA, 22µl of cocktail mix [10xPCR buffer-2.5µl; $MgCl_2$ (25mM) - 2µl; dNTPs (10mM) (INVITROGEN, USA)- 1µl; Primer mixed (Bract1 - 5'GACATCACCAAATTTGAATGGCACATGG 3' and Bract2 - 5'CCATTATCACTCGATCAATACCTCACAG 3' by Rodoni *et al.* (1997) - 2µl; Ex*Taq* (TAKARA, JAPAN) – 0.25µl and double distilled water (q.s) – 14.25 µl was added to 3µl first-strand DNA product. The following thermal cycles were followed; one cycle of 94°C for 1 min; 32 cycles of 94°C for 30 sec; 56°C for 1 min and 72°C for 1 min; one cycle of 72°C for 3 min and finally soaking at 4°C for 2 h prior to electrophoresis.

Analysis of PCR products

PCR products were assessed by electrophoresis using 1.5% agarose gel (Roche, Mannheim, Germany) in 1xTAE [40 mM Tris-acetate (pH 8.0) 1 mM EDTA]. After electrophoresis, the gel was stained with ethidium bromide (0.5µg/ml), visualized and analyzed under UV transilluminator (KODAK, Japan). The 100-bp DNA Ladder set (Promega, Madison, WI, USA) was included as size marker.

RESULTS

Optimization of gamma irradiation

Abaca cvs. TP and TG subjected to varying doses of gamma irradiation (^{60}Co) showed similar physiological (plant survival and growth) effects. Forty-five (45) days after irradiation, survival of explants ranged from 36 to 90% on 5 to 20 Gy doses in cv. TP while 52-92% in cv. TG and 88 to 100% in the non-irradiated control. The percent survival of irradiated shoots decreased with increasing dose of gamma irradiation, more than 50% mortality was rated on shoot subjected to 20 Gy and higher (Table 1). However, not all surviving explants produced multiple shoots, some developed buds or nubbins while others remained dormant. The occurrence of buds or nubbins and dormant explants increased with an increase in irradiation dose. Shoots subjected to 30 Gy or higher, though still surviving, did not show further growth even after the end of 45 days recovery period. Both TP and TG showed similar level of sensitivity to gamma rays although TG showed 52% survival at 20 Gy.

Shoot proliferation was likewise affected by the radiation dosage. Shoots irradiated at low dose of 5 to 10 Gy showed higher shoot multiplication while shoots irradiated at 20 to 40 Gy showed more than 70% reduction in proliferation. Except for 5 Gy and 10 Gy, irradiated shoots exhibited reduction in proliferation with each sub-culture cycle (Fig. 1). Highest shoot proliferation was noted in TP and TG at 5 Gy and 10 Gy, respectively on sub-culture cycle 3. Subsequently, TG tolerated and produced multiple shoots at 20 Gy on sub-culture cycle 3 and up to 100 Gy on the first sub-culture cycle. The number of shoots generated from TP on the other hand continuously declined from 10 to 100 Gy indicating low tolerance to higher gamma irradiation.

To establish the LD_{30} both the radiosensitivity and post radiation recovery of abaca shoot cultures were measured by survival and rate of shoot multiplication 45 days after irradiation (M_1V_2). For TP, cultures irradiated with low doses (5 to 10 Gy) showed the same rate of multiplication as the non-irradiated cultures (control), while cultures irradiated with higher doses showed more than 40% reduction in the multiplication rate. TG cultures irradiated with low doses of 5 to 15 Gy showed 34-45% reduction in the multiplication rate while cultures irradiated with higher doses 20 to 100 Gy showed more than 67% reduction in the shoot proliferation rate. Thus based on the percent survival and shoot multiplication rate the LD_{30} was estimated at around 10 to 15 Gy (Figure 2).

Table 1. Percent survival and growth of abaca shoot cultures subjected to gamma irradiation (0 to 100 Gy) measured 45 days after irradiation.

Radiation Dose (Gy)	Tinawagan Pula		Tangongon	
	Survival (%)[1]	Growth Response	Survival (%)[1]	Growth Response
0	88	New Growth	100	New Growth
5	90	New Growth	92	New Growth
10	79	New Growth	98	New Growth
15	30	New Growth	100	New Growth
20	36	New Growth	52	New Growth
30	23	No Growth	32	No Growth
40	60	No Growth	7	No Growth
60	46	No Growth	19	No Growth
80	13	No Growth	13	No Growth
100	13	No Growth	15	No Growth

[1]Percentage survival was obtained from the number of shoots resuming growth over 30 shoot tip clusters

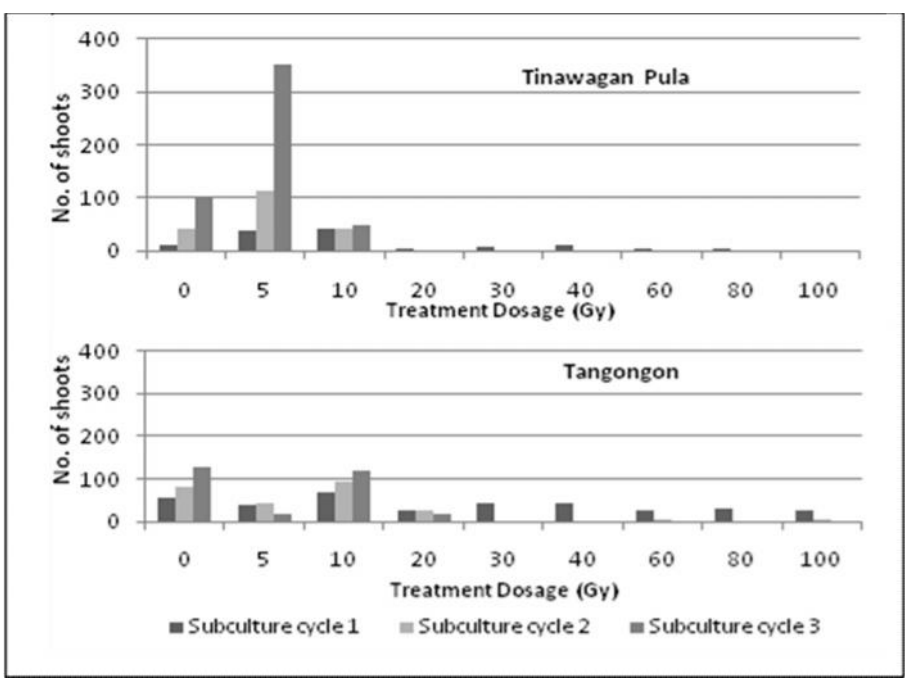

Fig. 1. Shoots proliferated at a given gamma irradiation dosage for every sub-culture cycle.

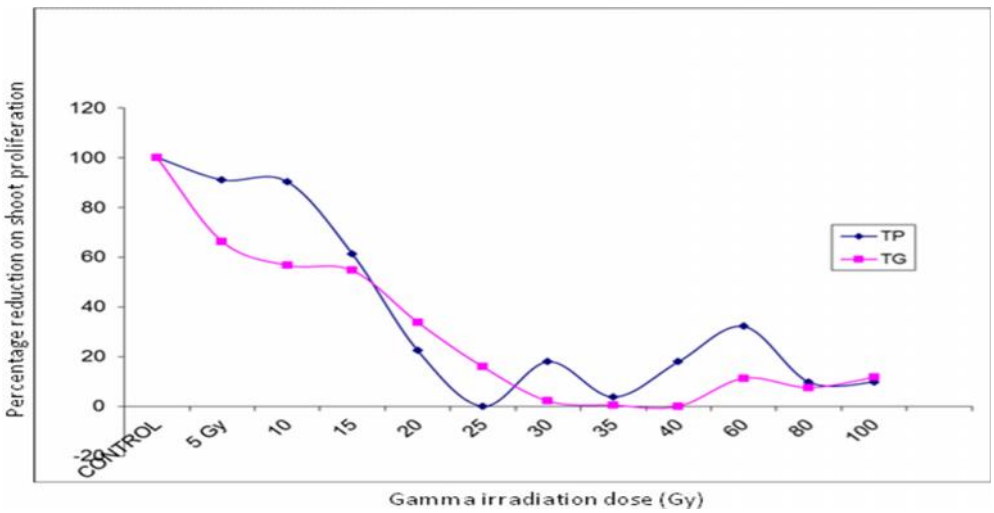

Fig. 2. Survival and rate of shoot multiplication of abaca cvs.Tinawagan Pula (TP) and Tangongon (TG) 45 days after irradiation (M_1V_2).

Screening for putative resistant lines

Three months after aphid transmission, inoculated plants (irradiated and non-irradiated) showing typical bunchy top and mosaic symptoms were considered susceptible and removed from the greenhouse and kept in an isolated place to avoid disease spread. BBTV- inoculated abaca (irradiated and non-irradiated) cv. TP (2,296 plants) and cv. TG (974 plants), showing vein-clearing to symptomless appearance were sampled and subjected to ELISA and PCR for symptom comparison and detection. From the initial inoculation test, 43 TP (0.6%) and 9 TG (0.9%) were found negative to this virus. BBTV was detected from the leaf extract of irradiated abaca cvs. TP and TG (5 Gy and 10 Gy) showing mild symptoms 3 months after aphid inoculation. An absorbance values A_{405nm} of 0.05 to 0.25 (data not shown) were observed from irradiated and non-irradiated plants showing bunchy top symptoms which were higher than the non-inoculated control. Consequently, those showing no pronounced symptoms were found negative to ELISA (data not shown). These BBTV-free abaca which are considered putative resistant (PR) lines were micropropagated again up to 5 cycles (M_1V_5) and re-inoculated with BBTV following the same standard inoculation procedures. Three months after re-inoculation with the same number of aphids, only 8 representative PR lines were consistently found negative to BBTV out of the total 11 lines tested (Fig. 3). As shown in the PCR assay, only 3 PR lines (TG1-1, TG1-17 and TP39) showed the expected band size of 1.1kb as amplified by BBTV DNA-R primers. PR line TP27 without symptom but severely colonized with aphids, *P. nigronervosa* was found negative to BBTV, in contrast to same PR line (TP27+) which shows vein-clearing symptom (Figure 4).

In BBrMV- inoculated plants (TP = 2,416 and TG= 1,349) only 51 plants (36 TP and 15 TG) were found negative from the first inoculation test. Majority of BBrMV-inoculated abaca were found positive to the virus regardless of symptom expression and irradiation doses. Three months after inoculation, the virus has been detected using both serological and IC-RT-PCR assays on irradiated TP and TG (data not shown). We also observed that late symptom development occurred in irradiated abaca. Due to this late symptom manifestation in BBrMV-inoculated plants, abaca lines

were maintained for several months (8-10 months) for observation and further virus detection. Due to bacterial contamination only 7 lines of TP were micropropagated and survived and still on-going.

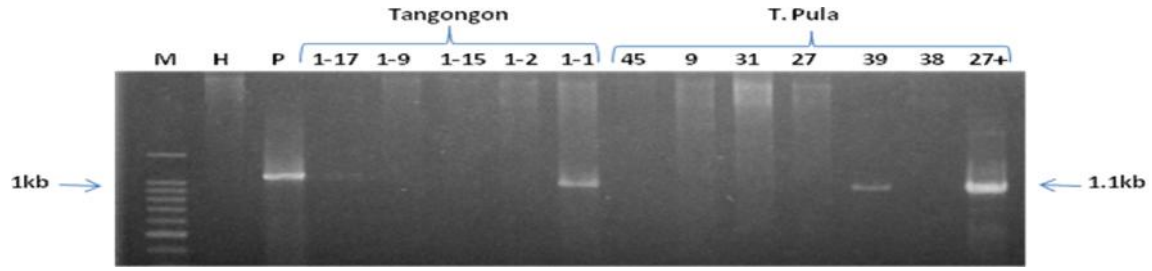

Fig. 3. PCR assay on *Banana bunchy top virus* (BBTV) – inoculated abaca PR lines with D11/D12 primer followed by electrophoresis analysis. The PCR band with approx. size of 1.1 kb DNA-R (arrowed) was amplified from PR lines 1-17, 1-1, 39 and 27+ (infected). No band was amplified from PR lines 1-9, 1-15, 1-2, 45, 9, 31, 27 and 38 as well as the healthy control (H). The 100-bp DNA ladder was included as marker.

Fig. 4. Putative resistant lines screened for BBTV 3 months after inoculation (left). No typical symptoms were observed even aphids severely colonized and multiplied in abaca lines under greenhouse condition (middle). Irradiated TP (PR27 -15Gy) showing vein-clearing symptom and found positive to BBTV by PCR 3 months after re- inoculation using aphids (right).

DISCUSSION

Developing *Mus*a varieties with improved morphological (bunch size, shape and plant height) and physiological (disease resistance or tolerance) characteristics have been achieved through time with the aid of breeding. Both conventional and induced mutation breeding contributed to desirable traits and able to generate promising lines with resistance to diseases in particular (Bhagwat and Duncа, 1998; Roux, 2004; Reyes-Borja *et al.,* 2007). In fact since 1928, varietal improvement in abaca in the Philippines was already developed through conventional breeding mainly for disease resistance screening (Lalusin, 2010). This was followed by series of varietal improvement programs from CSC-IPB,UPLB in the 1950's and identified Pacol (*M. balbisiana*) as a source of resistance to bunchy top disease. This was further hybridized with abaca. Moreover, as cited by Lalusin (2010), Diaz (1997) has generated F1 hybrids of Mininonga crossed with 6 varieties of abaca. Of the F1 hybrids, Malaniceron x Mininonga, Itolaus 39 x Mininonga and Layahon x Mininonga found resistant to bunchy top while Sogmad Pula x Mininonga has moderate resistance. In addition, genetic stocks Magsarapong, Tetraploid 1 and Itolaus 39 possessed moderate resistance to mosaic and resistance to

bunchy top virus under greenhouse and highly resistant under field evaluations. However, these genetic stocks have low fiber quality and recovery.

So far, the country already produced 71 abaca crosses through conventional breeding for varietal collection, classification, evaluation, establishment of disease observation nurseries, clonal selection and intra- and inter-specific hybridization purposes. Recently, breeders from the same research institution have evaluated BC2 (Pacol x abaca) hybrids and able to produced 6 promising clones having resistance to bunchy top virus and of good fiber quality. However, classical breeding takes several years to generate putative lines of desirable traits due to polyploidy and low reproductive fertility (Rowe and Richardson, 1975; Shepherd, 1999) and as for bunchy top resistance; there is always risks of resistance breakdown probably due to virus mutation and abundant insect-vector all year round. Thus, to fast track the evaluation time for disease resistance in particular, induced mutation whether in the form of chemical mutagents or irradiation coupled with *in vitro* micropropagation has been explored (Roux, 2004)

In this study we are able to determine and establish for the first time the radiosensitivity of abaca with LD_{30} of 10 to 15 Gy with significant shoot proliferation rate. This is in contrast with the LD_{50} established in banana cv. Lakatan which is 20-25 Gy (Damasco *et al.*, 2006) using the same induced mutation method. As we expected that abaca would have higher lethal dosage than banana since it consists of high fiber or lignin (18%). The plants regenerated and screened for resistance to BBT and BBrM under greenhouse conditions were of the M_1V_4-M_1V_5 generations with irradiation dosage of 5 to 20 Gy. However, only very low percentage of inoculated plants was consistently found negative to BBTV. According to Tilney-Bassett (1986), formation of chimeras with mutated and non-mutated sectors is usually the results from mutagenic irradiation. But, by repeated micropropagation, periclonal and/or homohistant structures can be obtained (Novak *et al.*, 1990).

Although in mutation breeding, it is generally accepted that the mutation frequency increases with an increase in dosage or dosage rate, but the capacity to regenerate decreases (Bhagwat and Duncan, 1998; Novak *et al.*, 1990). However, the low selection rate of mutant lines using gamma rays ^{60}Co in irradiated banana has been a usual scenario and could be the same with abaca. This may interfere in selecting putative resistant lines.

Screening of planting materials for banana bunchy top virus resistance has been thoroughly conducted on several banana cultivars (Anandhi *et al.*, 2007). Using gamma rays for induced mutation, improved morphological characteristics (bunch weight and fruit shape); increased tolerance to *F. oxysporum* and to toxin of *M. fijiensis* in different banana mutants have been achieved (Reyes-Borja *et al.*, 2007; Roux, 2004) and even salinity resistant banana (Miri *et al.*, 2009). However, in abaca this is the first attempt to use induced mutation in the form of gamma rays. Abaca which belongs to section Australimusa with basic chromosome number of 10 and T genome has not been explored yet for gamma irradiation. Thus, possible irradiation effects on chromosome number and DNA analyses are necessary. This may provide explanations for the low tolerance to gamma rays and resistance mechanism of irradiated abaca to BBTV.

Virus detection assays, whether serological, molecular or sero-molecular techniques (Dhanya *et al.*, 2007; Su *et al.*, 2003; Yasmin *et al.*, 2005; Bateson and Dale, 1995; Dassanayake, 2001; Sharman *et al.*, 2000a) provides early, quick and efficient means of disease screening. However, serological variant (ELISA test) with monoclonal antibodies (Mabs) is found convenient but the sensitivity in detecting the virus with very low concentration limits its reliability (Su *et al.*, 2003). Low virus titer in the control samples showing mild bunchy top symptoms may give false negative results using ELISA. Thus, a more sensitive assay based on PCR has been developed for BBTV

(Hafner *et al.,* 1997). The DNA-R of BBTV infected samples was successfully amplified showing the expected band size of 1.1kb. However the non-detection of BBTV in samples showing mild bunchy top may be just a product of micropropagation that makes confusion to the symptom recognition.

The use of aphids, *P.nigronervosa* at 10 individuals including nymphs and adults on the other hand efficiently transmits both viruses after 24h AFP. Symptoms were expressed at 90 days after inoculation under greenhouse condition. In the case of BBrMV in particular, the same vector can also effectively transmit the virus after 30 min starvation and 24h AFP, however due to high number of aphids needed throughout the screening trial, sap inoculation was another option. Distinct mosaic symptom was not expressed after 3 months from inoculation but the virus can be detected at this stage. This is in contrast to the findings of Muñes (1992), wherein low infection rate was observed on banana artificially inoculated with BBrMV through *P. nigronervosa* after 10 sec, 1 min and 24h AFP with 24h to 1 week inoculation feeding period. Likewise, through banana aphid inoculation, abaca did not show symptoms.

Putative abaca lines initially found resistant to BBTV will be further evaluated under field condition with high disease pressure. This is to determine the stability of resistance to the disease and yield component analysis such as fiber quality and yield. Further analyses including chromosomal and molecular markers must take into consideration and be studied to provide reasons for such resistance of mutant lines to BBTV. Continuous screening for BBrMV resistance is being done to come up with PR lines. Although the effect of BBrMV infection on yield components of abaca is not yet conducted, the widespread occurrence of the said virus is alarming and may replaced or act in combination with BBTV and other *Musa* viruses. This may pose as a plant quarantine risk on further disease dissemination to several geographic locations.

CONCLUSION

As gamma irradiation dose (LD_{30}) coupled with *in vitro* propagation was established (10 to 15 Gy) in this study, the search for resistance at least for BBTV and possibly with other viruses infecting abaca can be fast tracked over the classical breeding works. Putative resistant lines obtained here, therefore can be used for field evaluation for resistance durability and further yield component analysis. Though, possible breakdown of resistance may occur over time, these relevant findings serve as benchmark in producing resistant/tolerant lines against abaca viruses. Furthermore, even exploring the genes that may confer resistance (if any) as triggered by gamma irradiation would be possible.

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PROFIT EFFICIENCY IN RICE PRODUCTION IN BRUNEI DARUSSALAM: A STOCHASTIC FRONTIER APPROACH

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ABSTRACT

Self sufficiency in rice production has been the main issue in Brunei agriculture. However, rice yield per hectare is only about 1.7 ton per hectare, significantly low compared to other rice producing countries. The best option and the most effective way to improve rice productivity is through more efficient utilization of scarce resources. This paper attempts to study the production efficiency among rice farmers in Brunei using a stochastic profit frontier and inefficiency effects model, analysed from its three components - technical, allocative and scale efficiencies. Empirical result shows that mean profit efficiency score is 80.7 percent and 19.3 percent of profit is lost due to a combination of technical, allocative and scale inefficiencies with average profit-loss of B$987.50. Factors that are related to profit-loss and profit inefficiency are non-membership of cooperative, no irrigation, lack of training and low yield variety.

Keywords: profit inefficiency, profit-loss, Bruneian rice farmers

INTRODUCTION

Food self-sufficiency is an important issue because Brunei Darussalam (hereafter Brunei) imports large bulk of overall food requirement from foreign countries. Natural disasters and political uncertainties in the producing countries where Brunei imports its food might affect food supply to the nation. For this reason, the government perceives that reaching self-sufficiency in food production is crucial (DAA, 2008). Consequently, the government has aggressively carried out various programs and plans in order to increase rice production. Although rice is the main staple food or traditional diet for Bruneians, domestic or local rice production is still at an unsatisfactory level. About 97 percent of domestic rice consumption is imported with about 3 percent of self-sufficiency level (DAA, 2009a). This poor production output in Brunei rice sector could be associated with poor infrastructures, where farmers are still practicing traditional methods, low rice yield, with an average rice yield of about 1 metric ton per hectare. Steps have been taken by the Department of Agriculture and Agribusiness (DAA) to raise domestic rice production from the present meager 3 per cent self-sufficiency to a more acceptable figure (DAA, 2009b).

The DAA is targeting a 20 per cent, equivalent to 6,000 metric ton increase of local rice production by 2010, and a 60 per cent (equivalent to 18,000 metric ton) increase by 2015 in a bid to achieve self-sufficiency in rice production (DAA, 2008). Bruneian farmers not only need to be more efficient in their production activities, but should also be responsive to market indicators, so that scarce resources are utilized efficiently to increase productivity as well as profitability. This study

concerns primarily with investigating the profit efficiency among rice farmers in Brunei. The main implication is that if significant inefficiencies exist, identification and elimination of these inefficiencies will result in more profit. Therefore, the specific objectives of this study are to examine the profit efficiency level among rice farmers in Brunei, recognizing that prices, fixed factors, and soil fertility may vary among farms, and to identify farm - specific characteristics or variables that explain variation in inefficiencies of individual farmers. An understanding of production efficiency, market indicators and farm - specific characteristics could provide the policy makers with information to design programs that can contribute to measures needed to expand the food production potential for the nation. To our knowledge, there are currently no studies available that measured efficiency among rice farmers in Brunei. For this reason, this motivates us to make the first attempt to estimate the efficiencies that are lacking in the Brunei agricultural literature, particularly in rice production.

ANALYTICAL FRAMEWORK

Measuring efficiency using stochastic frontier profit function

Profit efficiency is defined as the capability of a farm to achieve the highest possible profit, given the prices and levels of fixed factors of that farm (Ali and Flinn, 1989). Profit inefficiency in this context is defined as the profit-loss from not operating on the profit frontier, recognizing farm-specific prices and resource base. Rahman (2003) elaborated that production inefficiency is usually analyzed by its three components – technical, allocative, and scale inefficiency. In an agricultural perspective, a profit-maximizing farm can be inefficient due to these three components (Khumbhakar, 1987).

The most popular approach to measure efficiency is the use of stochastic frontier production function (Rahman, 2003; Coelli *et al*, 2005). Yotopoulos *et al* in Ali and Flinn (1989) argued that a frontier production function approach may not be appropriate when estimating efficiency when in reality farmers face different prices and have different factor endowments. As a result, they have different best-practice production functions and, thus, different optimal operating points (Rahman, 2003). This led to the application of stochastic profit function models to estimate farm - specific efficiency directly and simultaneously (Kumbhakar, 1987, 2001; Kumbhakar *et al*., 1989; Kumbhakar *et al*., 1991; Rahman, 2003; Ali and Flinn, 1989). Therefore, in order to identify the factors affecting rice yield and assess the profit efficiency of rice farmers in Brunei, stochastic profit frontier function models is applied in this study as set forth in Battese and Coelli (1995). The stochastic profit function specified for farmer in a given season is defined as;

$$\pi_i = f(X_i, \quad P_i) + \varepsilon_i \qquad (1)$$

where π_i is normalized profit of the *i*th farmer defined as gross revenue less variable cost, divided by farm specific - output price; X_i is the vector of variable input prices faced by the *i*th farm divided by output price; P_i is the vector of fixed factor of the *i*th farm. The essential idea behind the stochastic frontier model is that ε_i is a "composed" error term (Aigner *et al*. 1977; Meeusen and Van de Broeck, 1977). This error term is defined as;

$$\varepsilon_i = v_i - u_i \qquad (2)$$

The two components v_i and u_i are assumed to be independent of each other. The v_i represent random error or variations in output that are assumed to be independent and identically distributed as $N(0, \sigma_v^2)$ due to factors outside the control of farmers as well as the effects of measurement errors in the output variable and stochastic noise.

The u_i is a non-negative random variable, associated with inefficiencies of production, which are assumed to be independently distributed such that u_i is obtained by truncation (at zero) of the half - normal distribution ($u \sim |N(0,\sigma_u^2)|$) with mean δz_i, and variance, σ^2 (Battese and Coelli, 1995; Coelli *et al*, 2002). Z_i is a vector of explanatory variables associated with technical inefficiency of production of farmers over time and δ is a vector of unknown parameters to be estimated. In other words, the term u_i measures the profit shortfall (π_i) from its maximum possible value (π_i^*) given by the stochastic frontier (Ali and Flinn, 1989). The inefficiency effect, u_i, in the stochastic profit frontier model could be specified as below;

$$u_i = \delta Z_i + W_i \qquad (3)$$

where the random variable W_i, is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-\delta Z_i$ i.e., $W_i \geq -\delta Z_i$. These assumptions are consistent with u_i being a non - negative truncation of the $N(\delta Z_{ij}, \sigma^2)$ distribution.

The method of maximum likelihood function is proposed for simultaneous estimation of the unknown parameters of the stochastic frontier and the model for the profit inefficiency effects. The function is expressed in terms of the variance parameters;

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \qquad (4)$$

And

$$\gamma = \sigma_u^2 / \sigma^2 \qquad (5)$$

So that $0 \leq \gamma \leq 1$. Therefore, the production/profit efficiency for the *i*-th farmer (PE_i) in the context of stochastic frontier profit function is defines as:

$$PE_i = \exp(-\hat{u}_i) = \exp\{-E(u_i/\varepsilon_i)\} \qquad (6)$$

Jondrow *et al.* (1982) have further shown the assumptions made on the statistical distributions of *v* and *u*, making it possible to calculate the conditional mean of u_i given ε_i as ;

$$E(u_i | \varepsilon_i) = \sigma^* [f^*((\varepsilon_i \lambda)/\sigma))/(1 - F^*(*)((\varepsilon_i \lambda)/(\sigma))] \qquad (7)$$

where F^* and f^* are the standard normal density and distribution functions respectively, evaluated at $\varepsilon_i\lambda/\sigma$, and $\sigma^2 = \sigma_v^2 + \sigma_u^2 / \sigma^2$.

The (profit) efficiency of a farmer has to be between 0 and 1 and is inversely related to the level of the efficiency effects. If $u_i = 1$, the farmer is profit - efficient but if $u>1$, the farmer is profit - inefficient and loses profit because of inefficiency, since the production will lie below the frontier (Idiong, 2007). A farmer's profit - efficient level is predicted using the FRONTIER 4.1 software (Coelli, 1996), which is based on its conditional expectation, given the model assumptions.

MATERIALS AND METHODS

Source of Data

The primary data for this study were collected in a field survey through direct interview with rice farmers in Brunei/Muara District and Temburong District in June 2010. Farmers in Brunei plant and harvest rice once a year. In Brunei/District, three groups of farmer associations, namely KOSEKA (Cooperatives), Kg Bebuloh (Village) and Mukim Pengkalan Batu (Village) were interviewed. On the other hand, farmers in Temburong were randomly selected because there were no

farmer's associations or cooperatives available. Farmers were selected by the stratified random sampling procedure. A total of 82 farmers were interviewed with 62 farmers were in Brunei/Muara district and 20 farmers were in Temburong.

The questionnaire in this study was structured to elicit responses from the selected farmers on their households farming activities. These include information on farm size, material inputs and cost, labor supply and wages, and so on, as well as quantities of rice output and prices. This is expected to increase the explanatory power of the analysis significantly. Socio-economic data of the farmers such as age, level of education, farming experience, were also collected.

Empirical Model

The general form of the translog profit frontier, dropping the *i*th subscript for the farm, is specified as;

$$\ln\pi^* = \alpha_0 + \sum_{j=1}^{4} \alpha_j \ln P_j^* + \frac{1}{2}\sum_{j=1}^{4}\sum_{k=1}^{4} \tau_{jk} \ln P_j^* \ln P_k^* + \sum_{j=1}^{4}\sum_{l=1}^{3} \emptyset_{jl} \ln P_j^* \ln Q_l + \sum_{l=1}^{3} \beta_l \ln Q_l + \frac{1}{2}\sum_{l=1}^{3}\sum_{t=1}^{3} \varphi_{lt}$$

where π^* is the restricted profit (total revenue less the total cost of variable inputs) normalized by price of output (P_y). P_j^* is the price of j^{th} input (P_j) normalized by output price (P_y); where P_F is the price of fertilizer; P_H is the price of herbicide, P_P is the price of pesticide and P_L is the labor`s wage rate per month; Q_l is the quantity of input used, where l is the fertilizer used n kg , herbicide and pesticide; v is the two - sided random error; u is the one sided half normal error as explained in equation (2); *ln* is the natural logarithm.

Equation (3) models the inefficiency effects as functions of several exogenous determinants which explain differences in rice production efficiency among farmers and are explained in Table 1. There are some points worth discussing from Table 1. First, Bruneian farmers in this study are considered small - scale farmers by looking at the average size of farm of 1.96 hectares, where the largest scaled farmer operates 5 hectares and the smallest 0.8 hectares. The average age of farmers is between 40 – 50 years, where most of them are retirees (Galawat and Yabe, 2012).

The average level of experience of farmers is less than 10 years, probably one of the least in Asia, where the average duration of growing modern rice varieties is more than 10 years (Rahman, 2003). This is because farmers in Brunei only start to be involved in rice farming after they retire from the public or private sector, and the number of Bruneians who starts rice farming only increased few years back when the government emphasized on increasing local rice production by providing incentives to encourage Bruneians to plant rice. Soil fertility in Brunei is not considered as one of the best for rice planting, where only 24 percent of the farmers perceived the soil of their land as fertile. Only 31 percent of the farmers interviewed are members of a cooperative. Most of them stated during the survey that, lack of water supply in the rice field is one of the major constraints to achieve good yield where only 35 percent of farmers has access to irrigation.

Table 2 presents the summary statistics for some of the important variables used in the stochastic profit frontier function. Rice yield in Brunei is at a very unsatisfactory level of 1.74 ton per hectare compared to other rice producing countries in Asian where according to Barker *et al*. (1985), the average yield per hectare is 3.6 ton. This supports the findings on why rice self - sufficiency in Brunei is only 3 percent by DAA, (2009a). The estimated rice yield per hectare in Brunei ranged from 0.5 ton per hectare to 3.75 ton per hectare. This indicates that farmers who achieved low rice output can maximise their productivity by improving their efficiency. The same method can be applied in profit variable. The mean profit per hectare for farmers in Brunei is about B$2000 where

the least profitable farmer earns about B$580 and the most profitable farmer earns about B$5000. This clearly indicates that least profitable farmers can achieve maximum profit by improving their efficiency. However, this study is only interested in profit efficiency analysis, therefore it would be interesting to examine the determinants of proft loss due to inefficiency in the next section.

Table 1. Summary statistics of the farm-specific variables of rice farmers in Brunei, 2010.

Variables		n	%
Farm size (hectare)	<2.5	60	73.17
	>2.5	22	26.83
Age (years)	31 – 40	4	4.87
	41 – 50	22	26.83
	>51	56	68.30
Gender	Male	55	67.03
	Female	27	32.97
Education of the farmer	No education	17	20.73
	Primary – high school	57	69.51
	University	8	9.76
Experience (years)	<10	45	54.88
	11 – 15	11	13.41
	>20	26	31.71
Cooperative	Member	26	31.71
	Non-member	56	68.30
Soil fertility index	Fertile	20	24.39
	Not fertile	62	75.61
Irrigation	With irrigation	29	35.36
	Without irrigation	53	64.64
Training	Had training	65	79.27
	No training	17	9.66
Extension contact	Had contact	73	89.02
	No contact	9	10.98
Rice variety used	High yield variety	58	70.73
	Conventional/local	24	29.77
Number of observations		82	

Table 2. Summary statistics of the explanatory variables used in the profit efficiency model

Variable	Unit	Mean	Std. Deviation	Min	Max
Explanatory Variables for the profit function model					
Yield	Tons ha^{-1}	1.74	0.75	0.54	3.75
Fertilizer	kg ha^{-1}	182.04	100.92	18.19	450.00
Herbicide	ml ha^{-1}	12.30	7.44	2.23	30.00
Pesticide	ml ha^{-1}	2.60	2.06	0	8.00
Labor	Man-labor ha^{-1}	1.68	1.59	0	5.00
Profit	B$ ha^{-1}	2164.93	2131.46	581.20	5132.81
Fertilizer Price	B$ kg^{-1}	36.73	45.84	14.87	319.76
Herbicide Price	B$ ml^{-1}	27.53	10.91	10.00	65.39

Pesticide Price	B$ ml^{-1}	57.15	85.22	0	404.90
Labor Wage	B$ man^{-1}	390.93	407.29	0	1500.60

Note; USD1=B$1.25 (approximately) as of March, 2012 currency exchange rate.

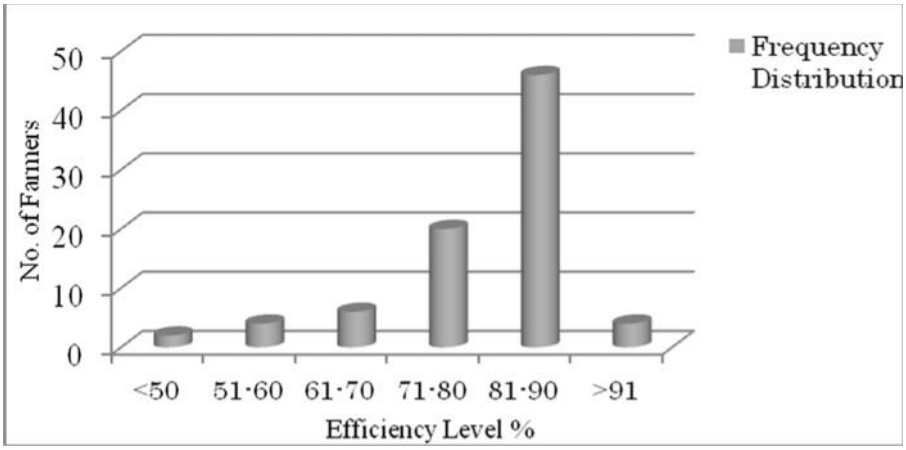
RESULTS AND DISCUSSION

The Maximum Likelihood Estimates (MLE) of parameters in the translog stochastic frontier profit function defined by equation (8) and the results of the profit frontier function are presented in Table 3.

Based on equation (4) we can derive key parameter of gamma (γ), defined by equation (5) which was associated with the variance in efficiency effects in the stochastic frontier. γ is the ratio of errors in equation (1) and is bounded between 0 and 1, where when γ = 0, inefficiency effects are absent, and when γ = 1, inefficiency effects are highly significant in the analysis (Battese and Coelli, 1995; Rahman, 2003). The estimated value of γ is 0.75 and strongly statistically significant at 1 percent level, indicating the fact that a high level of inefficiencies exists among rice farmers in Brunei. Therefore, profit can be optimized if the inefficiency effects among farmers are minimized.

Profit Efficiency and Profit-Loss among Rice Farmers in Brunei

Figure 1 shows the result of the frequency and percentage distribution of the profit efficiency of rice farmers in Brunei. The profit efficiency for each farmer in the study is estimated based on equation (6) and (7). This study reveals that the profit levels of rice farmers range from 45.2 percent to 99.2 percent, with a mean of profit efficiency score of 80.7 percent. This implies that, although farmers in Brunei are relatively profit - efficient, it is clear that there are opportunities that exist to increase the efficiency by an average of 20 percent through improving their technical, allocative and scale efficiencies. The 'best' practice farmer operated at 99 percent efficiency, while the 'least' practice farmers were found to operate at about 45 percent level. This shows that, there is room for improvement for low profit efficient farmers to achieve maximum efficiency like their most efficient counterparts if determinants of inefficiency are minimized. Also, from the result obtained, more than 46 percent of the farmers interviewed were more than 80 percent profit efficient.



Mean (%)	80.7
Minimum (%)	45.2

Maximum (%)	99.2

Fig. 1. Profit efficiency scores in percentage among rice farmers in Brunei, 2010.

Table 3. Maximum-likelihood estimates of profit frontier function among rice farmers in Brunei, 2010.

Variables	**Parameters**	**Coefficients**	**t-ratio**
Constant	α_0	-12.8432***	-3.09
$\ln P^*_F$	α_F	-3.2353***	-2.41
$\ln P^*_H$	α_H	-0.9784	-0.95
$\ln P^*_P$	α_P	-0.0961	-1.13
$\ln P^*_L$	α_L	0.2453***	-4.49
$^1/_2$ ($\ln P^*_F$ x $\ln P^*_F$)	τ_{FF}	0.3966	1.87
$^1/_2$ ($\ln P^*_H$ x $\ln P^*_H$)	τ_{HH}	0.1404**	1.98
$^1/_2$ ($\ln P^*_P$ x $\ln P^*_P$)	τ_{PP}	-1.5887**	-2.15
$^1/_2$ ($\ln P^*_L$ x $\ln P^*_L$)	τ_{LL}	0.0194	0.69
$\ln P^*_F$ x $\ln P^*_H$	τ_{FH}	1.2979	0.47
$\ln P^*_F$ x $\ln P^*_P$	τ_{FP}	-3.1984	-2.41
$\ln P^*_F$ x $\ln P^*_L$	τ_{FL}	0.0963	1.14
$\ln P^*_H$ x $\ln P^*_P$	τ_{HP}	2.0502	1.30
$\ln P^*_H$ x $\ln P^*_L$	τ_{HL}	0.0668	0.90
$\ln P^*_P$ x $\ln P^*_L$	τ_{PL}	-0.0978	-1.35
$\ln Q_F$	β_F	1.0882	0.67
$\ln Q_H$	β_H	-2.6850*	-1.65
$\ln Q_P$	β_P	-1.0917	1.37
$^1/_2$ ($\ln Q_F$ x $\ln Q_F$)	φ_{FF}	-0.5368	0.83
$^1/_2$ ($\ln Q_H$ x $\ln Q_H$)	φ_{HH}	-0.6568	-0.60
$^1/_2$ ($\ln Q_L$ x $\ln Q_L$)	φ_{LL}	-0.4841	-0.42
$\ln Q_F$ x $\ln Q_H$	φ_{FH}	0.3206	0.33
$\ln Q_F$ x $\ln Q_P$	φ_{FP}	-0.8032***	-2.63
$\ln Q_H$ x $\ln Q_P$	φ_{HP}	1.6353	1.45
$\ln P^*_F$ x $\ln Q_F$	$\emptyset_{FF}$	-1.8853	-1.43
$\ln P^*_F$ x $\ln Q_H$	$\emptyset_{FH}$	0.2077	0.25
$\ln P^*_F$ x $\ln Q_P$	$\emptyset_{FP}$	2.2983**	2.43
$\ln P^*_H$ x $\ln Q_F$	$\emptyset_{HF}$	-1.1746**	-2.07
$\ln P^*_H$ x $\ln Q_H$	$\emptyset_{HH}$	3.2055***	2.88
$\ln P^*_H$ x $\ln Q_P$	$\emptyset_{HP}$	-0.4116	-1.24
$\ln P^*_P$ x $\ln Q_F$	$\emptyset_{PF}$	3.9650	2.55
$\ln P^*_P$ x $\ln Q_H$	$\emptyset_{PH}$	-1.4591**	-1.54
$\ln P^*_P$ x $\ln Q_P$	$\emptyset_{PP}$	0.6557	1.21

$\ln P^*_L \times \ln Q_F$	$\emptyset_{LF}$	-0.0598	-0.71
$\ln P^*_L \times \ln Q_H$	$\emptyset_{LH}$	-0.0037	-0.06
$\ln P^*_L \times \ln Q_P$	$\emptyset_{LP}$	0.1015	1.16
Variance Parameters			
$\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.3434**	2.18
$\gamma = \sigma_u^2 / \sigma^2$		0.7582***	7.15
Log-likelihood		113.95	

Note; ***, ** and * are statistically significant at 1%, 5% and 10% respectively

In comparison with other findings in profit efficiency study, Rahman (2003) reported mean profit efficiency among Bangladeshi rice farmers to be 77 percent (range 6 – 83 percent) and 69 percent (range 13 – 95 percent) among Basmati rice producers in Pakistan Punjab (Ali and Flinn, 1989). Findings by Ali *et al.* (1994) in North-West Frontier Province of Pakistan showed that the profit efficiency level is 74 percent (range 6 – 92 percent). Wang *et al.* (1996) reported mean profit efficiency score of 62 percent (range 6 – 93percent) among Chinese farm household farms.

The frequency and percentage distribution of the loss in profit is shown in Table 4. Profit-loss[1] is defined as the amount that have been lost due to inefficiency in production given prices and fixed factor endowments (Rahman, 2003). The results show that the average of profit-loss among rice farmers in Brunei is B$987.50 per hectare which could be minimized by improving technical, allocative and scale efficiencies. Farmers in Brunei exhibited a wide range of profit loss, where the largest farm - specific profit loss was B$5858.74 and the least was B$14.07. This clearly suggest that clear opportunities exist to increase the profit levels of rice producers in Brunei, given their technology, prices, and levels of fixed factors.

Table 4 also shows that about 30 percent of farmers in the study incur profit-loss or more than B$1,000. This suggests that 70 percent of farmers incurred profit-loss of less than B$1,000, an indication that the farmers have tried to minimize their profit-loss.

Table 4. Frequency and percentage distribution of the profit-loss among rice farmers in Brunei. 2010.

Range of Profit –Loss		
B$ ha-^{1}	**No. of farmers**	**Percentage of Farmer Respondents**
Less than 500	32	39.05
501 – 1,000	25	30.48
1,001 – 1,500	7	8.53
1,501 – 2,000	5	6.09
2,001 – 2,500	5	6.09
Over than 2,501	8	9.76
Total	82	100
Mean (B$ ha^{-1})		987.50
Minimum (B$ ha^{-1})		14.07

[1] Profit-loss is calculated by multiplying profit maximum profit by (1-PE). Individual farmer's maximum profit per hectare =actual profit per hectare/ efficiency score.

Maximium (B$ ha^{-1})	5858.74

Note; USD1=B$1.25 (approximately) as of March, 2012 currency exchange rate.

Factors Explaining Inefficiency and Determinants of Profit-Loss

For policy purposes, it is very useful to identify the sources of these inefficiencies which can be done by investigating the relationship between farm/farmer characteristics and the computed profit inefficiency. The results of the inefficiency model defined by equations (3) and (9) are presented in Table 5. The variables of the inefficiency were expected to explain the determinants of profit efficiency in rice production among rice farmers. The sign of the variables in the inefficiency model is very important in explaining the observed level of profit efficiency of the farmers. A negative sign on the coefficient implies that the variable had an effect in reducing profit inefficiency, while a positive coefficient signifies the effect of increasing inefficiency (Shehu *et al,* 2007). Table 6 explains the profit-loss in key variables due to inefficiency from Table 5.

One of the variables most worth mentioning in relation to profit efficiency is *cooperative*. A negative relationship and statistically strong significant effect between inefficiencies and *cooperative* (Table 5) implies that farmers who joined a cooperatives association, or formed an organization incur less profit-loss and operate at significantly higher level of profit efficiency (Table 6). Membership in farmer`s organizations/cooperatives allow the farmers to have the opportunity of sharing information with other farmers especially on 'how to' knowledge and input prices on modern rice production practices by interacting with other farmers. Furthermore, farmers who joined or formed organization/cooperatives in Brunei are given priority to attend the 'Farmer's School Course' which was introduced and funded solely by the government through the Department of Agriculture. In this course, farmers were taught on rice field management, modern rice planting techniques, use of pesticide and other chemicals and so on. Beside the `Farmers School Course`, government also sent farmers to attend rice farming training abroad like in the Philippines, Malaysia and Indonesia.

Therefore, inefficiencies among farmers can be reduced if farmers join or form any organization or cooperative.

Table 5. ML estimates for determinant of profit and loss(in B$/ha) due to inefficiency among rice farmers in Brunei, 2010.

Variables	**Parameters**	**MLE**	
		Coefficients	**Std. Error**
Constant	δ_0	2.2028**	0.7865
Farm Size	δ_1	0.1015	0.1039
Age	δ_2	-0.0132	0.0611
Gender	δ_3	0.0105	0.0482
Education	δ_4	-0.0645	0.0790
Experience	δ_5	-0.1205	0.0972
Cooperative	δ_6	-0.0480***	0.0539
Soil	δ_7	0.1436	0.1330
Irrigation	δ_8	-1.1766**	0.6123

Training	δ_9	-0.0548**	0.6292
Extension	δ_{10}	-0.2213	0.1463
Variety	δ_{11}	-1.6019**	0.7014

Note; ***, ** and * are statistically significant at 1%, 5% and 10% respectively

It is evident in many researches that modern rice farming benefits significantly from better infrastructure (Rahman, 2003; Ali and Flinn, 1989; Hien, 2003). Table 5 reveals that infrastructure like irrigation has negative relationship on both technical, allocative and scale inefficiencies in rice farming as expected. Farmers who have access to irrigation perform significantly better in terms of earning actual profit per hectare, hence, incurring less profit-loss and operating at higher levels of efficiency as shown in Table 6.

In fact, most of the farmers interviewed, have limited or no availability of proper water supply because no irrigation system is available. They lamented on the unavailability of proper irrigation system as they believed it can help to improve rice yield and efficiency. Ali and Flinn (1989) reported that the main constraints of water supply in Basmati rice production in Gujranwala District, Pakistan were electric breakdown on water pumps, tubewell breakdowns and unscheduled closure of canals. On the contrary, the major issue of water supply in Brunei with regards to this study is due to the lack of proper irrigation available for rice farmers.

The *training* variable is found to have negative and statistically significant correlation with profit inefficiency (Table 5). This could explain by the fact that farmers who have attended training are profit efficient, while farmers who do not have training are inefficient, and thus subjected to low profit efficiency. Interestingly, this finding is uniform with result in Table 6 which shows that farmers who are member of an associations are more efficient and incur less profit-loss as these farmer' took part in the 'Farmer's School Course' and are given basic training on rice production. In addition, training are only given to farmers who joined a cooperation The dummy coefficient of *variety* variable showed negative correlation and is statistically significant, thus seemed to play a part to some extent in increasing efficiency (Table 5). Farmers who adopted high yield variety compared to conventional variety tend to have more profit efficiency and incur less profit-loss. In addition, farmers get high actual profit per hectare due to high output per hectare if they adopt the existing HYV seed as shown in Table 6. These results suggest that adopting modern variety in farming will improve profit efficiency.

Table 6. Key factors explaining profit inefficiency and estimated profit-loss per hectare among rice farmers in Brunei, 2010.

Farm Specific Characteristics	**N**	**Profit Efficiency**	**Actual Profit per ha**	**Estimated Profit-Loss per ha**
Profit Loss by Association Membership				
Cooperative	26	0.82	4745.59	803.12
No-membership	56	0.76	3501.05	1383.29
Profit-Loss by Water Supply				
Irrigation	29	0.81	5144.83	802.56
Rain-fed	53	0.79	3212.16	1325.69
Profit-Loss by Training				

Farmers have attended training	65	0.82	4172.39	950.17
Zero Training	17	0.77	2387.58	997.91
Profit-Loss by Rice Variety				
HYV	58	0.82	4326.99	954.31
Local Variety	24	0.78	2853.28	1001.24

Note; USD1=B$1.25 (approximately) as of March, 2012 currency exchange rate.

CONCLUSION AND RECOMMENDATIONS

One of the most interesting findings in this study is that profit level of rice farmers in Brunei range from 45.2 percent to 99.2 percent and the mean of profit efficiency is 80.7 percent. This implies that, although farmers in Brunei are relatively profit efficient, there are clear opportunities that exist for increasing their farming efficiencies by an average of 20 percent through their technical, allocative and scale efficiency.

It is also interesting to point out that the average of profit-loss among rice farmers in Brunei is B$987.50 per hectare which could be minimized by improving technical, allocative and scale efficiencies.

This study also shows that farmers who join associations or cooperatives are more efficient and may incur low-profit loss than farmers who do not. This finding is sufficient enough to encourage farmers to join or form an association as this may bring benefits to them such as improving their efficiency in rice production. Exchanging information among members on input markets and services enables farmers to adjust their resources relatively more effectively, such as timely availability of fertilizers, pesticides, and seeds at competitive prices, may positively influence their profitability, as proposed by Rahman (2003). The findings of the relationship between efficiency and training also send a strong indication that farmers who attended training not only improved their overall profit efficiencies but also increased their net income.

Improving infrastructure like irrigation may play a significant role in not only reducing inefficiency, but also minimizing profit-loss incurred by rice farmers in Brunei. Consequently, farmers can obtain high profit if access to proper irrigation is made available. Therefore, this finding is sufficient enough to make a strong case in favoring construction of proper irrigation systems to all rice farms in Brunei, and the Brunei government particularly DAA should consider improving infrastructure more seriously.

The contribution of adopting high yield rice variety in improving efficiency is also evident in this study. This justifies introducing high yield variety of rice seeds that not only reduce inefficiency but also increases profits among rice farmers in Brunei.

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LINKAGES IN PRODUCTION AND DISTRIBUTION OF EXPORTED VEGETABLES: PERSPECTIVES OF FARMERS AND FIRMS IN LUC NAM DISTRICT, BAC GIANG PROVINCE, VIETNAM

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ABSTRACT

The paper aims to show the positive effects that the current linkages models between vegetables producers and processed vegetable export companies in Luc Nam District, Bac Giang Province, Vietnam have brought to the participants, as well as discuss the obstacles and challenges that prevent the expansion and development of these linkage models in order to promote the linkages process in Bac Giang Province. A random survey was conducted on 50 households in the study area which specialize in cultivating the fruits and vegetables for the processed vegetable export companies. Up to 62% of the households do not participate in linkages, while the member households got higher and more stable incomes than non-member households, with a remarkable increase in profit of companies after joining the linkages. However, there are still some obstacles which prevent farmers to participate in the linkages. These include the small and scattered planted areas, the high requirements and initial investment, which makes some households maintain a risk-averse attitude, the informal information relating to lower collecting price, and the delay in payment of processed vegetable export companies in the previous unsuccessful linkages, which are still retained in farmers' minds. Based on the opinions of farmers about the benefits that linkages brought to them and challenges that they are facing in the current linkages, as well the companies'opinions about the state of current linkages models, some solutions in can be implemented to expand and strengthen the current linkage models in order to attract more farmers and companies to participate. These include (i) development of vegetable processing zones; (ii) participating in the Enterprise Association of Food Processing; (iii) coordination with input production suppliers; (iv) providing production techniques and vegetable markets information to producers; (v) sharing benefits with local authorities; (vi) sharing benefits and risks, rights and obligations should be mentioned clearly in contracts and (vii) support from the government.

Key words: Coordination, enterprises, models, producers, solutions

INTRODUCTION

The fruit and vegetable sector has become more and more important in contributing to the development of Vietnam agriculture. With high added value creation and generating employment, the fruit and vegetables sector has a significant contribution to the Vietnam rural development and therefore, this sector is one of the priority development sectors of the government. In Vietnam, in recent years, fruit and vegetable sector has made significant achievements. According to the Vietnam Fruit and Vegetable Association (VINAFRUIT), the export value of Vietnam's fruits and vegetables sector reached over 471 million USD in 2010, increased 33 million USD compared to 2009 (Tri, 2011). \And one of the explanations for this success is the awareness of processed vegetables export companies of the importance of building and developing the linkages with farmers and with other

companies involved in producing and consumption of vegetables. Linkages between stakeholders have existed in many sectors. Linkages models help the members to reduce the production cost, overcome the limitation of each member, create more added value and generate more employment, which contribute to the increase in product competitiveness, profit for companies, and improve livelihood for farmers in rural areas as well.

Bac Giang is a northern midland province which is composed of 10 districts and isabout 50 km from Hanoi to the north. Of its 382 thousand ha, 124 thousand ha are agricultural land. Bac Giang has a population of 1.5 million, of which 870 belong to the working age (Chien, 2003). The vegetable producing area in Bac Giang is 21,875 hectares, with a yield reaching 136.9 kg per ha at a production of 267,021 tons (Bac Giang Statistical Office, 2009). Bac Giang province is around 22,500 hectares of unused hilly land. This is also the potential for local vegetable production. And among the ten districts, Luc Nam district is the largest vegetable production area in Bac Giang province (approximately 2,000 hectares per year). It is one of the reasons for choosing this district for the survey.

In recent years, linkage models between seed suppliers, vegetable producers, agricultural co-operatives and processed vegetable export companies have been built in Bac Giang province, especially in Luc Nam district. The linkages are often operated in seeds supply, fresh vegetable production, processing and distribution. Among these, however, the linkage in the process of production are strongest and most popular in the province. Therefore, this paper focuses on the linkage models in the production process in the study area.

In general, the linkage models in Luc Nam district in fruit and vegetables sector are quite diverse, the existence of the vegetable producers' associations, agricultural cooperatives and the increase in the number of agribusiness companies, free traders and input materials suppliers contribute to the diversity of the linkage models. The linkages may be between farmers and farmers, or between farmers, cooperatives and agribusiness enterprises, or between seed suppliers, agribusiness enterprises, cooperatives and farmers. However, most of the linkages are conducted through verbal contracts, written contracts are also used but not popular. In general, the linkages often are small, simple, quite loose, unstable and scattered. Breaching of contracts is still quite popular in Luc Nam district, especially when the market experiences price fluctuation, or changes in input materials. This has resulted in serious losses for the vegetable producers when they could not sell their products, meanwhile processing companies did not have the quality raw materials input to supply for the signed contracts. Therefore, the strong and weak points of the current linkage models in study areas would be analysed. Then, the reasons for enhancing the development of linkages in vegetable sector would highlight the benefits that linkages brought to members. Finally, the solutions to enhance the development of linkages also are suggested, based on the current obstacles and challenges.

METHODOLOGY

Study area

Luc Nam is a mountain district of Bac Giang province that has 24 communes and a town with an area of 59,860 hectares. Luc Nam district is divided into 3 sub-regions, including mountainous, midland and delta regions. Farm land accounts for 35.5% and forestry land occupies 40% of the total area. The population of Luc Nam district is nearly 210,000 with eight ethic groups including King, Tay, Nung, Hoa, Dao, Cao Lan, San Diu and San Chi. Luc Nam district is known as the largest vegetable production location in Bac Giang province (2,000 hectares a year) (Bac Giang Statistic Office's Report, 2010). Dong Phu and Dong Hung are two mountain communes of Luc Nam district that were selected for this research. These two communes are located in the north of Bac Giang province with extensive cultivated areas, especially for fruits and vegetables.

Data collection

The annual report of food crops average yield, planted area and productivity of Bac Giang Statistics Office was collected, which includes the information of geographical and climate conditions, as well the socio-economic development condition of the study areas. In addition, the annual reports of the Government and Ministry of Agriculture and Rural Development (MARD also were used to generalize the situation of production and export the processed vegetables in the province in general and in these two surveyed communes in particular). Regarding the primary data, before interviewing each household, the focus group discussion (FGD) was conducted in these two communes of study area which aims to collect the information about the current situation of actions relating to the linkages between farmers (vegetable producers) and the vegetable exporting firms in the process of producing vegetables. The FGD that was conducted in two days (Table 1), supplied information about the farmers' opinion about the benefits obtained from the linkage models, as well the obstacles that prevented them from engaging the linkages. The solutions to strengthen the current linkage and to encourage the participation of more vegetable producers also were given by the members in the group discussion.

Table1. Respondent profile from Luc Nam District

Participants	Luc Nam District Communes	
	Dong Phu	***Dong Hung***
- Farmer	05	05
- Collector	01	01
- Chair of village	01	01
- Chair of commune	01	01
- Staff of the Department of Agriculture and Rural Development	01	01

Source: Survey, 2010

The household survey and exporting vegetable companies' survey were conducted after the FGD. On the one hand, to collect the characteristics information of the farms, the crops and the benefits that the farmers obtained from the linkages between them and the firms in production and distribution of exported vegetables, the questionnaires sheets were designed to interview 55 randomly chosen household heads (the vegetable producers) in Dong Phu and Dong Hung communes. On the other hand, to collect the information relating to the benefit that the vegetables exporting companies obtained and their linkage with the farmers, a semi-structured questionnaire was used to interview the companies that cooperated with the studied communes in producing, processing and distributing the export vegetables.

The primary data were managed by Microsoft Excel and then analyzed by SPSS 17.0. The characteristics and economic indicators of farms were analyzed and compared based on space (*two surveyed communes: Dong Phu and Dong Hung*) and the categories of "*farmers/agri-business in linkages*" and "*farmers/agri-business outside linkages*".

RESULTS AND DISCUSSION

The study area characteristics

Vegetable productivity in Luc Nam district is higher than those in other districts of Bac Giang province. Productivity of cucumber, cabbage and tomato reaches 3,279 tons, 2,271 tons and 3,865 tons, respectively. Higher productivity of vegetables requires the development of vertical linkages between farmers and firms in production and distribution of vegetables. With the large area for cultivating and a large number of labors in agricultural sector, the long-lasting experience in planting

fruits and vegetables, the farmers in the two study communes, Dong Phu and Dong Hung, have a lot of advantages in producing the exported fruit and vegetables. In facts, these two communes always were the leading areas in yielding high capacity and supplying the quality vegetables to the market in comparison with other communes in the district. As described in the Table 2, there are various types of fruits and vegetables planted in these areas.

In both sites, the vegetables types are planted for both local market and export. However, due to the high requirements of export vegetable production, as well the high initial investment for seeds and facilities, not all of the farmers can afford to invest in cultivating these vegetables, many of them simply plant the common vegetables for local market only. These also are the reasons why the linkages between farmers and agribusiness companies have shaped. However, with the quite strict and high requirements from these companies, many vegetable producers see these as the obstacles and are not ready to get involved in these linkages.

Currently, the planted area for exported vegetables in Dong Phu is about 71.2 hectares (accounting for 6.5% of total planted area). The export vegetables are planted in two crops, including summer and winter crops, in which the summer crop area is estimated at about 35.2 hectares and the winter one is about 36 hectares. In the summer, baby cucumber, Japanese cucumber and pumpkin are planted and their total areas is estimated about 35.2 hectares, in which the area for baby cucumber is the largest (accounting for 66%), followed by pumpkin (18%) and Japanese cucumber (Tru et al. 2010).

In Dong Hung, the export vegetable types planted are also quite diverse, to include baby cucumber, Japanese cucumber, baby maize and sweet maize. The planted area of export vegetables is about 186 hectares. Besides, there are many other popular fruits cultivated in this commune such as the Thieu lychee and longan. The planted area for Thieu lychee is about 300 hectares (accounting for about 30% of total planted area), followed by longan (5-7%).

In both areas, due to high area for agricultural cultivation and the high rate for labor working in agricultural sector, hence, the income from fruits and vegetables production is the main source which accounts for approximately 80% of communes' total income.

Table 2. Production of fruits and vegetables in Dong Phu and Dong Hung communes

Items	**Unit**	**Dong Phu**	**Dong Hung**
- Population	person	10,500	15,864
- Total of planted area	Hectares	1,523	3,759
- Planted area of fruits	Hectares	120	300
- Planted area of vegetables	Hectares	271.2	593.7
- Planted area of exported vegetables	Hectares	71.2	185.6
- Major types of fruit		Thieu Lychee, Persimmon	Thieu lychee, longan
- Major types of common vegetables		Kangkong, onion, garlic, cabbage, tomato, potato	Onion, garlic, cabbage, tomato, potato
- Major vegetable types for processing and export		Baby cucumber, Japanese cucumber, baby tomato	Baby cucumber, Japanese cucumber, baby maize, sweet maize
- Income from fruits and vegetables production	%	80	82

Source: Group discussion, 2010

Reasons that lead to the existence of linkages in study area:

The vegetable producers 'demand for quality input materials and technical supports

In Bac Giang province, most of vegetable producers often buy their inputs (seeds, fertilizers, pesticides, etc) from the local stores which is quite convenient and time saving but the quality is not guaranteed. Meanwhile, cooperating in the linkages with processed vegetable export companies, the farmers are provided the input materials in advance. The expenses of these input materials just are paid back after harvest. These materials are provided by the contracts between the vegetable processing companies and the input materials supplying companies, in order to ensure the quality of the vegetables, the price of which is often equal or lower than the market price. In addition, the farmers in study areas often produce fresh vegetables based on their traditional experience without applying the technical advances that affect quality and productivity. The linkages between farmers and vegetable processing companies help the farmers in learning the technical advances. Owing to that, the farmers understand the benefits of new seeds, with higher productivity, or application of new standardized cultivating, harvesting and storage processes. All these technical support are supplied for free by the vegetable processing companies. Therefore, if the linkage is effective, it will bring benefits to three parties: the vegetable processing companies, input supply enterprises and producers.

The limit of famer ability in finding markets for their vegetables

In the main harvest season of vegetables, the supply increases that forces the farmers to find the markets for their products. Meanwhile, most vegetables (cucumbers, tomatoes, etc) must be processed immediately after harvest. If no contract with the processing enterprises, producers will have to sell vegetables to the traders or to local markets which often do not bring the expected price and expected benefit for the farmers. Linkage in contract with vegetable processing enterprises is a solution to help the member farmers deal with the difficulty in finding markets and ensure an expected price as provisioned in contracts.

The lack of quality raw materials of processed vegetable export companies

There are six agricultural products processing enterprises in Bac Giang province with the design capacity of each company from 1000 to 3300 tons per year. However, the plants are not operated with all designed capacity because of the lack in raw material. For example, the processing machine system of BAVECO just operates with their 55% of the designed capacity. In recent years, the input raw materials for these companies are extended, however the quality is not good and the source is not stable. Meanwhile, the market demand for processed vegetables is more and more increasing. Therefore, the requirement of establishing raw materials supplying areas is the long term development of these companies. And building linkages with farmers is a way to help the company achieve their goal of having stable and quality supplying source through supplying the input materials and transferring the technical in advance to the farmers.

Characteristics of members in the linkages

Characteristics of farmers in and outside the linkages.

Through the survey in 50 households in Luc Nam district, the information of the current situation of linkages in study areas is described in the Table 3.

Among the surveyed households in two communes, there are more households outside linkages rather than those joining linkages. There were 38 farmers who had joined the linkage already (69%) and 17 farmers were free (31%). The producers are keeping the traditional habit which is producing in small scare, and mainly by their available sources, without considering the benefits that linkages. There are two main linkage methods; those are verbal contracts and written contracts. The verbal contracts often are used in linkages between farmers and farmers or farmers and free traders

who often supply seeds for them and collecting the vegetables on harvest seasons. This is a simple and quite loose linkage type. The written contracts are used in linkages among the vegetables producers, agricultural cooperatives and the input materials supplying companies; or among the vegetables producers and cooperatives and the vegetables processing companies.

Table 3: The state of linkages in Luc Nam District

Criteria	Lục Nam District	
	Dong Phu commune	**Dong Hung commune**
Total surveyed households (HH)	20	30
- Households in linkages	8	11
- Households outside linkages	12	19
Linkage methods	Verbal contracts and written contracts	Verbal contracts and written contracts
Products in linkages	Baby cucumbers, Japanese cucumbers, baby tomatoes, sweet maize, onions	Baby cucumbers, baby tomatoes, sweet maize, onions
Activities in linkages	Supplying seeds and other input materials, technical supports and consume products	Supplying seeds and other input materials, technical supports and consume products
No of signed contracts in 2010	11	8

Source: Survey, 2010

In Luc Nam province, the most popular vegetables in linkages are baby cucumbers, baby tomatoes, and sweet maize. In general, most of the vegetables in linkages often are export vegetables, which often are processed before being exported to foreign markets. The linkages often are built through the specific activities. In planting vegetables, linkages often are built in the links of supplying seeds and input materials, supplying technical support and marketing the produce.

In general, there are some differences between the farmers participating in linkages and the farmers do not cooperate with processed vegetable export companies. A majority of the household heads in both survey areas are male, among of them, the farmers who join the linkages (member farmers) often are younger than the farmers who did not participate in the linkages (non-member farmers). In addition, the number of laborers in member farmers' households is higher than those in non-member households for both sites. One quite striking point should be noted is that, the capital of member families is much higher than those of the non-member families, while the vegetable planted areas of member families are marginally higher than those of non-member families. However, the composition of income between member families and non-member families is different. In member families, the income from vegetable production account for 50-55% in Dong Phu, and 55-58% in Dong Hung, while this figure in non-member families of Dong Phu and Dong Hung are just from 35-40% and 30-35%, respectively (Table 4.)

Characteristics of processed vegetable export companies

These companies play the key role in the linkages. They often link with other input material supplying companies to supply seeds and input materials for farmers, then these companies also ensure about the output of products for farmers. Table 5 supplies general information about four big processed vegetable export companies in study Bac Giang province.

Table 4. Characteristics of member and non-member farmers in Dong Phu and Dong Hung communes

Characteristics	Unit	Dong Phu (n = 20)		Dong Hung (n = 30)	
		Member farms (n = 8)	Non-member farms (n =12)	Member farms (n = 11)	Non-member farms (n = 19)
- Age of household heads	years-old	41.3	45.7	38.2	44.6
- Gender of household heads					
+ Male	%	90.6	86.7	93.4	82.9
+ Female	%	9.4	13.3	6.6	17.1
- Number of family labors	person	2.4	2.2	2.5	2.1
- Business capital	million VND	52.1	30.5	58.5	34.6
- Total of planted area	m^2	3,015.6	2,978.7	5,911.7	5,722.8
- Planted area of vegetables	%	35.2	29.5	38.1	30.8
- Income from vegetable production/total income from agricultural production	%	50-55	35-40	55-58	30-35

Source: Surveyed data, 2010

There are two types of vegetable processing enterprises in Bac Giang province, one is a joint stock company (JSC) and one is limited liability companies (Ltd.). The JSCs often have more direct laborers than the Ltd companies. Business capital of JSCs is larger than the capital of the Ltd companies. The designed capacity of enterprises is ranging from 1000 to 3300 tones per year. However, the operating capacity often is much lower. Among the surveyed companies, Bac Giang Foodstuff Export Joint Stock Company (BAVECO) has the highest operating capacity but due to the high designed capacity; therefore the efficiency is not high in comparison with other companies.

Table 5. General characteristics of processed vegetable export companies in Bac Giang Province, 2010.

Enterprise	Business fields	Labor		Capital (mills VND)	Designed capacity (ton $year^{-1}$)	Operating capacity (ton $year^{-1}$)	Turnover (mills VND)
		Direct	Indirect				
1. BAVECO JSC	Process and export processed fruits and vegetables	155	35	50	3.300	1.834	35
2. Bac Giang Tobacco JSC	Produce and process foodstuffs	200	30	40	1.350	1.242	12
3. Phương Đông Ltd.	Export processed vegetables	130	55	20	2.500	1.526	20
4. Viet Nga Ltd.	Produce and process foodstuff	180	50	17	1.000	600	10

Source: Survey, 2010

The role of cooperatives and local governments

Cooperatives and local governments have important roles in promoting linkages between producers and enterprises. The legal status of the cooperative and the certification of local governments are important factors that bring the legal value for the contracts and manage the contract implementation of each partner in order to avoid breach of contracts in many cases.

The linkages models in producing and exporting the processed vegetables in study areas

1- Linkages in supplying the input materials for vegetable producers

Channel 1: Linkage between input materials suppliers - The processed vegetables export companies – Vegetable producers

In order to control the quality of vegetables, the processed vegetables export companies cooperate with input material suppliers to provide the necessary inputs such as seeds, fertilizers, pesticides through written contracts. The processed vegetables export companies are responsible for quality control of the inputs. By providing input materials, many vegetable processing companies build for their own the raw material producing areas, the farmers cultivating vegetables in these area would be given technical assistance in production, cultivation, harvest and storage of vegetables. Currently, Bac Giang Foodstuff Export Joint Stock Company (BAVECO) has been successful with this model. The contracts between these companies and farmers would be made through the chair of each village under the certification of the people committees of communes (Fig. 2).

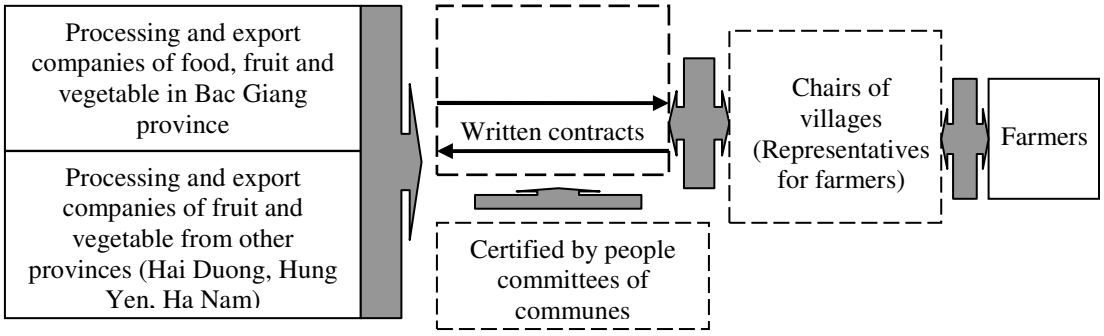

Fig. 2. Production linkages of export vegetables

Channel 2: Linkage between Input materials suppliers and Vegetable producers

Aside from channel 1, vegetable producers are also able to obtain input materials directly from supply companies. The volume and seed types are supplied to farmers subject to season and planted area and payment could be made after harvest (Fig. 3). Through this linkage, input suppliers .can introduce new seeds thereby expanding their market shares more quickly. The linkages are made through both written and verbal contracts. Besides the enterprises of Bac Giang province, the input supplying companies are also from the provinces such as Hai Duong, Hung Yen, Ha Nam.

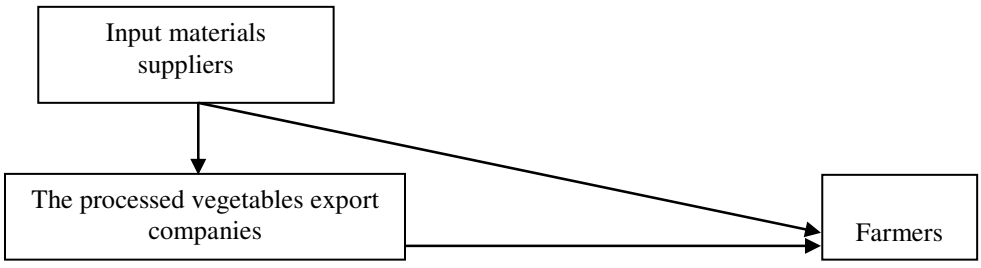

Fig. 3. Linkages in supplying the inputs for vegetable production

2- Linkages in producing and exporting the processed vegetables

Channel 1: Farmers --- Cooperatives --- processed vegetables exporters --- Export Markets

After being harvested, fresh vegetables are taken to the communes' cooperatives by the members. At this point, vegetables would be collected by the head of cooperatives then be transferred to the processed vegetable exporters' representatives. However, besides collecting vegetables from the members, in many cases the cooperatives also buy vegetables from the non-member farmers if the volume is not enough and the vegetables meet requirements. In this linkage model, the cooperative in each commune represents the famer members to sign the written contracts with processed vegetable export companies. In the contracts, the regulations of volume, quality, price and other specifications of vegetables would be provisioned. The head of cooperatives will sign the contracts after reaching the agreement with the member farmers. At this point, cooperatives have the responsibility of collecting the vegetables which follow the provisioned requirements and deliver to the collecting companies. The collecting companies often process and export the processed vegetables directly to the foreign markets or entrust them to the Vietnam National Vegetable, Fruit and Agricultural Products Corporation (Fig. 4).

Channel 2: Farmers --- Local Traders --- Processed vegetables exporters--- Export Markets

Vegetables going through this channel would be collected by the local traders directly in the field. Then, these traders sell the collected fresh vegetables to vegetable processing companies; these companies are the local companies or those from outside provinces. However, low volume of vegetables is purchased via this channel because the vegetable processing companies only buy the raw materials through this channel in case there is a serious shortage materials. Verbal contracts between local traders and companies are implemented in this case (Fig. 4).

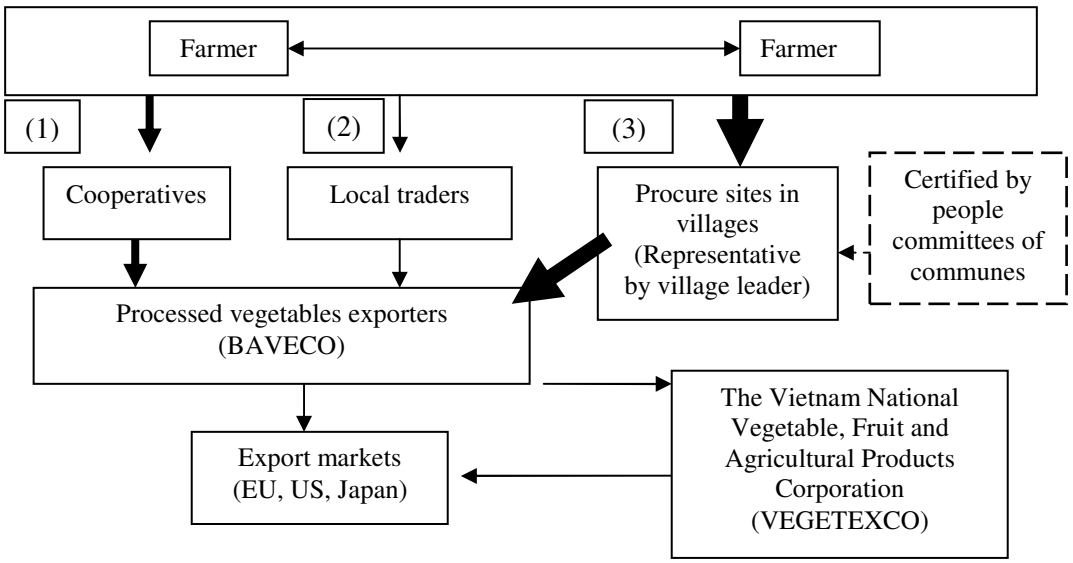

Fig. 4. Marketing channels of vegetables in Luc Nam district

3: Farmers --- Village leader --- Processed vegetables exporters --- Export Markets

This is the most popular channel in both study areas; majority of the vegetables were sold through this linkage model. After harvest, vegetables are transported by farmers to collection sites of

the villages. In this channel, the village leaders represents for the farmers to sign the contract with the processed vegetables exporters. The fresh collected vegetables are processed by processing companies and exported directly or via the VEGETEXCO to markets abroad. Even with written contracts, these simply provide the terms of volume, prices and collection time of vegetables. The other important clauses relating to sharing risks, the rights and obligations of the partners are not mentioned clearly in the contracts. Hence, conflicts between farmers and processing companies often occur during implementation. Especially in the peak period, when the market price is higher than the price provisioned in the formal contracts, the collecting companies do not want to increase the collecting price for the farmers. Meanwhile, free traders always have a higher price. Some farmers, therefore, break contracts and sell to free traders which affect the collected volume of companies. The reverse occurs when the market price is lower than the contract price, the processing companies want to reduce the farm gate price. Both farmers and processing companies also want to get more benefits for themselves. So, the reasonable benefit allocation which often is considered as the priority condition to ensure the success and stability of linkage has not been addressed yet. (Fig. 4).

In both sites, one of the quite famous companies which plays an important role in collecting fresh vegetables is the Bac Giang Foodstuff Export Joint Stock Company (BAVECO). This is a quite a proactive company, taking initiatives in creating the linkages with the communes, in supplying the production inputs, transferring the techniques for farmers and collecting the fresh vegetables after harvest. It can be said that BAVECO is the leader in building the linkages models, which shows a professional distribution channel of vegetables in the study sites.

In fact, BAVECO had written contracts with farmers in Luc Nam for various types of vegetables such as baby cucumber, Japanese cucumber, baby maize, sweet maize and baby tomato. The BAVECO signed contracts with the village's leaders, who are the representativea of the farmers in both sites. To legalize the contracts, people committees of communes would stamp on the contracts. The contract often contains the clauses of volume, categories, price of vegetables, planting and harvest procedures, etc. In order to avoid breach of contracts when there is a fluctuation in market price, the price clause in the contracts often are agreed that it would be adjusted 10% based on the market price. After signing contracts, village leaders would be responsible for managing the farmers in order to ensure the produced vegetables follow the provision requirements in the contracts. According to contracts, the BAVECO will provide the input materials such as seeds, fertilizer for the farmers, and the cost of these materials would be paid back just when the farmers sell vegetables. In addition, the BAVECO technical staff often collaborate with the Department of Agriculture and Rural Development and Agricultural Extension office in order to transit and assist farmers on the techniques in planting and harvesting the vegetables as a standard process (Fig. 5).

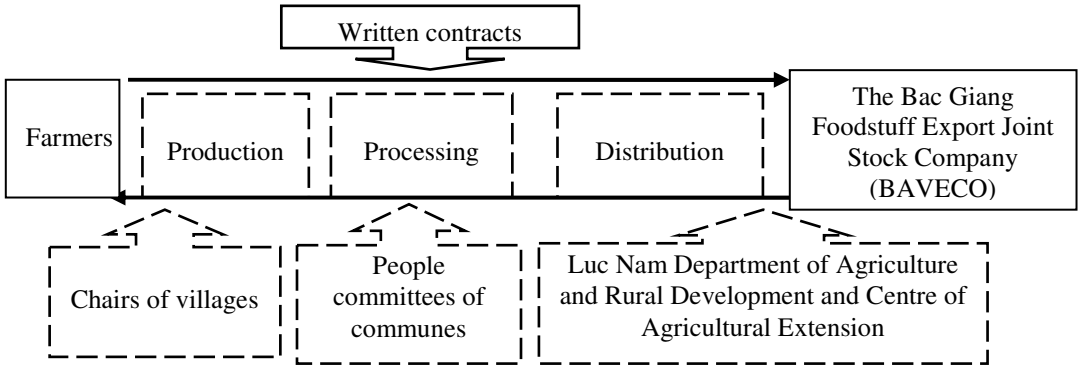

Fig. 5. Linkages in production, processing and distribution of export vegetables

Access the positive impacts of the current linkages to the members

1- Impacts to the member farmers

In order to address the impacts of linkage to the vegetable producers, 50 random households were investigated, among of them 19 households participated in the linkages (accounted for 38%), and 31 households were out site the linkages (accounted for 62%). The most popular vegetables which were chosen to compare were baby cucumber, sweet maize, and baby tomato. As shown in Table 6, the cost of labor and materials are the main components of the total cost, which account for 69% in households in linkages and 68% in households outside linkages. However, these costs of the households having linkages with agribusiness companies are higher than those outside the linkages. In average, the cost per *sao* of households outside the linkages is lower about 300 thousands VND than households in linkages. This is due to the fact that the households in linkages have to follow the a standard process from the step of choosing seeds, fertilizer and cultivating and harvesting processes which provisioned by the collecting companies, meanwhile the households outside linkages just plant baby cucumbers by their traditional experience.

The productivity of the fields supported by the linkages are higher by 50 kg per *sao* than those without linkages. In addition, the households in linkages that sign contract with the collecting companies can get a higher price than those outside the linkages. Therefore, the turnover of the farmers in linkages is quite higher than those outside the linkages. Hence, participating in the linkages, although it requires higher initial costs but in return the member farmers get higher productivity per *sao*, get a higher and more stable price which contributes to ensure a stable income for the farmers.

Table 6: The baby cucumber production results of Luc Nam district in 2010

(Unit: 1 Sao = 360 m2)

	Household in linkages (n = 19)	**Household outside linkages (n = 31)**
1. Cost (1.000 VND)		
- Seed	140.6	120.5
- Fertilizers		
Nitrogenous	120.5	115.6
Phosphate	76.2	74.3
Potassium	150.8	144.9
Manure	240.3	228.7
- Frames	960.6	900.8
- Pesticides	140.2	130.9
- Labor	1000.4	823.5
Total cost	2829.6	2528.2
2. Average productivity (kg per sao)	700	650
3. Average Price (VND per kg)	6 500	5 900
4. Turnover (thousand VND)	4 550	3 835
5. Income (thousand VND)	1 720.4	1 306.8

Source: Survey, 2010

For baby tomato production, the cost of pesticides, materials and manure also are the main parts of the total cost. As in the producing of baby cucumbers, the total cost of producing the baby

tomato of the households in the linkages also is higher than those of households outside the linkages. However, with higher productivity and higher price, the member family harvesting baby tomato has higher income of 1000 thousand VND per *sao* than those outside the linkages (this is a not small amount of money with the Vietnamese farmers) (Table 7) (Tru et al. 2010).

Table 7: Baby tomato production result of Luc Nam district in 2010

(Unit: 1 Sao = 360 m2)

	Household in linkages (n = 19)	**Household outside linkages (n = 31)**
1. Cost (thousand VND)		
- Seed	104,4	100,2
- Fertilizer		
Nitrogenous	48,2	43,6
Phosphate	57,5	50,3
Potassium	90,6	84,9
Manure	400,9	383,2
- Frames	405,4	400,2
- Pesticides	500,7	508,6
- Labor	108,4	91,3
Total cost	1716,1	1662,3
2. Average productivity (kg sao^{-1})	1400	1200
3. Average price (VND kg^{-1})	3500	3300
4. Turnover (thousand VND)	4900	3960
5. Income (thousand VND)	3183,9	2297,7

Source: Survey, 2010

And the situation is the same with the households producing sweet maize as illustrated in Table 8.

Table 8: Sweet maize production result of Luc Nam district in 2010

(Unit: 1 Sao = 360 m2)

	Household in linkages (n = 19)	**Household outside linkages (n = 31)**
1. Cost (thousand VND)		
- Seed	50,6	48,2
- Fertilizers		
Nitrogenous	96,2	90,1
Phosphate	57,1	55,6
Potassium	61,8	57,9
Manure	242,5	239,1
- Frames	480,2	486,9
- Pesticides	500,9	490,2
Total cost	1.489,3	1.468,0
2. Average productivity (kg sao^{-1})	200	190
3. Average price (VND kg^{-1})	13.000	11.500
4. Turnover (thousand VND)	2.600	2.185
5. Income (thousand VND)	1.110,7	717,0

Source: Survey, 2010

In order to investigate the famer opinions about the benefit of joining the linkages, 19 households in linkages were interviewed. The survey collected the assess opinion of farmers about which benefits of the linkages that were important to them. Among the benefits that the linkages bringing to the member farmers, the vegetable processing companies helps farmers sell the output was assessed the most important benefit, following is the benefit of supplying vegetable seeds and input materials, and next is the stable price that the vegetable processing companies ensure for the farmers. (Table 9) (Tru et al. 2010).

Table 9: Farmers' opinions about the benefit of joining the linkages.

Unit: %

Criteria	Luc Nam (n = 19)		
	(1)	(2)	(3)
- Supplying vegetable seeds and input materials	83,7	16,3	0,0
- Technical support	32,5	46,4	21,1
- Output for vegetables	91,8	8,2	0,0
- Stable price	81,6	12,7	5,7
- Creating jobs and increase income	62,3	26,9	10,8
- Improve the product quality	64,9	29,5	5,6

Source: Survey, 2010
Note: (1): very important; (2): important; (3): not important

2- Impact to the vegetable processing companies

It can be said from the above opinions of farmers about their assessment with the benefit that linkages brings to them, the vegetable processing companies play an important role in the linkages that help farmers ensure sale of produce, supply the qualified input materials for them, help farmers have stable incomes. As mentioned above, one of the big export processed vegetables and having most influenced the linkages with farmers in the study areas is Bac Giang Foodstuff Export Joint Stock Company (BAVECO). It can be said that BAVECO is one of the leading companies in taking initiative to build linkages with farmers.

Therefore, the research group chose BAVECO to compare the business results of BAVECO before and after building the linkages of farmers with agricultural inputs companies in order to know the benefit that linkages bring to the vegetable processing companies, such as BAVECO (Table 10).

Table 10: Processed vegetables business results of BAVECO

Criteria	Unit	2007	2008	2009
1. Raw Material Area	ha	-	-	589
2. Collection Quantity	ton			
- Baby cucumbers		2.000	1.500	1.500
- Baby tomatoes		400	250	300
- Baby maize		450	450	500
- Sweet maize		600	750	750
- France onions		100	100	300
3. Collection Price	millionsVND ton^{-1}			
- Baby cucumbers		5	5	3,8
- Baby tomatoes		4,5	4,5	3,2
- Baby maize		8,5	9,0	9,0
- Sweet maize		3,0	2,5	2,5
- France onions		5,0	5,0	5,0

Criteria	Unit	2007	2008	2009
4. Processing time				
- Baby cucumbers	No Data year^{-1}	120	120	120
- Baby tomatoes		120	120	120
- Baby maize		150	150	150
- Sweet maize		120	120	120
- France onions		40	40	40
5. Total revenue	Billion VND	28	30	35
- Revenue from processing vegetables		16	20	25
6. Profit from processing vegetables	Billion VND	0,8	1,0	1,2

Source: Survey, 2010

BAVECO built the linkages since 2009 and this helps BAVECO have a stable supply of its raw materials from a total area of 589 hectares. In fact, the quantity of raw materials increased for the period of three years, but the collection prices of some raw materials such as baby cucumber and baby tomatos decreased. This is due to the increase in supply sources and the world economic crisis which affected the business. However, over a period of three years, the total revenue from processing vegetable of BAVECO increased by 9 billion VND (56.25%), the profit also increased by 50%, from 0.8 billion VND in 2007 to 1.2 billion VND in 2009. Hence, it can be said that linkages contribute to expand the business of BAVECO, ensure a stable supply of raw materials and increase the profit for the company.

Challenges to members in the linkages

1- To vegetable producers In both surveyed communes, the increasing in the input materials prices is the biggest concern of farmers. One of the other concerns of the member farmers is the state of price squeeze of the collectors including the vegetable processing companies and the delay in payment from these companies. The collecting companies explained this matter by arguing that they have to face with the increase in the production cost, especially when the domestic economy was affected by the world economic crisis. However, the farmers also understand the difficulty of processing companies and often accept the delay in payment. (Table 11) (Tru et al. 2010). The lack of market information is also one of the difficult problems with farmers when they participate in the linkages, because most farmers just know to supply the vegetables to processing companies without knowing the price of vegetable after being processed or where it is delivered , etc. This, sometimes, affects the trust of member farmers to the processing companies.

Table 11: Obstacles affecting the linkages

Unit: %

	Luc Nam (n = 20)		
Obstacles	**(1)**	**(2)**	**(3)**
Climate change	38,6	52,4	8,9
Small and insufficient planted area	29,8	57,8	12,4
Price increase of inputs	76,2	18,5	5,3
Old harvest and storage equipment	31,1	48,1	20,8
Price squeeze of collectors	16,2	70,4	13,4
Delay in payment	27,8	64,3	7,9
Lack of market information	17,9	71,5	10,6

Source: Survey, 2010

Note: (1): very difficult; (2): difficult; (3): not difficult

2- To Vegetable processing companies Through the interview with the vegetable processing companies, some of the difficulties that these companies faced in making linkages were brought forth. The processing companies have not built up large raw material areas and concentrated in the province; small and scattered raw material areas lead to the lack in initiative in production and dependence on the local suppliers. In addition, the non-uniformity in quality and size of products are obstacles for processing companies which leads to the high removal rate of fruits and vegetables that contribute to the impossibility of operating with its designed capacity.
(Table 12) (Cuong et al. 2011).

Table 12: Difficulties in collecting, processing and distributing the processed vegetables by processing companies

	Companies' difficulties
1. Collecting	- Scatted and small raw material areas - Non-uniformity in product size and quality - Competion with others enterprises - Contracts broken of memeber farmers
2. Processing	- Lack of raw materials - High removal rate of vegetables - Increasing input costs (*e.g.*electricity, water)
3. Distributing	- Higher and higher quality and food safety requirements - World and domestic economic crisis - Limit in state policy of supporting and enhancing exporting agri-products

Source: Survey, 2010

Solutions to improve and develop the linkages models

1- Solutions for vegetable processing enterprises

Development of vegetable production zones- In order to maintain production and processing operations in the long-term, it is necessary for the vegetable processing companies to establish the material zones. To do that, the company should collaborate with the local authorities and farmers, offer more benefit for the vegetable producers.

Participating in the Enterprise Association of Food Processing- The Bac Giang Enterprise Association of Food Processing was founded in 2008 in Bac Giang city, Bac Giang province. At present, there are 8 enterprises which operate as members of this association. According to the members, the companies would obtain many benefits when they join the association. Being an association member, the enterprises would avoid the competition for materials among the processing companies; obtain the market information of vegetables provided by the association; and improve the market access capacity to domestic and foreign markets. The agreement between members would help to stabilize vegetable prices and avoid breach of contract by farmers.

Coordination with input production suppliers- In the study areas, there are just few companies aware of the benefit when they link with input material suppliers. If the cooperation in supplying input materials such as seeds, fertilizers, pesticides, capital and techniques is implemented, 3 partners can get benefits: 1) the vegetable processing companies can gain assistances related to capital and techniques from input suppliers; 2) the vegetable processing companies can control the quality of output products; 3) farmers can get capital, materials and technical assistances from input suppliers; 4) input suppliers can distribute to broader and more stable markets; and 5) reduced risks for input suppliers compared with selling materials directly to farmers (Fig. 6).

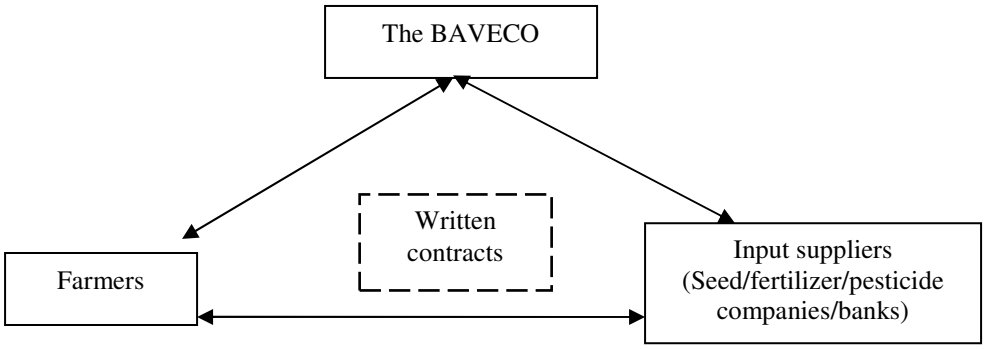

Fig 6. Linkages among the BAVECO, input suppliers and farmers

Providing production techniques and vegetable markets information to producers - Farmers grow vegetables, but they could not have access to the markets. Hence, the information related to markets, prices, volume of products and categories of products should be supplied by the Department of Industry and Commerce and the Department of Agriculture and Rural Development in Luc Nam district. Farmers can get information through discussions and/or via media tools inside communes. Information provided on time can assist farmers in making decisions on producing and distributing fruits and vegetables and ensure a mutual benefit in linkages.

Sharing benefits with local authorities- Village leaders in communes act as monitors who manage and supervise farmers to follow the regulations in contracts. In 2009, in Luc Nam district, processed and export company of food, fruit and vegetables collected baby cucumber from farmers at the price of 3,800 VND per kg. However, the companies often spend about 200 VND per kg to pay for the village leaders (Hoa 2009). This benefit encourages chairs of villages to do their work well. In addition, the technical staff of the Department of Agriculture and Rural Development and Centre of Agricultural Extension also play an important role in supporting the companies by transferring the techniques to vegetable producers. Therefore, the sharing of benefits for these staff would encourage them in finish their jobs well.

Sharing benefits and risks, rights and obligations should be mentioned clearly in contracts - Contract farming is like a tool of the vertical linkage. Relationships among members in the vertical linkages are revealed through contracts. The success of contract farming depends so much on issues: sharing benefits and risks, rights and obligations of partners. Actually, contracts between the agribusiness companies and farmers only focus on product volume, product quality characteristics, collection price and price adjustment, planting and harvest process. Contents of contracts lacked items regulating the risk sharing, rights and obligations of each side. There are a lot of risks in planting, harvest and processing of vegetables, such as changing of weather conditions, increase in insects pest populations, unexpected productivity, and price fluctuation. Rights and obligations item also are important issues because they mention the responsibility of each side in contract implemention process. For example, in the production process, these items regulate the responsibility of vegetable producers have to follow the the planting and harvest schedules, purchase and use of production inputs and materials (labor, capital, fertilizer, pesticide, equipments, facilities, etc) as provisioned. Or in the peak period, the risk and value sharing item would help stabilize the price, ensure the mutual benefit between both sides and make producers feel secure to plant vegetables.

2- Solutions for vegetable producers

These include large scale production, the vegetable producers should erase the bad traditional habit and apply the technology and advanced techniques in their areas. The farmers also should take initiative in obtaining information relating to the market, from that to aware of changing of customer

habit in marketing the agricultural products. Furthermore, the farmers should cooperate tightly with the vegetable processing companies, and not break the contracts for short term benefits.

3- Support from the government

Care more about the support for vegetable processing companies: The government still plays an minor role in the linkages. By supporting the companies building the material zones, or supplying credit for member producers and processing companies, the government could encourage the participation of members, improve and strengthen the linkages, in order to promote its benefits to social economic development. It also should release the guide in implementing the contracts, regulates the clear rights and obligations of each sides, this will help to reduce the contract broken of partners. Furthermore, the government should enhance the role of the Vietnam National Vegetable, Fruit and Agricultural Product Corporation (VEGETEXCO)in promoting and advertising the image of fruit and vegetables sector of Vietnam to international markets.

CONCLUSIONS

The linkage models between vegetable producers and agribusiness companies are bringing benefits to the social economic development in the local areas. However, there are many obstacles that prevent farmers and vegetable processing companies from participating in the linkages. The linkages brought benefits to producers including gaining the input materials provided by the agribusiness companies, access to technical assistance in production, cultivation and harvest, having stable prices and income, job creation and product quality improvement. In terms of the processing companies, they gained benefits from a stable supply and quality raw materials, taking initiative in processing and distributing the processed vegetables, reduced transaction cost and as a result increase in profit for companies.

The development of written contract procedure is a long term measure to ensure the sustainable development of the linkage models. Contents of contracts should not only mention the usual items, but should also include the risk and value sharing items.

The challenges of the linkages, include: 1) small-scale production; 2) increase in prices of input production; 3) poor storage and processing facilities; 4) late payment from processing and export companies; 5) lack of market information; 6) scattered production material zones; 7) non-uniformity of product sizes and quality; 8) difficulty in collection of raw materials between firms and 9) maintain stable export contracts.

In order to promote the linkages between processing and export companies and local farmers in Luc Nam district, Bac Giang province, it is necessary to raise the awareness of responsibilities of both sides. The vegetable processing companies should develop vegetable production zones, participate in the Enterprise Association of Food Processing and coordinate with input production suppliers, provide production techniques and vegetable markets information to producers, and share partly benefits with local authorities. The vegetable producers should apply new technologies in production and follow seriously the regulations provisioned in signed contracts. Finally, the government should strengthen its role by supporting members in the linkages by credit or technology transfer through VEGETEXCO to help enterprises promote and advertise the image of the fruit and vegetables sector of Vietnam to the international market.

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POTYVIRUS ASSOCIATED WITH MOSAIC DISEASE ON PATCHOULI (*Pogostemon cablin* (Blanco) Benth.) PLANTS IN INDONESIA

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ABSTRACT

This study was carried out to identify the virus associated with mosaic disease on patchouli in Indonesia. The diseased plant samples collected from Garut, Ciamis, Bogor (West Java) and West Pasaman (West Sumatera) strongly reacted with *Potyvirus* antiserum by enzyme-linked immunosorbent assay, but did not show any signal with antisera to *Cucumber mosaic virus*, *Tobacco mosaic virus*, *Broad bean wilt virus* 1 and *Broad bean wilt virus* 2; except the samples collected from Brebes (Central Java) which strongly reacted with Broad *bean wilt virus* 2 (*Fabavirus*) only. Besides that, the diseased plant samples collected from North Sumatera (Pakpak Bharat) did not react to any antiserum tested. The *Potyvirus* was then isolated. Positive results were obtained using a reverse transcriptase-polymerase chain reaction (RT-PCR) method to detect and identify *Potyvirus* from nucleic acid extracts of the symptomatic patchouli plants, using a pair of degenerate primers specific for *Potyvirus* CP gene. The sequence of this RT-PCR fragment, consisted of 800 bp, confirmed association of a *Potyvirus* with mosaic disease on patchouli plants in Indonesia. *Potyvirus* infecting patchouli plants in Indonesia are closely related to *Telosma mosaic virus* (TeMV) and *Passionfruit woodiness virus* (PaWP). This paper is the first report that TeMV, PaWP and *Fabavirus* are associated with mosaic disease on patchouli plants in Indonesia.

Key words: aromatic plant, *Telosma mosaic virus* (TeMV), *Passionfruit woodiness virus* (PaWP)

INTRODUCTION

Patchouli (*Pogostemon cablin* (Blanco) Benth.) is an aromatic herb, which contains oil glands in its leaves. The plant is believed to be a native of the Philippines; although the plant is grow wild or well cultivated in Indonesia, Malaysia, India and also distributed in China (Oyen, 1999). Foliage contains 2-6% oil extractable by distillation and it is used as a fixative for heavy perfumes and soaps (Schery, 1972). This plant can be maintained for more than one year, but the yield declines after about 3-4 cuttings. Therefore, planting new plants after growing them for least than two years is a common practice in Indonesia. The first harvesting time is around 6 month after planting. The second and next subsequent harvesting is between 3 and 4 month interval; depending on plant variety and its performance in the field (Nuryani *et al*., 2005).

Patchouli productions in Indonesia are unstable and so vary in quality and quantity. The main constraint in patchouli cultivation in Indonesia is the lack of good varieties (Nuryani *et al*., 2005), and occurrence of allelopathy (Djazuli, 2002). Another constraint in patchouli cultivation is the presence of pests and diseases caused by various organisms (Mustika and Asman, 2002). There are several reports of viruses naturally infect patchouli. In Brazil, at least five viruses were associated

with mosaic symptoms, they are tentatively named *Patchouli mosaic virus*, *Tobacco necrosis virus*, a presumed rhabdovirus and *Pepper ringspot virus* (Gama, 1979; Kitajima and Costa, 1979; Gama *et al*., 1980; Gama *et al*.,1982), and another virus is a potexvirus (Patchouli virus X, PatVX) (Meissner Filho *et al*., 1997, 2002). In Cuba, a possible rhabdovirus was also found (Rodriguez *et al*., 1989). In Japan a *Fabavirus* (*Patchouli mild mosaic virus*, PatMMV=*Broad bean wilt virus*) and a *Potyvirus* (*Patchouli mottle virus*, PatMoV) (Natsuaki *et al*., 1994) were identified from patchouli plant. In India, Sastry and Vasanthakumar (1981) reported a yellow mosaic virus of patchouli and then Rao and Nagar (1986) found a *Potyvirus* causing patchouli mosaic, named *Peanut stripe virus* (Singh *et al*, 2009). In Indonesia, the field study in Central Java showed that patchouli plant was infected by *Peanut stripe virus* causing yellow mosaic disease (Hartono, personal communication 2008). The disease intensity varied between 57-73%, and the disease was observed both in young and old plantation (Sumardiyono *et al*, 1995). During our survey in West Java, Indonesia, we found that patchouli plants in some locations were severely affected by mosaic disease. The diseased plants showed typical symptoms of pale green mosaic and malformation of the leaves and severe retardation of the plant growth (Noveriza *et al*., 2009). This study was carried out to identify the virus associated with mosaic disease on patchouli in Indonesia using ELISA and RT-PCR method.

MATERIALS AND METHODS

Virus Samples. Patchouli plants showing typical mosaic symptoms were collected from patchouli cultivation areas in West Java (Bogor, Ciamis, Garut), Central Java (Brebes), West Sumatera (West Pasaman), and North Sumatera (Pakpak Bharat), and used for virus identification (Figure 1). Infected plants were maintained by vegetative propagation under insect-proof screen house condition at 26-32°C.

Virus identification. Detection of viruses from infected plants were performed using indirect enzyme-linked immunosorbent assay (I-ELISA) and direct ELISA for the presence of *Potyvirus*, *Cucumber mosaic virus* (CMV), *Tobacco mosaic virus* (TMV), *Broad bean wilt virus* 1 (BBWV1), and *Broad bean wilt virus* 2 (BBWV2). The assays were done on polystyrene microtitre plate as described by Clark and Adams (1977). Quantitative analysis of ELISA result was done using spectrophotometer (ELISA reader) at 405 nm. Leaf samples tested positive in ELISA with *Potyvirus* specific antibodies (DSMZ) were directly assayed using polymerase chain reaction (PCR) technique or stored at -80°C until use.

RNA Extraction and cDNA Amplification. Total RNA was extracted from 0.15 g fresh leaf samples with the RNEasy Plant Mini Kit (Qiagen) according to the manufacturer's protocol, and resuspended in 40 µl double-distilled water. Two microlitres of the RNA was added to 8 µl of RT mixture component (1 µl buffer RT 10x, 0.35 µl DTT 50 mM, 2 µl dNTP 10 mM, 0.35 µl MMuLV, 0.75 µl Oligo d(T) 10 mM, 0.35 µl RNase H), and subjected to reverse transcription process following the programme: 25°C for 5 min, 42°C for 60 min, and 70°C for 15 min to yield cDNA. Two microlitres of cDNA was added to 23 µl of Go-Taq-Green Master Mix (Promega), containing degenerate primer pair CP9502 (5'-GCGGATCCTTTTTTTTTTTTTTTT-3') and CPUP (5'-TGAGGATCCTGGTGY ATHGARAAYG G-3'), specific for coat protein region of *Potyvirus*es as described by Van Der Vlugt *et al*. (1999). These primers amplify a 800 nt fragment, corresponding to partial coat protein gene and 3'UTR of the gene. The RT-PCR was subjected to the following programme: 94°C for 5 min, 35 cycles of 94°C for 30 s, 50°C for 1 min, and 72°C for 1 min, and a final step of 72°C for 10 min. After electrophoresis on 1.2% agarose gel, amplicons were stained with ethidium bromide and visualized under UV light. The 800 bp amplicons were then cleaned and used for sequencing.

Sequence Analysis. From the one DNA strands sequenced separately for each sample, a consensus sequence was constructed by using Bioedit software (Hall, 1999) and the Clustal W alignment module included in Bioedit. The consensus sequence was compared to the sequences registered in the

nucleotide databases using the Basic Local Alignment Search Tool (blastn; http: //www.ncbi.nlm.nih.gov/blast/). For the species giving the best match, sequences from the accessions giving the highest and the lowest match scores were downloaded, plus the closest matching sequence from a different species.

The topology of the phylogenetic trees was inferred and drawn from the aligned sequences, using Mega 5.05 sofware with distance estimator and Unweighted pairgroup method using Arithmetic averages (UPGMA) method (Tamura *et al*., 2011). The dataset was bootstrapped (100 replicates) to generate the confidence values of the phylogenetic tree. All branches with bootstrap values less than 40% were collapsed in the final phylogenetic tree.

RESULTS AND DISCUSSION

Symptoms and virus isolation

During our survey in West and Central Java, North and West Sumatera, we found that patchouli (*Pogostemon cablin* (Blanco) Benth.) plants were severely affected by mosaic disease. The diseased plants showed typical symptoms of yellow mosaic without malformation of the leaves, pale green mosaic with malformation of the leaves, severe mosaic, thickened leaves or stunted; and retardation of the plant growth (Fig. 1). Natsuaki *et al*. (1994) reported association of *Potyvirus* in patchouli plant showing no symptoms to any mild mottling; therefore we need to confirm the causal agent of mosaic disease in patchouli plant from Java and Sumatera. According to Sukamto *et al.* (2007), diagnosis of the disease based on symptomatological alone is not reliable for detecting the occurrence of viruses in plant material.

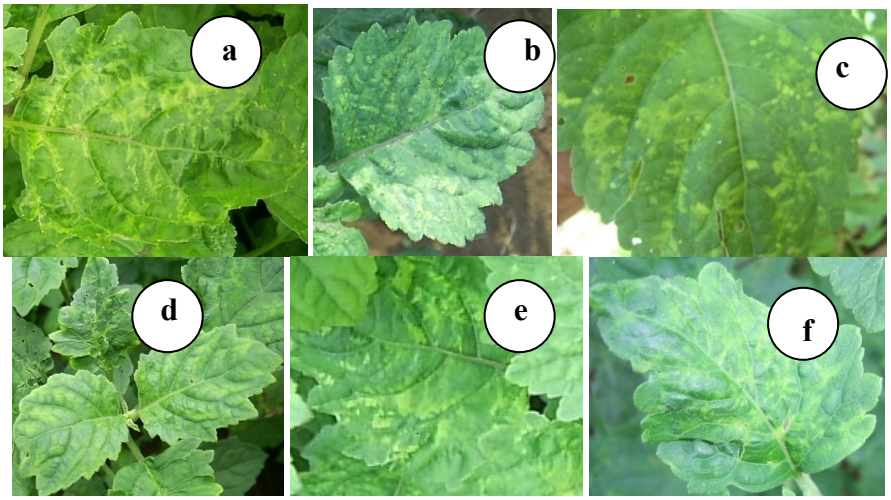

Fig. 1. The variation of mosaic symptom affected by *Potyvirus* and *Fabavirus* infection on patchouli plant: (a) to (e) mild to severe mosaic, thickened or stunted leaves caused by natural infection of *Potyvirus*, (f)severe mosaic symptoms caused by natural infection of *Fabavirus*.

Serological Analysis

Patchouli plants showing mild to severe mosaic symptoms from Bogor, Garut, Ciamis and West Pasaman, reacted strongly with antiserum to *Potyvirus*; but severe mosaic symptoms from Brebes reacted strongly with antiserum to *Fabavirus* (BBWV2). In addition, plant samples collected

from North Sumatera (Pakpak Bharat) did not react with any antiserum tested (Table 1). This is the first report indicated infection of *Fabavirus* (BBWV2) patchouli plant in Indonesia. According to Wahyuno (2009), group of virus causing mosaic and mottle diseases on patchouli plant are CMV and BCMV. However, based on our detection result, no serological reaction was observed for CMV. Our serological analysis presumed that *Potyvirus* and *Fabavirus* were associated with mosaic symptom in patchouli plants in Indonesia.

Table 1. Frequency of virus infection on patchouli plant samples with mosaic symptom from different location based on ELISA method.

No.	Virus Samples	Antiserum				
		Potyvirus	**TMV**	**CMV**	**BBWV1**	**BBWV2**
1	Bogor, West Java	2/5*	0/5	0/5	nt	nt
2	Garut, West Java	3/15	0/15	0/15	nt	nt
3	Ciamis, West Java	5/9	0/9	0/9	nt	nt
4	Sukabumi, West Java	0/20	0/20	0/20	7/20	0/20
5	Pasaman Barat, West Sumatera	20/45	nt	nt	1/45	0/45
6	Brebes, Central Java	0/23	0/23	0/23	0/23	9/23
7	Pakpak Bharat, North Sumatera	0/6	0/6	0/6	0/6	0/6

Note *a/b: proportion of infected samples to total samples tested.
nt : not tested

Molecular and Sequence Analysis

RT-PCR using *Potyvirus* group degenerate primers (CPUP and CP9502) produced an amplicon of approximately 800 bp of CP gene in patchouli samples (Fig. 2). This result confirmed the presence of *Potyvirus* on patchouli plants collected from different regions in Indonesia. The amplified fragment contains approximately 800 bp of CP gene and 3'UTR region of the *Potyvirus* (Fig. 3). Coat protein gene was chosen for sequence analysis of this virus because it is more useful and more easily applied than other properties for identification and classification of *Potyvirus*es (Shukla and Ward, 1989). After sequencing, the consensus sequence was compared to the sequences registered in the nucleotide databases using the Basic Local Alignment Search Tool (blastn; http: //www.ncbi.nlm.nih.gov/blast/). It showed that the sequences have 89–92% identity to coat protein sequence of *Telosma mosaic virus* (TeMV) and 88–91% identity to sequence of *Passionfruit woodness virus* Pangda 12 and Pangda15 (Table 2). According to the currently used criteria for *Potyvirus* classification, viruses sharing under 76-77% coat protein nucleotide identity would be considered members of distinct species (Adams *et al*., 2005). The amino acid sequence homology between distinct members of *Potyvirus*es, ranged from 38 to 71% (average 54%) while that inter strains of the one virus ranged from 90 to 99% (average 95%) (Shukla and Ward, 1989). We tentatively presume that patchouli plants in Indonesia are infected with *Potyvirus* species closely related to *Telosma mosaic virus* Hanoi isolate (TeMV.Hanoi), *Passionfruit woodness virus* Pangda 12 isolate (Pangda12.1) and *Passionfruit woodness virus* Pangda15 isolate (Pangda15.1).

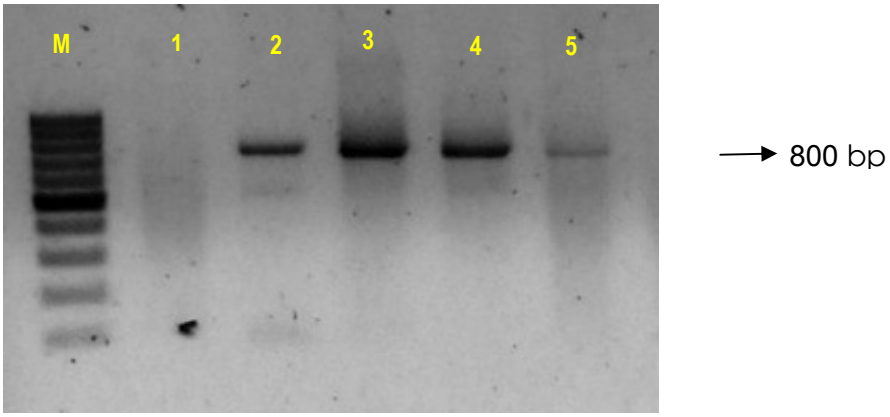

Fig 2. RT-PCR of RNA extracted from patchouli samples using degenerate primers (CPUP&CP9502) on 1% agarose gel electrophoresis showed amplicon of 800 bp. M= marker DNA 100 bp; (1) without leaf sample (negative sample); (2) leaf sample from Pasaman; (3) leaf sample from Ciamis; (4) leaf sample from Garut; and (5) leaf sample from Bogor.

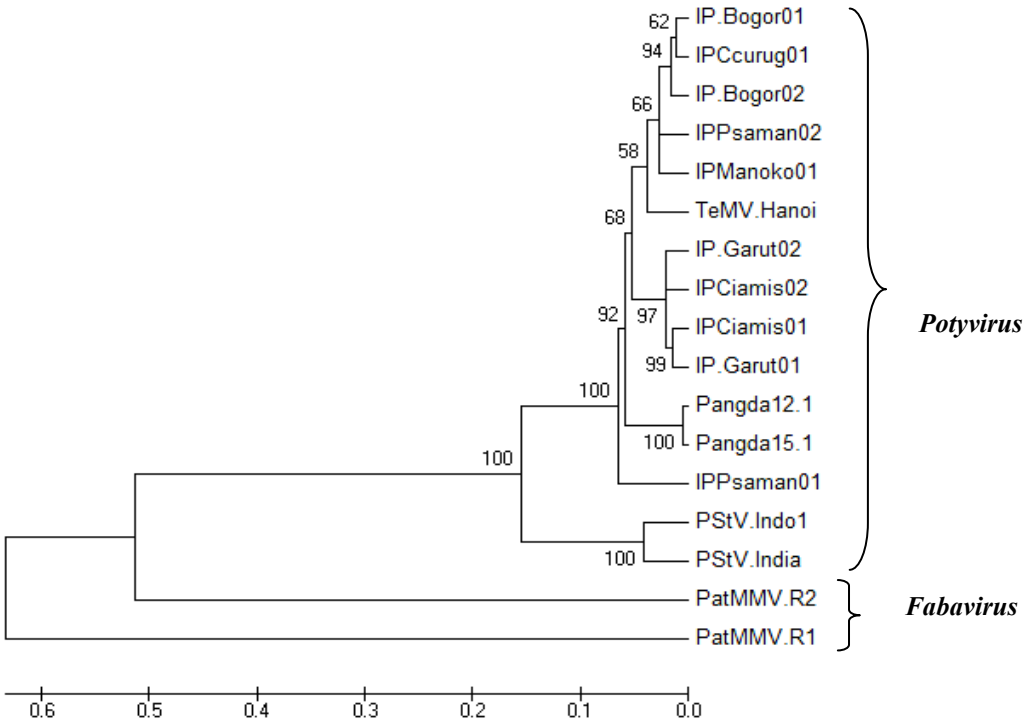

Fig. 3. Phylogenetic tree of *Potyvirus* infecting patchouli plants in Indonesia and their relation to other *Potyvirus*es and *Fabavirus*es previously reported based on CP gene nucleotide sequence (393 bp) by UPGMA method with 10,000 bootstrap replicates values using Mega 5.05.

Table 2. Percent identity between *Potyvirus* infecting patchouli plants in Indonesia and those previously reported in GenBank.

Virus isolate from Indonesia	Virus isolate in the Gene Bank (Nucleotide Accesion No.)	Sequence identity (%)	
		Nucleotide	Amino acid
IP.Bogor01	*Passionfruit woodiness virus* isolate Pangda15 (AM409188.1)	91	92
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	91	91
	Telosma mosaic virus isolate Hanoi (DQ851493.1)	89	92
IP.Bogor02	*Passionfruit woodiness virus* isolate Pangda15 (AM409188.1)	90	92
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	90	92
	Telosma mosaic virus isolate Hanoi (DQ851493.1)	89	92
IPCiamis01	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	91	94
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	90	96
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	89	97
IPCiamis02	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	92	91
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	90	91
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	90	91
IP.Garut01	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	91	92
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	89	92
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	89	91
IP.Garut02	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	92	91
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	90	91
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	89	92
IPPsaman01	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	88	79
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	88	86
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	88	81
IPPsaman02	*Passionfruit woodiness virus* isolate Pangda12 (AM409187.1)	92	91
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	92	91
	Telosma mosaic virus isolate Hanoi (DQ851493.1)	89	92
IPCcurug01	*Telosma mosaic virus* isolate Hanoi (DQ851493.1)	95	92
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	92	89
	Passionfruit woodiness virus isolate Pangda12 (AM409187.1)	91	90
IPManoko01	*Passionfruit woodiness virus* isolate Pangda12 (AM409187.1)	91	94
	Telosma mosaic virus isolate Hanoi (DQ851493.1)	90	92
	Passionfruit woodiness virus isolate Pangda15 (AM409188.1)	90	93

Molecular characterization of ten nucleotide sequence of *Potyvirus* coat protein from patchouli plants in Indonesia with those related species previously reported in GenBank (Table 3) were further performed. All ten isolates shared high (> 85%) nucleotide sequence identities with TeMV Hanoi, Pangda12.1 and Pangda15.1 and it should be classified as those spesies but different strain (Table 4). The virus sequences did not show any similarity with *Peanut stripe virus* Indonesia isolate (PStV Indo1), *Peanut stripe virus* Palampur isolate (PStV India), *Patchouli mild mosaic virus* RNA 1 isolate Philippines (PatMMV R1) and *Patchouli mild mosaic virus* RNA 2 isolate Philippines (PatMMV R2), because nucleotide sequence identities shared less than 80%. According to Orilio *et al*. (2009), virus shared less than 80% nucleotide identity with any other *Potyvirus* sequence, might indicate a member of new species. When those nucleotide or amino acid sequences have identity more than 85%, indicated that it is a member of that species, but different strain (Nascimento *et al*., 2006). This suggests that the ten *Potyvirus* isolates from Indonesia patchouli plant consists of several different strains but the same species with *Telosma mosaic virus* Hanoi isolate (TeMV Hanoi) and *Passionfruit woodness virus* Pangda 12 isolate (Pangda12.1) and *Passionfruit woodness virus* Pangda15 isolate (Pangda15.1).

Table 3. List of viruses (*Potyvirus* and *Fabavirus*) used for viral sequencing analysis.

No.	Virus isolate	Geographic origin	Host plant	GenBank Accession No.	Sequence length (bp)
1	IP.Bogor01	Bogor, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	754
2	IP.Bogor02	Bogor, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	757
3	IPCiamis01	Ciamis, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	731
4	IPCiamis02	Ciamis, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	807
5	IP.Garut01	Garut, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	733
6	IP.Garut02	Garut, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	795
7	IPPsaman01	West Pasaman,West Sumatera, Indonesia	*Pogostemon cablin* (patchouli)	-	708
8	IPPsaman02	West Pasaman, West Sumatera, Indonesia	*Pogostemon cablin* (patchouli)	-	811
9	IPCcurug01	Cicurug, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	364
10	IPManoko01	Manoko, West Java, Indonesia	*Pogostemon cablin* (patchouli)	-	824
11	*Peanut stripe virus* isolate Indonesia=PStV.Indo1	Central Java, Indonesia	*Pogostemon cablin* (patchouli)	-	454
12	*Peanut stripe virus* isolate Palampur (*Bean common mosaic virus* strain *peanut*	Palampur, India	*Pogostemon cablin* (patchouli)	AJ851894.1	454

No.	Virus isolate	Geographic origin	Host plant	GenBank Accession No.	Sequence length (bp)
	stripe)=PStV.India				
13	*Telosma mosaic virus* isolate Hanoi=TeMV.Hanoi	Hanoi, Vietnam	*Telosma cordata*	DQ851493.1	9689
14	*Passionfruit woodiness virus* isolate Pangda12=Pangda12.1	Thailand	purple passionfruit	AM409187.1	966
15	*Passionfruit woodiness virus* isolate Pangda15=Pangda15.1	Thailand	purple passionfruit	AM409188.1	1455
16	*Patchouli mild mosaic virus* RNA 1 isolate Philippines=PatMMV.R1	Philippines	*Pogostemon cablin* (patchouli)	NC_003975.2	5956
17	*Patchouli mild mosaic virus* RNA 2 isolate Philippines=PatMMV.R2	Philippines	*Pogostemon cablin* (patchouli)	NC_003974.1	3591

The phylogenetic tree was constructed by bootstrap of the closest *Potyvirus* CP nucleotide sequences, including one sequence from patchouli plant (not yet published) and those sequences reported in GenBank. The alignment of the 393 bp fragment clearly clustered isolates of the closely related species and separated distinct species (Fig. 3). The existence of three major groups of viruses, namely group *Fabavirus* RNA1, RNA 2, and *Potyvirus* were shown in the phylogenetic tree. The *Potyvirus* group consisted of two groups : the first group consisted of PStV.Indo1 and PStV.India virus isolates; the second group consisted of 13 virus isolates (IP.Bogor01, IP.Bogor02, IPCcurug01, IPPsaman02, IPManoko01, TeMV.Hanoi, IPCiamis02, IP.Garut02, IPCiamis01, IP.Garut01, Pangda12.1, Pangda15.1 and IPPsaman01).

It was clear that all isolates collected from this study was included in the *Potyvirus* group, and all these isolates differ from isolates from PStV India patchouli and also from other PStV Indonesian patchouli. According to Sing *et al*. (2009) patchouli plants in India were infected with PStV and patchouli plant in Indonesia were infected with *Bean common mosaic virus* (BCMV) strain and PStV (Hartono, personal communication, 2008).

Table 4. Percent identity for the coat protein sequence of *Potyvirus*-inducing mosaic symptom on patchouli plant from Indonesia, India, Philippines and some closely related *Potyvirus*.

Sequence	Isolate**	Sequence Identity (%)*																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	IP.Bogor01																	
2	IP.Bogor02	97.7																
3	IPCiamis01	92.6	91.4															
4	IPCiamis02	91.1	92.6	95.7														
5	IP.Garut01	91.4	90.9	97.4	95.1													
6	IP.Garut02	89.7	90.0	94.6	94.3	94.3												
7	IPPsaman01	86.7	85.5	85.4	86.4	85.5	84.4											
8	IPPsaman02	93.4	94.9	90.6	92.3	90.0	89.2	86.7										
9	IPCcurug01	96.9	95.5	91.2	89.8	90.4	87.9	85.9	92.6									
10	IPManoko01	91.3	92.4	85.7	88.3	85.2	85.7	84.1	91.9	90.0								
11	PStV.Indo1	74.5	74.7	74.7	75.0	73.9	73.0	70.6	73.7	73.8	73.2							
12	PStV.India	70.8	71.1	72.5	72.8	71.9	71.1	67.5	70.6	70.7	69.9	93.7						
13	TeMV.Hanoi	92.9	92.3	91.2	91.2	91.2	89.8	85.3	90.9	91.5	88.8	76.2	73.6					
14	Pangda12.1	88.6	88.3	88.3	88.1	88.1	87.5	85.0	88.9	88.2	86.0	75.9	75.0	90.6				
15	Pangda15.1	88.9	88.6	88.6	88.3	88.3	87.5	85.0	89.2	88.4	85.7	76.2	75.3	90.9	98.8			
16	PatMMV.R1	40.0	39.2	39.7	38.9	39.4	39.2	37.6	38.6	39.4	38.4	37.8	35.5	38.9	39.2	39.4		
17	PatMMV.R2	42.4	43.0	41.9	41.7	42.4	41.4	41.1	41.4	42.4	40.7	37.3	37.3	41.4	39.3	39.1	28.1	

Note: * Pairwise comparisons made with BioEdit version 7.0.0, using the Fast Alignment option with the following parameters: BLOSUM62 matrix, Gap open=10, Gap extension=0.1

** As in Table 3.

```
Bogor01      CCAACCCCAA AA----ATTA ATGC-CGTGT GGGTCAT-GA TGGACGGAGA
Bogor02      CAATCCCCAG AA----ATCA ATGG-CCAGA GGGTCAT-GA TGGACGGAGA
Ciamis01     CCGAACCAGG AA----ATTA ATGG-CGTGT GGGTGAT-GA TGGACGGAGA
Ciamis02     AATTTTCTTA AA----ATCA CTGG-CCCGA GGGTGAT-GA TGGACGGAGA
Garut01      CTGGACCCTG AA-----TTT ATGG-CGTGT GGGTGAT-GA TGGACGGAGA
Garut02      AAAAAAAAAA AA----ATAA ATGGGCGTGT GGGTG-T-GA TGGACGGAGA
Pasaman01    CCGGTTATCA AATT---TAT TTGGGCCTGG GCGT-AT-GA TGGACGGAGT
Pasaman02    CAATTCCCCT TA---AACCA GGGG-CCTGA GGGTTAT-GA TGGACGGAGA
Manoko01     CAATTTTCCA TTTT--ACCA GGGT-CAAAA GGGCTAAAGA TGGACGGAGA
Cicurug01    CCGCCCCCAA CCCCAAATTA ATGG-CGTGT GGGTCAT-GA TGGACGGAGA

Bogor01      AGAACAAGTT G-AATACCCA TTG---AAAC CAATGGTTGA AAATGCAAAG
Bogor02      AGAACAAGTT G-AATACCCA TTG---AAAC CAATGGTTGA AAATGCAAAG
Ciamis01     AGA-CAAGTT G-AATACCCA CTG---AAGC CAATGGTTGA AAATGCAAAG
Ciamis02     AGAACAAGTT G-AATACCCA CTG---AAGC CAATGGTTGA AAATGCAAAG
Garut01      AGAACAAGTT G-AATACCCA CTG---AAGC CAATGGTTGA AAATGCAAAG
Garut02      AGAACAAGTT G-AATACCCA CTG---AAGC CAATGGTTGA AAATGCAAAG
Pasaman01    AGA-CAGGTT G-AATACCCA CTA---CAGC CAATGGTTGA AAATGCAAAG
Pasaman02    AGAACAAGTT G-AATACCCA CTA---AAGC CAATGGTTGA AAATGCAAAG
Manoko01     AGAACAAGTT GGAATACCCA TCCTGCAAAC CAATGGTTGA AAATGCAAAG
Cicurug01    AGAACAAGTT G-AATACCCA CTG---AAAC CAATGGTTGA AAATGCAAAG

Bogor01      CCAACACTGA GACAAATCAT GCATCATTTC TCAGATGCGG CTGAAGCATA
Bogor02      CCAACACTGA GACAAATCAT GCATCATTTC TCAGATGCGG CTGAAGCATA
Ciamis01     CCGACATTGA GACAAATAAT GCATCACTTT TCAGATGCGG CTGAAGCATA
Ciamis02     CCGACATTGA GACAAATAAT GCATCACTTC TCAGATGCGG CTGAAGCATA
Garut01      CCGACATTGA GACAAATAAT GCATCACTTT TCAGATGCGG CTGAAGCATA
Garut02      CCGACATTGA GACAAATAAT GCATCACTTT TCAGATGCGG CTGAAGCATA
Pasaman01    CCGACATTGA AACAATTCAT GCTTCATTTC TCAAATGCGG TTGAAGCATA
Pasaman02    CCGACATTGA GACAAATCAT GCATCATTTC TCAGATGCGG CTGAAGCATA
Manoko01     CCAACACTGA GACAAATCAT GCATCATTTC TCAGATGCGG CTGAAGCATA
Cicurug01    CCAACACTGA GACAAATCAT GCATCATTTC TCAGATGCGG CTGAAGCATA

Bogor01      CATAGAAATG AGGAACTCTG AGGGATTGTA CATGCCTAGG TATGGTCTCC
Bogor02      CATAGAAATG AGGAACTCTG AGGGATTGTA CATGCCTAGG TATGGTCTCC
Ciamis01     TATTGAAATG AGGAATTCTG AGGGATTATA CATGCCTAGG TATGGTCTCC
Ciamis02     TATTGAAATG AGGAATTCTG AGGGATTATA CATGCCTAGG TATGGTCTCC
Garut01      TATTGAAATG AGGAATTCTG AGGGATTATA CATGCCTAGG TATGGTCTCC
Garut02      TATTGAAATG AGGAATTCTG AGGGATTATA CATGCCTAGG TATGGTCTCC
Pasaman01    CATAGAAATG AGGATTTCTG AGGGATTATA CATGCCTAGG TATGGTCTTC
Pasaman02    CATAGAAATG AGGAACTCTG AGGGATTGTA CATGCCTAGG TATGGTCTTC
Manoko01     CATAGAAATG AGGAACTCTG AGGGATTGTA CATGCCTAGG TATGGTCTCC
Cicurug01    CATAGAAATG AGGAACTCTG AGGGATTGTA CATGCCTAGG TATGGTCTCC

Bogor01      TCAGGAACCT GAGGGATAGA AGTCTGGCGC GATATGCATT CGATTTCTAT
Bogor02      TCAGGAACCT GAGGGATAGA AGTCTGGCGC GATATGCATT CGATTTCTAT
Ciamis01     TTAGGAACCT GAGGGATAAA AGTCTGGCGC GATATGCTTT CGATTTCTAT
Ciamis02     TTAGGAACCT GAGGGATAAA AGTCTGGCGC GATATGCTTT CGATTTCTAT
Garut01      TTAGAAACCT GAGGGATAAA AGTCTGGCGC GATATGCTTT CGATTTCTAT
Garut02      TTAGAAACCT GAGGGATAAA AGTCTGGCGC GATATGCTTT CGATTTCTAT
Pasaman01    TCAGGAACCT GAGGGATAGA ATTCTGGCGC AATATGCATT CAATTTCTAT
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Pasaman02     TCAGGAACCT GAGGGATAGA AGTTTGGCGC GATATGCATT CGATTTCTAT
Manoko01      TCAGGAACCT GAGGGATAAA AGTCTGGCGC GATATGCATT CGATTTCTAT
Cicurug01     TCAGGAACCT GAGGGATAGA AGTCTGGCGC GATATGCATT CGATTTCTAT

Bogor01       GAGGTGAACT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAAAT
Bogor02       GAGGTGAACT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAAAT
Ciamis01      GAGGTAACCT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAGAT
Ciamis02      GAGGTAACCT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAGAT
Garut01       GAGGTAACCT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAGAT
Garut02       GAGGTAACCT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAGAT
Pasaman01     GAGGTGAACT CTAAAACTTC AGATAAAGCT AAAGAAGCTG TCCCACAGAT
Pasaman02     GAGGTGAACT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAGAT
Manoko01      GAGGTGAACT CTAAGACGTC AGACAGAGCT AAGGAAGCTG TCACACAAAT
Cicurug01     GAGGTGAACT CTAAGACGTC AGACAGAGCT AAAGAAGCTG TCACACAAAT

Bogor01       GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG
Bogor02       GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG
Ciamis01      GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAGATGTTT GGATTGGATG
Ciamis02      GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAGATGTTT GGATTGGATG
Garut01       GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAGATGTTT GGATTGGATG
Garut02       GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAGATGTTT GGATTGGATG
Pasaman01     GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG
Pasaman02     GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG
Manoko01      GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG
Cicurug01     GAAGGCAGCC GCCCTCGTTG GCACTACGAA TAAAATGTTT GGATTGGATG

Bogor01       GTAGTGTCAG CACAAATGGC GAAGATACTG AGAGGCACAC TGCAAGAGAT
Bogor02       GTAGTGTCAG CACAAATGGC GAAGATACTG AGAGGCACAC TGCAAGAGAT
Ciamis01      GTAGTGTCAG CACAACTGGC GAAGATACTG AAAGGCACAC TGCTAGAGAC
Ciamis02      GTAGTGTCAG CACAACTGGC GAAGATACTG AAAGGCACAC TGCTAGAGAC
Garut01       GTGGTGTCAG CACAACTAGC GAAGATACTG AAAGGCACAC TGCGAGAGAC
Garut02       GTGGTGTCAG CACAACTGGC GAAGATACTG AAAGGCACAC TGCGAGAGAC
Pasaman01     GTAGTGTCAG CACAAATGGC GAAAATACTG AAAGGCACAC TGCAAGAGAT
Pasaman02     GTAGTGTCAG CACAAATGGC GAAGATACTG AAAGGCACAC TGCAAGAGAT
Manoko01      GTAGTGTCAG CACAAATAGC GAAAATACTG AAAGGCACAC TGCAAGAGAT
Cicurug01     GTAGTGTCAC CAC------- ---------- ---------- ----------

Bogor01       GTTAATCAGA ACATGCACTC CTTGCTCGGA GTGGGCTCCG TGCAGTAAAG
Bogor02       GTTAATCAGA ACATGCACTC CTTGCTCGGA GTGGGCTCCG TGCAGTAAAG
Ciamis01      GTGAATAAAA ACATGCATTC CTTGCTTGGA GTAAGCTCTG TGCAGTAAAG
Ciamis02      GTGAATAAAA ACATGCATTC CTTGCTTGGA GTAAGCTCTG TGCAGTAAAG
Garut01       GTGAATCAAA ACATGCATTC CTTGCTTGGA GTAAGCTCTG TGCAGTAAAG
Garut02       GTGAATCAAA ACATGCATTC CTTGCTTGGA GTAAGCTCTG TGCAGTAAAG
Pasaman01     GTTAATCAGA ACATGCTCTC CTTGCTTGGA GTGGGCTCTG TGCAGTAAAG
Pasaman02     GTTAATCAGA ACATGCACTC CTTGCTTGGA GTGGGCTCTG TGCAGTAAAG
Manoko01      GTTAATCAGA ACATGCACTC CTTGCTCGGG GTGGGCTCCG TGCAGTAAAG
Cicurug01     ---------- ---------- ---------- ---------- ----------

Bogor01       GCTAGGTAAA CTGGCCACAG TTAGAACTTC GCGTTGCCTG GTATCCATTA
Bogor02       GCTAGGTAAA CTGGCCACAG TTAGAACTTC GCGTTGCCTG GTATCCATTA
Ciamis01      GCTAGGTAAA CTGGCCACAG TTAGAACTTT GCGTTGCTTA GTAGCCCTTA
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Ciamis02      GCTAGGTAAA CTGGCCACAG TTAGAACTTT GCGTTGCTTA GTAGCCCTTA
Garut01       GCTAGGTAAA CTGGCCACAG TTAGAACTTT GCGTTGCTTA GTAGCCCTTA
Garut02       GCTAGGTAAA CTGGCCACAG TTAGAACTTT GCGTTGCTTA GTAGCCCTTA
Pasaman01     GCTAGGTAAA CTGGCCACAG TTAGAACTTC GCGTTGCCTG GTATCCATTA
Pasaman02     GCTAGGTGAA CTGGCCACAG TTAGAACTTC GCGTTGCCTG GTACCCATTA
Manoko01      GCTAGGTAAA CTGGCCACAG TTAGAACTTC GCGTTGCCTG GTATCCATTA
Cicurug01     ---------- ---------- ---------- ---------- ----------

Bogor01       GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAC ACCACCATGT
Bogor02       GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAC ACCACCATGT
Ciamis01      GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCATGT
Ciamis02      GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCATGT
Garut01       GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCACGT
Garut02       GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCACGT
Pasaman01     GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCATGT
Pasaman02     GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCATGT
Manoko01      GTACTTTACT TTCACTCTCT TTACTTTCCA GAGTGGTTAT ACCACCATGT
Cicurug01     ---------- ---------- ---------- ---------- ----------

Bogor01       TCTTAAGTAT TGCGATAGCG TGGCACGGCC ACCAGTGTTT GTT-TCCTTA
Bogor02       TCTTAAGTAT TGCGATAGCG TGGCACGGCC ACCAGTGTTT GTT-TCCTTA
Ciamis01      TCTTAAGTAT TGTGATAGTG TGGCACAGCC ACCAGTGTTT GTTATTTCAA
Ciamis02      TCTTAAGTAT TGTGATAGTG TGGCACAGCC ACCAGTGTTT GTTATTTCAA
Garut01       TCTTAAGTAT TGTGATAGTG TGGCACAGCC ACCAGTGTTT GTTATTTCAA
Garut02       TCTTAAGTAT TGTGATAGTG TGGCACAGCC ACCAGTGTTT GTTATTTCAA
Pasaman01     TCTTAAGTAT TGCGATAGCG TGGCACGGCC ACCAGTGTTT GTT-TCTTTA
Pasaman02     TCTTAAGTAT TGCGATAGCG TGGCACGGCC ACCAGTGTTT GTT-TCTATA
Manoko01      TCTTAAGTAT TGTGATAGCG TGGCACGGCC ACCAGTGTTT ATT-TCCTTA
Cicurug01     ---------- ---------- ---------- ---------- ----------

Bogor01       GTACTTTTTT TGGAACTACA GGTGTGAAAA ACCGTTAAAT CAAAAAGCTT
Bogor02       GTACTTTTTT TGGAACTACA GGTGTGAAAA ACCGTTAAAT CAAAAAGCTT
Ciamis01      GTACTCT--- GAAAACTACA GGCGTGGAGA ACCATTAGAT CAGAGAGCTT
Ciamis02      GTACTCT--- GAAAACTACA GGCGTGGAGA ACCATTAGAT CAGAGAGCTT
Garut01       GTACTTT--- GAAAACTACA GGCGTGGAGA ACCATTAGAT CAGAGAGCTT
Garut02       GTACTCT--- GAAAACTACA GGCGTGGAGA ACCATTAGAT CAGAGAGCTC
Pasaman01     GTACTTTCTT TGGAACTATA CGGGTGAAAA AACGTATTAT ATAAGAGCTC
Pasaman02     GTATTTT--- -GGAACTACA GGTGTGAAGA ACCGTTAGAT CAAAGAGCTT
Manoko01      GTACTTTTT- -GGAACTACA GGTGTGAAGA ACCTTTAGAT CAGAGAGCTT
Cicurug01     ---------- ---------- ---------- ---------- ----------

Bogor01       CTGTAGTGAG GTCGAACCTT CGATGGAGTT ATCTGCCTTA -ACGTTCGT-
Bogor02       CTGTAGTGAG GTCGAACCTT CGATGGAGTT ATCTGCCTTA -ACGTTCGT-
Ciamis01      CTGTAGTGAG GTTGAACCTC CAATGAAGTA ATCTGCCTTA -ATGTTTGT-
Ciamis02      CTGTAGTGAG GTTGAACCTC CAATGAAGTA ATCTGCCTTA -ATGTTTGT-
Garut01       CTGTAGTGAG GTTGAACCTC CAATGAAGTA ATCTGCCTTA -ATGTTTGT-
Garut02       CTGTAGTGAG GTTGAACCTC CAATGGAGTA ATCTGCCTTA -ATGTTTGT-
Pasaman01     CTGTGAAGTG GAGTAACCCC TGAAGTAGTC TTTTTTCCTG TACGTTCGTC
Pasaman02     CTGTAGTGAG GTTGAACCTT CGATGGAGTT ATTTGCCTTA -ACGTTCGT-
Manoko01      CTGTAGTGAG GTCAAACCTT CTATGGAGTT ATCTGCCTTA -ATGTTCGT-
Cicurug01     ---------- ---------- ---------- ---------- ----------
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Bogor01       TGTTCCAAAA AAAAAAAA
Bogor02       TGTTCCAAAA AAAAAAAA
Ciamis01      TGTCCCAAAA AAAAAAAA
Ciamis02      TGTCCCAAAA AAAAAAAA
Garut01       TGTCCCAAAA AAAAAAAA
Garut02       TGTCCCAAAA AAAAAAAA
Pasaman01     TGTGCCCCAA AAAAAAAA
Pasaman02     TGTTCCAAAA AAAAAAAA
Manoko01      TGTTCCAAAA AAAAAAAA
Cicurug01     ---------- --------
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Fig. 3. Multiple alignment of ten sequences of *Potyvirus* coat protein (718 bp) isolated from patchouli plants in Indonesia using ClustalW Multiple Alignment BioEdit version 7.0.0.

CONCLUSION

We can conclude that the diseased plants showed typical symptoms of yellow mosaic without malformation of the leaves, pale green mosaic with malformation of the leaves, severe mosaic, thickened leaves or stunted and retardation of the plant growth. Positive results were also obtained by using a RT-PCR method to detect and identify *Potyvirus* from nucleic acid extracts of the symptomatic patchouli plants, using a pair of degenerate primers specific for *Potyvirus* coat protein gene. The sequence of this RT-PCR fragment, consisted of 800 bp, confirmed that a *Potyvirus* associated with mosaic disease on patchouli plants in Indonesia. *Potyvirus* infecting patchouli plants in Indonesia are closely related to *Telosma mosaic virus* (TeMV) and *Passionfruit woodiness virus* (PaWP). This paper is the first report that TeMV, PaWP and *Fabavirus* are associated with mosaic disease on patchouli plants in Indonesia.

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TRAMLINE TRANSPORT FACILITIES INCREASE THE PRODUCTIVITY OF TEMPERATE VEGETABLE FARMS IN THE UPLANDS OF BENGUET PROVINCE, PHILIPPINES

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ABSTRACT

While the country is endowed with vast agricultural lands, almost half of this is considered as either idle or not very productive. This can be attributed to the mountainous topography that renders transport difficult, labor intensive and costly. The provision of farm-to-market roads (FMR) in these areas is also not an option because the steep slopes make construction of the latter technically difficult and economically nonviable. The uplands thus remain marginalized and low in productivity given its isolation from the market. To address this condition and improve the productivity of these upland farms, the government introduced tramline transport facilities in selected mountainous areas like the Benguet province. Tramlines are hauling facilities that utilize a series of steel cables, pulleys and post structures to transport products from the farms to the nearest roads accessible by vehicle. Tramlines are commonly used for the transport of temperate vegetables like potato *(Solanum tuberosum)* cabbage *(Brassica oleracea)*, carrot *(Daucus carota)* and lettuce *(Lactuca sativa)* which are commercially produced in Benguet Province. The provision of tramline facilities influence the decision of upland farmers in the type of land use, level of input utilization and cropping intensity. Because of the reduction of the cost of transport, farms serviced with tramline facilities apply higher amounts of fertilizer, devote more areas for cropping and have higher cropping intensities resulting in higher productivity. Upland farmers are also relieved from the drudgery of the traditional manual transport.

Key words: mountainous areas, market access, cropping intensity

INTRODUCTION

There is great potential in growing high value temperate fruits and vegetables in the vast uplands in the Philippines. The fertility of these soils, coupled with the cool temperature, make these areas ideal for growing these types of crops that cannot be grown in the lowlands. However, this potential is largely untapped because the terrain in these areas is rugged and largely inaccessible due to the absence of FMR. A report of the European Commission (2005) mentions that more than half of the country's land area is classified as uplands with slopes exceeding 18 percent. About 8,557,479 has., roughly 28.7 percent of the total land area of the country, are steeply sloping while 6 million has. have 30 to 50 percent slopes and over 2 million has. have slopes greater than 50 percent (De Jesus, undated as mentioned in Idago 2007). About 4 million hectares of cultivated lands are already severely eroded and only marginally productive.

According to Ramos (1998), given the lack of FMRs, the most immediate concern for enhancing the productivity of the country's mountainous regions is to improve their access to the local and regional markets. In these areas, farm produce have to be manually carried on their backs as they traverse the treacherous terrain of the mountainous slopes to the nearest road accessible by vehicle that can transport them to the nearest market centers. The farm inputs are brought up to these upland farms in the same way, manually. With this manual system, the cost of transporting the farm produce to the nearest road ranges from 20 to 30 percent of the value of the produce (Paz, 2003). On the other hand, the cost of transporting production inputs from the nearest road to the production areas ranges from 30 to 50 percent of the cost of inputs, depending on the distance.

The findings of Edmonds (2002) shows that the cost of moving products and inputs between the farm and market significantly affects decisions on farm land use and production decisions such as cropping intensity and application of fertilizers. The higher the transport costs, the less likely that the farms would intensify their cropping as well as utilize greater amounts of production inputs such as fertilizers. This is especially significant during the peak season of harvest and farm operations when farm labor is scarce.

To address this problem, the Department of Agriculture (DA) through the Agriculture and Fishery Modernization Program (AFMP) invested in additional transport infrastructures such as FMR's and in year 2000 on tramline transport facilities in remote areas that cannot be accessed by road networks. The tramline technology utilizes a series of steel cables, pulleys and post structures to carry products from the farm to the road accessible by vehicle (Fig. 1). The facility is easy to construct since most of its parts use locally available materials.

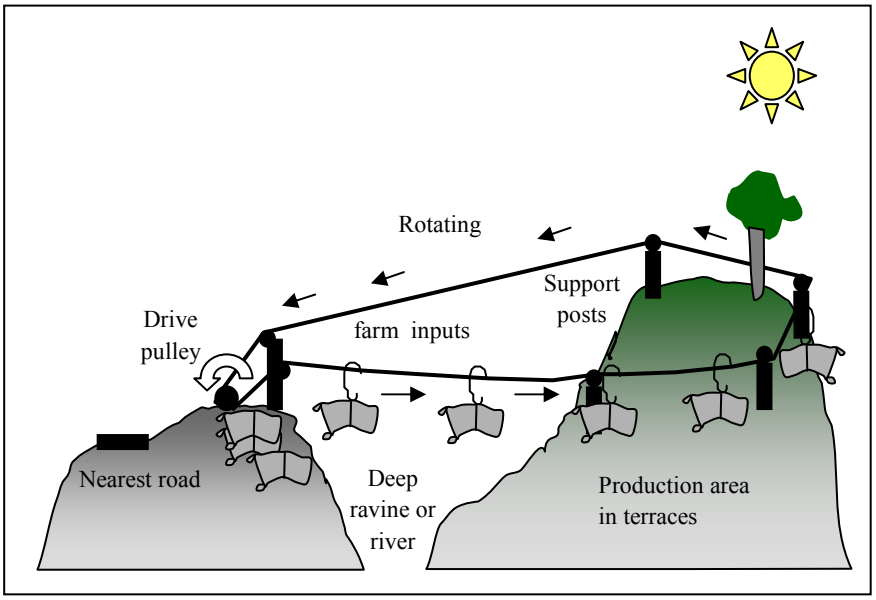

Fig. 1. The tramline facility used for hauling production inputs from the road to the production area.

The history of the tramline is very obscure, but apparently the first installation was made in Germany. Countries like Jamaica, Mauritius, Guatemala, Australia utilizes tramline (popularly known as ropeway in some countries) for the transport of agricultural products like fruits (like bananas), cereals (like wheat), and other plantation produce like cotton, tea-leaf or sugar cane. These goods

were mostly transported from the fields to a mill or railway station. Tramlines were in use on sugar plantations for the delivery of canes to the crushing mills (Low Tech Magazine, 2011). In Nepal, where 83 percent of the total land area is covered by mountains and hills, small farmers living in the hilltop and untouched by commercial means of transport and majority of their time and energy is spent on transport, tramline is the most advanced means of transportation (Singh, 2010). With high transportation losses, shortage of young working manpower in the village, migration of young people toward cities, among others, tramlines became an essential infrastructure and was also included in the list of infrastructure projects for climate change mitigation (Adhikary, 2007). In the Alps, people use simple cable-cars to transport supplies and agricultural products to and from remote farms (Mais, 2011).

In the Philippines, tramlines were first used in mining, logging and lately in agriculture. Some of the small-scale mining operations such as the Kias Gold Mine in Benguet used tramlines for ore transport. In logging operations, tramlines were used for wood harvesting. In agriculture, tramlines were used for hauling agricultural commodities such as fruits, bagged grains, vegetables and farm inputs (Dela Cruz *et. al*, 2000). Tramlines have great advantage over most methods of transportation where products have to be transported over long distances in areas where the topography is extremely rough or slopes are steep. It is also more environment-friendly relative to other access infrastructure such as FMR because the natural physical condition of the area is not altered during its installation. T he vegetation need not be cut or cleared as long as the structures are strategically positioned and selected. In Benguet province with its rugged terrain, tramline facilities have been effectively and popularly employed for hauling of production inputs and vegetable produce.

According to Ramos (1998), 70 percent of 137 farmers surveyed in Benguet utilized the tramline facility to haul the requirements of their farms. Although there are limited studies or documentations available about this technology, it is believed that the majority of the tramline facilities in the country today emanated from the Benguet province. Miners and loggers in the province who were displaced from their work because of log bans and closure of mining operations shifted to farming and custom-designed the tramline facility for use in agriculture. From year 2000 to 2004, a total of 15 tramline facilities were installed in selected mountainous areas of the country under the AFMP. In 2007, another batch of tramlines consisting of 12 units worth approximately P15M were also installed.

Idago, *et.al* (2009) determined the financial and economic viability of installing tramlines in the mountainous areas of the country to transport farm inputs and products. The findings of the study show that while the financial returns to such an investment is not sufficient to make it a viable private investment, the economic returns of 33% are sufficiently high to make it a viable public investment.

This paper discusses the potential of tramlines for enhancing the productivity in the mountainous uplands as they affect land use patterns, cropping intensity and level of fertilizer use in these areas.

RESEARCH METHODOLOGY

Theoretical Framework

The theoretical foundation of the paper is anchored in Von Thunen's rent theory. Rent theory states that the use of land is a function of the cost of transport to the market and the land rent a farmer can afford to pay. The rent theory highlights the influence of location and transportation cost in influencing spatially explicit economic activities. This is illustrated in Figure 2 showing the relationship of land rent generated by the same piece of land at varying distances from the nearest

market. Production of crops, say crops *i* and *j,* would yield different amounts of land rent. At distance less than D1, it will be profitable to produce crop *i* since it will yield higher rent compared to producing crop *j*. At the intersection, crops *i* and *j* would yield equal amounts of rent. Beyond the distance of D1 up to distance D2, it is more profitable to produce crop *j* since it will yield higher rent than crop *i*. Beyond distance D2, neither of the crops *i* and *j* would generate any land rent.

Based on this theoretical framework, provision of a tramline facility that lowers the cost of transporting products will have a direct influence on the choice of land use, cropping intensity and level of input use. It is hypothesized that farmers will use the land for the activity that will generate the highest rent (or profit) given the farmgate input and output price.

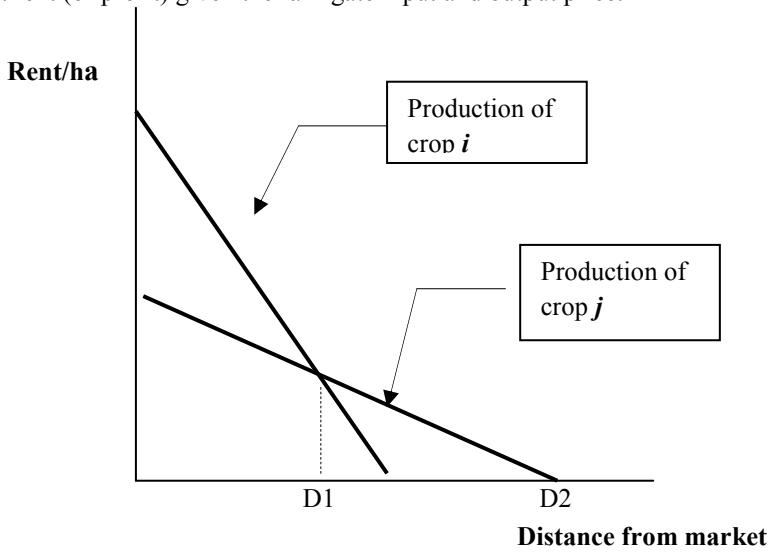

Fig. 2. Bid rent function of two different agricultural activities at the same piece of land.

Analytical Framework

The study draws from the works of Edmonds (2002) and Nelson (2001) that recognized socioeconomic and biophysical attributes as the major determinants influencing land use and production decision. Land use, in this paper, is aptly described as the purpose to which the land is committed. Examples of land use would include crop production, pasture, idle/fallow, forest and their relative allocations in a given area. Production decision, on the other hand, refers to the choice by the landowners on the types of crops grown, cropping pattern, cropping intensity, rate of fertilizer application, purpose of production and rate of capitalization. The production system thus can be considered as a function of the land use and production decision.

Without the tramline facility, farmers are limited in terms of the kinds of upland crops that they could grow economically. It is expected that the production system will change with the introduction of the tramline facility that will provide a more efficient mode of transport over the existing manual method of transport.

The area devoted to crop production is expected to increase with the introduction of the tramline facility due to the reduction in the cost of transport of products as shown in equation 1 as follows:

$$LUc = f(t, B, S) \ldots. \quad \text{equation 1}$$

where:

LUc = land use for crop production
t= transport cost of products to and from the farm
B= vector of biophysical characteristics
S = vector of socio economic characteristics

and $\partial LUc/\partial t < 0$;

Any reduction in the cost of transport increases the level of profit and encourages the increase in the area devoted to crop production. In the same way, the level of fertilizer use also increases with the reduction in the cost of transport and consequent increase in area devoted to crop production. This is shown in equation 2 as follows:

$$'FU = f(t, p, B, S) \ldots. \quad \text{equation 2}$$

where:

FU = fertilizer utilization
t = transport cost
p= market price of fertilizer
B= vector of biophysical characteristics
S= vector of socioeconomic characteristics

and $\partial FU/\partial t < 0$;

The Study Areas

The study was conducted in the municipalities of Atok and Buguias, the top two vegetable producing municipalities of Benguet that have the most number of tramlines. Atok is a vast farming community located 44 kms. away from Baguio city. It is the top producer of potato *(Solanum tuberosum)*, in the province given its high elevation and cool climatic condition. Buguias is also a vast farming community in the northern part of the province located 88 kms. from Baguio City. It is considered as the top producer of temperate vegetables such as cabbage *(Brassica oleracea)*, carrot *(Daucus carota)* and lettuce *(Lactuca sativa)*. The province produces 64 percent of the vegetables in the Cordillera Administrative region.

Majority of the tramlines in Benguet were put up with government funding because of the high cost of installation. These facilities are managed and operated by their direct beneficiaries. To sustain its operation, the revenue generated from the toll is used to cover for the cost of operation and maintenance. These facilities are generally located in areas that are intensively cultivated for crop productions but have no access to transport facilities.

Sampling and Selection of Respondents

Cross-section data covering two cropping seasons, the wet and dry seasons, were collected from two groups of farmers:

a. Farmers "without" access to tramline facility referring to remote farms that utilized only manual methods of transport from production to hauling of produce.
b. Farmers "with" access to tramline transport facility referring to remote farms that utilized tramline transport facility for hauling their products.

The respondents for the "with" and "without" scenarios were taken from the same location where all factors such as sociocultural (income, production system, crops planted, etc.) and biophysical (topography, distance, slope, etc.) conditions can be assumed as constant except for their

access to the tramline facility. A single tramline facility, on the average, serves an effective area of about 7 to 10 hectares and can be adjacent to farms that practice manual transport.

A total of 180 respondents were covered by the study, 90 respondents representing "with" and 90 respondents representing "without" tramline facilities. The respondents were selected through purposive sampling.

Methods of Analysis

The study compared two types of remote production areas wherein the only difference characterizing these locations is the presence or absence of tramline described in this paper as the "with" and "without" scenarios. T test was employed to determine if there are significant differences in cropping intensity, land use, rate of inputs utilization and average yield.

Regression Analysis

Regression analysis was used to determine the factors influencing the percentage of land used for production, the cropping intensity, rate of input utilization and average yield. It was hypothesized that the presence of the tramline transport facility as well as the percentage of farm irrigated, size of farm, number of family labor, annual household income had positive influences on these dependent variables. In contrast, the distance of farm to nearest road was hypothesized to have a negative influence on these dependent variables because of its effect on transport cost.

Land use model

Land use for crop production *(LU)* is measured as the percentage of total land area that is used for production of crops. Selected socioeconomic (years of farming, annual household income, agriculture-related trainings, numbers of family labor) and biophysical (tramline, farm size, percent farm irrigated) factors are hypothesized to have a significant influence on *LU*. The land use model is specified as:

$$LU = \alpha + \beta_1 T + \beta_2 I - \beta_3 d + \beta_4 s + \beta_5 H + \beta_6 tr + \beta_7 L + \mu$$

*w*here:

$LU \approx$ Percent of land used for crop production
$\alpha \approx$ constant
$T \approx$ tramline dummy; 1=with; 0= without
$I \approx$ land serviced with irrigation facility, in percent of total area
$D \approx$ distance of farm to nearest farm-to-market road, in meters
$S \approx$ size of farm, in hectares
$H \approx$ total household income per year, in pesos
$tr \approx$ no. of agricultural-related trainings attended
$L \approx$ number of family labor
$\mu \approx$ error term

Cropping intensity model

Cropping intensity *(CI)* is classified as either "intensive" or "less intensive". "Intensive" is defined as cropping two to three times a year. "Less intensive", on the other hand is defined as cropping only once a year. A logistic regression model is used given the binary dependent variable that takes a value of either a 1 or 0. The cropping intensity model is specified as

$$CI = \frac{1}{(1+e^{-z})}$$

where $z = \alpha + \beta_1 T + \beta_2 I - \beta_3 d + \beta_4 s + \beta_5 H + \beta_6 tr + \beta_7 L + \mu$

$CI \approx$ cropping intensity dummy;
1 ≈ highly intensive; cropped two to three times a year
0 ≈ less intensive; cropped once a year

Fertilizer utilization model

$$FU = \alpha + \beta_1 T + \beta_2 I - \beta_3 d + \beta_4 s + \beta_5 H + \beta_6 tr + \beta_7 L + \beta_8 C + \mu$$

where: $FU \approx$ fertilizer utilization, bags/ha/season @ 50kg/bag
$C \approx$ cropping season dummy
1 ≈ dry season ; 0 ≈ wet season

RESULTS AND DISCUSSIONS

Land Use

The results of the t-test shows that farms with access to tramline facilities cultivate more areas for crop production because the cost of transport is significantly reduced (Table 1). In the highlands where the average farm holding is very small, each small patch of land is considered very valuable so that given the opportunity, they will tend to maximize the use of these lands for crop production.

In contrast, farmers in hard-to-reach areas that have no access to transport facilities have little motivation to utilize their land for full production because of the drudgery and high cost of moving their products to and from their farms. When market price of the farm produce is very low, farmers would not even attempt to harvest their farm produce because the revenue from sales would not even be sufficient to pay for the transportation cost. The prevailing market price is very crucial for highly perishable temperate crops like cabbage, carrot and Chinese cabbage because these crops cannot be stored. Once these crops reach maturity, these have to be harvested and sold immediately. In contrast, farmers can store potato until they can get a more favorable price.

Table 1. Percent land distribution, with and without tramline transport facility, Benguet, 2008.

Land use type	With	Without	Mean difference
1. Crop production	84.96	43.48	41.49**
2. Idle/fallow	1.83	6.85	-5.03*
3. Forest	8.10	32.58	-24.48**

** significant at 1% level of significance
* significant at 5% level of significance

Factors Influencing Land Use

Land use for crop production *(LU)* is measured in percent of the total land that is used for production of crops. Result of the regression analysis showed that access to a tramline facility has a positive influence on *LU* while farm size has a negative influence (Table 2). Access to a tramline facility encourages land utilization for crop production because it reduces cost of hauling the farm produce to the market. On the other hand, farm size has a negative influence on LU because of the scarcity of farm labor. With most farm operations in the uplands done manually, the area that a farmer can cultivate is limited. The bigger the farm sizes therefore, the smaller the percentage of the area that can be cultivated.

The other factors such as the years of experience in farming, agriculture related trainings, household income, and other factors did not influence *LU*. The model is significant given an adjusted R^2 value of 0.60.

Table 2. Result of the regression model for land use, Benguet, 2008.

Predictors	Coefficients	Std. error
Constant	-132.94 ns	78.52
Tramline dummy	50.78***	10.11
Years of exp in farming	-1.55 ns	2.15
Annual household income	0.001 ns	0.00
No. of agricultural trainings	2.37 ns	10.89
Farm size	-2.83**	1.37
No. of family labor	5.17 ns	5.97
Percent farm irrigated	0.05 ns	0.175

***significant at 1% level of significance
* * significant at 5% level of significance
ns not significant

Cropping Intensity

Result of the regression showed that access to a tramline facility has a positive effect on cropping intensity at the 10% level of significance (Table 3). This is also corroborated by the result of the t-test in Table 1 that shows that farms with access to tramline facilities cultivate more areas for crop production. Again, this is because tramline facilities reduce the cost of transport of both farm inputs and products. On the other hand, distance of farm to road has a negative effect on cropping intensity because of the increased cost of transport and the drudgery of moving agricultural products to and from the farm.

Table 3. Result of the regression model for cropping intensity, Benguet, 2008.

Predictors	Coefficients	Standard error
Constant	1.289ns	0.93
Tramline dummy	1.547*	0.91
Percent farm irrigated	0.036***	0.01
Distance of farm to road	-1.55ns	2.15
Annual household income	0.001ns	0.00

-2 Log Likelihood= 44.50
***significant at 1% level of significance
* * significant at 5% level of significance
* significant at 10% level of significance
ns not significant

Access to an irrigation facility has a positive influence on cropping intensity. Without irrigation, farmers cannot plant during the dry months and thus reduces cropping intensity. Annual household income does not have a significant effect on cropping intensity because the average household income is sufficient to finance farm operations and may not pose a significant constraint to intensifying cropping.

Fertilizer Utilization

Organic fertilizer utilization. Results show that the majority of the farms with access to a tramline tend to apply higher levels of organic fertilizer (Table 4). This may be explained by the fact that farmers recognize the advantage of applying organic fertilizers on their farms. However, the transport of organic fertilizers is expensive because it is bulky. The presence therefore of tramlines that reduce the cost of transport encourages farmers to apply the recommended amount of organic fertilizers. On the other hand, those without access to the tramline facility would apply inorganic fertilizer instead because it is less bulky. In the same way, distance of the farm to the market has a negative influence on use of organic fertilizer because of its effect on transport cost.

Table 4. Organic fertilizer utilization of farms "with" and "without" tramline transport facility for wet and dry seasons, Benguet, 2008.

Crops		Bags ha^{-1} season^{-1} "With"	"Without"	Mean Difference
1. Potato	Wet	191.65	122.07	69.58**
	Dry	184.45	150.81	33.64 ^{ns}
2. Cabbage	Wet	245.47	135.26	110.21**
	Dry	238.75	130.78	107.97**
3. Carrot	Wet	161.44	93.97	67.47**
	Dry	145.3	80.23	65.07**
4. Chinese cabbage	Wet	227.38	89.5	137.88**
	Dry	172.58	82.25	90.33 ^{ns}

** significant at 1% level of significance
* significant at 5% level of significance ns - not significant at 5% level

Factors such as the size of family labor, access to farm irrigation and household income have a significant influence on the application of organic fertilizer for some crops as shown in Table 5. Available family labor is important because it provides more work force to haul and apply fertilizer. The higher household income would also allow farmers to afford the cost of fertilizer.

The other predictors like household income, trainings attended, years of experience in farming, farm size, percent farm irrigated, number of family labor and cropping season did not have a significant influence on fertilizer utilization. Simply knowing that the application of fertilizer will increase productivity is not as important as the relative cost of transporting the inputs and products in or out of the area. The cost of transport and the drudgery seems to have greater influence in their decision to apply fertilizer. Hence, the presence of the tramline facility and distance of farm to road were significant factors affecting fertilizer utilization.

Inorganic fertilizer. Farmers apply a significant amount of inorganic fertilizer only on chayote and Chinese cabbage in areas serviced by tramline facility (Table 6). On the other hand, the amount of inorganic fertilizer applied to the other crops is minimal so that there is no significant difference in inorganic utilization between those farms with access and no access to tramline facilities. The small amount of inorganic fertilizer requirement can easily be manually transported to the farms.

Table 5. Factors affecting organic fertilizer utilization for various crops, Benguet, 2008.

Predictor	Crops			
	Potato	**Cabbage**	**Carrot**	**Chayote**
Constant	101.7**	171.0***	108.4***	82.92**
Tramline dummy	100.6***	62.09*	27.37	61.66***
Years in farming	1.0E-3	-2.0E-3	1.0E-4	-0.04
Household income	1.0E-3	2.0E-5	0.001	0.01
Trainings attended	-7.44	-1.48	-14.40*	-10.82
Farm size	3.98	12.11	2.98	2.11
Irrigation	-0.74**	0.35	0.11	-0.27
Distance of farm to road	-0.5**	-0.06*	-0.03**	-0.05**
Family labor	19.46***	-1.14	2.45	5.43
Cropping season	-1.46	-22.53	-5.89	

Notes: Chayote has no cropping season dummy because it is an annual crop.
***significant at 1% level of significance
* * significant at 5% level of significance
*significant at 10% level of significance

Table 6. Inorganic fertilizer application of farms "with" and "without" tramline transport facility for wet and dry season, Benguet, 2008.

Crops	Bags ha^{-1} $season^{-1}$		Mean difference
	"With"	**"Without"**	
1. Potato			
Wet	11.67	10.21	1.46 ^{ns}
Dry	13.37	12.73	0.64 ^{ns}
2. Cabbage			
Wet	15.77	11.35	4.42 ^{ns}
Dry	14.67	11.62	3.05 ^{ns}
3. Carrot			
Wet	9.06	8.92	0.14 ^{ns}
Dry	14.15	8.53	5.62*
4. Chinese cabbage			
Wet	25.61	10.40	15.21**
Dry	22.67	8.50	14.17**
5. Chayote			
	27.30	19.89	7.41**

** significant at 1% level of significance
* significant at 5% level of significance
ns – not significant at 5 % level of significance

Results show that the presence of the tramline facility does not have a significant influence on the application of inorganic fertilizer (Table 7). This is because inorganic fertilizer is not commonly applied in the small farm plots in the area.

Table 7. Factors influencing inorganic fertilizer application for various crops, Benguet, 2008.

Predictor	Potato	Cabbage	Carrot	Chayote
Constant	22.84	-0.90	5.34	18.35***
Tramline dummy	6.32	-0.81	6.16	6.98
Years in farming	-4.0E-3	-1.0E-3	-9.6E-5	0.33
Household income	2.0E-5	3.7E-5	2.7E-5	7.7E-5
Trainings attended	-4.74	3.96*	1.34	1.92
Farm size	1.31*	3.54*	-0.46	-2.04
Irrigation	-0.08	-0.01	0.01	-0.01
Distance of farm to road	-4.0E-3	0.01	-5.0E-3	0.01
Family labor	-0.48	-0.26	0.45	-1.57
Cropping season dummy	-0.90	-0.43	2.17	=

Notes: Chayote has no cropping season dummy because it is an annual crop.
***significant at 1% level of significance
* * significant at 5% level of significance
*significant at 10% level of significance

Influence of Tramline Facility on Crop Yield

The results in Table 8 shows that access to the tramline facility has a significant influence on yield of crops such as potato, carrot, cabbage and Chinese cabbage that are normally applied with organic fertilizer. The reduced cost of hauling provides an incentive for farmers to apply more organic fertilizer that result in higher productivity. In contrast, the amount of organic fertilizer applied to chayote is minimal compared to the above-mentioned crops so that access to the facility does not have a significant effect on productivity.

Table 8. Average yield of crops in farms "with" and "without" tramline facility, Benguet, 2008.

Crops	Yield, kg per season		Mean difference
	"With"	"Without"	
1. Potato			
Wet	17,389.53	9 194.36	8,195.17**
Dry	18,456.86	10,516.92	7,939.94**
2. Cabbage			
Wet	27,276.60	22,034.52	5,242.08ns
Dry	26,348.09	16,524.44	9,823.65*
3. Carrot			
Wet	18,243.25	9,465.06	8,778.19**
Dry	18,350.41	10,503.48	7,846.93**
4. Chinese cabbage			
Wet	33,983.33	12,738.18	21,245.15**
Dry	32,496.29	16,563.33	15,932.96*
5. Chayote	57,190.58	55,609.45	1,581.13^{ns}

** significant at 1% level of significance
* significant at 5% level of significance
ns – not significant at 5 % level of significance

CONCLUSION

The provision of tramline transport facility in the remote uplands has a strong influence on the type and intensity of land utilization. Farms with access to the tramline facility tend to be more intensively cultivated because of the ease of transporting farm inputs and products. In addition, the availability of irrigation water also influences cropping intensity.

The presence of a tramline facility has a positive influence also on the rate of use of organic fertilizer. In the uplands, more organic fertilizer is applied relative to inorganic fertilizer. However, organic fertilizer is bulky making its transport more costly and difficult because of the scarcity of manual labor. Tramline facilities reduce the cost of transporting farm inputs such fertilizers into their farms.

All of these findings collectively support the contention that provision of tramline transport facility in the remote uplands, not serviceable by FMR, is an effective and practical approach to increase productivity of the upland farms and enhance the utilization of the vast upland resources.

ACKNOWLEDGEMENTS

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THE NUMBER OF GRAFTED SCIONS AND REMAINING PRODUCTIVE BRANCHES AFFECT NEW SHOOT GROWTH AND FLOWERING OF SIDE-GRAFTED CASHEW (*Anacardium occidentale* L.)

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ABSTRACT

Two field experiments were conducted in Eastern Indonesia to test a new rejuvenation method for cashew trees. The first experiment was aimed at studying the effect of relative humidity on the growth of scions. A relative air humidity of 74.57% was found to give a 100% scion survival rate. The objective of the second experiment was to study the effects of two factors, i.e. the number of grafted scions per tree (one or two scions), and the number of productive branches remaining per tree (all, two or three productive branches) on new shoot length, number of leaves, and percent of flowers bearing fruits. The treatment combination of two scions grafted and two productive branches remaining resulted in the highest figures for new shoot length (24.85 cm), number of leaves (27.91 leaves) and percent of flowers bearing fruits (69.57%). The survival rate of scions grafted was 81.55 % at 210 days after grafting (DAG), and 75% of the new shoots flowered at 113 DAG. It was concluded that the side grafting technique of two scions combined with two productive branches remaining on the tree was the quickest and most effective technique to rejuvenate cashew trees. However, a longer term experiment is, however, required to study the possibility for restoring the productivity of trees older than 18 years old using this technique.

Key words: propagation, rootstock, rejuvenation, scions

INTRODUCTION

The island of Flores in the East Lesser Sunda Island (Nusa Tenggara Timur/NTT) province is one of the dry regions in Indonesia that has become a centre for cashew production. Cashew nuts are an important source of income for the farmers in the area. Government and other agencies encourage cultivation of cashew trees because of the high value of cashew in export markets and at the same time the trees have been valuable for conserving the environment. The cashew nut price in the world market (3.30 USD kg^{-1} in December 2010) has been promising along with the rising demand for cashew nuts (Paiva *et al*., 2009; Fitzpatrick, 2010). Cashew trees are drought resistant and adapted well to poor soil conditions. However, the average production per tree in the area is approximately 3.0 kg (0.6 ton ha^{-1} $year^{-1}$), which is low compared to production averages of over 1 ton ha^{-1} in other cashew-producing countries such as India, Vietnam, Australia, Tanzania and Nigeria (Martin *et al.,* 1997).

The productive age of cashew trees varies between 25-30 years, depending on soil fertility and crop management practices (Cahyono, 2001; Anonymous, 2006; Asogwa *et al.*, 2008). The age of

many cashew trees on the island of Flores is more than 30 years (these were planted in 1980), with a very high tree density (more than 250 trees ha^{-1}, spaced at 3m x 3m, or 4m x 4m), and with almost no fertilizer (organic or inorganic) applications. These factors have probably contributed to the low yields. Moreover, the farmers have never used superior cashew seed and use only simple technologies, such as soaking seeds in water for the selection of local seeds, and weeding at the beginning of planting and harvest seasons (Zaubin and Daras, 2000). Rejuvenation of old trees using the conventional method of thinning and direct seed planting is expensive and time consuming. These two methods are not preferred by the farmers due to extremely long time required (two years) for production.

A side-grafting technique which has been applied on cocoa has successfully rejuvenated trees and restored the production (Prawoto, 2007). Side grafting for cacao rejuvenation was introduced in Indonesia in 2004, and adopted by cacao farmers from 2007 onwards. Prawoto (2007) also reported that the survival rate of scions grafted could reach 80% in average air temperature of 27.7^{o}C and relative humidity (RH) of 76.23% in Jember area, East Java, Indonesia. Based on the success in cocoa, the technique is expected to be potentially used for rejuvenating cashew trees. However, the drier environmental conditions (higher air temperature and lower humidity, lower rainfall and soil moisture content) may become constraints in applying the technique on cashews, particularly in drier areas of Flores. The higher population density per hectare, and the close plant spacing will create unfavorable microclimates which may limit the growth of productive branches below the canopy, due to higher competition for growth factors and assimilates. In order to reduce such competition and to increase productivity of cashews, favorable microclimates have to be provided by pruning and maintaining a certain number productive branches. Retaining too many or few branches on a tree may result in poor growth and finally the productivity of the new shoots, which are associated with competition for growth factors as well as for assimilates (Ohler, 1979).

The research was conducted in two stages. The first experiment aimed to study the effect of plastic cover on the success of side-grafting. In this experiment the effect of relative humidity on the survival rate of grafting on the rootstock in the field was studied. In the second experiment, the effect of the number of scions grafted and the number of productive branches that remained on the tree was studied on several variables measured. Research reports on cashew rejuvenation using side-grafting technique and the effect of pruning is limited. The objective of the overall study was to determine the optimum combination of number of scions grafted and number of remaining productive branches for the success of cashew rejuvenation.

MATERIALS AND METHODS

Sites and time of experiments

Two field experiments were conducted in the cashew growing areas in Lewobele Village, East Flores Regency, NTT province, Indonesia. The first experiment was conducted in the period of February-April 2010, and the second experiment was carried out from May to December 2010. The two experiments were conducted on sandy clay soil with pH of 5.10, located at an elevation of 300 m above sea level with an annual rainfall of 1,850 mm (Anonymous, 2010). The relative humidity (74.57-79.58%) and with an average air temperature (between 31.23-32.13^{o}C) were directly measured at the experimental location.

Grafting materials

A total of 72 cashew trees, 18 years old (MPF-1 yellow variety) were used as rootstocks (P) and 100 healthy scions (S), originating from the centre nursery (MPF-1 red variety), were the

materials for grafting (Anonymous, 2008). The age of 18 year-old rootstock was determined based on the total carbohydrates content and the concentration of the growth hormones auxin, cytokinin and gibberellin in the rootstocks and scions (endogenous plant hormone analysis) and on an identification survey of 67 farmers of the cashew organic group of Lewobele Village. The criteria for the scions were cashew tree branches with circumferences of 5-10 cm; scions with five buds, green-brown color; growing healthy and with no signs of pest or disease incidence.

Endogenous plant hormone analysis

Laboratory analysis was performed at the beginning of the research to determine the total carbohydrate content, and the concentration of the growth hormones auxin, cytokinin and gibberellin in the rootstocks and scions. Six rootstock samples were taken at 60 cm from the base of the stem, the outer layers were sliced away until the wood layer was visible. A dry weight of 7.2 grams was sent to the laboratory for the analysis of hormone content. The sample was taken randomly from the scions selected as grafting material. A similar sample was used for the carbohydrate analysis.

Samples (of scions and rootstocks) were extracted in 100% methanol, for volumes of 40 ml and 10 ml. The methanol solution was then concentrated to 80% through evaporation, so that only 40% of the initial volume remained. Aquabidest was added to this solution so that the methanol concentration became 60% with a pH of 2.5. Three partitions were made afterward, each of which using a volume of 15 ml of ethyl acetate. The ethyl acetate fractions were collected and three partitions were made with 5% $NaHCO_3$, each time with 15 ml. The water fractions were collected, and their pH brought to 2.5, after which another three partitions of 15 ml were made with ethyl acetate. The ethyl acetate fractions were collected and evaporated until dry. The sample was then diluted with 1 ml of methanol, and analyzed by High Performance Liquid Chromatography (HPLC) (Waters 515 HPLC pump, Waters Corporation USA). The HPLC conditions were column (C_{18}), 250 mm x 4.6 ID, with a temperature of 25 + 0.1^{o}C. The sorting by isocratic elution was done with a flow rate of 1 ml minute^{-1}. Hormone signaling components were monitored at a wavelength of 254 nm and a mobile phase of acetonitrile: water (30:70%, v/v) containing 30 nM phosphoric acid on pH of 4. The hormone standard used for the analysis was auxin 200 ppm (Merck, Germany), gibberellin 100 ppm (Merck, Germany), cytokinin 100 ppm and abscisic acid 300 ppm (Sigma, Germany).

The total carbohydrate test was performed using the method of SNI 01-2891-1992, which was an analysis using the method of Luff-Schoorl (Manikharda, 2011; Brooks *et al*., 1992).

Analyses of plant hormones were conducted at the laboratory of plant physiology of the Faculty of Biology, at Gadjah Mada University (Yogyakarta), while the analysis of total carbohydrate percentage content was carried out in the analytical laboratory of Udayana University.

Soil analysis

Soil samples were taken at the research location, at the beginning and at the end of the research, and were both analyzed in the soil laboratory of the Bogor Agriculture University and in the laboratory of chemistry and soil fertility of Sebelas Maret University, Surakarta. The methods used for soil nutrient analysis were as follows; The Kjeldahl method was used to determine the total N while P was extracted using Bray-1 and analyzed using UV 660 nm spectrophotometer. Potassium and organic C, were analyzed using the Walkey & Black method and NH_4OAc at pH of 7.0 and SNI 13 6974 -2003, respectively and the pH analysis was performed using the SNI 06-6989.11-2004 method (Sulaeman *et al*., 2005; Anonymous, 2004).

Treatments and experimental designs

Randomized complete block designs (RCBD) were used in these experiments. Three block stratas were established due to differences in slope of the farm : block 1 (slope was less than 20%); block 2 (slope was more than 20%; and block 3 (was the plateau area, which was located about 25m above the block 1 area).

The first experiment studied the effect of relative air humidity around the scions on the success of the grafting. A clear plastic sheet (a transparent plastic of 0.1 mm thickness, 50 cm wide and 150 cm long) was used to cover the scion grafted area on nine cashew plants (rootstocks), while graftings on the other nine plants were left uncovered. Plastic covers were placed on the cashew trees at 150 cm height from the ground. The effect of humidity on grafting survival rate was compared between the two different conditions. The plastic covers were removed at 30 days after grafting (DAG). All treatments were replicated three times.

The second experiment studied the effect of two factors (i.e. the number of scions grafted per tree, and the number of productive branches remaining on the trees) on the survival and growth of new shoots that emerged from the grafting. The two factors were factorially arranged in a randomized complete block design. One scion (S1) and two scions (S2) were grafted per tree, and all (P1), only two (P2), three (P3) productive branches remained on the tree.

A healthy productive branch would have a circumference of 25-40 cm, leafy and grow laterally. Non-productive branches were cut 10 days prior to the imposition of grafting treatments. All treatments were replicated three times. The treatments combinations are shown in Fig. 1.

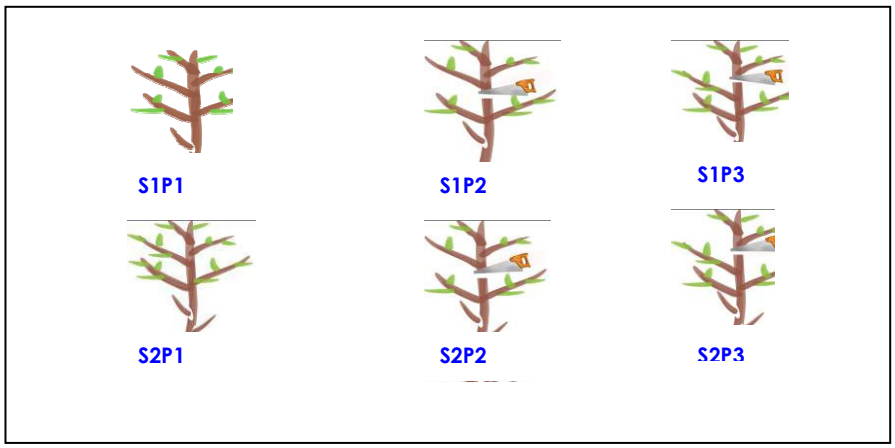

Fig. 1. Model of treatment combinations

One scion (S1) or two scions (S2) were grafted sideways on each rootstock. In the S1 treatment, the grafting position was at 60 cm above the ground. In the S2 treatment, the first grafting was positioned similarly at 60 cm above the ground while the second one was at 30 cm higher but at the opposite site to the first grafting. Both positions of grafting would allow scions to receive equal amounts of sunlight. No other treatments were taken to stimulate the growth of the scions.

Organic fertilizer (composted cow manure) was applied at 50 kg tree^{-1} in split application, half rate was applied at ten days before and after the experiment (harvest).

Data collection and analysis

Data were collected weekly, starting at seven days after grafting (DAG). The parameters observed were the number of new shoots and leaf emergence, the survival percentage of scions, flowering time of new shoots, the percentage of flowers, and flowers bearing fruits. Air temperature and relative humidity (RH) were directly recorded daily during the period of February-April 2010 in the first experiment, and during the period of May-December 2010 in the second experiment.

A *t*-test was conducted to determine the effect of grafting with and without plastic cover on the variables studied. The *t*-test formula is presented below (Pasaribu, 1981; Mangkuatmodjo, 2003):

$$t = \frac{\bar{x}-\mu}{s/\sqrt{n-1}} \qquad \text{With } s = \sqrt{\frac{\alpha(1-\alpha)}{n}} \qquad (1)$$

s = standard deviation
α = level of significance (set at 95%)
n = number of population

The null hypothesis for the analysis is that there was no effect of the plastic cover on the survival rate of the grafts. If the analysis shows that the null hypothesis must be rejected, it means that the plastic cover of the scions did have an effect on the survival rate of the grafts.

The data of the second experiment was analyzed using the software application of Minitab 15 for Windows (Anonymous, 2007). Duncan's multiple range test (DMRT) at 5% probability level was used for comparing means of each treatment combination (Gomez and Gomez, 2007).

RESULTS AND DISCUSSION

The survival rate of grafting, shoot and leaf emergence, relative humidity (RH) and air temperature for treatments with and without plastic covering at 60 days after grafting (DAG)

The plastic cover had no significant effect on the survival rate (success) of the grafting. The *t*-value for 5% probability was -2.79, which was lower than the *t*-value from the lookup table (2.89). However, the plastic cover did have significant effects on shoot and leaf emergence. The *t*-values were 5.57 (for shoots) and 17.51 (for leaves), which were higher than the *t*-value from the lookup table (2.89). There was a comparable survival rate of scions grafted without plastic cover (100%) and those with plastic cover (99%) observed at 60 DAG (Table 1). Shoots emerged two days earlier while leaves did seven days earlier on the uncovered graftings than those on covered ones. The breeze in the open air treatment might contribute to the slightly lower RH and air temperature and consequently favored grafting survival.

The quality of the scions (mature and healthy) and of rootstocks strongly determine the success of grafting through the appropriate unification between the two components (Suryadi and Zaubin, 2000; Anonymous, 2006; Usman, 2008). The success of side grafting in this experiment was indicated by rapid unification between scions and rootstock, which occurred one week after grafting.

The high compatibility between the healthy-mature scions and rootstocks resulted in rapid unification of grafting, was associated with more or less similar levels of total carbohydrates, endogenous plant hormones (auxin, cytokinin and gibberellin) both in the scions and rootstock (Table 2). The scions and rootstocks must have equitable levels of carbohydrates and the plant hormones in order to be compatible and to support new shoot growth (Babu and Lavania, 1985; Das *et al*., 1996; D'Silva and D'Souza, 1992; Leva and Falcone, 1990 and Lievens *et al*., 1989). The hormones auxin

and cytokinin in the scions stimulate the growth of new shoots and leaves, and gibberellin supports the growth of new organs (Leopold and Kriedemann, 1975; Salisbury and Ross, 1992). Fast unification is important due to its sensitivity to fungal infections causing the death of grafted scions (Nelson *et al*., 1955; Hartmann and Kester, 1975). In this study, the healed wound with the brown lump of sap appeared around the incision at 60 DAG, indicated high compatibility between the healthy-mature scions and rootstocks.

Table 1. Comparison of scions grafted with and without plastic covering on the time of new shoot and leaf emergence and survival percentage of scions, average relative humidity and air temperature measured at 60 DAG.

Variables measured	Scion grafted with plastic covering	Scion grafted without plastic covering (in open air)
Grafting survival rate (%)	99	100
Time of shoot emerging (DAG)	10	8
Time of leaf emerging (DAG)	22	15
Average of relative humidity (%)	79.58	74.57
Average air temperature (ºC)	32.13	31.23

Table 2. The auxin, cytokinin, gibberellin levels and total carbohydrate percentage in scions and rootstocks

Sample	Auxins (ng*)	Gibberellins (ng)	Cytokinins (ng)	Total carbohydrates (%)
Rootstock	7265	0.530	79.89	27.03
Scions	8277.5	undetected	539	27.83

ng*: nanogram

The condition of low rainfall (at an average of 188.87 mm) (Anonymous, 2010) during the period of this study contributed much on the wound healing process of grafting. Under high rainfall condition, infection could occur at the grafting site, as dirty water runs along the stem and gets into the incision, which could consequently delay the healing of the stem wound and prevent the unification. These results indicated that grafting could be safely done under open air, low rainfall conditions, moderate temperature and humidity. Oliveira *et al.* (2004) recorded 79.6% of success in citrus grafting, mainly due to active growth of the mother plant during March (moderate temperature of 32.4^{o}C to 36.4^{o}C and RH of 70.2%). Similar results were expressed by Teaotia *et al.* (1963) in jackfruit, Mulla (2007) in jamun (*Syzygium cumini* Skeels) and Ferraz *et al.* (1974), and Sahani and Patro (1985) in cashew.

Development of leaf and shoot growth

Leaf and shoot growth gradually increased from 30 DAG (at the early leaf formation) until 120 DAG in all treatments (Fig.2 and 3). The S2P2 treatment combination always had a higher average number of leaves and new shoots lengths compared to other treatment combinations. After 120 DAG the number of leaves and new shoot lengths of S1P1 and S2P1 treatment combinations only increased slightly, while those of the S2P2, S2P3, S1P2 and S1P3 treatment combination continuously increased. In this period (August-September 2010) the growth of leaves and shoots of S1P1 and S2P1

treatment combinations almost remained steady until 150 DAG (in September 2010) due to the beginning of flowering and fruit filling (Gardner *et al.* 1985). Those S1P1 and S2P1 treatment combinations with all productive branches remaining on the tree, which had more branches and leaves, might compete for assimilates, compared to the other treatments, particularly the S2P2 treatment.

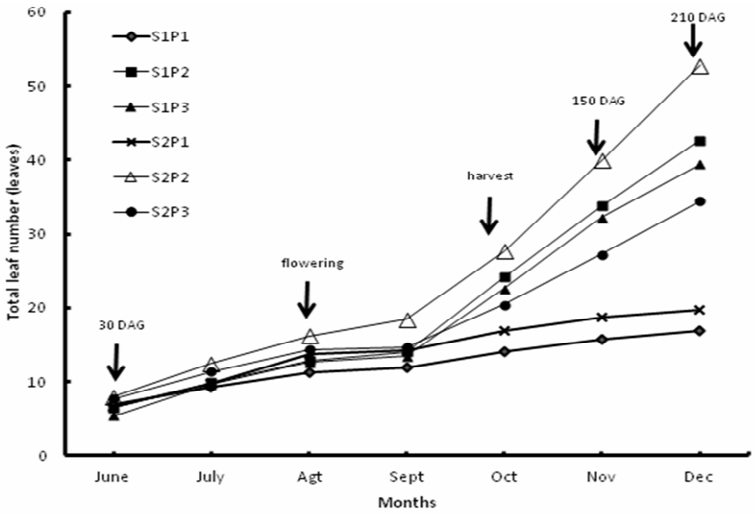

Fig. 2. Effect of treatment combination on number of leaves from 30 to 210 DAG

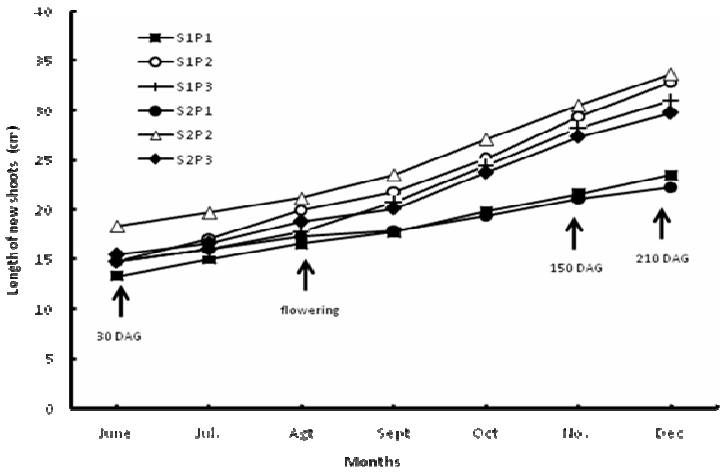

Fig. 3. Effect of treatment combination on new shoot lengths from 30 to 210 DAG

Further development of leaves and shoot growths occurred after the end of harvest (late September to the middle of October 2010). The growth of both components were always higher in the treatment combinations of S2P2, S1P2, S1P3, S2P3 compared to the other treatments until 210 DAG. Reduced competition for assimilates, sunlight interception through the canopy and lower RH might contribute to more rapid growth of the both components of three and particularly two productive branches remained on the tree.

At 135 DAG, the effects of interaction between numbers of scions grafted (S) and number of remaining productive branches were significant on the tree (P) on grafting survival rates, shoot and leaf emergence, flowering time and percentage of flower on new shoots (Table 3). The two scions grafted (S2) with the three treatments of maintaining productive branches on the tree (P1, P2 and P3) resulted in longer time of shoot emergence, time of flowering and higher percentage of flowers on new shoots compared to one scion (S1) grafted trees.

The survival of grafting were the highest (81.65% and 81.55%) on the treatments of both one and two scions grafted with two remained productive branches on the tree (S1P2 and S2P2), respectively. These high figures indicated that maintaining two productive branches on the tree created the most favorable microclimate for the grafting. The combination of two scions grafted and two remaining branches on the tree (S2P2), which resulted in earlier shoot and leaf emergence, may be associated with a more favorable microclimate. The survival rate of the grafts in this present experiment was significantly higher compared to that reported in India, where only 60-62% scions survived, grafted on three years old rootstocks under air temperature of 28°-30°C (Sahani and Patro, 1985); and 67.54% survived on four months rootstocks grafted under air temperature of 35°C and relative humidity (RH) around 50-87% (Sagar, 2007).

Table 3. The effect of interaction between number of grafted scions and productive branches remained on the tree at 135 DAG on shoot and leaf emergence, grafting survival percentage, time of flowering and flower percentage of new shoots.

Number of grafted scions	Productive branches remained on the tree		
	All remained (P1)	**Two remained (P2)**	**Three remained (P3)**
Variable: Shoot emergence (DAG)			
One (S1)	14.83[b]	10.00[d]	13.33[c]
Two (S2)	16.67[a]	10.67[d]	15.00[b]
Variable: Leaf emergence (DAG)			
One (S1)	17.17[b]	15.17[c]	16.17[c]
Two (S2)	20.67[a]	15.83[c]	17.83[b]
Variable: Grafting survival percentage (%)			
One (S1)	68.61[d]	81.65[a]	77.72[b]
Two (S2)	75.93[c]	81.55[a]	70.71[c]
Variable: Flowering time (DAG)			
One (S1)	121.83[b]	112.50[f]	116.33[d]
Two (S2)	125.17[a]	113.83[e]	119.83[c]
Variable: Percentage of flowering on new shoot (%)			
One (S1)	25.00[f]	50.00[b]	50.00[b]
Two (S2)	58.33[e]	75.00[a]	66.67[c]

Note: Figures followed by the same letter within the same variable are not significantly different at 5% Duncan Multiple Range Test (DMRT)

New shoots on the S2P2 treatment combination flowered much earlier (at 113 DAG) than the other treatment combinations and reached 100% flowering at 135 DAG. This was unexpected because normally using other cashew propagation techniques, flowering and fruiting only occur at least two years of propagation. During the present experiment period (May-December 2010), the air temperature and relative humidity (RH) recorded, were in the range of 26.08-30.28°C and 65.00-

71.18%, respectively. These moderate climatic conditions may have supported the growth of the scions.

Effects of treatment combinations on new shoot length, number of leaves and percentage of flowers bearing fruits

At 210 DAG, the effect of interaction between number of scions grafted (S) and number of productive branches remaining on the tree (P) on new shoots length, number of leaves and percentage of flowers bearing fruits were also significant ($p<0.05$) (Table 4). Grafting two scions with two productive branches on the tree significantly gave the longest new shoot length (24.85 cm), the highest number of leaves (27.91 leaves) and the higher percentage of flowers bearing fruits (69.57%) compared to the other treatments.

When all productive branches remained on the tree (P1), the new shoot length was significantly shorter and the percentage of flowers bearing fruits was lower compared to those when three or two branches remained. High competition for assimilates among all productive branches remaining on the tree, compared to only three or two of them left, may be the cause of those lower growth components. Better microclimates, sunlight in particular, due to the pruning of the branches, may favor the growth of new shoots, leaves and flowers to become more productive. Full sunlight promotes vegetative and generative growth of cashew trees (Ngaji, 2004). Climate conditions, such as air temperature (32.4-36.4^{o}C) and relative humidity (80-85%) were reported to determine the success of grafting propagation on cashew (Sagar, 2007) and on woodapple (*Fernia limonia* L.) (Naik, 2008).

Table 4. The effect of interaction between the number of scions grafted and the number of productive branches remaining on the tree on number of leaves, new shoot length and percent of flowers bearing fruit at 210 DAG

Number of grafted scions	No. of productive branches remaining on tree		
	All remaining (P1)	Two branches (P2)	Three branches (P3)
Variable: New shoot length (cm)			
One (S1)	17.45^{e}	20.35^{b}	19.80^{d}
Two (S2)	17.79^{e}	24.85^{a}	21.36^{c}
Variable: Number of leaves (leaf)			
One (S1)	13.47^{d}	19.29^{b}	16.41^{c}
Two (S2)	13.38^{d}	27.91^{a}	16.53^{c}
Variable: Flowers bearing fruit (%)			
One (S1)	39.04^{f}	53.56^{b}	46.75^{d}
Two (S2)	44.52^{e}	69.57^{a}	49.09^{c}

Note: Figures followed by the same letter within the same variable are not significantly different at 5% Duncan Multiple Range Test (DMRT)

The results of this present experiment were in fact much better than those of conventional propagation techniques used by adjacent farmers, particularly in terms of early flowering (135 DAG) compared to two years (Cahyono, 2001; Anonymous, 2006; Usman, 2008) and more fruits of new shoots (69.57%).

The results of soil analysis indicated that the application of organic fertilizers before the treatment imposed and after harvest, increased the C soil organic content from 1.32% to 2.29%, the C/N ratio and the soil pH from 17.48 to 11.29 and from 5.10 to 5.62, respectively (Table 5). Organic fertilizer increased soil organic matter of the sandy clay soil at the research location, which resulted in increased ability of the soil to bind water and cations, thus improving the soil structure and its biological activities (Hardjowigeno, 1987). The rise of the soil pH to relatively close to neutral value has probably increased the availability of P (as P_2O_5) in the soil (Grundon, 1999). The condition where more sunlight can reach the soil as several branches have been pruned (Gardner *et al.*, 1985), may have resulted in the increase of K (as K_2O) in the soil. These increases in P and K nutrients in the soil could contribute to the better growth of cashews in the present experiment.

Table 5. Soil nutrient content at the beginning and at the end of the research, at 210 DAG

Nutrient Contents at:	N total (%)	P_2O_5 (ppm)	K_2O (me %)	C organic (%)	C/N ratio	pH
The start of the research	0.14	5.93	0.13	1.32	17.48	5.10
The end of the research	0.23	7.63	0.41	2.29	11.29	5.62

CONCLUSION

The combination of two scions grafted and two productive branches remaining on the tree resulted in the best growth of new shoots, the earliest flowering and the highest percentage of flowers bearing fruits compared to the other treatments. The combination technique resulted in a high survival rate (81.65%) of grafted scions, new shoots started to flower at 113 DAG and complete (100%) flowering at 135 DAG (which was significantly faster than the two years to flowering when not using side-grafting techniques). The new technique also resulted in 69.57% of the flowers bearing fruits.

Side grafting has a high potential to be applied as a technique to rejuvenate cashew trees due to its simplicity and ease, provided the scions and rootstocks are healthy and compatible, and the climate conditions are favorable (air temperature and relative humidity in the range of 26.08-30.28^{o}C and 65.00-71.18%, respectively). However, longer-term of experiments are required to ensure that the technique can restore cashew productivity. The ages of rootstocks used in these experiments were 18 years old, but a research must be done to investigate whether similar results will be obtained when rootstocks older than 18 years are used.

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HAPLOID PLANT PRODUCTION THROUGH ANTHER CULTURE IN DAY-NEUTRAL STRAWBERRY *(FRAGARIA X ANANASSA* DUCH) CV. ALBION

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ABSTRACT

The overall goal of this study is to develop an anther culture system to produce haploid plant of day-neutral strawberry *(Fragaria x ananassa* Duch) cv. 'Albion' for use in breeding program. This study was conducted to optimize the effect of plant growth regulators (PGRs) on callus induction and plant regeneration. Moreover, we investigated the influence of three different callus age (1-month-old, 2-month-old, and 3-month-old) and three media (MS, B5, and H1) on plantlets induction. Anthers containing microspores at the uninucleate stage were produced the highest callus formation frequency (70.0%) on Dumas De Vaulx medium (C – medium) containing 0.4 mg L^{-1} benzyl adenine (BA), 0.1 mg L^{-1} 3-indole acetic acid (IAA), and 2.0 mg L^{-1} 2,4-Dichlorophenoxyacetic acid (2,4-D). The combination of 1 mg L^{-1} BA and 2 mg L^{-1} IAA in MS medium showed highest shoot regeneration (8.1%). Finally, 2-month-old callus cultured on B5 medium containing IAA and BA gave the highest regeneration rate (16.0%) and the roots were fully developed on hormone-free B5 medium after 2 months of culture. Cytological analysis of 33 regenerants showed that 6.0% were haploid (4x = 28 chromosomes), but 3.0% hexaploid (6x = 42), 69.7% octoploid (8x = 56), 6.1% doubled-octoploid (16x = 112) and 15.2% aneuploid plants were also determined.

Key words*:* uninucleate, callus age, plant growth regulators, shoot formation, haploid.

INTRODUCTION

The production of homozygotes is important both for genetic studies and hybrid seed production in highly cross pollinated crops. In fruit crops, high heterozygosity, long generation cycle with long juvenile period, large size, and often self-incompatibility do not allow the haploidization easily through the conventional methods (Germanà, 2006). *In vitro* androgenesis is single-step to produce haploid or double haploid plant from heterozygous origins (Srivastava and Chaturvedi, 2008).

The commercial strawberry (*Fragaria x ananassa* Duch.) is grown in the most arable regions of the world. It is a popular fruit eaten raw or used in making juice, desserts, jam, and wine. The cultivated strawberry is highly heterozygous (2n = 8x = 56 chromosomes) (Hancoock *et al*., 1996). Traditional breeding is labor intensive, costly and time-consuming (Owen and Miller, 1996). The production of haploid plants (n = 4x = 28) through anther culture is widely used for breeding purposes, as an alternative to the numerous cycles of inbreeding or backcrossing usually needed to obtain pure lines in conventional breeding (Debnath *et al*., 2007). Haploid plant production in strawberry has been attempted through anther culture (Niemirowicz-Szczytt *et al*., 1983; Owen and Miller, 1996), or through interspecific hybridization of diploids with two stages of colchicine doubling (Evans, 1977). Successful utilization of microspore-derived plants in strawberry breeding has not made much

headway owing to their very low induction frequencies, poor reproducibility and doubtful ploidy status. Quarta *et al*. (1991) obtained anther callusing at a frequency of 100% but failed to achieve haploid shoot regeneration. Niemirowicz-Szczytt (1990) reported plant regeneration from anther culture but regenerated plantlet was very few and most regenerants were octoploid. The regeneration of true haploids from cultured anthers in strawberry is often accompanied with production of polyploid or aneuploid plants (Quarta *et al*., 1991). On the other hand, this has yet to be achieved in fruit crops breeding since the development of gametic embryogenesis in fruit crops improvement is still hampered by low frequencies of embryo induction, albinism, plant regeneration, plant survival and the genotype dependent response (Germanà, 2006).

Concentrating on view the above limitations for high scale applicability of the technique, the present investigation has been undertaken with an objective to critical analyze some special factors which influence the anther response *in vitro* and enhance the haploid plant production through anther culture in day-neutral strawberry.

MATERIALS AND METHODS

Plant materials

Day-neutral strawberry cv. 'Albion' plants were maintained at Kangwon National University, Kangwon, South Korea, and used in this study. Flower buds (1.0 – 1.2 mm in length) with anther containing microspores at the uninucleate stage were collected and kept refrigerated at 4^{o}C for 4 days as a cold treatment (Na *et al*., 2009).

Anther culture and plant regeneration

After pretreatment, flower buds were disinfected with 70% ethanol for 15 seconds and 1% sodium hypochlorite for 10 minutes, followed by three times rinsing with sterilized distilled water. Media were autoclaved at 121^{o}C (108 kPa) for 15 minutes and pH of the media were adjusted to 5.8 prior to autoclave. 30 mL of medium was poured into each petri-dish (90 x15 mm) and Petri dishes were sealed by parafilm.

Anthers without filament were cultured on C medium (Dumas De Vaulx, 1981) containing 0.2 M glucose with four different concentrations of IAA (0.0, 0.1, 1.0 and 2.0 mg L^{-1}), five different concentrations of BA (0.0, 0.1, 0.4, 1.0 and 2.0 mg L^{-1}), and three different concentrations of 2,4-D (0.0, 0.4 and 2.0 mg L^{-1}) for callus induction and their combinations are given in Table 1 (Appendix 1). Twenty anthers were placed in Petri dishes. Each treatment was repeated five times (five Petri dishes), and arranged in a completely randomized design (CRD). Then anthers were incubated in the dark at 25^{o}C for two months.

Callus (compact and white-cream) were transferred to MS medium supplemented with 0.2 M glucose, and different combinations of BA (0.0, 0.5, 1.0 or 2.0 mg L^{-1}) and IAA (0.0, 0.5, 1.0 or 2.0 mg L^{-1}) for shoot regeneration. Ten callus were placed in Petri dishes. Each treatment was repeated five times (five Petri dishes), and arranged in a completely randomized design (CRD). Then callus were kept at 25^{o}C, 60 - 70% relative humidity under 16 h photoperiod and light intensity of 40 µmol m^{-2} s^{-1} provided by cool white fluorescent tubes.

The callus with different ages (1, 2, and 3-month-old) were subcultured on different medium: MS (Murashige and Skoog, 1962), B5 (Gamborg *et al*. 1968), and H1 (Owen and Miller, 1996) for shoot regeneration. All medium were contained 0.2 M glucose, 1 mg L^{-1} BA, and 2 mg L^{-1} IAA. Ten callus were placed in Petri dishes. Each treatment was repeated five times (five Petri dishes), and arranged in a completely randomized design (CRD). After that callus were kept at 25^{o}C, 60 - 70%

relative humidity under 16 h photoperiod and light intensity of 40 µmol m^{-2} s^{-1} provided by cool white fluorescent tubes.

In vitro rooting and acclimatization of anther-derived plants

All shoots obtained *in vitro* were rooted on hormone-free B5 medium for two months. Well-rooted shoots were acclimatized by removing them carefully from culture vessels. Agar clinging to roots was removed gently under running tap water. Plantlets were individually cultivated in plastic boxes (9 x 11 x 8 cm: width/length/height) with Canadian sphagnum peat moss (70%) + perlite + vermiculite (Berger Peat Moss, Canada). The boxes were covered with transparent plastic for 7 days and placed under reduced light intensity by covering with 50% shading net in a glasshouse used to maintain donor plants. After 2 months acclimatization, plantlets were subcultured to plastic pot (22 cm in diameter and 30 cm in height) with 'Plant World' commercial media (Nongwoo Bio, Korea) to maximize plantlet growth until flowers bloomed.

Ploidy levels determination

The cytology of all regenerants was evaluated by using the modified root tip chromosome counting with method described by Preeda *et al*. (2007) and Yanagi *et al*. (2010). The root tips were collected from anther derived plants in the early evening (around 5:00 p.m.), pretreated with 2 mM 8-hydroxyquinoline solution for 1 h at room temperature, and incubated at 4 ^{o}C for 15 h. The root tips were fixed in absolute alcohol-glacial acetic acid solution (3:1, v/v) for 40 min at room temperature, then softened by 1 N HCl for 2 h at room temperature and subsequently at 60 ^{o}C for 10 min, followed by brief rinsing in distilled water. The fixed root tip (2-3 mm) was placed on a glass slide (Paul Marienfeld GmbH & Co.KG, Germany) and digested using enzyme solution containing 4% cellulose Onozuka RS (Yakult Co. Ltd., Tokyo), 1% pectolyase Y-23 (Seishin Pharmaceutical Co. Ltd., Tokyo), 2.1% macerozyme R10, 0.07 M KCl, and 1 mM ethylene diamine tetra-acetic acid (EDTA) pH 4.2 at 42 ^{o}C for 40 min. After that, it was short-rinsed in distilled water and refixed in a drop of 3:1 acetic acid and ethyl alcohol at – 20^{o}c for 5 min, then spread by tapping with fine tweezers using a few drop of acetic alcohol (3:1), air-dried. After that glass slides were stained in the 4% Giemsa solution (Kanto chemical Co., INC) diluted with 1/15 M phosphate buffer (pH 6.8) for 3-5 minutes and rinsed briefly with distilled water, air dry. Chromosomes were observed at 10 to 60x magnification under a light microscope (Eclipse E400, Nikon, Japan). Well-spread chromosomes at the metaphase stage were captured using a 3CCD camera (Niko DS-U2/L2 USB) connected to a computer running NIS-Elements F3.00 software (Niko Corp.). Chromosome numbers were calculated from at least 5 cells per root tip of each different regenerants, i.e., haploid (4x), hexaploid (6x), octoploid (8x), doubled-octoploid (16x), and aneuploid

Chloroplast observation was carried out with the method described by Winarto *et al*. (2011). The abaxial epidermis of full leaves was carefully peeled off using a tissue culture blade. The epidermis was then placed on a glass slide with a drop of distilled water for at least 5 min and covered with 22 x 22 mm cover slip. Chloroplasts were calculated from ten guard cell pairs for each different regenerants under microscope at 40 to 60x magnification. Clear and informative chloroplast images were photographed using a 3CCD camera (Niko DS-U2/L2 USB) connected to a computer running NIS-Elements F3.00 software (Niko Corp.)

Statistical analysis

Analysis of variance and mean were calculated using ANOVA and LSD procedures from IRRISTAT 4.0. Standard errors were calculated using Microsoft Excel version 2007 for Windows Vista.

RESULTS AND DISCUSSION

Effect of plant growth regulator on callus induction

Anthers responses of 'Albion' were observed at 2 months after culture. Anthers produced the callus in all the auxin and cytokinin combinations except hormone-free treatment (Fig. 1a and b). The combination of 0.4 mg L^{-1} BA + 0.1 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D had produced the highest percentage of callus induction (70%), followed by combination of 1.0 mg L^{-1} BA + 1.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D, 2.0 mg L^{-1} BA + 0.1 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D, 0.1 mg L^{-1} BA + 0.4 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D, 0.1 mg L^{-1} BA + 2.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D with 65.0%, 58.0%, 45.0%, 43.0%, respectively. Likewise, the callus weight was highest (32.70 mg) in the same combination of plant growth regulators (PGRs). The hormone-free treatment gave the lowest callus induction rate (0.0%). Callus structures were also affected by the levels of auxin and cytokinin. The compact and white-cream to yellow-green calli were observed in the combinations of 0.4 mg L^{-1} BA + 0.1 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D and 1.0 mg L^{-1} BA + 1.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D (Fig. 2d and 2e). The soft, watery, friable, and brown calli were found in the combinations of 0.1 mg L^{-1} BA + 2.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D or 0.1 mg L^{-1} BA + 0.4 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D, or 2.0 mg L^{-1} BA + 0.1mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D (Fig. 2b, 2c, and 2f). In contrast, anthers which were cultured on medium free hormone failed to produce callus (Fig. 2a).

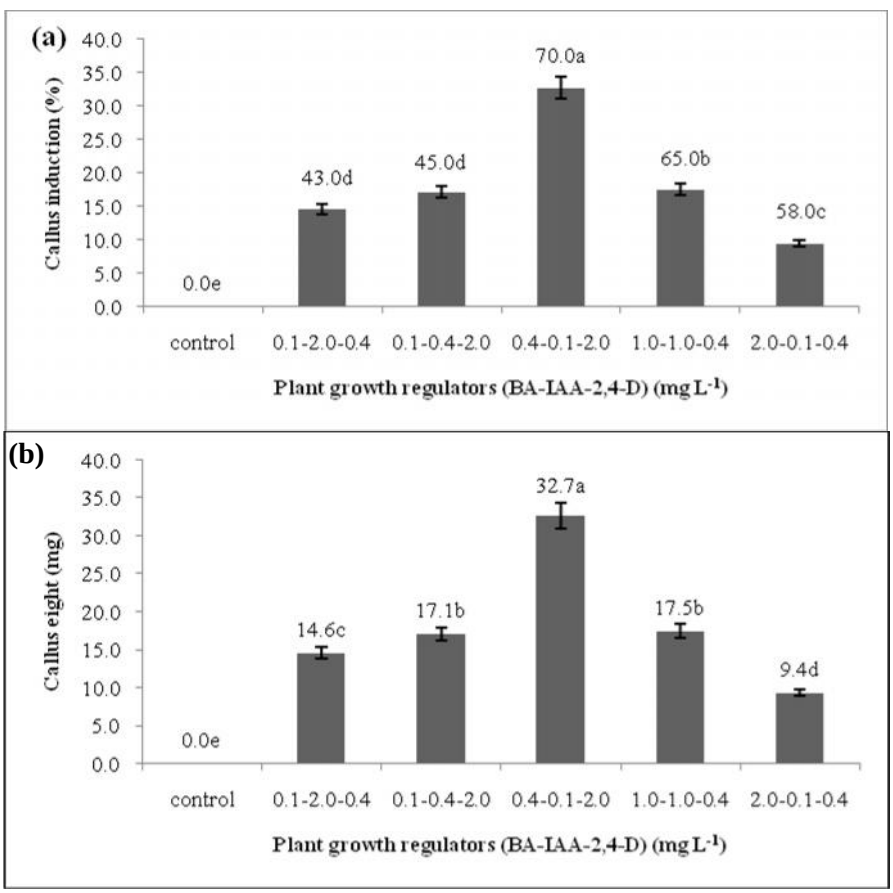

Fig. 1. Effect of plant regulators on (a) callus formation and (b) callus weight in day-neutral strawberry cv 'Albion', observed after two months. Values followed by the same are not significantly different ($P \leq 0.05$); Vertical bars represent ±SD (n = 5).

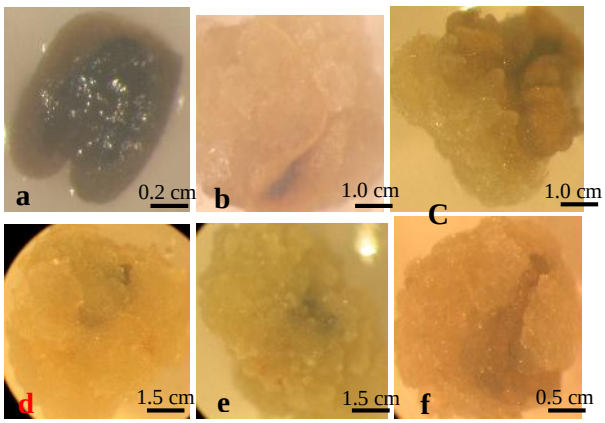

Fig. 2. Callus growth response on different auxin/cytokinin combinations two months after culture in day-neutral strawberry cv. 'Albion'
a. control: anther failed to produce callus, bar = 0.2 cm; **b**. 0.1 mg L^{-1} BA + 2.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D: callus growth response: grey white, soft, watery, and friable; c. 0.1 mg L^{-1} BA + 0.4 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D: callus growth response: brown, soft, and friable; **d**. 0.4 mg L^{-1} BA + 0.1 mg L^{-1} IAA +2.0 mg L^{-1} 2,4-D: callus growth response: compact, white-cream, largest volume; **e**. 1.0 mg L^{-1} BA + 1.0 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D: callus growth response: compact and yellow-green; **f**. 2.0 mg L^{-1} BA + 0.1 mg L^{-1} IAA + 0.4 mg L^{-1} 2,4-D: callus growth response: soft, watery, brown, small volume

Niemirowicz-Szczytt (1990) reported that a combination of 0.4 mg L^{-1} BA + 0.1 mg L^{-1} IAA + 2.0 mg L^{-1} 2,4-D was good for inducing callus in strawberry anther culture and was similar to this results. Jiajun and Kai-hua (2008) reported that MS medium supplemented with 2.0 mg L^{-1} BA + 1.0 mg L^{-1} 2,4-D produced higher callus in strawberry cv. 'Dajiangjun' than that of cv. Xiangfei. In the other hand, Perera *et al*. (2009) showed that combination of auxin and cytokinin is more beneficial than cytokinin alone for callus induction. They stated that kinetin and 2-Isopentyl adenine enhanced the production of callus when 100 μM 2,4-D which was presented in the culture medium for coconut anther culture. In this experiment, the response for callusing reduced as the level of BA increased (≥ 1 mg L^{-1}) and this finding was similar to those reported by Nehra *et al*. (1990). In contrast, Quarta *et al*. (1991) used only 23 μM kinetin in both solid and liquid media (GD medium) and received highest callus induction rate in strawberry anther culture. Markedly, genotypes were reported to play an important role in callusing response in *Gentiana triflora* (Doi *et al*., 2010) and *Carum carvi* L. (Smýkalová *et al*., 2009) although anthers were cultured in the same conditions and perhaps as Saji and Sujatha (1998) said the different callus response could be due to the presence of different level of endogenous hormones in sunflower anther culture.

Effect of plant growth regulator on plant regeneration

Various combinations of BA and IAA had a considerable effect on plant regeneration (Table 2 and Fig. 3). Out of seven combinations of hormones, the callus cultured on MS medium containing 2.0 mg L^{-1} IAA and 1.0 mg L^{-1} BA gave highest shoot regeneration (8.1%) and the number of shoot per callus (5.0). In the combination of 1.0 mg L^{-1} IAA + 0.5 mg L^{-1} BA, the regeneration frequency rate and number of shoot per callus were low (3.2%, and 1.1 shoots, respectively). Controversially, callus size increased in the media with 2.0 mg L^{-1} IAA + 0.5 mg L^{-1} BA without shoot occurrence (Fig. 3f). On the media without hormones (control) or 0.5 mg L^{-1} IAA + 1.0 mg L^{-1} BA or 0.5 mg L^{-1} IAA

+ 2.0 mg L^{-1} BA or 1.0 mg L^{-1} IAA + 2.0 mg L^{-1} BA, callus turned brown, and finally died (Fig. 3a, 3b, 3c, and 3e).

Table 2. Effect of different combinations of IAA and BA on callus response and shoot regeneration in day-neutral strawberry cv 'Albion', observed after two months

Plant growth regulators (mg L^{-1})		Types of callus	% shoot formation	No. of shoot per callus
IAA	BA			
0.0	0.0	Brown, slow growing	0.0c	0.0c
0.5	1.0	yellow	0.0c	0.0c
0.5	2.0	brown, necrotic, slow growing	0.0c	0.0c
1.0	0.5	green-red, fast growing	3.2b	1.1b
1.0	2.0	brown, slow growing	0.0c	0.0c
2.0	0.5	green, friable callus	0.0c	0.0c
2.0	1.0	green-red, fast growing	8.1a	5.0a

Values followed by the same letters within a column are not significantly different ($P \leq 0.05$); Duncan's Multiple Range Test (DMRT).

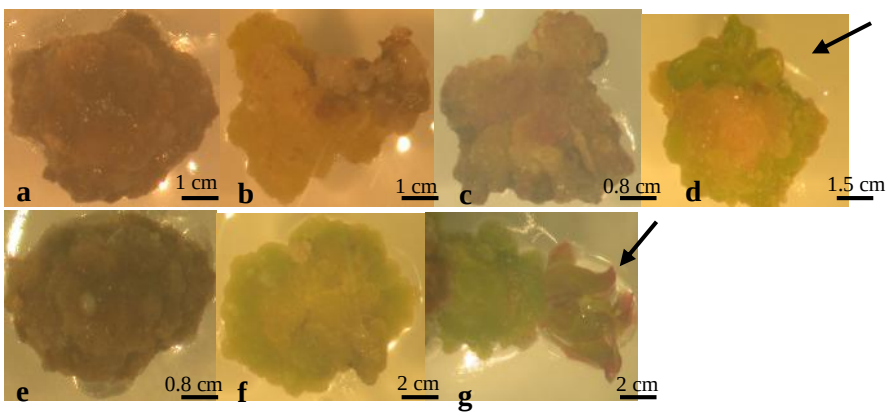

Fig. 3. Callus response on regeneration medium two months after culture in day-neutral strawberry cv. 'Albion'
a. control: callus turned to brown and gradually died; **b**. 0.5 mg L^{-1} IAA+1.0 mg L^{-1}BA: callus no increasing size and turned yellow; **c**. 0.5 mg L^{-1} IAA+2.0 mg L^{-1}BA: callus turned to brown and died sooner; **d**. 1.0 mg L^{-1} IAA+0.5 mg L^{-1}BA: callus turned to green, increased size, and appeared shoot; **e**.1.0 mg L^{-1} IAA+2.0 mg L^{-1}BA: callus turned to brown and died sooner; **f**. 2.0 mg L^{-1} IAA+0.5 mg L^{-1}BA: callus turned green and increased size; **g**. 2.0 mg L^{-1} IAA+1.0 mg L^{-1}BA: callus turned green, increased size, and appeared shoot; Arrow indicated shoot formation

A previous researcher had shown similar results with our study. Owen and Miller (1996) indicated that the best regeneration (8.0%) were obtained from MS medium containing 2.0 mg L^{-1} IAA + 1.0 mg L^{-1} BA in three American strawberry cultivars. Whereas, Savel'ev *et al*. (2010) reported that nine strawberry cultivars were produced 10% plant regeneration when callus were subcultured on MS medium supplemented with 2 mg L^{-1} BA and 1 mg L^{-1} IAA. Zhennan *et al*. (1995) highlighted the optimum medium for plantlet regeneration in anther culture was the MS medium supplemented with 2.0 mg L^{-1} BA + 2.0 mg L^{-1} Zeatin + 4.0 mg L^{-1} IAA which gave the highest shoot regeneration rate (40.0%). Nehra *et al*. (1990) also mentioned that the combination of 10 µM BA and 1 µM NAA showed better shoot regeneration with minimum callusing from immature leaf in day-neutral

strawberry cultivars. However, in the current experiment a shoot formation did not occur when BA concentration exceeds 2 mg L^{-1}. Na *et al*. (2009) reported that the highest shoot regeneration rate (23%) of strawberry cultivar, namely 'Sulhyang' was obtained when anther-derived callus were cultured on MS medium supplemented with 4 mg L^{-1} Thidiazuron (TDZ), whereas we failed this experiment (data not shown).

Effect of media and callus age on plant regeneration

The effects of various media cultured with different age of the callus on plant regeneration are given in Table 3 and Fig. 4. The effect of media on plant regeneration was highly significant ($P \leq 0.01$). Plant regeneration was highest (16.0%) on B5 medium and the lowest was in MS medium (5.0%). Effect of callus age on plant regeneration rate was also highly significant ($P \leq 0.01$). The shoot formation was highest (16.0%) at 2-month-old callus cultured on B5 medium followed by H1 medium at the same callus age (12.0%). Similarly, callus age significantly affected the number of shoot per callus ($P \leq 0.01$). Shoot number per callus was also highest (8.2) when 2-month-old callus was cultured in B5 medium (Fig. 4b and Fig. 4e). However, the shoot did not produce in both 1-month-old callus (Table 3, Fig. 4a and 4d) and 3-month-old callus, while the roots occurred in 3-month-old callus (Fig. 4f)

Table 3. Effects of media and callus age on shoot regeneration rate and shoot number per callus in day-neutral strawberry cv 'Albion', observed after two months.

Treatment	% shoot formation	No. of shoot per callus
MS		
1-month-old	0.0d	0.0d
2-month-old	5.0c	3.5c
3-month-old	0.0d	0.0d
B5		
1-month-old	0.0d	0.0d
2-month-old	16.0a	8.2a
3-month-old	0.0d	0.0d
H1		
1-month-old	0.0d	0.0d
2-month-old	12.0b	5.1b
3-month-old	0.0d	0.0d
Medium	**	**
Callus age	**	**
Medium x Callus age	**	**

**Highly significant at P = 0.01. Values followed by the same letters within a column are not significantly different ($P \leq 0.05$); Duncan's Multiple Range Test (DMRT).

The medium compositions also affected the plant regeneration efficiency in anther culture. Among three tested media (B5, MS, and H1), B5 medium showed highest plant regeneration. On this basis of revised medium, the different content of ammonium nitrate has been observed to be an important determinant for the success of anther culture. This finding was similar to previous studies such as Zhennan *et al*. (1995), and Owen and Miller (1996). Moreover, the media with lower ammonium nitrogen have also been found to be more suitable for rice, wheat and barley anther culture (Grimes and Hodges, 1990; Mordhorst and Lorz, 1993). On the other hand B5 medium has enhanced to be useful for plant regeneration from microspore culture in hot pepper (Kim *et al*., 2008).

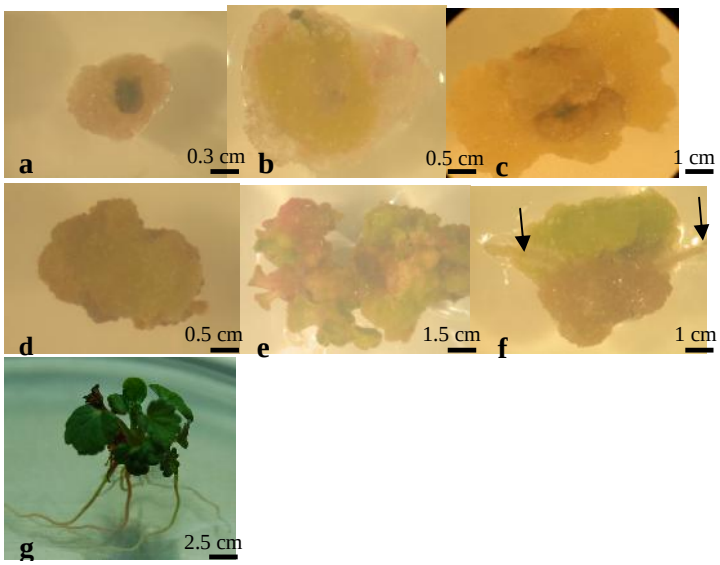

Fig. 4. Plant regeneration by different callus ages in day-neutral strawberry cv. 'Albion'
a.1-month-old callus: small volume, soft; **b**. 2-month-old callus: compact, green-yellow; **c**: 3-month-old callus: compact, yellow, large volume; **d**: 1-month-old callus after 2 months subculture, brown; **e**: 2-month-old callus after 2 months subculture, shoot formation; **f**: 3-month-old callus after 2 months subculture, root formation; **g**: plantlet on B5 medium without hormone 2 months after subculture. Arrow indicated root formation

Jiajun and Kai-hua (2008) indicated that the physiological condition and developmental stage of explants played an important role in regeneration. Naveed *et al*. (2009) reported that the highest plant regeneration frequency in wheat embryogenic-callus culture (95% by cv. 'Chakwal-97') was obtained from 26 days old callus, whereas 48 days old calli showed the lowest (13%). Decreasing of regeneration capability with increasing age of callus is a critical problem for callus maintenance and regeneration in *Miscanthus x giganteus* plant regeneration (Kim *et al*., 2010) and this finding was similar to our results. On the other hand, Singh *et al*. (2011) reported that the reduction of peroxidase activity can be highly correlated with increasing callus age and affected plant regeneration rate in *Narigi crenulata* (Roxb) culture. In strawberry, the plant regenerated from 8-week-old callus did not show any distinct morphological variants while a significant proportion of deformed leaf shape (6 - 13%) and yellow leaf (21 – 29%) was obtained among plants regenerated from 16 and 24-week-old calli (Nehra *et al*., 1992). In our own results, the 3-month-old callus was degenerated and formed roots (Fig. 3F) such as Niemirowicz-Szcytt (1990) reported.

Ploidy and cytological evaluation.

When evaluating cytology, the regenerants derived from anther culture had different ploidy levels: haploid, hexaploid, octoploid, and doubled-octoploid. The number of chromosomes in haploid was 28.3 chromosomes/cell, 41.6 for hexaploid, 55.8 for octoploid, 110.6 for doubled-octoploid, and 52.9 for aneuploid (Table 4 and Fig 5a; 5b; 5c). Variation in ploidy was confirmed by counting number of chloroplast in a stomata guard cell. Number of chloroplast per guard cell was 11.8, 17.4, 20.9, 34.9, and 19.1 obtained from haploid, hexaploid, octoploid, doubled-octoploid, and aneuploid regenerants, respectively (Table 4 and Fig 5d; 5e; 5f). The ploidy ratio of regenerants via anther culture of day-neutral strawberry was 6.1% haploid (tetraploid), 3% hexaploid, 69.7% octoploid, 6.1% doubled-octoploid, and 15.2% aneuploid (Table 4).

Table 4. Chromosome and chloroplast count of regenerated plants

Ploidy of regenerants	No. of chromosomes	Ploidy Ratio (%)	No. of chloroplast
Haploid (4x)	28.3 ± 0.58	2 (6.0)	11.8 ± 1.39
Hexaploid (6x)	41.6 ± 0.58	1 (3.0)	17.4 ± 2.02
Octoploid (8x)	55.8 ± 0.40	23 (69.7)	20.9 ± 1.81
Doubled-octoploid (16x)	110.6 ± 2.97	2 (6.0)	34.9 ± 3.27
Aneuploid	52.9 ± 1.76	5 (15.3)	19,1 ± 1.13

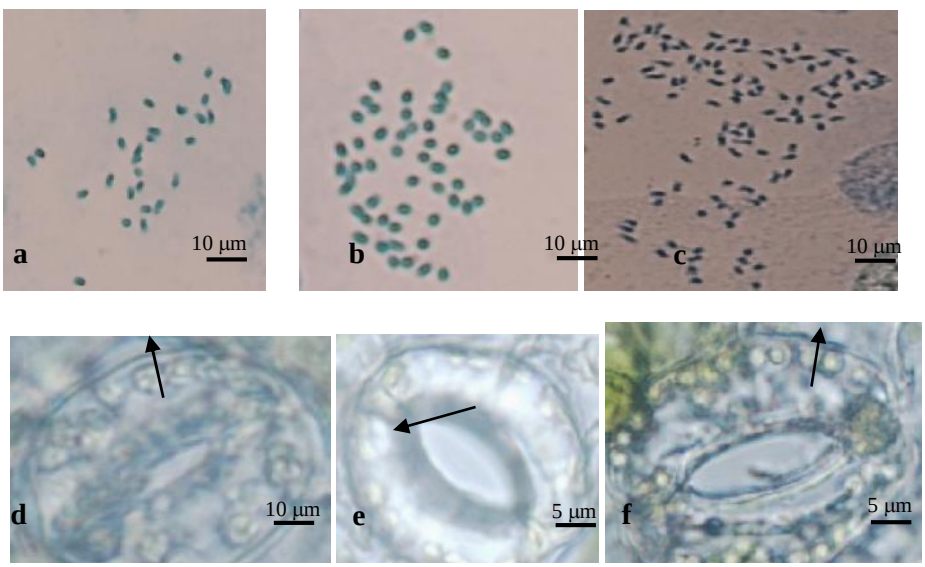

Fig. 5. Mitotic chromosomes in root tips cell and chloroplast in guard cell of regenerants derived from anther culture in day-neutral strawberry cv 'Albion'
a, **b**, and **c**: Metaphase chromosomes in root tips cell of haploid (n = 4x = 28), octoploid (2n = 8x = 56), and doubled-octoploid (2n = 16x = 112), respectively; **d**, **e**, and **f**: guard cell of haploid, octoploid, and doubled-octoploid plant, respectively. Arrow indicated the chloroplast

Different ploidy levels of regenerants also caused alteration in plant morphology. Haploid regenerants usually grew abnormally, flowers were smaller, and some of them had varied buds. Fruit size was smaller and most were reniform (Fig. 6d). Double-octoploid plants were bigger and had larger flower but no fruit set (Fig. 6f). Hexaploid or aneuploid has almost similar to octoploid plants (Fig. 6b-e). Morphological differences in some cases were also observed in leaf shape. Haploid regenerants had acute leaves, a serrate margin at terminal leaflet (Fig. 6a). A round leaf, crenate margin leaf, thick leaf, and strong glossiness leaf for double-octoploid (Fig. 6c)

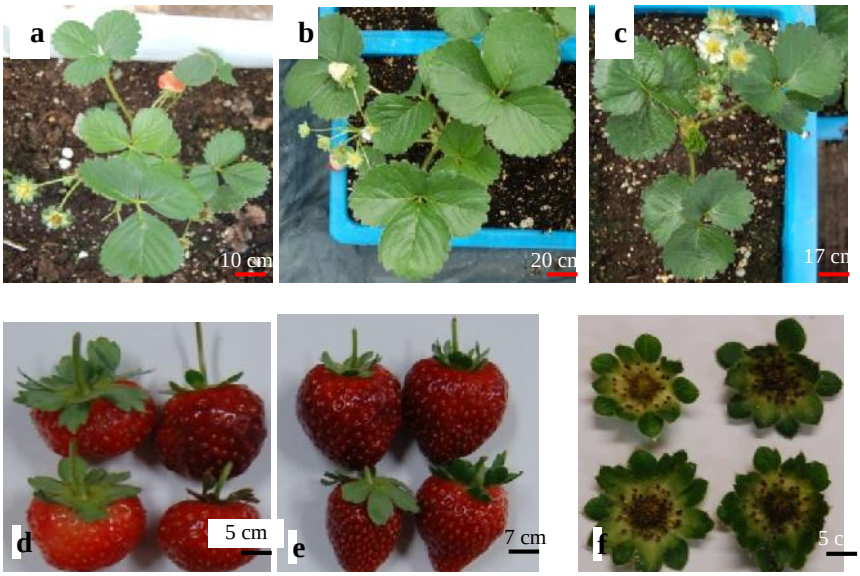

Fig. 6. Variation in leaf morphology and fruit shape among haploid (a and d), octoploid (b and e), and doubled-octoploid (c and f) plants.

CONCLUSION

In conclusion, our successful generation of plants from anther culture is mainly attributed to two key factors: (1) culture in B5 medium supplemented with 1 mg L^{-1} BA and 2 mg L^{-1} IAA, and (2) an optimization of callus age at 2-month-old. This protocol is simple, quite efficient, and rapid (haploid plants recovery within eight weeks). Further studies should be investigated the phenotypic characters of regenerants in field trails, and can be used in plant breeding and genetic studies also.

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Appendix.

Table 1. Different combinations of plant growth regulators used in the anther culture for callus induction

Plant growth regulators (mg L^{-1})		
BA	**IAA**	**2,4-D**
0.0	0.0	0.0
0.1	2.0	0.4
0.1	0.4	2.0
0.4	0.1	2.0
1.0	1.0	0.4
2.0	0.1	0.4

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BIOEFFICACY AND CHARACTERIZATION OF PLANT GROWTH-PROMOTING BACTERIA TO CONTROL THE BACTERIAL WILT DISEASE OF PEANUT IN INDONESIA

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ABSTRACT

The use of bactericides and resistant varieties to control the bacterial wilt disease have been explored by Indonesian farmers but the pathogen is still difficult to control. The application of biocontrol agents (BCA) is an alternative measure to control the bacterial wilt disease of peanut. The experiments were conducted to study the effectiveness of *Pseudomonas fluorescens* RH4003 and *Bacillus subtilis* AB89 to control the bacterial wilt disease of peanut, and to detect some characters of several BCA. Six candidate BCA were evaluated for their effects on seed viability and the effectiveness to control the bacterial wilt disease of peanut in the green house. Disease index of the plants treated with the BCA was significantly different compared with the control but there were no differences among the BCA. Index suppression on six weeks after planting caused by 0.02% streptomycin sulphate, *P. fluorescens* RH4003, *Bacillus* sp. KS2, *P. fluorescens* CK5, *B. subtilis* AB89, *P. fluorescens* ES32 was up to 85.7, 83.5, 77.6, 75.3, 67.5, and 58.8 %, respectively. The percentage of seed viability up to 14 days was not significantly different compared with control. Seedling height and number of branches on the seeds treated with *Bacillus* sp. KS2 were significantly higher compared with those in control and another BCA treatments. Height of the plants treated with BCA were significantly higher compared with those in control treatment.

Key words: Biocontrol, *P. fluorescens*, *B. subtilis,* siderophore, *Ralstonia solanacearum*

INTRODUCTION

Peanut (*Arachis hypogea* L.) is one of the important crops in Indonesia as a source of protein and oil. The crops are grown on the low land up to 500 m above sea level. The optimum temperature for growing peanut is 28 – 32 ^{o}C with RH 65 -75% with full sunlight. The government always seeks to increase peanut production but one of the most important constraints is the occurrence of the disease that causes both qualitative and quantitative losses.

Several pathogens attack peanut in the field and one of the important pathogens is *Ralstonia solanacearum* that causes bacterial wilt disease. Machmud (1986) reported that the bacterial wilt disease has spread widely in North Sumatra, West Sumatra, Lampung, West Java, Central Java, Bali, and South Sulawesi causing yield loss of 15 – 35% and 60 – 90% in case of susceptibility.

The bacterial wilt disease still caused the reduction of peanut production despite the use of bactericides, resistant varieties, field sanitation and cultural practices. Continuous application of bactericides causes the development of resistant pathogens and may cause the build up of new races, in addition to risks for human as well as environmental health (Machmud and Hayward, 1993).

The use of resistant variety is one of the alternatives as a control method of this disease, but breeding the resistant variety may also cause the build up of new virulent race that can cause the breaking of the resistance. Disease control by cultural practices with crop rotation could suppress the disease inoculums in the field, but according to Machmud and Hayward (1993) this method was un-effective because it needs longer time to decrease the population of the inoculums. Another alternative to control this disease is the application of biocontrol agents isolated from the field. By means of biological control technique, the negative effects caused by the other control methods stated above will be reduced.

Pseudomonas fluorescens RH4003 and *Bacillus subtilis* AB89 has been successfully tested to control bacterial wilt disease of tomato (Nawangsih et al. 2005). *P. fluorescens* RH4003 was isolated from the tomato rhizosphere while *B. subtilis* AB89 from rice leaves. The biocontrol agents also have the probability to be applied as broad spectrum agents. It will be more profitable if the biocontrol agents could suppress *R. solanacearum* in the host other than tomato.

This experiment was conducted to investigate some characters related to disease suppression and the bio-efficacies of *P. fluorescens* RH4003, *B. subtilis* AB89 and other bacteria isolated from the rhizosphere of peanut against the bacterial wilt disease of peanut.

MATERIALS AND METHODS

Biocontrol agents

Heat tolerant bacteria and fluorescent pseudomonads bacteria were isolated from the rhizosphere of healthy peanut plants among the infected plants as candidate biocontrol agents. Rhizosphere samples were collected from the peanut fields in Bogor, West Java.

To isolate fluorescent pseudomonads, each 10 grams of soil samples were suspended into 100 ml sterilized distilled water and then placed on the rotary shaker 161 rpm for 15 minutes. After a serial dilution, each 50 µl of 10^{-6}, 10^{-7}, and 10^{-8} diluted samples were spread on to the King's B agar plate. To isolate the heat tolerance bacteria, the suspension was heated up to 80^{o}C for 10 minutes and after a serial dilution, each 50 µl of diluted samples were spread on to the Tryptic Soy Agar (TSA) plate. The plates were incubated in room temperature (about 28 ^{o}C) for 24 hours. Bacterial colonies emerged were separated each other to get the pure cultures. The other biocontrol agents used in this experiment were *P. fluorescens* RH4003 and *B. subtilis* AB89. *P. fluorescens* RH4003 was isolated from tomato rhizosphere while *B. subtilis* AB89 was isolated from the leaf of rice. Both bacteria belong to the collection of Laboratory of Plant Bacteriology, Faculty of Agriculture, Bogor Agricultural University, Indonesia (Nawangsih et al. 2005).

Hypersensitive Reaction (HR) test

The fluorescent pseudomonads and heat tolerant bacteria isolated from the rhizosphere were tested for their hypersensitive reaction (HR) on the tobacco leaves. Tobacco leaves were used as indicator of hypersensitive reaction because tobacco is not the host of the tested plant growth-promoting bacteria (PGPB) and the leaves are easily inoculated (Klement et al. 1990). Each isolate was suspended in sterilized distilled water to adjust the concentration 10^{8}-10^{9} cfu ml^{-1}. The bacterial suspension was injected into the tobacco leaf. Bacteria with positive reaction causing the necrotic area development 24 hours after injection were eliminated from the candidates of biocontrol agents.

Antibiosis activity test

The peanut's rhizosphere bacteria were detected their ability to produce inhibition zone to *R. solanacearum* on King's B agar medium. The isolate of *R. solanacearum* was suspended in sterilized distilled water and the population density was adjusted to 10^8 -10^9 cfu ml^{-1}. One milliliter of the suspension was spreaded onto the surface of King's B agar plate. A piece of sterile blotter paper (diameter 0.5 cm) was dipped into the biocontrol suspension (10^8 – 10^9 cfu ml^{-1}) and put on the center of the plate containing one biocontrol agent each other. The treatments were replicated three times. Development and the diameter of the inhibition zone were observed daily.

Effects on the viability and the growth of peanut seeds

The effects of biocontrol agents on peanut seed viabilit, plant height and number of branches were investigated by dipping the seeds into the suspension of biocontrol agent (10^{10} – 10^{11} cfu ml^{-1}) added with 0.01% xanthan gum for 10 hours. Seeds were dipped into the sterilized distilled water with 0.01% xanthan gum as a control.

Seeds were air dried in sterilized Petri dishes and then grown in plastic pots (diameter 10cm) filled with sterilized soil. Each pot was filled with three seeds and they were replicated 3 times. Seed's viability, height of the seedlings, and number of the branches were counted daily. Seed viability was determined by counting the successfully emergence seedling, shown by fully opened cotyledones and raising of main bud, divided by 100 planted seeds.

Effects on the development of peanut bacterial wilt disease and height of the plants

The experiment was arranged as randomized complete block design with six replications. The biocontrol agents used in this experiment were *P. fluorescens* RH4003, *B. subtilis* AB89, fluorescent pseudomonads isolate CK5, heat tolerant bacterial isolate KS2 and *P. fluorescens* ES32. Two peanut seeds were grown in each polyethylene bag filled with 1.5 kg soil infested with 200 ml of *R. solanacearum* suspension (10^8 – 10^9 cfu ml^{-1}). At two weeks after planting, 200 ml of each biocontrol agent suspension was poured into the soil. Sterilized distilled water or streptomycin sulphate 0.02% were used as a control treatment. Plant height and disease incidence were calculated every week. Disease index was estimated using the following formula:

$$\text{Disease Severity (DS)} = \frac{\sum (n_i \times v_i)}{N \times V} \times 100\%$$

ni = number of plants with certain disease severity scale
vi = numerical number of disease severity scale
i = disease severity scale
N = total number of sample plants
V = the highest scale of disease severity

Disease severity was recorded using the scale: 0 = no symptom, 1 = only one leaf wilted, 2 = 2 – 4 leaves wilted, 3 = 5 or all leaves wilted but the plant is still alive, and 4 = the whole plant died.

Index suppression caused by biocontrol agents was calculated using formula:

$$\text{Index Suppression} = \frac{\text{DS control} - \text{DS treatment}}{\text{DS control}} \times 100\%$$

Data were statistically compared using Statistical Analysis System (SAS) and the significance was measured using Duncan Multiple Range Test (DMRT) with $\alpha = 0.05$.

RESULTS AND DISCUSSION

Hypersensitive reaction of biocontrol agents isolated from peanut rhizosphere

There were 18 isolates of fluorescent pseudomonads and 21 isolates of heat tolerant bacteria which were successfully isolated from the rhizosphere of peanut. Among these, six isolates of fluorescent pseudomonads and two isolates of heat tolerant bacteria caused hypersensitive reaction (HR) positively on tobacco plant. Those isolates were fluorescent pseudomonads CK1, CK2, CK3, CK4, CK9, CK10 and heat tolerant bacteria isolates KS1and KS7. Positive results in the hypersensitivity reaction showed that the bacteria has the potential as a plant pathogen and was therefore not eligible as a candidate biocontrol agent.

Detection of antibiosis mechanism (antagonistic activity)

Based on the antibiosis mechanism (antagonistic activity) test toward ten isolates of fluorescent pseudomonads, 16 isolates of heat tolerant bacteria, both from the rhizosphere of peanut, and 6 isolates belonging to the collection of the Laboratory of Plant Bacteriology, Faculty of Agriculture, Bogor Agricultural University, five isolates positively produced inhibition zones, i.e. fluorescent pseudomonads CK5, *P. fluorescens* ES32, *P. fluorescens* RH4003, *B. subtilis* AB89, and heat tolerant bacteria KS2. Among these, at 4 days after treatment, *P. fluorescens* ES32 isolated from the rhizosphere of Graminae plant produced the largest inhibition zone with 21 mm diameter, followed by *B. subtilis* AB89, fluorescence pseudomonads CK5, heat tolerant bacteria KS2, and *P. fluorescens* RH4003 and control with the inhibition zone diameter of 13 mm, 8 mm, 8 mm, 3 mm, and 0 mm, respectively.

One of the antibiotic compounds produced by plant growth-promoting bacteria is a siderophore, which is a low molecular weight (< 10,000 D), ferric specific ligands produced by microbes in order to combat Fe insolubility (Sayyed et al. 2005; Crowley 2001). From the rhizosphere of groundnut (*Arachis hypogaea*), Sayyed et al. (2010) found that *Alcaligenes faecalis* BCCM 2374 produced siderophore in modified succinic acid medium (SM). The bacterium enhanced seed germination, root length, shoots length, and chlorophyll content.

Effects on seed viability and number of branches

The viability of peanut seeds dipped into the suspension of *B. subtilis* AB89 and *P. fluorescens* ES32 decreased compared with those dipped in sterilized distilled water (control) while *P. fluorescens* RH4003, fluorescent pseudomonads isolate CK5 and heat tolerant bacterial isolate KS2 increased the viability of the seeds (Table 1). Notably, KS2, the heat tolerant bacterium, showed the best seed viability among the isolates tested, however, the percentage seedling emergence was not significantly different among the treatments.

At 14 days after treatment the percentage of seedling emergence after application of KS2, RH4003, control, and AB89 was up to 93.3, 86.7, 73.3, and 53.3%, respectively. Biocontrol agent isolate KS2 and RH4003 tended to increase the percentage of seedling emergence while isolate AB89 decreased it compared with control. Isolates KS2 and RH4003 are rhizosphere bacteria while AB89 is a phyllosphere bacteria. Even though both isolates KS2 and AB89 belong to the genus *Bacillus*, their effects were different on the peanut seedling.

Seedling height was affected by the isolate of biocontrol agents (Table 2). Seeds treated with *Bacillus* sp. KS-2 grew faster compared with those treated with the other biocontrol agents or control. Seedling stems produced by those seeds on 14 days after treatment was the highest, up to 3.7 cm, and significantly different compared with those on control, i.e. 2.7 cm.

Table 1. Percentage of seed viability after dipping into the biocontrol agents suspension.

Treatment	Seed Viability (%)						
	2 DAP*	4 DAP	6 DAP	8 DAP	10 DAP	12 DAP	14 DAP
Bacillus subtilis AB89	0 d**	46.67 c	46.67 c	46.67 c	46.67 c	46.67 c	53.33 c
Bacillus sp. KS-2	40.0 ab	93.33 a	93.33 a	93.33 a	93.33 a	93.33 a	93.33 a
P. fluorescens RH4003	60.0 a	80.00 ab	86.67 a	86.67 a	86.67 ab	86.67 ab	86.67 ab
P. fluorescens ES32	26.66 bcd	53.33 abc	53.33 bc	53.33 bc	60.00 bc	60.00 bc	60.00 bc
P. fluorescens CK-5	33.33 abc	80.0 ab	80.00 ab	80.00 ab	80.00 ab	80.00 ab	80.00 ab
Control	6.67 cd	73.33 abc	73.33 abc	73.33 abc	73.33 abc	73.33 abc	73.33 abc

* Days after planting of the seeds

** Means of the same column, followed by the same letter do not differ according to Duncan Multiple Range Test ($P<0.05$)

Table 2. Effect of the biocontrol agents on peanut seedling height.

Treatment	Height of seedlings (cm)						
	2 DAP*	4 DAP	6 DAP	8 DAP	10 DAP	12 DAP	14 DAP
Bacillus subtilis AB89	1.1 b**	1.1 b	1.2 b	1.2 b	1.3 b	1.3 b	1.4 b
Bacillus sp. KS-2	2.9 a	2.9 a	3.1 a	3.3 a	3.4 a	3.5 a	3.7 a
P. fluorescens RH4003	1.7 b	1.8 b	1.9 b	2.1 b	2.2 b	2.4 b	2.5 b
P. fluorescens ES32	1.1 b	1.2 b	1.3 b	1.4 b	1.5 b	1.6 b	1.6 b
P. fluorescens CK-5	1.7 b	1.8 b	1.9 b	1.9 b	2.1 b	2.2 b	2.3 b
Control	1.8 b	1.9 b	2.0 b	2.1 b	2.2 b	2.2 b	2.7 b

* Days after planting of the seeds

** Means of the same column, followed by the same letter do not differ according to Duncan Multiple Range Test ($P<0.05$)

The number of branches of seedlings from seeds treated with *B. subtilis* AB89 was lower compared with those in control (Table 3). Fourteen days after planting, the average branch number of peanut plant treated with AB89 was 3.7 while 4.8 in the non-treated control. The highest number of branches, 6.7 branches was from KS2, the heat tolerant bacterium.

An increase in the number of branches was expected to increase the number of flowers. One of the factors affecting the number and development of branches, caused by plant growth-promoting bacteria, is the production of growth regulators. Khakipour et al. (2008) reported based on some literatures there are five groups of plant regulators, i.e. auxins, gibberellins, cytokinines, abscisic acids and ethylene. Auxins are a group of herbal hormones where IAA (indole-3-acetic acid) is the most important. IAA is a natural auxin with vast physiological effects that plays an important role in growth and distinction (Glick 1995). Among the plant-growth microorganisms which are capable of producing herbal hormones are *Azotobacter, Pseudomonas, Azosprillium, Rhizobium, Bacillus, Entherobacter,* and Mycorrhiza fungus (Khakipour et al. 2008). Karnwal (2009) reported that *P. fluorescens* AK1 and *P. aeruginosa* AK2 produced indole acetic acid in the presence of L-tryptophan.

Based on the data shown in Table 1, Table 2, and Table 3, it appears that *B. subtilis* AB89 caused negative effects on peanut plants. These bacteria decreased the number of branches, seed viability, and seedling height. Because IAA levels were not analyzed, there are two possibilities

related with the production of IAA by *B. subtilis* AB89, i.e. the bacteria did not produce IAA or they produced IAA in higher concentration beyond the tolerance of peanut plants.

Table 3. Number of branches after the application of biocontrol agents.

Treatment	Number of branches						
	2 DAP*	4 DAP	6 DAP	8 DAP	10 DAP	12 DAP	14 DAP
Bacillus subtilis AB89	0 c**	0.9 b	1.3 b	1.7 c	2.4 c	2.8 b	2.9 c
Bacillus sp. KS-2	1.2 a	1.9 a	2.9 a	4.8 a	5.3 a	5.9 a	6.7 a
P. fluorescens RH4003	0.8 a	1.6 ab	2.7 a	3.3 ab	4.3 abc	4.8 ab	5.2 ab
P. fluorescens ES32	0.7 ab	1.1 b	2.1 ab	2.5 bc	3.1 bc	3.6 b	3.7 bc
P. fluorescens CK-5	0.7 ab	1.6 ab	2.7 a	3.2 bc	3.5 abc	4.4 ab	4.7 bc
Control	0.1 bc	1.5 ab	2.5 a	3.5 ab	4.4 ab	4.5 ab	4.8 b

* Days after planting of the seeds

** Means of the same column, followed by the same letter do not differ according to Duncan Multiple Range Test ($P<0.05$).

Effects on plant height and disease development

The effects of the biocontrol agents on plant height show that plants treated with *Bacillus* sp. KS-2, *P. fluorescens* RH4003, or *P. fluorescens* CK-5 were taller than the control at five and six weeks after planting the seeds (Table 4). Plant height, i.e. 34.2 cm, 33.6 cm, and 36.5 cm, respectively, were not significantly different compared with plants treated with streptomycin sulphate 0.02%, i.e. 37.1 cm. The results show that the biocontrol agents can possibly be used as alternative control to substitute synthetic antibiotics. Plant growth-promotion by the biocontrol agents might be advantageous because the young plants could avoid pathogen attack, such as, damping off.

Table 4. Effects of the biocontrol agents on plant height.

Treatments	Plant Height (cm)					
	1 WAP*	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
Bacillus subtilis AB89	8.00 a**	14.80 a	18.00 a	21.10 a	25.20 ab	29.20 ab
Bacillus sp. KS-2	8.20 a	15.10 a	19.30 a	24.10 a	29.00 a	34.20 a
P. fluorescens RH4003	6.40 a	13.70 a	17.80 a	21.90 a	27.10 ab	33.60 a
P. fluorescens ES32	8.90 a	16.20 a	19.90 a	22.70 a	27.20 ab	32.80 ab
P. fluorescens CK-5	9.10 a	16.50 a	20.80 a	25.50 a	30.80 a	36.50 a
Streptomycin sulphate	8.90 a	15.90 a	20.20 a	24.90 a	30.40 a	37.10 a
Control	8.90 a	15.90 a	18.70 a	20.40 a	21.20 b	22.30 b

* Weeks after planting of the seeds

** Means of the same column, followed by the same letter do not differ according to Duncan Multiple Range Test ($P<0.05$)

Disease severity of bacterial wilt at 6 weeks after planting is shown in Table 5. All of the biocontrol agents tested were able to suppress the disease index, with 0.02% streptomycin sulphate as the most effective. Among the biocontrol agents, *P. fluorescens* RH4003 showed the most suppressive effect on the disease index. Disease severity on the plants treated with biocontrol agents at 6 weeks after planting were varied from 5 to 15% while up to 35% in control.

Disease severity observed six weeks after planting on the plants treated with 0.02% of streptomycin sulphate, *P. fluorescens* RH4003, *Bacillus* sp. KS2, *P. fluorescens* CK5, *B. subtilis* AB89, *P. fluorescens* ES32 and non treated was up to 5.0, 5.8, 7.9, 9.2, 10.8, 14.58 and 35.4%,

respectively. However, *P. fluorescens* RH4003 and *B. subtilis* AB89 were able to control the disease up to this time. Index suppression on six weeks after planting caused by 0.02% streptomycin sulphate, *P. fluorescens* RH4003, *Bacillus* sp. KS2, *P. fluorescens* CK5, *B. subtilis* AB89, *P. fluorescens* ES32 was up to 85.7, 83.5, 77.6, 75.3, 67.5, and 58.8 %, respectively.

Among the biocontrol agents tested in this present study, two isolates, i.e. *B. subtilis* AB89 and *P. fluorescens* ES32 decreased seed viability, seedling height, and number of branches. *P. fluorescens* ES32 produced the widest diameter of the inhibition zone, but it decreased the number of branches, height of the seedlings, and seed viability compared with those in control plants. *B. subtilis* AB89 was previously applied as seed treatment on tomato and did not cause negative effects (Nawangsih et al. 2005).

One of the factors affecting the success of biocontrol in the field is the ability of the biocontrol agent to colonize the root system (Lugtenberg et al. 2001; Brimecombe *et al.* 2001) Inadequate colonization leads to decreased biocontrol activity. The biocontrol agents tested in this experiment were able to control the disease incidence up to 6 weeks after planting of the seeds but the relation with the ability for root colonization must be investigated later.

Table 5. Disease severity of the bacterial wilt on the plants treated with the biocontrol agents.

Treatments	Disease Severity (%)					Index Suppression at 6 WAP (%)
	2 WAP *	3 WAP	4 WAP	5 WAP	6 WAP	
Bacillus subtilis AB89	3.75 b**	5.42 b	8.33 b	10.00 b	10.83 b	67.5
Bacillus sp. KS-2	3.33 b	4.17 b	5.42 b	7.08 b	7.92 b	77.6
P. fluorescens RH4003	2.92 b	3.75 b	5.00 b	5.83 b	5.83 b	83.5
P. fluorescens ES32	5.83 b	7.92 b	12.92 b	14.17 b	14.58 b	58.8
P. fluorescens CK-5	4.58 b	5.83 b	7.50 b	7.92 b	9.17 b	75.3
Streptomycin sulphate	2.50 b	2.92 b	3.75 b	4.58 b	5.00 b	85.7
Control	16.25 a	23.75 a	28.33 a	33.75 a	35.42 a	0

* Weeks after planting of the seeds

** Means of the same column, followed by the same letter do not differ according to Duncan test ($P<0.05$)

CONCLUSIONS

All of the plant growth-promoting bacteria (PGPB) was able to suppress the bacterial wilt disease of peanut. The application of *P. fluorescens* RH4003 caused the highest value of disease suppression among the PGPB which was up to 83.5%, while the commercial product (0.02% streptomycin sulphate) was up to 85.7%. *P. fluorescens* RH4003, *Bacillus* sp. KS2, and *P. fluorescens* CK5 were able to increase the seed viability, height of the seedlings, and number of branches, but *P. fluorescens* ES32 and *B. subtilis* AB89 suppressed these variables. *P. fluorescens* RH4003 has the potential as a biocontrol agent of *R. solanacearum* in peanut but it requires further study on peanut root colonization.

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A Holistic Approach in Establishing Food Security: Securing Food Supplies to Meet the Future Food Demand of the Increasing Population

November 7-10, 2011, Bogor Agricultural University (IPB), Bogor, Indonesia

PLENARY PAPER ABSTRACTS

Inclusive Value Chains in the Indonesian Poultry Industry

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The poultry industry continues to play a significant role in meeting the demand of animal protein in Indonesia. Poultry meat contributes more than 60 percent of the total meat production in the country. The outlook for the Indonesian poultry industry appears optimistic because the country's per capita consumption of poultry meat is currently among the lowest in Asia. Sustained economic and income growth, a fast-growing urban population, and the increasing integration of global agri-food markets are fueling rapid growth in the demand for high-value food commodities such as poultry products. Growing demand for poultry products is opening up the opportunities for smallholders to diversify toward these high-value commodities. The major impediments for smallholders to participate in the poultry value chains are lack of access to markets, capital, inputs and technology and extension services. Improving the capability of smallholders to participate in the poultry value chains requires close linkages between farmers, processors, traders and retailers to coordinate supply and demand. Contract farming is an important means of linking producers with markets, as well as a source of credit, high quality inputs, improved technology, information and services. Contract farming is seen by proponents as a way to raise small-farm income by delivering technology and market information to small farmers, incorporating them into remunerative new markets. But there is evidence that contract farming may have a negative effect on the welfare of smallholders. There is also concern that contractors favour larger producers and hence poorer producers may be excluded from the value chains. Nonetheless, there is growing evidence that the advantages associated with contract farming outweight its disadvantages.

Food Diversification in Japan: Recent Development in Functional Foods

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The term 'physiologically functional food', which first appeared in 'Nature' journal, 1993 with the headline "Japan explores the boundary between food and medicine" gave a strong international impact. Functional foods, defined as those that have the potential to reduce the risk of lifestyle-related diseases and associated abnormal modalities, have garnered global interest since the 1980s when the systematic research had humble beginnings as a national project in Japan. In 1991, the project led to the launch of the national food for specified health uses (FOSHU) policy; almost 1000 FOSHU products with eight categories of health claims have been approved up to the present.

Since 1991, food functionalities have been extensively researched, and novel functional food genomics based on nutrigenomics have also been introduced. The availability of these functional foods is evaluated by using the omics techniques to cyclopedically analyze how gene expression fluctuates in each intravital tissue after consuming a functional food or its component. Since the availability of functional foods has been adequately assessed, the focus has now turned to the evaluation of safety and the necessity of risk assessment.

The Food Safety Commission of the Cabinet Office assesses the risk and safety of foods including the "so-called health foods" and FOSHU. After the shapes of tablets and capsules were finalized and brought into effect by the health-promoting food system in April 2001, the assessment of safety has been specifically emphasized. As an initiative, the Food Safety Commission of the Cabinet conducted a safety evaluation on soy isoflavones, and issued a Notice: "Basic approaches to evaluating the safety of FOSHU containing soy isoflavones" in 2006.

During the past few years, only the validity, namely, the benefits, of FOSHU was evaluated. Therefore, lately, risk evaluation has been promoted in Japan. Risks and benefits posed by functional foods should be collaterally evaluated in the near future, and risk-benefit analyses should be performed to investigate the correlation between these two factors.

In this presentation, I will outline the recent trend by reviewing the history and background of functional foods in Japan, discuss the safety evaluation on soy isoflavones, and introduce some studies conducted on the functionality and safety of foods.

Development of Eco-agricultural Inputs for Sustainable Crop Production

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Agriculture is a leading and essential sector in the economy of many countries. It is important to meet the food security and provide raw materials to the manufacturing sectors. The typical commercial agricultural system uses high inputs in order to obtain and sustain the economical level of crop production. The high inputs are normally associated with the decline in diversity of crops, deteriorating of soil fertility and environmental and health impacts of pesticides. These negative impacts have intensified the need for the change of the crop production systems. The ideas of low-input, reduced-input, sustainable, organic, biological, regenerative, and alternative agriculture have been suggested and presented in many literatures. The terms usually refer to the utilization of ecological and environmental friendly inputs that will generate a sustainable crop production. The crop production system requires seed or planting material, fertilizers, crop protection and irrigation to get a maximum attainable yield. Sustainable crop production should begin with activities on conservation and storage of local plant genetic resources. Accessions of different crops collected should be registered and deposited in the collection centre. The documentation of efficient and sustainable use of the plant genetic resources should be investigated together with exchange of scientific and traditional crop production system among the parties involved. High yielding varieties normally need to be cultivated in a package, with chemical fertilizers and pesticides, and availability of efficient irrigation system. Often this is not attainable by the farmers due to lack of understanding on agronomic practices, over reliance on fertilizers and pesticides that have resulted in degraded soils, increased resistance to pesticides and decline yields. Any program on seed or planting material should take into account on the local environment and farmer's knowledge for successful and sustainable crop production. The nitrogen fixing bacteria like *Rhizobium*, *Azotobacter* and *Azospirillum* are normally used for eco-agricultural biofertilizers. The bacteria can fix free nitrogen in

association with legumes and eventually are able to replace conventional inorganic nitrogen such as urea. The availability of phosphorus to the plant could be increased by using mycorrhizal fungi. Other technologies for sustainable use of fertilizers include the use of green manures and leguminous cover crops and utilization of controlled release technology for efficient use of conventional fertilizers. The pest management uses pesticides as the last resort and the pesticides must be compatible with other control methods. The use of naturally occurring compounds and microbiols should be able to meet the requirement of eco-inputs. The botanical pesticides are normally used by the farmers in the form of crude extract of plant material in water and applied directly to the crop. Often the result on pest control is not consistent due to the compounds are generally unstable and short-lived under that condition and inconsistency in term of the actual amount of active ingredients applied to the crop. Thus, these botanical compounds are needed to be formulated as the conventional pesticides. The technology to produce green formulation using plant based as carrier and additives should be explored. The production of bio-control agents (fungus, bacteria, nematodes, viruses and beneficial insects) and field utilization is in the early stage. The success of biopesticides in the field depends on the right choice of organisms and the manner they are formulated. The formulation should not only maintain the virulence and infectivity of the organisms but have physicochemical properties of conventional pesticides. Their use and field application should be similar to the current practices. All these factors are discussed in the paper. The use of eco-agriculture inputs could decrease the dependence on conventional inputs and provide a sustainable crop production.

Market Chain of Horticultural Products in Thailand

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In Thailand, the horticulture industries are heading the sufficient production quantity for both domestic market and export market. In these recent years, the industries also aim for superb quality horticultural products that support developing new consumer markets. The market chain focuses on efficient cultivation and elite cultivars. For example, durian, mango and some vegetable crops already have superb cultivars in the domestic and in the export markets, yet the breeding programs are still searching for new and high value cultivars, such as cultivars for nutrition-rich functional fruits. With recent efforts on researches, innovation and technological development, cultivation of superb product has been advanced from laboratory to production. These technological solutions also help resolving issues on increasing yield, pest and disease invasion, tolerance to both biotic and abiotic stress and also on production cost management on various horticultural crops. Food safety and quality are elemental concerns in the market chain. For export market, horticultural crops, harvesting and postharvest handling must be strictly following the protocol (i.e. Good Agricultural Practice - GAP) and be monitored by the industries and the government agency. The trade system also evolved from individual farmers towards contract farming and corporate farming. These changes redefine new roles in the marketing and the logistic practices in the free-trade market chain. The successes of Thai horticultural products build on technological development, appropriate cultivation, good practice and good cooperation from everyone – farmers, exporters, agriculture industries and government.

ABSTRACTS

Adaptation to Climate Change

Comparison CO_2 Emission from Corn Fields in Tropical and Subarctic Area

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Carbon cycling rate in the terrestrial ecosystem is influenced by climate. This research compares the CO_2 emissions from the mineral soils of the corn field in different climate area. Measurement of CO_2 flux from soil was conducted from August 2008 to September 2009 at dent corn field in Southeast Hokkaido, Japan and from November 2010 to June 2011 at sweet corn field in West Java, Indonesia. Two experiment plots, planted plot and bare plot, were established in each site. All biomasses were removed from the bare plot. Growing period was defined from the next day of harvesting previous crop until the harvest date of corn. We carried out the measurements for one growing period in Japan and for two growing periods in Indonesia. CO_2 flux was measured by closed chamber method. Total net primary production (NPP) of corn including the roots and residue was measured at eight replicates at the time of harvest. Growing period was 394 days in Hokkaido, 91 and 90 days in Java. The NPP was 8.09±2.2 Mg C ha^{-1} in Japan, 4.62±0.55 and 4.33±0.65 Mg C ha^{-1} in Java. There was a residue of 1.36 ± 0.53 Mg C ha^{-1} in Hokkaido, but zero in Java (all stables and roots were harvested as a feed for cattle). For a growing period, CO_2 emission from planted plot (soil organic matter decomposition + root respiration) was 7.88±1.56 Mg C ha^{-1} in Hokkaido, 4.03±0.12 and 3.31±0.10 Mg C ha^{-1} in Java. CO_2 emission from bare plot (soil organic matter decomposition only) was 5.74±0.17 Mg C ha^{-1} in Hokkaido, 3.08±0.53 and 3.24±0.13 Mg C ha^{-1} in Java. C cycling rates were almost doubled in Java compared to Hokkaido. The rates of soil organic matter decomposition and corn growth compared to root respiration rate was higher in Java than Hokkaido. It is interesting that higher corn growth rate and soil organic matter decomposition were maintained although the residue of corn was not applied to the field in Java. There may be a mechanism of organic matter enrichment through crop rotation. Further research focusing on the relationship between C cycling and crop rotation is required.

CO_2 Gas Emission Evolved from Agricultural Lands of Corn, Peanut, and Cassava at Bogor, Indonesia

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Climate change is one of global issues that became a warm topic of discussion over the world. Three greenhouse gases (GHG) that most contribute to the increase in GHG emissions are CO_2, CH_4 and N_2O. Besides industrial areas, CO_2 gas emission from agricultural land is considerable higher than from the other areas. However, researches on CO_2 emissions from tropical agricultural land are very limited especially on mineral soil. This study aims to measure the amount of CO_2 emissions on different landuses as well as to understand the controlling factors of CO_2 emission at mineral soil. This research was conducted on corn, peanut and cassava fields at Bogor, West Java, Indonesia. The climate variables such as air temperature, soil temperature at 5 cm depth, and relative humidity were measured every two weeks from planting until harvest. In order to compare each site,

we assumed that these fields were continued to be planted same crop for one year for calculation. CO_2 emission from corn field was 12.68 tons C/ha/year, followed by 10.19 tons C/ha/year in cassava field and 8.32 tons C/ha/year in peanut field. In corn field and cassava field, CO_2 flux on row was higher than inter row. Soil water content was positively correlated with CO_2 flux on row, but did not correlated with CO_2 flux inter row. These results suggest that plant activity may influence CO_2 emission and high water content could increase CO_2 emitted from the soil.

Vulnerability to Climate Change of the Indigenous People in the Bicol Region, Philippines

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It is widely accepted that indigenous peoples (IPs) are severely impacted by climate change. Climate change impacts are already being observed, indicating an urgent need for measures to minimize vulnerabilities. For the vulnerable communities like the IPs, living on fragile and degraded lands, these measures are urgently needed. The Bicol region, Philippines is highly vulnerable to the impacts of climate change. The IPs have to cope with an average of 20 tropical cyclones a year. Most of these occurred during October to January with wind velocity greater than 117 kilometers per hour. The El Niño and La Niña phenomena greatly affected the region's agricultural productivity, aggravating the poverty situation in the region. The study described the profile of the indigenous peoples (IPs) in the Bicol region and determined their vulnerability to climate change in terms of their livelihood and well- being. Survey, participatory rapid appraisal and transect walk were conducted to gather the data. Majority of the IPs belonged to Agta-Tabangnon tribe with an average family size of five and reached elementary level. Majority informally used lands with the owner's permission and earned an average monthly income of $72. Since the main source of income of the IPs were either farming or fishing, their livelihood were very vulnerable to disease and pest infestation, droughts, floods, landslide, typhoons, storm surge and sea water rise. Due to the kind of dwelling, source of water and location of their houses, their well-being were very vulnerable to droughts, floods, landslide, typhoons and storm surge.

Assessment and Valuation of Greenhouse Gases Mitigation of Climate-Friendly Farming Practices in Lowland Rice Agroecosystems in Isabela, Philippines

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Greenhouse gases (GHGs) trap heat in the atmosphere that results to global warming or enhanced greenhouse effect. Major GHG emitted from rice cultivation is methane (CH_4) produced by anaerobic decomposition of rice straws in flooded fields. GHG assessment based on 2006 IPCC Guidelines was conducted in 30 selected Irrigators Associations (IAs) covering 7,789.34 ha lowland irrigated rice service area in NIA-Magat River Integrated Irrigation System (MRIIS) District 2 in CY 2008. Existing farming practices emit 5,882.93 tons yr^{-1} CH_4 while shifting to mid-season drainage, rice straw aerobic composting and simultaneous drainage and composting results to 2,823.81, 3,756.44, and 4,777.16 tons yr^{-1} or 48, 64 and 81% CH_4 emission reductions, respectively. Values of emission reductions using 2009 World Bank price of US$12 ton^{-1} CO_2e assuming Php48 $1US\$^{-1}$ are Php34.16, Php45.44, and Php57.78 million yr^{-1} for mid-season drainage, aerobic composting and simultaneous drainage and composting, respectively. Partial budget analysis indicates incremental benefit of Php138.95 million yr^{-1} if farmers shift the existing practices to climate-friendly practices. STELLA simulation results indicate that: keeping on existing farming practices results to linear accumulation of 5,882.93 tons yr^{-1} CH_4; annual CH_4 emission stabilizes at 13,000, 10,000 and 8,000 tons within 12 years for mid-season drainage, aerobic composting and simultaneous draining and

composting, respectively. This information were shared to farmers, IAs, NIA-MRIIS and LGUs through production of IEC materials (posters, flyers, brochures) and conduct of awareness-raising seminars, fora as well as other policy advocacy activities. On-farm trials need to be established.

Adaptation to Climate Change of Farmers in Northern Isabela, The Philippines

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Climate change is one of the biggest environmental, social and economic threats the world is experiencing at the moment. Projections on climate change show that the global temperature is continuously increasing. The Philippines is vulnerable to climate change. In the recent years, natural disasters such as floods, droughts, and typhoons are becoming frequent. The extreme climate variabilities experienced in Isabela include strong typhoons such as typhoon Imbudo, and supertyphoons Paeng and Juan in July 2003, November 2006, and October 18, 2010 respectively. Due to the poor infrastructure and location, the northern towns of Isabela are particularly vulnerable to climate change. In November 2008 and November 2010, some *barangays* (villages) in the municipalities of Cabagan and Santo Tomas in Isabela were flooded. This study documents some climate change adaptation strategies of farmers in Northern Isabela in the Philippines. It also discusses the perceptions of the farmers on climate change. The study was done in the municipalities of Cabagan and Santo Tomas. The agricultural sector in these areas is vulnerable to climate change. The data in this study were obtained from interviews with farmers. The adaptation strategies that are directly related to climate change as experienced by the farmers include the following: Use of multicropping to increase soil quality or planting other crops in between cropping;; use of organic fertilizer or compost; adjusting the plant calendar or changing the planting schedule; optimizing rice productivity and optimum use of fertilizers and other inputs; irrigating the farm; planting drought-resistant varieties of corn; use of disease-and-pest-tolerant crop varieties of rice; delay in planting until flood subsides; and planting when there is still soil moisture.

Effects of Climate Change at Pinacanauan de San Pablo Watershed: Land Use and Infrastructure Assessment

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The study was conducted to assess land use and infrastructures due to effects of climate change in the Pinacanauan de San Pablo Watershed the northernmost part of Isabela, Philippines. The methods used were review and analysis of existing maps and development plans; site assessment, i.e. photo documentation, site observation and informal interviews; secondary data at the local government unit, Department of Environment and Natural Resources and National Irrigation Administration; preparation of base maps, i.e. road and irrigation maps. The watershed covers thirteen barangays with an aggregate area of 33,553.72 hectares. Its vast aquatic resources include the Cagayan River and the tributaries like the Pincanauan River in the center, and Balulu Creek in the south as source of fish, transport and irrigation water. The effects of climate change is evident on the drying up of some of its water resources during dry season. On the other hand during wet season and or occurrence of heavy rain during typhoons almost all of the barangays located on the lower areas are flooded and the overflow of the Pinacanauan River and Cagayan River causes soil erosion on fifty (50%) of the barangays. The infrastructure i.e. irrigation facilities, road network were poorly managed and has not been fully operational due to the unpredictability of climate change. With the frequency of

flood during the rainy season, there is indeed a watershed degradation due to soil erosion, sedimentation and landslides that affects the productivity of the land. This results to unstable water flow that floods lower areas, and leads to low agricultural yield, loss of income and induced increase in poverty. The study recommends rehabilitation and reforestation of the watershed area, the need for river control protection, upgrading, repair and concreting of roads, construction of pump wells as a source of potable water and rehabilitation of irrigation facilities and expansion of its area of coverage.

Promoting Agroforestry as a Climate Change Adaptation Strategy in Southeast Asia: Experience of the Philippine Agroforestry Education and Research Network

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Climate change is the one of the pressing issues in the world today. The causes and challenging issues of climate change, particularly its negative impacts to the vulnerable countries and communities have become the interest of research and development-oriented groups and organizations. This paper argues that agroforestry is one of the key climate change adaptation strategies in the agriculture sector, particularly the smallholder farmers in Southeast Asia. Agroforestry is a land use management system that integrates woody perennials and agricultural crops, livestock and/or aquatic resources in the same piece of land for the twin purpose of achieving economic productivity and environmental stability. With this potential, agroforestry has always been integrated as a major production technology in the community-based forest management programs in vulnerable communities. Likewise, several studies have been pointing out the many uses of agroforestry in carbon sequestration, and in restoring the degraded and marginal upland areas. Recognizing the need to disseminate and publicize the potentials of agroforestry in climate change adaptation, PAFERN embarked on a regional project involving the collaboration of five collaborating countries of the Southeast Asian Network for Agroforestry Education (SEANAFE). The project's end goal is scaling-up agroforestry promotion towards climate change mitigation and adaptation. Specifically, the project focused mainly on creating public awareness about the potentials of agroforestry in adapting to the impacts of climate change. These include information materials development, training of junior lecturers, National Agroforestry Roadshows and seminars, and production of a policy brief. The outputs and outcomes of the project implementation led to the development of the Second Phase of the Project which calls for institutionalizing agroforestry as a climate change adaptation strategy through local capacity and policy development in Southeast Asia. The current state of the uplands and natural resources management, coupled with global climate change, calls for the integration of agroforestry as a key strategy in development-oriented programs.

Climate Change Adaptation of Priority Faunal Species in Mount Isarog Natural Park

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Mount ISAROG is one of the few mountains in the Philippines abounding with great variety of wildlife species. Its possible threats for biodiversity decline come directly from climate change and population pressure of the human settlers at the base slopes of the mountain. The study aimed to determine the effect of climate change to the biodiversity trends of priority faunal species and the threats in Mount Isarog Natural Park using the Biodiversity Monitoring System and Threat Reduction Assessment tool. The trends on the population of faunal species have shown that Baboydamo (*Sus*

scrofa), Bayakan (*Pteropus speciosus)*, Unggoy (*Macaca fascicularis*) and Punay (*Gallicolumba luzonica)* are remaining as the dominant species, while population decline has become evident among the species of Sawa (*Phyton reticulates)*, Sabit (*Spizaetus phillipensis)*, Usa (*Cervus marianus)* and Salibad (*Microhierax erythrogynys)*. No significant difference was obtained in terms of presence, frequency and population density of faunal species. These findings are indicative of a continuing reduction in the biodiversity population of faunal species. One important finding in this study was the significant differences in the biodiversity population among the sites. This finding may imply that species are forced to move out of their habitats they are accustomed to resulting to reduction in "species richness" and biodiversity conservation was differentially implemented among the research sites. Scalogram analysis also indicated that the most common biodiversity threats exerted by the communities to the mountain ecosystem involve the utilization of the mountain resources for subsistence and other basic needs of the household.

Climate Change Adaptation in Selected Lowland Rice Areas in Bicol Region, Philippines

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Existing literature has indicated the vulnerability of agriculture to climate change. It is expected that changes in temperature and precipitation will result in changes in land and water regimes that will subsequently affect agricultural productivity. Due to its geographic location and physical environment, the Bicol Region is highly vulnerable and at risk to climate and weather-related changes. Climate change will, therefore, exacerbate the poverty condition in the region because of its dependence on agriculture. A technical cooperation project is being implemented in the region by the Food and Agriculture Organization in collaboration with the Department of Agriculture, selected local government units, PAGASA, and selected universities. One of the objectives of the project is to improve the livelihood resilience and food security of households who are highly vulnerable to the frequent occurrence of extreme climatic events thru the introduction of good practice options for climate change adaptation. Early maturing rice variety was introduced in selected sites to reduce the risk of crop failure due to typhoon and flooding. Stress-tolerant varieties were also introduced in selected sites to address the risks due to flooding and saline water intrusion. Results revealed a significant difference in yield performance between early maturing variety and local variety at 5% significance level. On the other hand, yield of stress-tolerant varieties was not significantly different from the local variety planted by farmers. The results indicate that planting early rice maturing varieties would be an effective climate change adaptation strategy for lowland rice areas.

Good Practices Options for Climate Change Adaptation in Upland Agro-Ecological Zone in the Bicol Region, Philippines

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Natural disasters have severely destabilized the socio-economic fabric of the Bicol Region in the last four years, with the most devastating impacts experienced in 2006. Typhoon *Reming*, which hit on 30 November 2006 was the most destructive, severely affecting all the six provinces of the Bicol Region. Typhoon *Reming,* which brought 466 mm of rainfall, the highest in 40 years, damaged 18,786 hectares planted to rice at varying stages of growth and the damage to investment losses in terms of input costs such as seeds, fertilizers and labor was valued at PhP 153.8 million. The project aimed to develop and implement climate risk management measures that will contribute to improve

the livelihoods and food security of small-scale farmers in disaster prone areas in the upland. The project was implemented in three disaster-prone villages in each of the three municipalities of the provinces of Bicol Region. Thirty farmer per village were selected as cooperators based on set criteria. Among the GP options tested, coconut leaf pruning (CLP) and strip cropping (SC) were found to alleviate the impact of climate change. Crops like early maturing cassava and peanut were feasible for wet season panting and corn, hot chili and sweet potato for dry season cropping for CLP technology. In SC, the crop combination that provided good results during the wet season were combination of cassava and peanut, and corn. During the dry season combination of corn, string beans, snap bean, squash, okra, hot chili, tomato and eggplant proved to be highly feasible.

Changes in *Jatropha* Annual Production Pattern as Influenced by Climate Alteration

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In recent years, *Jatropha curcas L.* has been suggested as the alternative source for biofuel production. Mutation breeding program in CAIRT has obtained five homogeneous *Jatropha* mutant lines with high seed oil content. It was necessary to learn the production capacity of these lines before they can be officially released as varieties. Since *Jatropha* is a perennial tree plant, the observation must be carried out until the plant reached the optimal production age. The research was conducted in Pasarjumat, South Jakarta since 2006. The objective of this research was to analyse the influence of climatic factors in production of *Jatropha* mutant lines in the second to fourth year of plant age (2008 – 2010). It was observed that climatic environment has huge influence to monthly fruit production. Barlett's test proved that production weight among five mutant lines and the parental variety as control has no significant difference. The data analyses showed that the monthly productions were highly varied within a year, and in general correspond to the monthly rainfall precipitation, day of rain per month, and average temperature data from BMKG Jakarta. The alteration in wet season pattern has corresponded to the shifting of peak production periods in *Jatropha* each year. In particular, the prolonged wet season in 2010 has resulted into three smaller peaks instead of the usual two high peak periods. This research provided an example of how the climate alteration would affect the perennial tree phenology.

Crop Production and Improvement

Screening and Evaluation of Some Wild Rices for Potential Traits in the Improvement of Cultivated Rice

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Anatomical and physiological characteristics of selected "stay-green" wild rices were determined. to select the most slowly senescing rices from the 19 genotypes initially collected. Significant variation in chlorenchyma thickness and distance between vascular bundles were found among the selected "stay-green" rices. Evaluation of their "stay-green" characteristics revealed that the amount of chlorophylls a, b and total chlorophyll were significantly highest in *O. ridleyi* and lowest chlorophyll b and total chlorophyll in *O. officinalis 100896* x *O. officinalis 10116*). However, the initial measurements of chlorophylls from fresh leaf samples showed that these pigments were significantly highest in *O. officinalis 100896 x O. officinalis 10116*. The very weak linear correlations obtained between initial and final chlorophyll a and total chlorophyll were not statistically significant.

The senescence of the rices, therefore, was not dependent on initial chlorophyll content but on the rate of chlorophyll breakdown which seemed to be slowest in *O. ridleyi.* In addition, senescence was delayed longer in rices belonging to *O. ridleyi* and *O. meyeriana* complex than the rices in *O. officinalis* complex. As a genetically controlled program, senescence behavior of the selected "stay-green" wild rices can also be attributed to differences in their genetic constitution, which could be further studied. The application of more sensitive bioassays can also be carried out to determine endogenous cytokinin levels. Moreover, other wild rices in the species-complexes can be evaluated for their potential as sources of "stay-green" characteristics for the improvement of cultivated rice.

Utilization of Bionoculant and Different Fertilizer Materials in the Production of Drought Resistant Rice Variety (NSIC RC 192): An Approach to Enhancing Rice Self-Sufficiency and Food Security

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This study was envisioned to contribute to the domestic rice sufficiency in support to national food security program. The study utilized bioinoculant and different fertilizer materials to determine the agronomic and yield characteristics, arthropods diversity and economic return of NSIC Rc192 drought resistant rice variety. Experimentation was done following the Randomized Complete Block Design 2X6 Factorial. Utilization of bioinoculant influenced the plant height at vegetative growth stage and yield components in terms of productive tillers and number of filled grains but not in other agronomic and yield characteristics as well as the return on investment. Fertilizer materials did not affect the height of rice at 14 to 28 DAT but affected by Inorganic Granular (IG) and in combination with Natural Organic Foliar (NOF) at 35 to 75 DAT. Rice fertilized with IG and IG+ Chicken Manure (CM) showed the highest leaf color index at 14-42 DAT. From 49-70 DAT, IG and in combination with NOF and CM have the highest leaf color index. Rice has the same number of tillers even treated with different fertilizer materials. Fertilization of IG and in combination with NOF and CM influenced the length of panicle and number of field grains per panicle while, IG increased the number of panicle per hill produced and IG in combination with NOF attained the highest grain yield per hectare. High arthropods diversity was observed during the different growth stages of rice. Fertilization of IG in combination with CM gave the highest return on investment.

Influence of Bioinoculant and Organic Fertilizers in the Production of Traditional Upland Rice Variety

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The study was conducted to determine the influence of bioinoculant and organic fertilizers on the morphological and yield characteristics of traditional upland rice variety and arthropods population and diversity. The factors and the factor levels used in the study were: Factor A (A1- with bioinoculant and A2- without bioinoculant) while Factor B includes: B1-100% inorganic granular fertilizer, B2-100% natural organic foliar fertilizer, B3-100% chicken manure; B4-50% inorganic granular fertilizer + 50% natural foliar fertilizer, B5-50% inorganic granular fertilizer + 50% chicken manure, B6-50% natural organic foliar fertilizer + 50% chicken manure. The results revealed that bioinoculant did not influence the morhopological, and yield characteristics of traditional upland rice variety as well as the population and diversity of beneficial and harmful arthropods. The rice applied with 100% chicken manure and or natural organic foliar and in combination with inorganic fertilizer have comparable height with those applied with 100% inorganic fertilizer. Rice plants exposed to 100% inorganic fertilizer and chicken manure and 50% inorganic

fertilizer+50% chicken manure produced the same weight of grain, yield (tons) per hectare, number of tillers and number of panicles. No effect was noted on other parameters. Utilization of 100% chicken manure or in combination with inorganic granular fertilizer gave better economic return, thus chicken manure as an organic fertilizer is a good alternative to inorganic fertilizer.

Utilization of Cocopeat on Lowland Rice in Lahar-laden Areas

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Natural calamities usually affect agricultural production in the Bicol Region. Agricultural areas were covered with volumes of mudflow hence, the agricultural lands became barren and unproductive. An experiment was conducted for two years to determine the effects of cocopeat utilization in the production of rice in lowland lahar-laden areas specifically in Padang, Legazpi City. The experimental site was located in a lowland lahar-laden area in Padang, Legazpi City. The soil is sandy loam and is classified as Typic Tropopsamment. It belongs to type II climate, with no pronounced dry and wet season. The following were the treatments: control, recommended inorganic fertilizer, recommended coco peat, 25% cocopeat + 75% inorganic fertilizer, 50% cocopeat + 50% inorganic fertilizer and 75% coco peat + 25% inorganic fertilizer. These were replicated three times. During the third and fourth cropping, the split-plot design was used with cocopeat frequency of application as main plot and rate of cocopeat plus the inorganic fertilizer as the subplot with 6 treatments and 3 replications. The following were the subplot treatments: control, recommended inorganic fertilizer, recommended cocopeat, 25% cocopeat + 75% inorganic fertilizer, 50% cocopeat + 50% inorganic fertilizer, 75% cocopeat + 25% inorganic fertilizer while the mainplot treatments are: application of cocopeat for the first year only and application of cocopeat for the first and second year. In all cropping seasons, rice was not affected with cocopeat fertilization alone. Response of rice plants under full cocopeat amendment was the same with those without fertilizer application. Response of plants to inorganic fertilization was quite pronounced as indicated by significantly higher yield of grains. A smaller amount of cocopeat (25%) with inorganic fertilizer (75%) was observed to be comparable with the full recommended inorganic fertilizer. Cocopeat could be an excellent organic material for improving lahar laden lowland rice fields because of its excellent physico-chemical properties. These characteristics were manifested in all cropping seasons because the material had very slow disintegration and decomposition Reapplication of cocopeat did not significantly increased yield of rice in all treatments. The treatment with 25% recommended cocopeat plus 75% recommended inorganic fertilizer obtained the highest return on investment.

Performance of Lowland Rice Variety (NSIC RC 156) and Arthropod Diversity as Affected by Bioinoculant and Varied Fertilizer Materials Application

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The study aimed to determine the agronomic response of inbred rice, NSIC Rc 156 and arthropod diversity to bioinoculant and fertilizer materials. Factor A involves the application and non-application of bioinoculant while Factor B composed of six different fertilizer materials namely: 100% inorganic granular (100%IG), 100% natural organic foliar (100%NOF), 100% chicken manure (100%CM), 50% inorganic granular+50% natural organic foliar fertilizer (50%IG+50%NOF), 50% inorganic granular+50% chicken manure (50%IG+50%CM), 50% natural organic foliar + 50% chicken manure (50% NOF+50%CM). Bioinoculant promotes the development of productive tillers, however, no effect was observed on the other parameters tested. The height and color index of the test

crop were the same regardless of the kinds of fertilizer materials applied. Rice plants fertilized with 50%IGF+50% CM and 50% IGF+50%NOF have comparable response in terms of yield and yield components. Bioinoculant and the use of organic fertilizer enhanced arthropods diversity and species heterogeneity at the rice experimental area during vegetative growth stage of the test crop. Significant interaction effects between bioinoculant and fertilizer materials were evident on leaf color index, harvest index, aboveground arthropods diversity during vegetative and maturity stages. Inoculated NSIC Rc 156 fertilized with equal amount of inorganic granular fertilizer and chicken manure realized the highest Return on Investment (ROI).

Dynamics of Thai Maize Production towards Feed Security

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Maize is one kind of crucial farm production towards feed security in Thailand. Total production, accounting for 91.3% of 4.6 million ton per year is used in domestic livestock industrial sectors and exported as feed and hybrid seed. This paper determined trends in both maize production and competition crops and the impacts of maize production on favorable and unfavorable environments. The benchmark survey was conducted in crop year 2009/2010. Six sample villages were chosen to represent different production environments as comparison study between main production land and marginal land through multi–stage sampling technique. The results revealed that major maize growing belt located in the northern region, accounted for 62.4 of the whole maize cultivated area, with around 1.13 million hectares. The rest are in the northeastern and central region. From 1957-2010, despite declining trend of maize cultivated area, the average yield of the whole kingdom continues to be higher significantly as almost two times over 50 years or rose at 3.22% per annum. As a result, modern hybrid varieties are commonly grown. In addition, the limitation of land particularly the trends of other upland crops increased significantly as change was induced by the relatively higher price of those crops. During the past two decades, the major competitive crops such as rubber tree area rose at 5.52% per annum and sugar cane rose at 2.23 % per annum while maize area decline 1.92% per annum. From 2000 to 2010, it showed from the remote sensing areas that maize area both in main production land and marginal land of the northern and the central region declined significantly at 9.91% per annum and 22.12% per annum, respectively. On the contrary, maize area both in main production land and marginal land of the northeastern region rose 102.84% per annum and 78.66% per annum, respectively. Some backwards of modern technologies in sustainable maize cultivation particularly in marginal land caused the deterioration of environment and also low quality of yield inevitably. Moreover, climate change and energy shortage along with the long –term declining trend in maize prices, compared with the increased competitive crops, have raised concerns whether Thailand can maintain future competitiveness and food security towards sustainable maize production promotion.

Responses of Soilless Grown Tomato Plants to Arbuscular Mycorrhizal Fungal Colonization in Well-Watered and Water Stress Conditions

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An arbuscular mycorrhizal fungi (AMF) is known as the beneficial biological interactions that must be considered in the design of sustainable system. Mixed culture of AMF (*Scutellospora*

calospora and *Glomus mosseae*) was used to determine its effects on tomato physiological changes, yield and root infection of plants grown under well-watered and water stress conditions. The plants were irrigated based on substrate water holding capacity at 100% (well-watered) and 25% (water stress) of water availability (WA). This factorial experiment was evaluated using a split plot arrangement in randomized completely block design, with AMF inoculation as main plot and WA as sub-plot. Chlorophyll content per unit leaf area, photosynthesis, stomatal conductance and relative water content were significantly lower with reduction in WA at 4 week. The number of fruits, fruit dry weight and total fruit fresh weight were significantly reduced when WA was depleted. There were no significant effects by water availability on number of spores and root colonization. However, number of spores and root colonization absolutely increased with inoculation. There were no significant effect by AMF and interaction between AMF and WA on physiological changes and yield.

Promotion of Improved Off-Season Tomato Technologies for Sustainable Production

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Tomato is important cash crop among the vegetable growers in the province of Tarlac. However, production in the area is concentrated during the dry season which causes market gluts and shortage during the rainy season. New technologies to improve tomato production during the off-season were developed by the AVRDC and are being tested across environments in the Philippines. Studies showed that under protective structures, farmers tend to produce tomatoes continuously when grafted with eggplant variety EG 203 that tolerates flooding and showed considerable resistance to bacterial wilt. Since 2001, TCA had been involved in grafted tomato or "Kamlong" research, development and production projects through the collaborative effort of AVRDC and allies from CLSU and Bureau of Plant Industry, Los Banos, Laguna. Promoting and adopting the technology had been undertaken. The said technology has been tested in the municipalities of Sta Ignacia, Mayantoc, Anao, Gerona, Paniqui, Bataan and San Ildefonso, Bulacan based at Bulacan Agricultural State College and was proven to be effective since the use of grafted tomato under protective structures promotes longevity of tomato plants, thus increasing yield and benefits among farmers-adopters. Farmer-adopters from Sta Ignacia and Mayantoc, Tarlac continuously plant *kamlong*, and expanded their production areas considering their sustained increased income and benefits. An average ROI 80-100% was generated from a 200 m^2 tomato fruit production area. Furthermore, around 40% increase in the number of technology adopters including walk-in buyers in Tarlac and nearby localities such as Bulacan, Urdaneta City, Pangasinan and Bataan. Promoting these proven technologies in a commercial scale is essential in order to increase off-season production, maximize available resources, increasing farming household's productivity and eventually broaden impact while year round supply of affordable fresh tomato is ensured.

Increasing Productivity through an Environment-Friendly Package of Production Technology for Multiplier Onion (*Allium cepa* L.) in Region 1, Philippines

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The Ilocos Integrated Agricultural Research Center (ILIARC) of the Department of Agriculture, Regional Field Unit I (DA-RFU I) in the Philippines pilot tested enhanced production technology for multiplier onion or shallot, *Allium cepa* L., for wet and dry seasons in four sites of two provinces of Northern Luzon: Ilocos Norte and Ilocos Sur, Philippines involving 58 farmers-partners. The enhanced technology components tested are combined into TC1 (bioorganic fertilizer, bio-fungicide, (organism/fruit extract), bio-insecticide, insect light trap, GA3, bio-control agent); TC2 (bioorganic fertilizer, bio-fungicide (organism and fruit extract), bio-insecticide, insect light trap, liquid bio-fertilizer, bio-control agent, and TC3 (bioorganic fertilizer, bio-fungicide (fruit extract),

bio-insecticide, insect light trap, GA3, bio-control agent). For wet season, TC2 yielded 11.54 tons/ha, or 4.5 tons (64.12%) higher than comparative farm, TC1 yielded 8.23 tons/ha or 9.23% higher than comparative farms but TC3 yielded low, 5.6 tons, 6.55% lower than comparative farms. Dry season yield of TC2 was 8.3 tons/ha or a yield difference of 1.8 tons/ha or 22% higher than comparative farmers. Bioorganic fertilizer improved soil friability, reduced use of inorganic fertilizer; bio-fungicides controlled spread of the anthracnose disease resulting to as high as 20 tons/ha shallot yield; bio-insecticide, bio-control agent and light trap controlled the insect pests reducing pesticide use and organophosphates residue in multiplier onion. The TC 2 for two seasons is technically feasible and environment-friendly, thus recommended for promotion to farmers planting multiplier onion in locations similar to the growing environment of the test site during wet and dry seasons.

The Effect of Number of Grafted Scions and Productive Branches Remained on the New Shoot Growth and Flowering of Side-Grafting Cashew (*Anacardium occidentale* L.)

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The productivity of cashew trees usually decline with age, and up to now there is no appropriate technique of rejuvenation, other than conventional method, to improve the productivity. A method is urgently required to simply and quickly increase the crop productivity in cashew centre areas, such as in East Leser Sunda Island (NTT) Province, as also in other places in Indonesia. Two field experiments were conducted at cashew centre areas in East Flores Regency, NTT Province. The first experiment was aimed at studying the effect of relative humidity on the growth of scions. The relative humidity of 74.57% (air humidity) was found to give scion survival percentage of 100%, comparable to higher relative humidity. The second experiment was a factorial experiment with two treatment factors (number of grafted scions and number of remained productive branches per tree) in a randomized complete block design with three replications. One (S1) and two scions (S2) were grafted per tree, and all (P1), two (P2) and three (P3) productive branches remained on the tree. The treatments were replicated three times. Treatment combination of two scions grafted per tree and two productive branches remained on the tree (S2P2 treatment) resulted in the highest ($p< 0.05$) figures for all variables measured such as new shoot length (24.85cm), number of leaves (27.91 leaves) and 69.57% of flower bearing fruits. The survival percentages of scions grafted were reached 81.55 % at 210 days after grafting (DAG), 75% new shoot flowered at 113 DAG and 69.57% flower bore fruits. It is concluded that side grafting technique of two scions were grafted combined with two branches remaining on the tree can be used as a simple and quick technique to rejuvenate cashew trees, however a longer term experiment is required to study whether the technique can restore the productivity of old cashew trees.

Artificial Seed Production and Regeneration from Encapsulated Protocorm-like Bodies of *Dendrobium* 'Savin White'

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Micropropagation is currently the most popular method for orchid propagation through the production of protocorm like bodies (PLBs). PLBs are active material thus; it either continues to proliferate or form plantlets hindering the process of arresting PLBs development for storage and transport. It is suggested that converting the PLBs into artificial seeds by encapsulation can be useful

especially in overcoming the above mentioned problems as well as in using the artificial seeds for direct establishment in the field. Prior to the production of artificial seeds, the best developmental stage of PLBs for increased conversion to plantlet has to be determined. Stage of development is often related to PLBs size therefore three PLBs sizes namely ≤ 2 mm, 2–4 mm and 4–6 mm diameter were obtained from three months old *Dendrobium* Savin White cultures. Both PLBs of 2–4 mm and 4–6 mm gave significantly higher conversion percentage (85% and 90% respectively) as compared to ≤ 2 mm (30%). Thus, all PLBs of ≤ 2 mm were not used for the production of artificial seeds. For uniformity PLBs of 3-5 mm were used for encapsulation with sodium alginate to form artificial seeds. The encapsulated PLBs were cultured onto semi-solid ½MS basal medium devoid of plant growth regulators and were allowed to regenerate in order to observe the effects of encapsulation on PLBs regeneration. Naked PLBs were used as a control. Encapsulation had no effect on PLBs regeneration nor did it affect the speed of emergence where both encapsulated and naked PLBs gave comparable results on all data observed, namely germination percentage, days taken to germinate, conversion percentage, days taken for conversion, number and length of shoot and number and length of root.

Transgenic *Dendrobium* 'Sonia' Earsakul Possessed Antisense *CPACO* Gene Exhibits Similar Morphological Characters to the Non-transgenic Line

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As one of the major cut flower of Thailand, *Dendrobium* orchid has been export world-wide. However, the production of ethylene by their flowers caused the shorter vase-life of this type of orchid. According to the new technology of plant genetic transformation, this problem can be solved by transformation of the orchid plants with the genes that control ethylene production in an antisense orientation. The *ACC oxidase (*or *ACO)* gene, the gene in the last step of ethylene production pathway, is one of the most interesting gene for this purpose. The transgene will block the expression of native gene thus cause the lower to none of ethylene production in that transgenic orchid plant. From our previous research work, we successfully transferred *ACO* gene from papaya (*CPACO* gene) which was about 70% similar to *ACO* genes in orchids into *Dendrobium* 'Sonia' Earsakul using *Agrobacterium*-mediated transformation. In order to transform the target gene into *Dendrobium* plbs, *A. tumefaciens* strain ALG-1 possessed pCAMBIA 1301a*ACO1* containing reverse orientation of *CPACO1* cDNA from papaya and *hygromycin phosphotrasferase (hpt)* selectable marker gene under the control of 35SCaMV was used. Four transgenic lines were obtained after 6 weeks of selection in hygromycin containing selective medium. The stable transformation was confirmed in those lines using PCR, Southern PCR hybridization and dot blot analysis. Evaluation in laboratory, at 6 and 12 months after transplanted, the morphological character of transgenic orchid lines, in overall, similar to original, non-tranformed line, however, demonstrated the better growth.

Improving Potato Production through Sul-Po-Mag Supplementation and Promoting Potato Chips Processing

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Sul-Po-Mag is unique in nature as water-soluble source of magnesium, sulphur and potassium. Sul-Po-Mag contains 22 or 22.4% water soluble K_2O, 11% Mg and 22% S. For that reason, it is often referred to as the 3-in-1 fertilizer materials. It can be used to cover the nutritional needs for sulphur and magnesium for the majority of crops, while supplying a portion of the overall potassium requirement. A science and technology based intervention which was aimed to improve productivity and income of farmers by providing additional Sul-Po-Mag fertilizer was implemented in Atok, Benguet, Philippines from September 2009 to April 2011. Sul-Po-Mag application had increased yield of the farmer scientist by 35% during the first cycle (September 2009 to January 2010) and 24% during the second cycle. For the first farmer adopter, 3rd cycle. Sul-Po-Mag application had increased the yield by 20% (December 2010 to April 2011). Similarly, the intervention had increased the dry matter content of harvested potato from 21% to 24% which have lowered the perceived oiliness of chips. The profitability however, depends on the farm gate price of potatoes. When the farm gate price of potatoes is P25/kg and below, processing is profitable. However, when the farm gate price of potatoes is above P30/kg, marketing of potatoes is more appropriate than processing of chips.

Potato Pea-sized Tubers for Tuber Seed Production on Farmers' Field

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Pea-sized tubers (< 5g) resembles the size of a pea seed hence its description. These are basic tuber seeds from staggered harvesting, rooted stem cuttings and from the mother plants where stem cuttings are derived in the greenhouse. However, pea-sized tuber is not common to farmers. Thus, the feasibility of the potato pea-sized tuber as planting material for G-one seed production was validated on-farm. Its optimum plant density and its comparison to the usual tuber seed sizes (6 to 50 g per tuber) were demonstrated on farmers' field. The pea-sized tubers that were planted at a distance of 10 cm between hills (24.87 t/ha) out yielded the pea-sized tubers that were planted at a distance of 15, 20, 25, and 30 cm between hills with tuber yield that ranges from 9.96 to 12.19 t/ha. Moreover, pea-sized tubers planted at a plant density of 3 tubers per hill at a planting distance of 25 cm between hills significantly showed the highest yield per hectare with 16.33 t/ha than those tubers planted at 1, 2, and 4 pea-sized tubers per hill with tuber yield that ranges from 9.43 to 14.09 t/ha. Further, return on cash expenses (ROCE) was apparently greater on 3 tubers/hill. On the other hand, bigger seed size tubers distinctly had higher tuber yield than the pea-sized tubers per plant, either in terms of weight, number of tubers per hill and profit. However, when pea-sized tubers were planted at 3 tubers/hill, the yield and profit were comparable to bigger sized tubers (6 to 50 g/tuber). In one on- farm trial, the percentage profit for bigger size tubers (20-40 g/tuber) was 58.4% while pea-sized tubers (3-5 g/tuber) had 56.0%.

Effects of Al^{3+} and H^+ on Rice Root Elongation, Surface Area and Exudation of Organic Acids

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Low pH and high Al concentration are affecting the growth of rice seedlings, which in the end reduces yield. A study was conducted to determine the effects of pH and/or Al on the morphology rice root and organic acids release. Two experiments were carried out: 1) Rice seeds (MR 219) undergoing germination were exposed to 0.5 mM $CaCl_2$ solutions containing various concentration of Al (10, 20, 30, 40 and 50 µM); and 2) The seeds were soaked in water taken from an acid sulfate soil area in Malaysia for which the pH was adjusted to a range of values using 0.01 M HCl or NaOH. Under acidic condition, Al^{3+} is the most common species in solution. The study showed that root

length decreased with increasing Al concentration. On the other hand, root length increased with pH. The trend in the change of root surface area with Al concentration and pH is the same as that of the root length. The critical Al concentration for rice seedling growth is 15 µM. This means MR 219 (grown on 90% of the granary areas in Malaysia) is relatively less tolerant to acidity compared to other varieties. At high Al concentration, the rice roots secreted citrate and/or oxalate which subsequently formed Al-citrate and Al-oxalate, respectively. This is the mechanism how rice is able to reduce Al toxicity.

Introduction, Evaluation and Utilization of Chickpea (*Cicer arietanum* L.) in the northern Philippines

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Chickpea (common name is '*garbansos*') which can be grown profitably in Cordillera Administrative Region (CAR) specifically in Benguet where cool season prevails. Aside from being an alternative high value crop for CAR farmers as source of livelihood, chickpea can also serve as an additional or supplementary legume food because of its high protein content. Selected varieties from the study on germplasm, collection, characterization and evaluation of chickpea varieties under lowland (Desi type varieties namely; ICCV 10, ICCV 93952, ICCV 07114, and Kabuli-type; ICCV 92311, ICCV 95332 and ICCV 07307) and highland (Desi-type varieties; ICCV 93954, ICCV 93952, ICCV 06102, and Kabuli-type varieties; ICCV 92311, ICCV 95334 and ICCV 07307) conditions of Benguet were used for the package of technology (POT) trials. These were planted in Benguet State University (highland condition with 1,245 masl) and in Dalupirip, Itogon Benguet (300 masl), Gumatdang, Itogon, Benguet (380 masl), Tuel, Tublay, Benguet (420 masl) for the lowland condition to produce technology on appropriate planting distance, best source of organic fertilizer, optimum level of NPK/ha, minimum duration of weed control, optimum frequency of irrigation and to determine the postharvest and processing qualities of chickpea under lowland and highland conditions of CAR. Results showed that in the highlands, ICCV 93952 (Desi-type) and ICCV 92311 (Kabuli-type) produced the highest seed yield when planted at 30 cm x 20 cm, applied with Sagana 100 at 5 tons/ha for organic farming, 45-100-45 kg NPK/ha, weed free from sowing to first pod stage and was irrigated every 15 days after seedling stage. For the lowland conditions, ICCV 93952 and ICCV 07114 (Desi-type), ICCV 95332 and ICCV 92311 were the highest yielder when planted at 30 cm x 10 cm with either processed chicken manure or Sagana 100 at 5 tons/ha for organic farming, 45-100-45 kg NPK/ha, weed free from sowing to harvest and irrigated every 5 days from seedling stage. ICCV 07307, (Kabuli-type) had the highest milling percentage recovery when harvested at brown pod stage and has the highest cookability of whole seed and dhal. Initial fungal development of cooked whole seed of ICCV 95332 and cooked dhal of ICCV 92311 when harvested at yellow brown pod stage was observed after 3 days. Based on sensory evaluation, ICCV 92311 harvested at yellow pod stage had the highest acceptability rating with regards to color, odor, texture and taste Desi type varieties were utilized for flour, cookie and puto. Kabuli type varieties were made into fingerfood.

Performance of Yam (*Dioscorea alata* L. var. Ubeng-Ube) at Different Period and Concentration of Naphthalene Acetic Acid Applications

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Naphthalene acetic acid, a growth hormone was applied on yam at different period and concentration. Its effect on growth and yield performance was determined The period of application

significantly affected the percentage emergence and average number of shoots developed 14 DAHA, percentage emergence of yam 15DAP, average number of leaves 30 DAP, average days to emergence, days to maturity, number of marketable tubers, and the average length of tubers. Similarly, the applications of the different concentration NAA affected the number and length of roots and shoots developed 14 DAHA, percentage emergence 15 DAP, average number of leaves 30 DAP, average days to emergence, and average days to maturity, average number of marketable tubers, and average length of tubers. Interaction effects between the period and concentration of NAA applications were observed to be different on the percentage emergence and average number of shoots developed 14DAHA, percentage emergence 15DAP, average days to maturity, and average number of marketable tubers. These showed that the application of at least 100 ppm of NAA inhibits the emergence and shoot formation of yam setts. Root formation was enhanced by the application of 1000ppm while root elongation was inhibited by the application of 550ppm. Shoots and leaf development was also initiated by the use of NAA .Early maturation was stimulated by its application but it has no influenced on the number, weight and diameter of tubers as well as the ROI.

Effects of Tuber Weight and Cutting Method on Growth and Yield of Safed Musli (*Chlorophytum borivillianum*)

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Safed musli, or *Chlorophytum borivilianum* is a new potential herb in Malaysia. As a new herb, there is lack of information regarding its cultivation practices. Safed musli is grown using tubers which play a dual role of being the organ of economic importance as well as the planting material. In this crop, it is necessary to utilize the planting material efficiently, as the increased use of tuber as planting material will increase the production cost as well as limit usable yield. Therefore, it is necessary to study the quantity of planting material (by weight) required for effective field establishment and the potential of cutting method in order to minimize the production cost. Safed musli tubers were separated into three weight categories (3, 6 and 9 g) and tubers belonging to the three categories were either whole or cut tubers. Experiment was conducted in randomized complete block design with two factors namely weight and cutting method. Results showed that there was no interaction between tuber weight and cutting method. All tubers in different weight categories did not show significant difference in all parameters studied, but cutting had significantly higher leaf area index and fibrous root length compared to whole tubers. Cut tubers was also able to produce bigger tuber diameter (6.64 mm) with higher number of tubers (21 tubers per bulk) compared to the use of whole tubers as the planting material with 18 tubers measuring 5.36 mm in diameter. It was also found that cut tubers from all tuber weight category resulted in 13.5% increase in yield. Therefore, it is proposed that the use of cut tubers weighing 3 g alone is sufficient to obtain optimum yield. This recommendation, will allow a saving of 66% in the cost of planting material.

Silvicultural Treatment on *Gigantochloa ligulata* Bamboo to Increase Bamboo Shoot Production for Food Consumption

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In Malaysia, bamboo shoots have been relished as food since the early days. At present, bamboo shoot of *Gigantochloa ligulata* (buluh tumpat) is considered one of the commercial bamboo species in Malaysia. Owing to its demand as food, especially in the northern part of the country, and since there has been no study done on the thinning of this species, a study on the effect of thinning intensity as one of the silvicultural treatment on *G. ligulata* bamboo was conducted at Taman Wetland, Putrajaya, Malaysia. The study was done from March to June 2005. Thinning intensities of 0% (control), 30% and 60% were applied twice every two months within the four months period. The three thinning intensities including the control were done in replicates and there was six replicates altogether comprising of 18 samples clumps. Thinning was based on the selection of culms three years old and above out of the total available culms within the clump. Thinning of 30% means 3 culms out of ten culms within the clump were cut. Each clump in all the replicates was applied once with 3 kg of goat dung in granule form. The organic fertilizer was applied in a circular form around the clump's periphery. Parameters involved were number of shoots sprouted, weight of shoots and the number of culms. This included the clump expansion pattern of the selected treatment clumps. New shoots were tagged and recorded every week. A shoot which up to 30 cm and from the ground was considered as a shoot. The weights of shoots with or without sheath were recorded on a weekly basis. The distribution pattern of the shoots' sprouting was also observed. It was found that 30% thinning intensity gave more shoots compared with other intensities including the control.

The Stability and Expression of β-Glucuronidase Gene in Transgenic *Dendrobium* 'Sonia' Earsakul

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Dendrobium orchid is the major export cut flower not only in Thailand but also for several ASEAN countries. There are attemps to improve yield and quality of this orchid conventionally. However, with the new technology of genetic transformation, it's offer the mean of non-barrier genetic transfer throughout the living organisms. Thus plant transformation is the challenge technology for orchid improvement. For *Dendrobium* orchid transformation, we successfully transformed protocorm like bodies (PLBs) of *Dendrobium* 'Sonia' Earsakul using *Agrobacterium*-mediated transformation technique. *A. tumefaciens* strain EHA 105 possessed pCAMBIA 1301 vector plasmid containing β-glucuronidase (*gus*) reporter gene and hygromycin phosphotrasferase *(hpt)* selectable marker gene under the control of 35S CaMV promoter was used. The plbs were co-cultivated with *A. tumefasiens* suspension ($5x10^8$ cells/ml; OD_{600} ~ 1) on VW solid medium supplemented with 500 μM acetosyringone. After co-cultivation for 2 days, *A. tumefasiens* were eliminated and transgenic cells were selectyed on VW solid medium supplemented with 30 mg/l hygromycin and 250 mg/l cefotaxime for 3 month. The 5% plbs were regenerated to the stable transformed plbs and all of them still exhibit the stable transformed event after 1 year of culture. The existent and expression of *gus* gene in 1-year-old *in vitro* plantlets were respectively confirmed by PCR and GUS histochemical assay.

In vitro Propagation of Limau Purut (*Citrus hystrix*)

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Citrus hystrix belongs to the family Rutaceae. Citrus and its relatives is one of the most important commercial crops based on its nutritional, medicinal and economic value. Recent researches reveal vast potential of this underutilised species for commercialization. Essential oils extracted from *C. hystrix* peels contain antibacterial properties and induce calming effects on users. Its fruits contain high antioxidants. In citriculture, *C. hystrix* can be utilised as a rootstock or interstock to *C. reticulata* to increase resistance against greening disease. These novel properties have great potential for citrus breeding. An efficient *in vitro* propagation protocol will greatly accelerate breeding via genetic transformation. In this study, 7 week-old *in vitro* seedlings were excised into five parts, which consisted of shoot tip, epicotyl, cotyledon, hypocotyl and primary root. The explants were cultured on shoot induction medium consisting of MS medium supplemented with various concentrations of 6-benzyl amino purine (BAP) ranging from 0.125 to 3 mg/L. After 8 weeks of culture, optimum shoot induction was obtained on hypocotyl explant placed on medium containing 0.5 mg/L BAP. High percentage of shoot senescence occurred on shoot tip culture. The addition of calcium gluconate in medium containing 0.5 mg/L BAP improved shoot number and reduced shoot senescence for shoot tip culture. However, the presence of calcium gluconate reduced the number of shoots regenerated from epicotyl, cotyledon, hypocotyl and primary root.

Tolerance Estimation of Hybrid Rice towards Droughts by Using Polyethylene Glycol (PEG 6000)

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The polyethylene glycol (PEG) use in testing the seed resistance towards the droughts has been used many times. PEG 6000 is expected can be used to detect initially the rice hybrid genotype in which is drought tolerance so it can solve the problems of many cultivars that will be tested in the field and accelerate the selection cycle in improving program and variety assembling. The aim of this research is to get the method of initial testing and accurate character of hybrid rice towards droughts tolerance that has potential can be developed in the rainfed lowland rice. Designing of the research method consists of : (i) complete random designing by treatments of PEG concentration levels and (ii) split plot designing by treatments of PEG concentration and hybrid rice genotype. The result research indicates that PEG concentration of 25% (w/v) can significantly decrease the seedling growth of drought sensitive check variety (IR 64), but it is not signicantly decrease the seedling growth of drought tolerance check variety (Limboto, Situbagendit and Inpari 10). PEG concentration of 25% can be used to estimate initially the hybrid rice drought tolerance. Based on the length of root, density of root (quality of root dry), ratio of crown root and level of leaves dryness indicators at seedlings phase, so genotype BI485A/BP3, BI485A/BP12, BI485A/BP15 and BI559A/BP15 estimated are drought tolerance. Genotype BI559A/BP15 is most consistent and indicates the criteria of drought tolerance, so it is estimated to have potential for being developed in the rainfed lowland rice.

Improvement of Production and Quality of Komatsuna Vegetable by Adding Chicken Manure Composts

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The use of animal manure in fields is considered to be one of the most effective method in reducing the use of industrially produced chemical fertilizer as well as utilizing the minerals nutrients in farm wastes. Furthermore, animal manure have an ecological advantage in the development of sustainable agriculture. In most circumstances, the uptake of nitrogen by a growing plant and the accumulation of mineral nitrogen in soil are both preceded by, and dependent on nitrogen mineralization. The study was conducted in two consecutive experiments to observe the effect of ten chicken-manure composts with different nitrogen content and to investigate their residual effect on the crop yield and its quality (the content of vitamin C, reducing sugar and nitrate accumulation of plant). Equivalent to 1 g N/pot of chicken-manure composts were applied to 2 kg soil for pot experiment. Komatsuna vegetable was used as a sink of mineralized-N from chicken-manure composts. Unmanured pot was used as control, whereas pot fertilized with urea (0.5 g N/pot as standard of comparison for chemical fertilizer. The addition of KCl and Triple Super Phosphate (TSP) at rate of 0.5 g P_2O_5/pot and 0.5 g K_2O/pot in the urea plot to assure the good initial growth. In the second experiment in the urea plot was added again by KCl and TSP with the same rate as the above mentioned. The addition of chicken-manure composts indicated significant difference than control to the yield of Komatsuna but Ch-5 and Ch-8 had no significant differences with urea. The effect of residual Ch-5 and Ch-8 still showed the increase in Komatsuna yield, and it enhanced significantly than residual urea; whereas the other treatments exhibited lower yield than those in the first experiment. The increase of Komatsuna yield might be caused by the higher N mineralization by which a residual inorganic N remained in the soil. Nitrate accumulation in plant induced by increased N mineralization in soils. The application of Ch-5 and Ch-8 and urea greatly increase nitrate accumulation in Komatsuna plant, while Ch-1 which had slower N mineralization induced a small nitrate accumulation. The content of glucose and reducing sugar was low with the increase of nitrate content of Komatsuna.

Performance of Yam (*Dioscorea alata* L. var. Ubeng-Ube) at Different Period and Concentration of Naphthalene Acetic Acid Applications

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Naphthalene acetic acid, a growth hormone was applied on yam at different period and concentration. Its effect on growth and yield performance was determined The period of application significantly affected the percentage emergence and average number of shoots developed 14 DAHA, percentage emergence of yam 15DAP, average number of leaves 30 DAP, average days to emergence, days to maturity, number of marketable tubers, and the average length of tubers. Similarly, the applications of the different concentration NAA affected the number and length of roots and shoots developed 14 DAHA, percentage emergence 15 DAP, average number of leaves 30 DAP, average days to emergence, and average days to maturity, average number of marketable tubers, and average length of tubers. Interaction effects between the period and concentration of NAA applications were observed to be different on the percentage emergence and average number of shoots developed 14DAHA, percentage emergence 15DAP, average days to maturity, and average number of marketable tubers. These showed that the application of at least 100 ppm of NAA inhibits the

emergence and shoot formation of yam setts. Root formation was enhanced by the application of 1000ppm while root elongation was inhibited by the application of 550ppm. Shoots and leaf development was also initiated by the use of NAA .Early maturation was stimulated by its application but it has no influenced on the number, weight and diameter of tubers as well as the ROI.

Nutritional Quality of *Cosmos caudatus* in Response to Fertilizer Rates and Sources

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Nutrient management is important for sustainable production of quality herbal plants. Besides its direct impact on vegetative growth, fertilizer has been reported to influence nutritional quality which includes vitamins and antioxidant activities, of green vegetables. However, its effect on phytonutritional quality is still contradictory. Since documentation on local herbs in relation to fertilization and phytonutritional is scarcely available, this experiment was conducted to evaluate the effects of fertilizer rates and sources on phytonutritional quality of *Cosmos caudatus*. Commercial organic fertilizer 8%N: 8%P_2O_5: 8%K_2O and inorganic fertilizer 15%N: 15%P_2O_5:15%K_2O were evaluated based on N element at 0, 30, 60, 90, 120 kg ha^{-1}. The fertilizer was applied at 2 and 4 weeks after transplanting. The young expanded leaves were used to determine nutrients, chlorophyll, nitrate, vitamin C and antioxidant activity. The leaves were dried, ground and analyzed for total N and P, K, Ca, Mg, chlorophyll and nitrate content. Mineral content in leaf tissue was highly influenced by fertilizer rates. Application of fertilizer significantly improved nutrient elements and chlorophyll contents. The chlorophyll was linearly increased with the higher N content in leaf tissue. Organic fertilized plants, the leaves contain higher ascorbic acid and lower nitrate compared to the inorganic plants. For maximum ascorbic acid content, regardless of fertilizer sources, this crop did not require a high amount of fertilizer. In both cases, the ascorbic acid content decreased with increased in fertilizer rates. Within the rate ranges tested, this crop probably requires only 30 to 60 $kgha^{-1}$ of N. Regardless of fertilizer sources, fertilized plants exhibited higher antioxidant activities than those without fertilization. The activity however was not significantly different amongst fertilized plants. The 30 to 90 $kgha^{-1}$ N treatments exhibited a stronger antioxidative property. The strong activity exhibited by fertilized plants suggesting that in herbal production nutrient application is necessity for quality herbs. Oganic fertilizer should be used as a source of nutrients and 60 $kgha^{-1}$ of N should be sufficient for quality *C. caudatus.*

Biofertilizer and Biopesticide Effects of Goat Manure Tea on Rice and Tomato

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Goat manure tea (GMT) was evaluated as a biofertilizer cum biopesticide on rice (var. PSB RC 82) and tomato (var. Magilas). GMT was produced by steeping shredded goat manure in water at 1:2 goat manure:water ratio for 15 days. A dark brown liquid with shelf -life of more than three months, GMT was initially pungent whose odor gradually faded upon storage. NPK analysis showed a highly reduced content in comparison with the raw shredded goat manure and vermicast. Under laboratory conditions, GMT exhibited molluscicidal action against golden snails, *Pomacea* sp. a serious pest of lowland rice, at 2.5% to 15% concentration. Plant damage was inversely proportional to GMT concentration. Based on a choice test, GMT caused a slight antifeedant effect on *Helicoverpa armigera* larvae. GMT also inhibited larval growth by lengthening number of days to pupation; although their respective pupae had shorter days than control. GMT soil-drenched on tomato seedlings showed the nutrient enhancing property with taller, more robust and greener leaves than

untreated ones. However, GMT inhibited tomato seed germination more than rice seeds but no antagonistic effect on damping-off organisms infecting tomato seedlings. Microbial analysis showed bacteria as the major component of GMT. Presumably, in addition to the beneficial bacteria, the cocktail of partially and undigested foods, digestive juices and urine are the components responsible for the dual properties of GMT. The potential of GMT as biofertilizer cum biopesticide for lowland rice and tomato will be ascertained under field conditions.

Likas Saka: Promotion of Farm Wastes Recycling and Re-Use for Organic Based Crop Production

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Phanerochaete chrysosporium, is a new fungal strain isolated and developed as Likas Saka inoculant found to shorten the decomposition of agricultural wastes. Piles inoculated with Likas Saka at 100 and 200 g matured in 33 days as results of the trials conducted at Bicol Experiment Station, San Agustin, Pili and Bombon, Camarines Sur from 2007 to 2011. Piles inoculated with *Trichoderma* BIOCON™ matured in 38 days. Samples taken in Day 36 revealed lower levels of C:N ratio during the period when stable temperature lower than 40 °C was achieved. The *Azotobacter* enriched compost obtained higher organic carbon (OM), and nitrogen, phosphorous, and potassium (NPK) content than the unenriched compost. OM ranged from the enriched compost was between 15.59% to 19.11% while those from the unenriched from between 2.14% to 2.46 %. The average increase in NPK contents were 1.40%, 1.36%, and 1.37%, respectively. At 50% recovery of Likas-Saka at total NPK of 8.69%, one could get 150% more of organic fertilizer pegged at 385,952.5 tons (385,952,500 kg) or approximately 7,719,650 50-kg bags of organic fertilizer or 1,608,260.42 bags of complete fertilizer (14-14-14). With the enactment of the Organic Agriculture Act of 7010, it provides another option for the promotion of organic agriculture.

Genetic Variation among Okra (*Abelmoschus esculentus* L. Moench) Varieties

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Abelmoschus esculentus or okra is valued for its edible green fruits that are harvested immature and eaten as a vegetable. There are many available okra varieties that differ for traits such as fruit characteristics, maturity and height. An evaluation was conducted at two sites in Universiti Putra Malaysia, to compare agronomic performance of 18 commercial varieties and 7 varieties from AVRDC. The varieties were planted in a randomized complete block design with three replications. The planting arrangement was 60 cm x 45 cm. Principal component analysis was performed and four groups were distinctly identifíed based on qualitative traits. For quantitative traits, the okra varieties showed highly significant differences in plant height, fruit length, number of nodes, days to flowering, stem diameter, fruit fírmness, and weight per fruit. However, there was no significant difference among varieties for number of fruits per plant and yield per hectare. The highest heritability value was found for days to flovvering (71.6 in Field 2 and 77.2 in Field 10), while the lowest value was yield per hectare (1.9 in Field 2 and 9.3 in Field 10). Highly signifícant correlation was observed between number of fruits per plant and yield per hectare, with values of 0.87 in Field 2 and 0.91 in Field 10. Combined ANOVA of both sites also gave highly signifícant effects of varieties for these traits.

Results showed that the variety Trio gave the best performance in Field 2, while 989 Jackpot gave the best performance in Field 10. These varieties can be suggested for commercial planting and have potential to be used in breeding programs.

Agrobacterium-mediated Transformation of Teak (*Tectona grandis* L.f.)

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Teak (*Tectona grandis* L.f.) is one of the most important tropical hardwood species widely planted in Thailand and Southeast Asian countries. However, teak plantation has various problems including susceptible to various pests and diseases. Genetic engineering is a possible approach to overcome these problems. *Agrobacterium*-mediated gene transformation is effective method for gene transfer in various plant species. However, as with many woody species, teak has appeared recalcitrant to genetic transformation. The proposition of this study was to introduce foreign gene into teak *via Agrobacterium*-mediated gene transformation, thus parameters including bacterial strain, type of teak tissue and inoculation techniques were tested. The *A. tumefaciens* strain EHA105 and AGL-1 possess the binary vector pCAMBIA1304 containing *gus* gene as a reporter gene and *glyphosate resistance gene (aroA)* gene as selectable marker gene were used to transform leaf base and nodal segments of teak. The transient expression of *gus* gene revealed that nodal segment was more suitable to be used as explants than the leaf base tissue. Extra wounding by sonication promoted transformation efficiency in nodal segment as well. The *Agrobacterium* strain EHA105 and the inoculation period of 5 hours followed by 3-5 days of co-cultivation were successfully used for teak transformation. The existent and the expression of *aro*A gene were confirmed by polymerase chain reaction (PCR) in putative transformed lines after 6 weeks of selection in glyphosate-containing selective medium. The results of GUS histochemical assay was also confirmed the expression of *gus* gene in those lines.

(*Elaeis guineensis* Jacq.) Polyembryoids from Cell Suspension Based on Micromorphological Evidence

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Oil palm is economically one of the most important oil producing crops in the world. It is an important source of vegetable oil and the most traded vegetable oil in the International market which is increasingly used in the food industry. Therefore, with worldwide yearly increases in demand for palm oil, the cultivation of oil palm has expanded enormously in recent years. Oil palm, a perennial crop species with long breeding cycle and a single growing apex is generally propagated using hybrid seeds, however, in recent year micro-propagation of oil palm via somatic embryogenesis has become the key method for multiplication of oil palm elite genotypes. Shoot segments are cultured and embryogenic callus in induced, which is then converted into suspension culture. The growth and developmental stages from cell suspension to the formation of polyembryoid was traced using

scanning electron microscopy in order to clearly distinguish the morphological sequence of events. Five major stages in development are reported inclusive of distinct morphological and structural conformation. This report also reveal that the transition from one stage to another is time consuming and the whole chain from cell suspension culture to the production of polyembryoid require circa one and half year .

Induction of Hairy Roots from *Eurycoma longifolia* a Difficult-to-Transform Valuable Medicinal Plant Using Wild Strains of *Agrobacterium Rhizogenes*

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Production of hairy roots from the difficult-to-transform medicinally important plant *Eurycoma longifolia* will ensure continuous supply of secondary metabolites thus minimizing the use of plants from the wild. Seed morphology and histology analysis of *Eurycoma longifolia* by light microscopes revealed seeds structures of this important medicinal plant at different growing stages. The seed development phases and the development of the vascular system on the progression of germination provide insights on the cotyledon development period. Seeds may facilitate the generation of the hairy roots, as it evidently has the essential features like tracheas, which are the main site of infection for *Agrobacterium rhizogenes*. Chemotaxis using the swarm agar plate method initiates the process of bacterial infection towards the plant cells and thus conferring beneficial attributes to the host. Strong positive chemotactic response was observed in most of the tested bacteria strains towards the *in vitro* root and somatic embryos. Hairy roots were successfully initiated using three wild strains of *Agrobacterium rhizogenes* namely MAFF 210265, MAFF 301726, and MAFF 720002 at the hypocotyls region of *Eurycoma longifolia*. Amplification of the *rol* gene at 1100 bp by PCR analysis confirmed the T-DNA integration of the Ri plasmid in the hairy roots. Generating hairy roots in *Eurycoma longifolia* will be highly beneficial to the pharmaceutical industry with valuable secondary metabolites which is directly linked to its root differentiation at a low biomass starting material.

The Expression of *rol* Genes in Plantlets Regenerated from Hairy Root of *Plumbago indica* L. Leads to the Phenotypic Deformation and the Increased in Plumbagin Content

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The hairy root culture of *Plumbago indica* L., induced by *Rhizobium rhizogenes* strain K599, was found easily to regenerate plantlets. However, morphology of the plantlets was differed from the original plant. These phenotypic deformed such as wrinkled leave surface, dwarf phenotypes cluster branching, abnormal stem growth and short internodes were observed. The detection of *rol* genes by

PCR technique revealed the integration of the *rolA, rolB* and *rolC* genes from *R. rhizogenes* into those plantlets genome with the variation in the gene transferred events. According to the deformation of the plantlets and the presence of each *rol* gene, it can be suggested that *rolA* gene might be involved in the dwarfism. For *rolB* and *rolC* genes, the correlation to the phenotypic deformation was not clearly relevant. However, plants contained *rolA, rolB* and together with *rolC* genes were found to be much more abnormal than those contained only 1 or 2 of these genes. The quantification of plumbagin, the main secondary metabolite accumulated in the root part of this plant species also suggested that *rolC* gene might be involved in the increase of plumbagin content as the roots of the *rolC* containing plants showed higher plumbagin content than those of the control roots. Thus, the use of plantlet regeneration from *R. rhizogenes*-induced hairy root might offer the way to induce genetic variation in the regenerated plantlets and can be useful especially in the case of *in vitro* production of plant secondary metabolite.

The Scale-Up of *Plumbago indica* L. Hairy Root Culture in Stirred Tank Bioreactor

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The plant tissue and organ cultures are preferred over the conventional source for a number of proteins, secondary metabolites and biologically active substances. Hairy root obtained from genetic transformation by *Rhizobium rhizogenes* are genetically stable and express faster growth rate and secondary metabolite production than the normal root. This study was conducted to scale-up the hairy root culture of *Plumbago indica* L. in 5 l stirred tank bioreactor. The 2.0% (w/v) hairy root were cultured in 3 l of ½ MS media supplemented with 20 g/l sucrose under 25±2 °C, dark condition and stirred at 80 rpm. The growth and plumbagin production of hairy root were affected by root morphology, aeration rate and medium circulation. Using small root clump and 0.6 volume of air per liter of medium per minute (vvm) aeration rate exhibited higher growth and higher plumbagin production than using large root clump and the aeration rate of 0.3 vvm. For medium circulation, the all-time stirred for 20 days showed the higher in growth but lower plumbagin production than 16 days stirred followed by 4 days pause.

Land Resources Management

Study of *Pekarangan* Agro-Biodiversity in the Upper Stream of Kalibekasi Watershed, Bogor District, Indonesia

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Pekarangan, an Indonesian typical home garden, has several ecological potential of agro-biodiversity. On the other hand, *pekarangan* management in Indonesia is facing several problems, such as decreasing plot size, decreasing plant species for production function, but increasing ornamental plants for aesthetic function. The objectives of research are to analyze *pekarangan* agro-biodiversity, particularly in relation with agroecological zones of watershed, urbanization and conservation of agro-biodiversity resource. This research was conducted in Cimandala, Landeuh and Leuwijambe Hamlets which represented of the upper part, the middle part and the lower part of the

upper stream of Kalibekasi Watershed. Totally 36 samples of *pekarangan* were observed and analyzed for the structure and function of plants and live stocks species. The numbers of Margalef index, Shannon-Wiener and index Sørensen coefficient show that the upper part has the highest plant's diversity. While, the middle part is the species similarity connection place of the upper and lower part. Spatial analyzed regarding agro-ecological zones found that *pekarangan* size influences the plant and live stock diversity. In addition, front yard (*buruan*) has the higher biodiversity than right and left sides (*pipir*) and back yard (*kebon*) of *pekarangan*. It was found that urbanization caused increasing of exotic species of ornamental plants and pet in *pekarangan* due to smaller plot size and adapting urban lifestyle. We concluded that pekarangan in the upper stream of Kalibekasi Watershed still has a potential as a site for ex-situ agro-biodiversity recourses conservation.

Edible Landscaping: A Promising Technology for Urban Agriculture in the Philippines

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In the Philippines, the practice of urban agriculture aims to augment the availability of food for the increasing population particularly in urban areas. However, these practices are less appealing in the urban communities which edible landscaping tries to solve. Edible Landscaping (EL) is a new concept of blending aesthetic and functionality of space with an extra reward of producing safe and nutritious food for the family and the community. It utilizes vegetables, herbs and fruit trees as major softscape materials to substitute for the ornamental plants used in conventional landscaping. EL is governed by various principles in designing, implementation and maintenance as similarly done in conventional landscaping. It combines the traditional and new methods of crop production applicable from seedling establishment to harvesting but with a different twist to increase people's interest while providing suitable conditions for better growth of the crops. Currently, EL is open for further development and is intensively promoted through creation of various demo-gardens, providing lectures and seminars to different organized groups, television and radio interviews and participation in different congresses and conventions. Production of instruction manual and brochures are also in the pipeline to cater the raising number of possible adaptors of the technology.

Enhancing Watershed Resources Management for Food Security and Climate Change: Is There A Role of Institutions, Trusts, and Collective Action?

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This research examined the institutional and collective behaviour of households within the Pinacanauan de San Pablo River Watershed. There were eight barangays covered with 306 household-respondents sampled through systematic random sampling and afterwhich data were generated using an interview schedule. Results of the study showed that the households are too dependent on traders for their credit needs indicating and imperfect credit market situation in the study sites. This condition may entail a manipulative behavior on the part of the lender-trader in the absence of formal credit institutions which could lead to abject poverty of the households. Few households (21%) are members of cooperatives because households reasoned out that they have no time required for cooperative membership which indicates high transaction cost for cooperative membership. The participative behavior of households in community activities indicates that the more formal institutional structures like the local government units (LGUs) and leadership factor may enhance community or group participation, such as roads and bridges construction and maintenance. The high and favorable rating

for collective social behavior of the respondents in the study areas indicate the potential for positive involvement of the households in the sustainable management of watershed resources. The respondents' willingness to participate in finding solutions to community problems is positively related to willingness. Several researchers, on the other hand, suggested the support or involvement of NGOs and external agencies (notwithstanding the critical role of LGUs), especially in the initial stages not as the main drivers or implementers but as facilitators.

Evaluation of Major Agricultural Soils Towards Rational Land Area Allocation for Food and Biofuel Feedstocks Production in Cagayan Valley, Philippines

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The Biofuels Act of 2006 mandates the use of biofuel as a measure to ensure availability of alternative energy without detriment to the natural ecosystem, biodiversity and food reserves of the country, and production shall be done within marginal areas. The study aimed to identify sites considered prime agricultural lands for food and feed production and in the process delineate marginal lands that may be allocated for biofuel feedstock growing in Cagayan Valley. It employed soil characterization and suitability assessment of agricultural soils. With the total delineated agricultural area of 911,167 hectares, there were about 360,193 hectares considered as prime agricultural lands to meet the regional requirement up to the projected 40 years period. There were also about 431,044 hectares of marginal lands with high to moderate suitability to cassava, coconut, *Jatropha*, oil palm, sweet sorghum, sugarcane, and switch grass. The productivity of these marginal areas were limited by shallow rooting depth, topography, acidity and low inherent fertility, surface run-off and drainage conditions of the soils. To enhance productivity, investment on soil management and improvement has to be done. A second level suitability assessment showed that 84% of the marginal land is suitable for switch grass and 54% for cassava, coconut, *Jatropha*, oil palm, sweet sorghum and sugarcane. About 16% were considered permanently not suitable for biofuel crops and were recommended for afforestation for watershed purposes. Switch grass, sugar cane, cassava and oil palm proved to be more productive in terms of biomass yield, biofuel potential, and soil suitability than J*atropha*, coconut and sweet sorghum. Based on the above findings, national and local planners may find this study valuable land allocation. Foremost is to ensure food security and at the same time allow Cagayan Valley to locally produce alternative energy to conform to the national program of promoting biofuel production.

State of System of Resident Areas in Quang Xuong District, Thanh Hoa Province, Vietnam

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The study analyzed the nature of resident areas of Quang Xuong district in response to "*A Set of National Criteria for Renewing Rural Areas*" and **"***Tam nong***"** policy in Vietnam. The data were gathered from all of 392 resident areas of district.The results show that Quang Xuong district locates in the center part of Vietnam with its population 265,249 people, 65,172 households, and its total area 22780.12 hectares. The land for residential areas is 4353.79 hectares, including 3350.35 hectares for housing; 261.30 hectares for public construction systems; 526.33 hectares for transportation; 97.59 hectares for growing green trees; 114.27 hectares for small scale industries; and 3.76 hectares for other purposes. It consists of 41 communes with 392 resident areas. In average, each commune has 10 resident areas and there are 676 people and 166 households in each resident area. "*A Set of National*

Criteria for Renewing Rural Areas" includes 19 Criteria with 5 groups: planning, socio-economic infrastructure, economics and productive organizing, culture-society-environment; and politic system. Based on that, 392 resident areas of Quang Xuong were classified into 3 levels: level 1 with 71; level 2 with 134; and 187 level 3 with 187 resident areas. There are some drawbacks in terms of landscape architecture and there is great difference between urban and rural resident areas. By 2020, the system of resident areas will develop for 4 regions with 5 towns and 1 center of commune group according to regional advantages. At that time, QuangXuong district will have 363 resident areas: level 1 with 140; level 2 with 158; and level 3 with 65 resident areas. In which urban resident areas are 46 and urban resident areas are 317. To develop a united residential areas and enhance living quality of local people, local authority should improve all types of planning and make appropriated policy to get capital from government, NGOs, and people.

Thermal Distribution Analysis in a Tunnel Greenhouse by Coupling Ventilation

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Many types of greenhouses had been assembled in Indonesia. This research was conducted in Bogor area, West Jawa, and to study a modified tunnel greenhouse using a couple of ventilation. The added second ventilation was built at the roof construction, as an effort to find the appropriate condition of the suitable tropical environment for establishing *Chrysanthemum* plantation. Efforts to change the environment by adding the fan, was expressed in changing the temperatures around the plants. The environmental condition of this area affected photosynthesis of plants and produced O_2. The prerequisites optimal growth of plants in a greenhouse need the humidity around 70% to 85% and the temperatures in range of 18 – 22 °C. It means that the temperature distribution pattern in the greenhouse tunnel is important. Heat transfer that occurs in these greenhouses was radiation, convection and conduction. The combination of the natural ventilation and fan are used to convert the heat transfer inside the greenhouse to cool the air. The aims of this study were looking for patterns of temperature distribution inside the building and find the place to move out the heat. The temperature distribution patterns and changes in the movement of air flow are mapped using a method of graphically mapping program Surfer 8. The observation is done as the temperature changes inside the greenhouse from 6:00 a.m. to 18:00 p.m. It showed that the maximum humidity was more than 85% especially around 06.00-08.00 a.m. and after 14.00 p.m. The coefficient of magnitude radiation (kr) in several surface types such as kr_{floor} was 27.24 W m^{-2}, kr_{roof} was 26.57 W m^{-2}. The coefficient of convection of air (hc) among roof environment outside is 630.45 W m^{-2}, at roof was 209.1 W m^{-2}, at the floor surface inside the greenhouse was 1369.4 W m^{-2}. The coefficient of conduction of soil (k_{soil}) was 156.68 W m^{-2}, at roof (k_{roof}) was 20.62 W m^{-2}.

Microstructure and Properties of the Bionanocomposite of Polypropylene Reinforced with Cellulose Nanoparticles Biomass of Rattan

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Cellulose is the most abundant natural polymer, found in plant cells walls. Recent interest in greener cellulose materials for general applications, especially in the automotive industry have sparked the development of green composite materials. Our aim have been to develop

bionanocomposites by ultrasonic and injection moulding method, analysis of the microstructure and morphology of the nanocomposite have been characterized by Scanning Electron Microscope (SEM), Particle Size Analyzer (PSA), Energy Dispersive X-Ray Spectroscopy (EDS) and tensile mechanical properties. Bionanocomposite were successfully developed using cellulose nanoparticles biomass of rattan as the reinforcing and polypropylene as the matrix. Bionanocomposite with cellulose nanorattan are of great interest due to their renewable nature, small density, good mechanical properties, develop an energy efficient and cost effective processing methodology. It was to development of new biodegradable and environmental friendly nanocomposites. This new type of nanocomposites is expected to have remarkable improvement of material properties when compared with milli, micro composite materials and compared to that obtained for fiber glass reinforced PP composites. The cellulose nanoparticles rattan were previously prepared by ultrasonic method (f = 20 kHz, t = 1, 2, 3 h) and the maximum size particle was ultrasonicated 3 hours. PSA shows diameter particle 146,3 nm, number distribution 32% and volume distribution 15%. The excellent compatibility between these matrix and the natural reinforcing cellulose, observed by SEM was reflected in the element's atomic structure analysis or EDS characterization of the bionanocomposite consist mass percent of C = 81,59%, O = 17,68% and Si = 0,20%, K = 0,34%, Ca = 0,18%.

Potential Use of Sugar Cane Slash as Organic Mulch - An Effective Method to Reduce Soil Compaction, Weeds, and Surface Run-Off

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Soil compaction has been a serious matter in sugar cane plantation for long time. The problem occured due to accumulative effect of field machinery traffic during cultivation i.e. land preparation to harvesting activities. Direct influence of soil compaction to plant growth found when the plant in the stage of vegetative growth. It is because during that stage, plant root is affected by mechanical impedance. There is also problem in sugar cane field which is considered serious is weed and surface run-off. During the early stage, plant is suffered by competition with weeds to get nutrition, air, water from the soil. In order to minimize the use of chemicals, organic based approach is considered to be an effective method to control weed, surface run-off as well as soil compaction. Organic matter used in this study was sugar cane slash which is available in the field after harvesting. The objective of this study was to examine the effectiveness of sugar cane slash to control soil compaction, weeds and surface run-off as well. The observation of soil compaction effect was done up to the depth of 40 cm, while for the effect of weeds was conducted until 2 months plant stage. To see the effect to surface run-off, the measurement was done up to the depth of 20 cm. From this study, the method of using organic material i.e sugar cane slash was found very effective.

Food Production Strategy Through Infrastructure Development in the Irrigated Paddy Field

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Food production tends to decrease due to conversion of agricultural land. Uncertainty of food production in Indonesia also caused by traditional farming and farmer’s income below the poverty line. To overcome low production of food and farmer's income is the development of farm infrastructures on agricultural land. Thus, a specified model of farm infrastructure development for Indonesian irrigated field is necessary. The purpose of study were (1) to identify the integrated infrastructures development model, (2) and to make recommendations on development of

infrastructure for food production in the irrigated paddy field. A dynamic modelling was adopted in this study. Steps of the systematic approach in dynamic modelling were done, such as analysis of farm infrastructures, problem formulation, system identification, model devlopment using STELLA, model validation, sensitivity analysis, and model simulation. As a result were: farmers need more suitable farm infrastructure, such as pipe irrigation and farm roads as for on-farm infrastructures and also rice processing complex and groat processing machine as for off-farm infrastructure. The model was tested in the infrastructure development planning in Cihea irrigation system, Cianjur Indonesia. Infrastructures development should be done in integrated farming system with minimum total area of 3000 hectares. It provided the benefits for the farmers if every farmer had a minimum of 3 hectares of land area.

Insect Ecology and Pest Management

Key Factor Analysis of Brown Planthopper *Nilaparvatalugens* (Stal) (Hemiptera: Delphacidae) Outbreak in Klaten Regency, Indonesia

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Outbreak of brown planthopper, *Nilaparvata lugens*, occurred during the year of 2010-2011 in rice producing area mainly in Java. The objective of this research was to analyze environmental factors and agricultural practices related to brown planthopper outbreak in Klaten Regency, Indonesia. Data of infestation level, biotic environment, field landscape, and agricultural practices such as rice varieties, fertilizer usage and pesticide spraying were collected from five districts in which outbreak was firstly reported, by using a structured questionnaire and direct observation. Cross tabulated followed by chi-square test were applied to analyze determining factors. Key factors related to brown planthopper outbreak were rice varieties, presence of predators as well as entomopathogenic fungi and colonization of endophytic fungi in rice plant, presence of other pests, active ingredient of insecticides, interval of insecticide spraying, and nitrogen fertilizer application.

The Population Fluctuation of *Apanteles* sp., Parasitoid of Rice Leaf Roller

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Apanteles sp. is one of the most abundance parasitoids found in rice field in Malaysia. However little is known about the ecology of this species. Therefore this study was initiated to investigate the population fluctuation of *Apanteles* sp. for one rice season and also to determine the active period of the species. Four malaise traps were set up randomly at the edge of a paddy plot a month after paddy was planted. Specimens was collected weekly for 11 consecutive weeks. The collected specimens were brought to the laboratory for sorting and counting of *Apanteles* sp. The number of individuals collected weekly were recorded. For the active period experiment, four malaise trap were placed at the edge of the paddy field. The samples will be collected at three different time which are at 12.00 p.m., 18.00 p.m., and 07.00 a.m.. The number of individuals obtained per period was counted and recorded. The experiment was repeated 3 times. Data from both experiments was analyzed using one-way Anova performed in SAS 9.2. The number of *Apanteles* sp. obtained was significantly different ($p < 0.001$) by week. The highest number of *Apanteles* sp. obtained was during the second week of sampling, when the paddy was between 39-45 days after transplanting. At this stage the population of pests was high which explain the high abundance of the parasitoids. The

abundance decreased in the following weeks until the sixth week when the population increased until the seventh week. At this period, there was no pesticide being applied to the crop. The abundance drastically went down on the eight week until harvesting. This was when the farmers had intensified the mangement of pests and diseases by chemical control. *Apanteles* sp. is significantly active during the morning hours (07.00-12.00 a.m.). This study gives the basic knowledge on the ecology of *Apanteles* sp. in order to further study the potential of this species as the biological control agent of rice leaf roller.

Performance of Entomopathogenic Fungi Endogenous Strains in Rice Pest Control towards Biological Method

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Rice insect pests are classified as major or key rice pests to control rice insect pest as augmentative biological control that could be carried out by using native or endemic natural enemies together with conservation programs and designed as a component of the integrated pest management program as well as to support rice organic farming. Overall objectives of this research are to evaluate the basic criteria and the feasibility of an augmentative biological control program for the rice insect pests, emphasizing on the utilization of endemic entomopathogen, *Beauveria bassian*a and *Metarhizium anisopliae*. In this study, the most virulent strain of *B. bassiana* and *M. anisopliae* will be selected from indigenous strains that collected from paddy fields in Phitsanulok Province, northern Thailand. The collected strains were tested for preliminary screening in laboratory and greenhouse experiments based on its pathogenicity potential on the rice insect pest. The results revealed that the attempts on the use of biological control, the naturally-occurring entomopathogenic pathogens in rice insect pests, the green rice leafhoppers and brown planthoppers were infected by various entomopathogenic fungi such as *M. anisopliae*, *M. flavoviride*, *B. bassiana*, and *Hirsutella citriformis*. In addition, biological control is mainly augmentative using the native or endemic natural enemies together with conservation programs.

Diversity of Sheath Endophytic Fungi andthe Role in Protection of Rice against Brown Planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae)

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The objectives of the research were to study the diversity of endophytic fungi of rice sheath in two rice cultivars and two regencies in West Java, Indonesia and to examine its importance in rice protection against brown plant hopper (BPH) *Nilaparvata lugens*. Endophytic fungi was isolated from rice sheath samples collected from two regencies in West Java, each location consisted of two cultivars Ciherang and Pandanwangi. Further sample collection was done in Cianjur regency with three level of field BPH infestation i.e. zero, low and high. Some predominant fungi were further tested their activity against BPH under greenhouse experiment. Number of isolated fungi, diversity index and total colonization of endophytic fungi in cv. Cianjur was higher than in Subang. Diversity index and total colonization of endophytic fungi in cv. Pandanwangi was higher than of Ciherang. *Nigrospora* sp 1, *Nigrospora* sp. 2 and *Nigrospora* sp.3 , which were predominant endophyte in free BPH rice increased host resistance against BPH indicated by suppressing nymph-adults survival, make host non preference and furthermore suppress population growth.

Preferences and Oviposition of Egg Parasitoid *Ooencyrtus erionotae* Ferr. in Various Age ofBanana Skipper *Erionota thrax* L. Host Egg

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An egg parasitoid *Ooencyrtus erionotae* Ferr. is one potential biocontrol agent to control the banana skipper *Erionota thrax* L. This study aims to determine the age of host eggs that suit for parasitoid *O. erionotae* development until the imago. The experiments were conducted at the Parasitoid and Predator Bioecology Laboratory, Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University(IPB) and IPB's Cikabayan experimental field. The results showed that parasitoid *O. erionotae* are gregarious and tends to choose younger host eggs (1-2 days) than the older ones (5 days). Oviposition occurred from morning to afternoon time. Oviposition time lastsed between 10-15 minutes on the host eggs aged 1-2 days and 25-35 minutes on the host eggs aged 3-4 days.

Egg parasitoids of *Chrysocoris javanus* Westw. (Hemiptera: Scutelleridae) on *Jatropha curcas* L. in Bogor, West, Java, Indonesia

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Physic nut (*Jatropha curcas*) is one of biofuel plants which is planned to be cultifated on large scale areas in Indonesia. *Chrysocoris javanus* is an important sucking pest attacking physic nut. To control this pest, various pest control measures have to be studies and implemented. The objectives of this research were to find out egg parasitoids which are potential as biological control agents and their parasitization level at three physic nut plantations in Bogor, West Java, Indonesia. Egg parasitoids found during the study were *Anastatus* sp. (Eupelmidae), Pteromalidae, and Scelionidae (Hymenoptera). Parasitized eggs of *C. javanus* were black in color, whereas the unparasitized eggs were orange. The pteromalid wasp was the dominant parasitoid found in two plantation. Parasitization level of three parasitoids ranged from 60.1% to 97.0%. Almost all of *C. javanus* egg clusters were parasitized (88.7% - 100%).

Some Bio-Ecological Characteristics of Larval Exoparasitoid *Elasmus s*p. (Hym.: Eulophidae) on Sesami Leaffolder *Antigastra catalaunalis* (Dup.) (Lep.: Pyralidae) in Vietnam

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Sesami is one industrial plant with many advantage characters. But as other plants, sesami is infested by many insect pests. Sesami leaffolder *Antigastra catalaunalis* (Dup.) is one of most important pest which appeared very common and damaged sesami production. To control this insect pest, farmer use chemical insecticides. But using chemical insecticides is not good any more for not only natural enemies, but also effect on biological balance, environmental pollution, impact negative on human health. So, in order to protect sesami production and our environment, investigate studying on parasitoid of sesami leaffolder *Elasmus* sp. (Hym.: Eulophidae) is needed. The life cycle of *Elasmus* sp. was about 9.17 ± 1.68 days under conditions of 29.9 ± 2.8 °C temperature and 78.5 ± 3.7% humidity at photoperiod of 12L:12D. Supplemental food quality affected adult longevity, as

well as oviposition capacity. Individuals which were fed pure honey can outlive those fed with 50 and 10% honey solution (10.7 days compared to 8.8 and 5.7 days); while those fed pure water lived only 3.9 days. And female can parasited 57.5, 44.8, 31.2, and 21.9 individuals of host with a number of egg of 241.4, 179.7, 128.5 and 87.1 eggs/female respectively. The behaviour of laying egg on host larvae of *Elasmus* sp. is agregated. Average number of egg laid by female on one larval host of third or fourth instar is about 4.38 eggs/individual. In condition of laboratory (average temperature and humidity of 29.9 ± 2.8 °C and 78.5 ± 3.7%), the emergence ratio of *Elasmus* sp. was 83.1 ± 17.9% and sex ratio of male to female was 1:2.4. The suitability of larval host was second to fourth instars.

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Parasitoids of *Aphis gossypii* Nymphs from South Sumatra and Their Parasitization Performance

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The objectives of this research were to determine parasitization by three parasitoid species, i.e. *Aphelinus* sp., *Lipolexis* sp., and *Tryoxis sinensis* on nymphs of *Aphis gossypii* (Hemiptera: Aphididae), and to study the biology of *T. sinensis*—the parasitoid species that exerted the highest parasitization rate (based on mummification rate) on *A. gossypii* nymphs. Parasitoid species collected from exploration on lowland and highland areas in South Sumatra were mass reared on *A. gossypii* nymphs in the laboratory. Mated females *T. sinensis* was infested on 100 nymphs of *A. gossypii* per female parasitoid every day until the parasitoid died. The number of *A. gossypii* nymphs mummified by *T. sinensis* (24.8 mummies per female) was the highest and significantly different from mummification rate by *Aphelinus* sp. (4 mummies per female) but not significantly different from that by *Lipolexis* sp. (15.4 mummies per female). The percentage of adult emergence of *T. sinensis* was not significantly different from that of the other parasitoids. The mean developmental time from egg to adult emergence of *T. sinensis* on *A. gossypii* was 5.66 days with a range of 4-8 days. The mean longevity of the adult parasitoid averaged 2.20 days. The sex ratio was slightly predominated by female (54.19%). Eggs were laid at an average of 47.20 eggs per female.

Efficacy of Some Essential Oil Extracted from Tropical Plants to Hairy Caterpillar

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Efficacy of some essential oils extracted from tropical plants to hairy caterpillars was evaluated in order to find out the method to control population of hairy caterpillars which increased drastically in 2010-2011 in Indonesia. The caterpillars were reported to attack some plants such as wooden plants; horticulture crops, especially, mango trees and some ornamental plants, but hitherto these caterpillars have not been found to attack food crops. This caterpillars caused some problems: scary, causing skin etches, etc., especially when these insects entered the residential housing. To control the caterpillars, recently, people used chemical insecticides, however the impact of chemical insecticides is dangerous to human being, livestock, and environment. Therefore to minimize those problems, the control methods should be environmental-friendly and safe against human being. One of those methods is utilizing botanical pesticides extracted from tropical plants. Six tropical plant species, i.e. clove (*Syzigium aromaticum*), citronellagrass (*Cymbopogon nardus*), lemongrass (*Cymbopogon citratus*), neem (*Azadirachta indica*), ginger (*Zingiber officinale*), and nutmeg (*Myristica fragrans*) were tested in this experiment to utilize them as botanical pesticides. The result showed that at a concentration of 10%, all of the essential oils were effective to kill the caterpillars

(90-100%). Therefore efficacy evaluation of essential oils at lower concentrations was conducted (5%, 2%, and 1%). Lemongrass oil at 1% was the most effective in killing the caterpillars (98%). The evaluation of lemongrass effectiveness was continued at concentrations lower than 1% (0.75%, 0.50%, and 0.25%), Lemongrass oil at 0.50% could kill the caterpillars up to 90%, while at 0.25% was moderately effective (mortality 50%).

Joint Action of Mixed Extracts of *Brucea javanica* (Simaroubaceae), *Piper aduncum* (Piperaceae), and *Tephrosia vogelii* (Leguminosae) as Botanical Insecticides Against Cabbage Head Caterpillar, *Crocidolomia pavonana*

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Extracts of *Brucea javanica* seeds, *Piper aduncum* fruits, and *Tephrosia vogelii* leaves were tested separately and in mixture (3:2.5:1) in the laboratory for their insecticidal activity against the cabbage head caterpillar, *Crocidolomia pavonana*. *B. javanica, P. aduncum*, and *T. vogelii* plant materials were extracted with ethyl acetate-methanol (9:1), ethyl acetate, and ethyl acetate, respectively, by maceration method. Insecticidal bioassays were done by a leaf-residue feeding method. Second-instar larvae *C. pavonana* were fed extract-treated broccoli leaves for 48 hours and then were presented untreated leaves until the surviving larvae reached the fourth-instar stage. Larval mortality was assessed at 5 days after treatment, and the data was analyzed by the probit method. The results showed that larval mortality started at first day treatment and increase at second day's treatment, after change with untreated leaves the mortality decrease significantly. Based on LC_{50} and LC_{95} value, *T. vogelii* leaf extract was the most toxic (LC_{50} 0.05%, LC_{95} 0.16%) among the three extracts, followed by *P. aduncum* fruit extract (LC_{50} 0.24%, LC_{95} 0.32%) and *B. javanica* seed extract (LC_{50} 0.17%, LC_{95} 0.41%). Based on LC_{50} (0.06%) and LC_{95} (0.12%) value, the toxicity of a mixture of *B. javanica, P. aduncum,* and *T. vogelii* extract (3:2.5:1) against *C. pavonana* larvae was less toxic. Based on the combination index according to the independent joint action model, the extract mixture had a strongly synergistic joint action against *C. pavonana* larvae, at LC_{95} level, with combination index of 0.445.

Antifeedant, Repellency and Adult Emergence Inhibitory Effect of *Piper nigrum* L. and *Jatropha curcas* L. Extracts Against Rice Moth, *Corcyra cephalonica* (Stainton)

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To determine the antifeedant, repellency and adult emergence inhibition of petroleum ether and chloroform extracts from fruits of *P. nigrum* and petroleum ether extracts from seeds of *J. curcas* on 3rd instar larvae of *C. cephalonica* in laboratory conditions. Order of serial dilution was prepared from petroleum ether extract of *P. nigrum* and *J. curcas* and chloroform extract from *P. nigrum*. Results showed that the plant extracts efficacy on feeding of *C. cephalonica* larvae, were significantly different among plant extracts ($F = 28.16$; $df = 2$; $P < 0.0001$) and also were significantly different among applied doses of plant extracts ($F = 297.24$; $df = 5$; $P < 0.0001$). Lower percentage of weight

loss was observed at a concentration higher than 4 µl/g of plant extracts. But the plant extracts at the calculated dosage did not show any repellency against *C. cephalonica* larvae in treatments and untreated as a control. The mean percent of F1 adults of *C. cephalonica* that emerged from the treatment rice kernels more marked on chloroform extracts of *P. nigrum* with 1.2 % and this followed by petroleum ether extracts of *P. nigrum* and *J. curcas* with 5.5 and 6.7%, respectively.

Joint Action of Mixtures of *Tephrosia vogelii* Leaf and *Piper aduncum* Fruit Extracts on the Cabbage Head Caterpillar, *Crocidolomia pavonana*

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Laboratory bioassays were conducted to assess the joint action of three mixtures of *Tephrosia vogelii* (Leguminosae) leaf and *Piper aduncum* (Piperaceae) fruit extracts on the cabbage head caterpillar, *Crocidolomia pavonana*. *T. vogelii* leaf and *P. aduncum* fruit powder were extracted with ethyl acetate (1:8 w/v) four and three times, respectively, by immersion method. The number of immersion was arbitrarily optimized based on extract yield and insecticidal activity among the extracts obtained with two to six times immersion of plant materials. Based on LC_{50} and LC_{95} at 72 hours after treatment (HAT), *T. vogelii* extract was about 1.27 and 1.09 times, respectively, more toxic to *C. pavonana* larvae than *P. aduncum* extract. At the LC_{50} level, *T. vogelii* and *P. aduncum* extract mixtures at 1:1, 5:1, and 1:1 concentration ratios (w/w) were 2.51, 2.40, and 3.48 times, respectively, more toxic than *T. vogelii* extract alone, and 3.28, 3.13, and 4.55 times more toxic than *P. aduncum* extract alone. Based on the independent joint action model, *T. vogelii* and *P. aduncum* extract mixtures at the three concentration ratios were strongly synergistic on *C. pavonana* larvae, both at LC_{50} and LC_{95} level; the combination indices of extract mixtures at the LC_{50} level - 96 HAT ranged from 0.240 to 0.419 and those at the LC_{95} level - 96 HAT ranged from 0.235 to 0.347. Thus, the synergistic *T. vogelii* and *P. aduncum* extract mixtures are potential to be used as alternatives to synthetic insecticides for the control of *C. pavonana*.

The Impact of Bo-Control Agents on the Occurrence of Major Insect Pests and Diseases on Rice in West Java

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Resistance of plant to plant pathogens or insect pests can be induced by applying some bio-control agents such as plant growth promoting rhizobacteria (PGPR), endophytic fungi, and guano. These bio-control agents can also stimulate or promote plant growth. Therefore, they can be incorporated as integrated pest management components. The objective of this research was to evaluate the role of PGPR, endophytic fungi, and guano to increase plant resistance against some insect pests and plant pathogens on rice. Those bio-control agents were applied either singly or in combination as seed treatment and sprayed at nursery and in the field. Rice variety used was Ciherang and planted with System Rice Intensification. Observation was conducted on rice stem borer, rice leaf folder, brown plant hopper, bacterial leaf blight, brown spot, and narrow spot. Results showed that combination of three bio-control agents can suppress the attack of those pests and diseases. In addition, productive tillers and rice production per plot were increased.

Population Correlates and Critical Pest Level (CPL) of the Leafhopper, *Amrasca biguttula* and Associated Insect Pests Attacking Okra, *Hibiscus esculentus* (L.)

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This study was conducted in two locations; San Manuel and Capas, Tarlac, respectively, from 2008-2010. It aimed to determine the population density of major insect pests attacking okra as affected by time of planting, establishment of critical pest level (CPL) of *Amrasca biguttula* and other associated insect pests, and to assess phenologically the rate of first instar larval/nymph emergence from an eggmass. Feeding tests of insect pests with host were conducted in an experiment nethouse with sufficient batches of trials which had established the critical pest level. *Amrasca* sp. and *Dysdercus cingulatus* were found with high population density during the dry seasons planting of 2009-2010, while *Spodoptera litura* registered a population mean ranging from 16.0-22.0 regardless of observation sites. High population of *Amrasca* sp. was evident during January and onwards which has exceeded the 10 percent% critical yield reduction level of the crop which confirmed that planting of okra during dry seasons would entail significant damage of the crop. With a series of feeding interaction tests conducted for *Amrasca biguttula,* its critical threshold level was established with a population ratio of 45.53 per 50 plants with an allowable yield reduction threshold of 10%. The generated data is recommended for adoption which contributes to reduced frequency of chemical application and production of quality exportable green okra. Moreover, phenological forecast on the eggmass hatchability of two major insect pests, namely *A. bigutula* and *D. cingulatus* were found correlated with temperature which is recommended as an input in pest management.

Evaluation of Five Chili Varieties and Some Insecticides for the Control of Fruitfly *Bactrocera dorsalis* (Diptera: Tephritidae)

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The objectives of this research were to evaluate the resistance of five chili varieties to fruit fly *Bactrocera dorsalis* and the efficacy of some insecticides against the fruit fly. This research was done at Megamendung and Katulampa, Bogor, West Java, Indonesia, since June 2010 until May 2011. The varieties of chili used were F3 (12x10), F3 (10x14), Hot Pepper Tornado, Keriting 09, dan SP Hot 77. The insecticides used were mixture of *Piper retrofactum* and *Annona squamosa* extract, *Cymbopogon nardus* extract, spinosad, and imidakloprid. The experimental design used was completely randomized design for evaluation of chili varieties and split plot design for insecticide efficacy test. The data of fruit fly attack was analyzed by analysis of variance followed by Duncan's multiple range tests at 5% significant level. The result of this research showed that Keriting 09 was more resistance to fruit fly than other varieties. Insecticide treatment did not significantly affect chili yield, but the treatment with *C. nardus* extract can prevent fruit fly attack.

Effect of Insecticide Used on Insect Diversity in Rice Field

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Rice (*Oryza sativa* L.) is one of the most important and leading cereal crops in the world and is the staple food of over half of the global population. In Malaysia, the planted area for paddy is 670,000 hectares, which only fulfilled 70% of the country self sufficiency level. Pest is one of the main problems in rice production; it has caused 30% reductions in field and 10-12% in storage.

Chemical control remains the major controlled strategy for the pest. However, over reliance of pesticide has caused insecticide resistance, environmental pollution and reduction of biodiversity. The study soughy to assess the effect of different insecticide used on insect diversity in rice ecosystem. The experiment was conducted in Sekinchan, Selangor, Malaysia with a control and three insecticides (Regent®; Padan® and Prevathon®) as treatments with different modes of action. Insecticides were applied every two weeks. All the samples were identified until family level for the purpose of insect abundance study and up to morphospesies for the insect diversity study. The result shown, there were 43 families collected with total of 4465 individuals from all treatments. From the total, 21% are pest (12 families) and 79% are beneficial (21 families). There was no significant difference in the abundance of individuals obtained in each treatment. The highest numbers of pest was from Padan® (425 individuals) and the highest numbers of beneficial insect was from treatment Prevathon® (1082 individuals). However, there was a significant difference in the numbers of morphospecies obtained between treatments, with highest value was from Regent® (58 morphospecies) and the lowest value from Prevathon® with (43 morphospecies). There was a significant difference in the number of pests and beneficial insects obtained between sampling periods. This was due to the weekly increment of species richness for both pests and beneficial insects as the crop approached maturity. There was no significant difference of rice yield between the treatments. In this study, although Prevathon® gives the highest numbers of insect abundance, but it has lower value of insect species. However, the use of Regent has highest number of insect diversity.

The Potency of Siam Weed Compost on Crop Chili and Arthropods

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Some experiments have shown the potency of Siam weed *Chromolaena odorata* (L.) R.M. King & H. Rob (syn. *Eupatorium odoratum* L.) as organic compost since it has high biomass and it also contains calcium, manganese, potassium and nitrogen in high concentration. It is then emerging an idea to utilize Siam weed as good substitution of synthetic fertilizer. The experiment has been conducted in the field experiment at Bangutapan, Bantul. The aim of this research was to answer questions on the effects of siam weed compost on chili performances, arthropod as herbivores and natural enemies. The results indicated that application of composted siam weed increased plant performances in terms of fruits number, weigth fresh and weight dry of fruits, weight fresh and weight dry of plant, total leaf nitrogen, compared to control and the others fertilizer (cow dung, synthetic fertilizer). It was suggested that composted weeds plant enhanced the resistance mechanism called pseudoresistance on plants. This experiments also showed that syrphid larvae as natural enemies increased significantly on plant treated with composted siam weed and it has direct influence on abundance of aphid as herbivores.

Microbial Ecology and Plant Disease Management

Molecular Diagnosis of Para Rubber White Root Disease in Indonesia

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White root disease (WRD) is known as one of the major diseases of para rubber (*Hevea brasiliensis*). WRD is very destructive and thus economically significant in natural rubber production. *Rigidoporus microporus*, a basidio-mycete fungus is the soil-borne pathogen of WRD and produces

large fruiting bodies at the foot of infected trees. To support rapid and accurate diagnosis of WRD, several *R. microporus*-like isolates were obtained by tissue transplanting technique from infected roots and fruiting bodies which were collected in North Sumatra and Purwakarta, Indonesia. White-flat mycelial colony, which was difficult to identify through microscopy, was observed on PDA medium 6 days after incubation at 28 °C. The internal transcribed spacer (ITS) regions of rDNA were amplified by PCR with fungus specific primer pair (ITS1/ITS4). The partial nucleotide sequences of the ITS region were determined by 3130xl Genetic Analyzer HITACHI (Applied Biosystems) and analyzed using Sequencing Analysis v5.2. Results showed high homology on some of the tested isolates with *R.microporus1* isolates (HQ400707, HQ400708, HQ400706, HQ400709) from Malaysia. Some of the isolates however, found to be not *R. microporus* by molecular analysis.

The Use of Spent Mushroom Substrates to Control Late Blight Disease (*Pyhtophthora infestas* [Mont] de Barry) in the Field-Grown Potato

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One of limiting factors in potato production is late blight disease caused by *Phytophthora infestans* (Mont) de Barry). The most common control measure of the disease is application of synthetic pesticides that is potentially harmful to human and the environment. One of environmentally-friendly control measure is the use of organic matters such as spent mushroom substrates. The objective of the research is to determine types of spent mushroom substrate and application interval of their water extract which suppress late blight disease in potato in the field. The experiment was conducted in the experimental field of Vegetables Crops Research Center, Lembang West Java, Indonesia. The experiment was arranged in Randomized Block Design, with 10 treatments and 3 replications. The treatments examined included spent substrates of *Plerotus ostreatus*, *Lentinula edodes*, *Auricularia auricula*, or their mixture applied in the planting site and spraying their water extract every 3 or 7 days, check and pesticide. The result showed that the application of spent substrates of *P. ostreatus*, *L. edodes*, *A. auricula*, applied in the planting site and spraying their water extract 3 or 7 days suppressed late blight disease in potato in the field by 16.7%-47.7%. Application of spent substrate of *L. edodes* in the planting site and spraying its water extract every 3 days showed the best disease suppression (47.7%).

Effects of Straw Mulch, PGPR, and Varieties on the Bacterial Pustule Disease and Abundance of Rhizosphere Bacteria of Soybean

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Bacterial pustule caused by *Xanthomonas axonopodis* pv. *glycines* is one of the important bacterial diseases of soybean in Indonesia. In the frame of Integrated Pests Management for sustainable agriculture, the development of alternative way to control the disease is needed. This research was conducted to observe the effects of straw mulch, plant growth-promoting rhizobacteria (PGPR) on the incidence of bacterial pustule disease and the abundance of chitinolytic bacteria, heat tolerant bacteria, and fluorescence bacteria on two soybean varieties. All of the factors as combinations were not significantly affected the value of total area under disease progress curve (AUDPC) of bacterial pustule. Factor that significantly affected the values of AUDPC was varieties. AUDPC value on Anjasmoro variety was significantly higher compared with those on Gepak Kuning variety. Abundance of fluorescence bacteria on soybean rhizosphere treated with PGPR was

significantly higher compared with those on plants without PGPR. The other treatments did not significantly affect the abundance of rhizosphere bacteria.

Organic Waste as Cultivation Media for *Pseudomonas fluorescens* to Control Dumping Off Caused *Sclerotium rolfsii* and Promoting Plant Growth of Pepper

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Biological control has been paid a lot of attention from scientists in order to provide alternative plant pathogen control methods. Among of biological control agents, *Pseudomonas fluotrescens* is the most popular Gram-negative bacteria caused of their capability to supress many kind of plant pathogens and promoting of plant growths. Microbes which capability to suppressed plant pathogen and induced plant growth is called plant probiotic. The aims of our research are to explore organic liquid waste as media for cultivation of *P. fluorescens*. *In Vitro* and *in vivo* test were performed to determine the effectiveness of organic waste composition as growth media for *P. fluorescens* with high activity in suppressing plant pathogen and inducing plant growth. We have formulated organic liquid waste as alternative media for cultivation of *P. fluorescens*. Combination of coconut water, liquid waste of toufu and exctract of fish processing waste (80:19:1) in pH 7.0 gave the good composition as alternative media for growing *P. florescens*. Application of these formulation suppressed *Sclerotium rolfsii* growth *in vitro* up to 90-100%, and suppressed diseases incidence of damping of 53%. On he other hand, seed treatment by formulation on pepper seed did not affect seed germination compared to control. Aplication 5% formulation on pepper seedling periodically once a week significanly increased pepper seedling growth.

Utilization of Coffee Leather Waste Compost Enriched by Selected Microbes, Humic Acid, Fulvic Acid and Zeolit for Increasing Suppression of Foot Rot Disease (*Phytophthora capsici*) on Lampung Black Pepper

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The aim of this research are to increase suppression of foot rot disease (*Phytophthora capsici*) on Lampung black pepper and to get the best formula of bioactivator compost to control foot rot disease by using coffee leather waste compost enriched with selected microbes, humic acid, fulvic acid and zeolite. Based on isolation from the root zone (rhizosphere) and the tissues of Lampung pepper plant (leaves, roots and fruits), 178 potential microbial isolates were identified. After selection of microbial isolates obtained 2 lignin-degrading microbes, 32 bacterial isolates which have ability as endophytic diazotroph bacteria (N2-fixer based on activity of nitrogenase enzyme), 18 microbial isolates of rhizosphere capable of dissolving phosphate and 15 microbial isolates as antagonist of *P. capsicii*. After selection of microbes based on their function, 15 microbial isolates were chosen as the best isolates for formulating bioactivator compost, then as many as 3 formulas of bioactivator compost that every formula consist of 5 isolated, were tested in field treatment in pepper farmer land in North Lampung. The formula 2 that is formulated from compost of coffee leather waste enriched humic acid, fulvic acid, zeolite and selected bacteria (consist of bacterial isolates P2SH2, D10, C, A2 and E2) is the best formula for controlling fot root disease of *P. capsicii* which suppress the attacks of *P. capsicii* as much as 94.1%.

Study of the Antifungal Activity of *Ralstonia pickettii* TT47 to the Rice Sheath Blight Pathogen *Rhizoctonia solani* Kűhn

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Ralstonia picketii TT47 was selected isolate having the potency of strong inhibited to growth of R. solani in vitro and suppress the development of rice sheath blight disease in vivo. The antifungal activity test of the filtrate from fermentation broth of the isolates proved that the growth of R. solani reduced significantly. Thus, in the culture broth of the isolates were be contained antifungal compounds. Antifungal activity in the culture broth of the isolates was significantly correlated with the cell growth of the isolates. Antifungal compounds from culture broth of TT47 isolate able to extracted by using buthanol or hexana solution. The active metabolites in filtrate from the fermentation broth of the isolates were relatively stable to acidic condition but were sensitive to thermal.

Populations of *Aspergillus* sp. from Field-Grown Maize and Groundnut Plants Treated with *Trichoderma harzianum* CB-Pin-01

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Aspergillus sp. causes seed contamination of maize and groundnut with aflatoxin bringing a problem to food production that is one important sources of its inoculum originates from soil – infested with plant debris. *Trichoderma harzianum* strain CB-Pin-01 that was antagonistic to the causal *Aspergillus* sp. in laboratory, had been studied the effects of seed, plus soil and foliar treatments of maize and groundnut grown under field conditions on population in soil; and harvested seeds, and aflatoxin infestation. Not surprisingly, population of *Aspergillus* sp. at 15 days before harvest were 4-and 3-fold lower in maize and groundnut–treated field soil than non-treated control respectively. Higher antagonistic population than pathogenesistic *Aspergillus* sp. was also observed throughout 8 times of twice weekly evaluation. However, their seed infestation with either pathogen population or aflatoxin were not differently significance, compared to non-treated control. This seems likely that there is other important sources of inocula except in soil, that will be discussed in this paper.

Reducing *Cercospora* Leaf Spot and *Fusarium* Crown and Root Rot of Strawberry Using *Trichoderma* and Soil Amendments

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Field trial of 1.8 and 2.4 kg *Trichoderma*, 10 kg vermicompost and 10 kg chicken manure added with triple-14 and applied singly was done to determine their potential in reducing *Cercospora*

leaf spot and *Fusarium* crown and root rot strawberry; and their effect on yield. The experiment utilized a plot size of 1 m x 10 m following the randomized complete block design with four replicates. Results showed that 1.8 and 2.4 kg *Trichoderma* with a spore concentration of $1x10^6$/ml applied in plots before transplanting the strawberry runners resulted in low *Cercospora* leaf spot infection (severity) and smallest lesions (spots) on leaves. Similarly, the lowest crown and root rot infection of 18% with slight vascular discoloration was obtained in plants applied with the same rate of *Trichoderma*, an indication that *Trichoderma* induced resistance in strawberry. A total yield of 13.7 and 14.6 tons/ha was obtained in plants applied with *Trichoderma* and was significantly higher than the 11 tons/ha produced by plants applied with 10 kg chicken added manure added with 1.2 kg triple-14. Yield from *Trichoderma* treated plants was also comparable to the 16.3 tons/ha obtained from the chicken manure treated plants at 10 kg/plot. The highest return on cash expenses (ROCE) of 3.0 was provided by the *Trichoderma* treated plants. Applying the biological control agent in the soil before transplanting helped minimized *Cercospora* leaf spot and *Fusarium* crown and root rot enabling the strawberry plants to produce acceptable yield.

Outbreaks of *Begomovirus* Associated with Eggplant Yellow Leaf Curl Disease in Indonesia

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Since 2009, outbreaks of yellowing and/or leaf curling disease in eggplant (*Solanum melongena* L.) crops have been occurred in Central Java Province, Indonesia. Disease incidence ranged from 30% to 90% and resulted in 50% to 80% yield loss. Symptomatic eggplant leaf tissues were positive in PCR assays using universal primers for *Begomoviruses*. The PCR products of the expected size (i.e. approx. 684 bp) was cloned and sequenced. The nucleotide sequence and BLAST search revealed the highest homology with *Tomato yellow leaf curl virus* Kanchanaburi from Thailand. To our knowledge, this is the first record of *Begomovirus* associated with eggplant yellow leaf curl disease in Indonesia.

Tolerance to Fusarium Wilt through induction of Defense-Related Mechanisms in the Plantlets of Susceptible Berangan Banana Pre-inoculated with *Pseudomonas* strain UPMP3 and *Burkholderia* strain UPMB3

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Banana production world-wide is under severe threat due to *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *cubense* (Foc). *Fusarium* wilt has destroyed thousand hectares of bananas in many tropical countries and, once established in an area, *Fusarium* cannot be controlled chemically or through cultural practices. Recently research has been carried out focusing at re-introduction of naturally occurring endophytes into banana plantlets before the plants are sold to growers. However, effectiveness of endophytes as a biological control agent depends largely on host specificity, ability to move within host tissues and ability to induce systemic resistance. A systematic study was carried out to determine the effect of pre-inoculation of bacterial endophytes (*Pseudomonas* strain UPMP3 and *Burkholderia* strain UPMB3 isolated from healthy oil palm (*Elaeis guineensis*) roots in eliciting the production of biochemical response related to defense mechanisms and improving plant vigor, which could contribute to the suppression of *Fusarium* wilt development caused by *F. oxysporum* race 4 (FocR4) in susceptible Berangan banana. Increased accumulation of resistance-related enzymes such as peroxidase (PO), phenylalanine ammonia lyase (PAL), lignithioglycolic acid (LTGA) and

pathogenesis-related (PR) proteins (chitinase and β-1, 3-glucanase) has been observed in plantlets treated with endophytic bacteria UPMP3 and UPMB3 singly or as mixture under glasshouse conditions. Pre-inoculation of banana plantlets with UPMP3 showed a significant reduction in *Fusarium* wilt incidence after challenged inoculation with FocR4. UPMB3 was less effective in suppressing *Fusarium* wilt compared to UPMP3, whereas, the mixture of both endophytes showed an intermediate effect. Based on these results, it is concluded that UPMP3 could be a promising biological control agent that can trigger resistance against *Fusarium* wilt in susceptible Berangan banana.

The Elimination of *Cymbidium mosaic virus* in *Dendrobium* Orchid PLBs by Tissue Culture Technique

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Orchid is one of the major exported crops for Southeast Asian countries. However, orchid production both for cut flower and potted plant is threatened by viral diseases. Virus infection is not only the cause of severe losses of yield and quality but also the serious problem for export due to the international trade barriers. Since the viral diseases cannot be cured, thus farm management is the vital part of production in which the first step is planting of virus-free orchid plants. The elimination of virus from elite orchid clone will offer the mean to the orchid production business. Several reports were confirmed the successful events of virus elimination *in vitro* using meristem culture. However, due to the very small size, meristem is difficult to extract and the low survival rate of meristem tissue is usually observed. In this report, we reported the easier but successful tissue culture technique to eliminate *Cymbidium mosaic virus* (CymMV) for the production of CymMV-free protocorm-like bodies (plbs) in *Dendrobium* orchid. The CymMV infected plbs were cultured in liquid and solid VW medium supplemented with BA or TDZ at the concentration of 0-2.0 µM with weekly subculture. The virus dilution concept was applied to the technique of subculture. As confirmed by ELISA and RT-PCR, at the 6th weeks of culture in 2.0 µM containing VW liquid medium, 2 out of 15 plbs (13.3%) were CymMV-free. For the other treatments, none of CymMV-free plbs observed.

Investigation of Biocontrol Activity of Endophytic Bacteria from Upland Rice to Fungal Pathogen *Rhizoctonia solani*

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Endophytic bacteria resident within plant tissues have attracted attention due to their interesting features related to plant growth and for the protection of plants against plant pests and diseases. In this study, Endophytic bacteria was collected and isolated from defferent varieties of upland rice from defferent regions in Indonesia. The isolation of bacterial endophyte was conducted using surface-sterilized method with alcohol and sodium hypochloride (NaOCl). More than 220 isolates of bacterial endophyte were isolated. The isolates were tested to determine their effect on plant growth and the biocontrol activity against fungal pathogen *Rhizoctonia solani*. The results

showed 34 isolates of endophytic bacteria were able to promote the plant growth and 41 isolates of bacterial endophytes with antibiosis activity on potato dextrose (PDA) and trypsic soy broth (TSA) medium to *Rhizoctonia solani*.

Detection and Genetic Diversities of Geminivirus on Weeds

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Geminiviruses are important plant virus for some cultivated plants and weeds. Weeds showing vein yellowing (netting) were analysed for the present of a geminivirus. Total DNA were extracted from leaves of thirteen weeds species collected from all the mayor chilli peppers producing areas from West Java (Bandung, Cianjur, Sukabumi, Bogor, Garut), Central Java (Brebes and Magelang), Yogyakarta (Sleman) and East Java (Malang and Kediri). Nine of the 13 samples were positive by PCR using coat protein specific primers. Seven samples are AgrBgr, AgrSkm, AgrMgl, AgrJgy, SplMgl, CtpMgl and PrlBgr of the nine samples were successfully sequenced. Virus isolates further genetic analysis showed that those geminivirus can be differentiated into two clusters, showing the possible genetic differences among them. They neither have a close relationship with other geminiviruses published earlier in the GenBank.

Evaluation of Integrated Disease Management Strategy for Yellow Leaf Curl Disease of Chilli Pepper in Central Java

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Chilli pepper (*Capsicum annuum*) is grown in all parts of Indonesia and has a high economic value. Incidence of virus infection becoming a major threat since early 2000. The most unique symptoms associated with the virus infection involved yellowing and leaf curling. The causal agent was known belong to Begomovirus group, and tentatively called pepper yellow leaf curl virus (PYLCV). Field experiment was conducted in Pakem, Yogyakarta in October 2009 to evaluate disease control strategies involving chilli varieties, botanical insecticides, and plant growth promoting rhizobacteria. Based on observation conducted since 3 weeks after transplant (WAT) to 10 WAT it was concluded that application of botanical insecticides (neems and cinnammon oil) and microorganism (PGPR and guano) potencially reduced disease incidence and increased plant growth as well as production. Application of neem oil, cinnamon oil, and the mixture of both oil reduced infection in average of 55.86%, 53.54%, 53.26% and increased production in average of 27.71%, 25.59%, 21.46%, respectiveley compared to the use of synthetic insecticide (imidaclopride). Application of PGPR –P, PGPR-B, and guano similarly caused reduction in disease severity in average of 58.67%, 62.81%, 64.68%, increased in plant height in average of 13.36%, 11.99%, 5.83%, and increased in production in average of 43.37%, 38.60%, 39.30%, respectively. Commercial varieties (TM 999, Hot Chilli, and Laris) performed better under high disease pressure than those of developing lines (IPB 12 x 14, and IPB 12 x 10). Integrated disease management for yellow leaf curl disease in chilli pepper is recommended which may include selected chilli variety, botanical insecticide and/or PGPR, border plants, and screen-protected nursery.

Exploration of Mild Isolates of Chilli Vienal Mottle Virus from Chilli Pepper in Java, Indonesia

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Among many viruses known to infect chilli pepper *Chilli veinal mottle virus* (ChiVMV) is reported as one important virus in chilli pepper in Indonesia. Due to its potential to cause yield loss, disease management has been practiced involving the use of tolerant varieties, controlling insect vectors, and other cultural practices aimed to suppress disease incidence. A research was initiated to employ cross protection approach for disease management to reduce the infection of ChiVMV. Initial exploration was conducted in chilli pepper growing areas in West Java, Central Java, and East Java to collect ChiVMV field isolates. In order to find mild and/or weak virus isolates the collection was focusing on plants showing mild symptoms and healthy looking plants surrounding plants with severe virus infection. Fifteen promising ChiVMV isolates was successfully collected and propagated in susceptible chilli pepper line (*Capsicum annuum* L.), IPB C13. Based on percentage of disease incidence and symptom development, ChiVMV isolates can be differentiated into 3 groups, i.e. strong isolate (CKB), mild isolate (CKL, and BLN), and weak isolate (SKB, PGL, CGN, CBR, KRN, KMT, KRD, STG, KLT, BNT, SLO, and WTE). Further characterization of promising ChiVMV isolates was under going to confirm the potency of virus isolates to be used in cross protection strategy to suppress disease incidence.

Induced Systemic Resistance of Orchid against *Odontoglossum ringspot virus* by Using Salicylic Acid

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Odontoglossum ringspot virus (ORSV) is a new emerging virus infecting orchids in Indonesian and most species were susceptible to the virus. *Dendrobium nindii* is one of the susceptible cultivars to ORSV. To improve orchid resistance to ORSV, salicylic acid (SA) was used as systemic resistance inducer on *D. Nindii*. SA was applied in tissue culture media with concentration ranged from 0, 1, 2, 4, 8, and 16 ppm. The results showed that SA treatment in tissue culture media at those concentrations did not affect plantlet length, shoot number, additional leaf number, leaf width, root number, and root length. The addition of SA into growth media had no adverse effect on plant growth. Challenge inoculation of treated plants with ORSV showed that SA at concentrations of 4-16 ppm increased plant resistance and caused only local lession symptom, suggesting that SA affects ORSV accumulation and dissease incidence. In comparison with SA treatment at 0-2 ppm, application of SA at 4-16 ppm increased the accumulation of SA and phenylalanine aminolase enzyme activit Incompare with 0-2 ppm, sugesting that induced resistance occurred in treated plants. The best SA concentration that can increase plant resistance and ORSV accumulation up to 95% was 16 ppm.

Application of Chitosan in Controlling *Bean common mosaic virus* Infecting Yard-long Bean

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Bean common mosaic virus (BCMV) is a major virus infecting yard-long bean worldwide and it caused yield loss economically. We tested the efficacy of chitosan against BCMV in greenhouse. Chitosan was applied as seed-treatment and leaf spray either before or after mechanical BCMV inoculation with concentration 0.1% and 1.0%. The incubation period, disease incidence, severity, viral accumulation and growth parameter were observed to determine the effect of chitosan against BCMV. All treated plants infected by BCMV showed longer incubation period, lower disease incidence, milder symptom and lower viral accumulation in compared with untreated control, respectively. The chitosan 1.0% and 0.1% able to reduced viral accumulation up to 86% and 82%, reduced the severity up to 65% and 55% in compared with untreated control, respectively. Application of chitosan 1.0% after BCMV inoculation gave higher inhibition of viral accumulation than prior inoculation, while opposite result showed by chitosan 0.1%. It suggesting that the effect of disease inhibition related with chitosan concentration and application time. The chitosan treated plants also showed better growth performance in compare with untreated control.

Construction and Transformation A Vector Containing Potyvirus Coat Protein to Generate Patchouli (*Pogostemon cablin* Benth.) Resistance to Potyvirus

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Patchouli (*Pogostemon cablin* Benth.) plant is important commodity for Indonesia, as it contributed about 50% of Indonesian total export of essential oil which valued about US$ 27.171 billion. In Indonesia, one of problems is the mosaic virus disease which causes leaf malformation and reduction of oil content. *Potyvirus* is known associated with this disease. One approach to combat this disease is to modify patchouli plant by *Potyvirus* coat protein gene, since there is no trait of resistance to virus available in patchouli germplasm. This study was conducted to provide patchouli resistant varieties to *Potyvirus* that can contribute to increase farmer income via decreasing of yield loss caused by *Potyvirus* infection. In order to do it, RNA virus was isolated from plants infected by a virulent strain of *Potyvirus*. cDNA was then made from it using RT-PCR. A PCR product was inserted into pJET1.2 vector and sequenced. Sequence was aligned with sequences available in the gene bank. Sequence was also analyses for possible proteins and ORFs using the VNTI Advance11. Results showed that sequences had several stop codons, whilst the longest ORF has 137 proteins (415 bps) and one stop codon. Due to that reason, new forward and reverse primers with *Nco*I and *Nhe*I restriction sites were designed and PCR were carried out to amplify ORF (CDS). New PCR product was cut by *Nhe*I and blunt end by klenow fragment. The *BstE*II is unique in the pCambia1301. A fragment was then inserted to a binary vector pCambia1301 at the *Nco*I and *BstE*II sites. A vector expression containing 35S::JPG12ORF was constructed and transformed into *Agrobacterium*. Progress and future activities are discussed.

Root-knot Nematode Species, *Meloidogyne* spp., Can be Associated with Scabies Tuber Disease on Potato in Indonesia

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In Indonesia, Scabies Tuber *Disease* is a raising problem in potato cultivation. Until now the cause of the disease is not clearly known, so needs a comprehesif research. The identification of the pathogen were conducted at laboratory of Plant Nematology, Department of plant pest and desease, faculty of Agriculture, Universitas Padjadjaran; and Plant Virology, Department of Plant Protection, Faculty of Agriculture, IPB, involving conventional and moleculer techniques. The research was conducted from Desember 2010 until July 2011. The results of conventional and molecular identification were found five species of RKN, namely *M. arenaria, M. falax, M. hapla, M. incognita,* and *M. javanica* can be associated with scabies tuber *disease* incidence.

Postharvest Product Management

Detection of *Listeria monocytogenes* by Conventional PCR Using DAS^{TM} KIT BIOTECH-UPLB in Selected Raw and Processed Meat Products

Bhakti Etza Setiani

The Polymerase Chain Reaction (PCR) shortens the time duration of conventional microbiological methods used to detect food pathogens because of its direct use on pre-enrichment media or food products (Rijpens and Herman, 2002). This study was conducted at the Laboratory of National Meat Inspection Services, Visayas Avenue, Quezon City, Metro Manila, Philippines and the Food, Feed and Specialty Products Laboratory (FFSPL) in The National Institute of Molecular Biology and Biotechnology (BIOTECH), University of the Philippines Los Baños (UPLB). All the isolation and identification steps were strictly done under biosafety II laminar cabinet, considering *Listeria monocytogenes* as pathogenic bacteria. PCR detection was done on fifty seven samples from both cell lysis of *Listeria* Enrichment Broth (LEB), 225 mL of 1st level enrichment with 24 hours incubation time and 225 mL of VIDAS 1st level enrichment broth (LxB) with 24 hours incubation time, and 6 mL VIDAS 2nd level enrichment broth with 48 hours incubation time. In this study, the use of specific primers that were developed by BIOTECH UPLB had successfully detected the presence of *Listeria monocytogenes* from direct enrichment samples.

Effect of Low Temperature Storage on the Quality of Mango Fruits (*Mangifera indica* L.) cv. Gedong Gincu

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In this study, the changes in quality of mango fruits cv. Gedong Gincu stored in low temperature was examined and the chilling induced of mango fruits during storage was examined by the changes in the rate of ion leakage. The quality of mango fruits during storage was examined through the changes in firmness, total soluble solid, weight loss and visual appearance. The storage conditions was set at 8, 13 °C and room temperature. The results showed that the maximum value of

firmness for mango fruits stored at room temperature occured at days 4. From the visual observation, mango fruits stored at room temperature remained in sound condition for up to 8 d. This showed that mango fruits were able to consume and physiologically those were on the optimum maturity during 4-8 d. The same value was achieved at days 14 for those stored at 13 °C. For mango fruis stored at 8 °C, there were no changes relatively until 20 d. Total soluble solid of mango fruits increased during its postharvest life which the value for those stored at room temperature was greater than that of 8 and 13 °C. For mango fruits stored at room temperature, the maximum total soluble solid was achieved at 4 d. The rate of ion leakage for mango fruits stored at 8 °C was higher than that at 13 °C, respectively. The increase in the rate of ion leakage indicates the chilling induced of cell membrane. For mango fruits stored at 8 °C, the slope of rate of ion leakage changed from 0.1533 at 0 d to 0.2121 at 4 d and decreased to 0.1720 at 8d. The different rate of ion leakage was found for mango fruits stored at 13 °C where the value was constant relatively until storage period of 8 d. From these findings it can be concluded that mango fruits stored at 8 °C beginning experienced chilling injury at days 4.

Development of Sweetpotato–Based Candies for Commercialization

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Sweetpotato is one of the most versatile nutritious crops available year round. It is rich in vitamin A, vitamin C, fibers and calcium. Consumption of sweetpotato provided 6–15% of the total RDA requirement for vitamin C, 3-5% vitamin A, 2-3% calcium, 1-3% iron, 1-2% energy, and less than 1% on protein. Promoting its commercialization is one strategy in helping reduce incidence of micro-nutrient deficiency. The study showed that product development involving consumers is important in developing quality attributes. It ensures that the products developed and marketed satisfy the needs and preferences of the consumers which is an important contributory factor in commercialization. The study showed that product development involving consumers is important in developing quality attributes. It ensures that the products developed and marketed satisfy the needs and preferences of the consumers which is an important contributory factor in commercialization. The sweetpotato based tamarind (camarind) and strawberry (camberry) candies has a sweet-sour taste. Specifically, camarind has a soft, leathery texture and seedless. Camberry has soft textural moistness. The quality of camberry was observed to change in three (3) months after processing. For camarind, the quality started to deteriorate eight (8) months after processing. At a selling price of P18.50/pack and a production cost of P13.55/pk and 14P.25/pk for camberry and camarind respectively, it can provide an estimated RCE of 36.51% and 29.82%, respectively.

Carbamates and Organophosphorus Pesticide and Residue Detection in Selected Vegetables from Benguet and Nueva Vizcaya: Its Implication to Food Safetyand Farmers' re-Entry

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This research aimed to determine the presence of carbamate and organophosphate (OP) pesticides and residues in vegetables belonging to Cruciferae such as cabbage, Chinese pechay, and cauliflower from two Vegetable Provincial producers: La Trinidad, Benguet and Bambang, Nueva Vizcaya and distributed in Cauayan City Public Market using the colorimetric spot technique (Rapid Detection Kit) provided by the National Crop Protection Center, University of the Philippines, Los Banos, Laguna. Two factors were considered in this research: first the location where vegetables were produced (factor A.) and second, the type of vegetables (factor B). This study used the randomized complete block sesign in factorial with three replications to allocate treatments. The effect

of location and type of vegetables were both found to be not statistically significant on the amount of pesticide residue. Location and vegetable combination interaction had no statistical significance on the amount of pesticide residue. However, cabbage (T_1) was found to have the highest amount of organophosphate pesticide residue followed by Chinese pechay (T_2) and cauliflower (T_3). In terms of location or vegetable source, Benguet (S_1) showed the highest mean pesticide residue followed by Nueva Vizcaya (S_2). String beans, Baguio Beans and tomatoes registered positive with the carbamate detection kit. None of the treatments analyzed exceeds the safe level of toxic substances.

Animal Science and Husbandry

Effect of *Leucaena leucocephala* on the Feed Intake and Rumen Fermentation Parameter of Carabao and Cattle

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A study was conducted to determine the effect of *Leucaena leucocephala* on the feed intake and rumen parameter of carabao and cattle. Three ruminally-fistulated carabaos and cattle with *Leucaena leucocephala* (0, 6%, 12% of ration) were randomly allotted to treatments in a 2 x 3 Randomized Completely Block Design (RCBD). The amount of feed offered was 2.5% of live weight on DM basis at 60:40 roughage: concentrate in two equal parts at 800 and 1500 hrs. *Leucaena leucocephala* contained 4.6% (LQCC, 2008); 5.1% (Hess et al., 2007). Feed offered was recorded daily for each animal during the morning and afternoon while feed refusal was taken before morning feeding of the following day. Feed offered and feed refusal was analyzed in duplicate. The DM and CP content of feed samples and other samples were determined (AOAC, 1984); NDF content of the samples by Goering and van Soest, 1970 modified by van Soest et al., 1991). Rumen digesta sampling was manually done through the rumen fistula from the surface and deeper parts of the rumen. Sampling was done as scheduled based on the parameters to be measured. In this study, *Leucaena leucocephala* is not only a better source of tannin but also a source of dietary protein for the host animal without significantly effecting rumen pH, temperature and NH_3-N. Intake of DM, CP, and NDF in carabao and cattle was significantly decreased by LCT.

Antioxidative Effect of Antimicrobial Growth Promoters

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Restriction on the use of the antimicrobial as growth promoter (AGPs) in livestock production has prompted a search for the effective alternatives. However, none of the alternatives have been as efficient as AGPs. Thus, the knowledge about the mechanism of AGPs to improve the animal health and growth performance can be useful for searching the non-antimicrobial compounds with the similar effect. Anti-oxidative property is one of the possible hypothesis to explain the indirect effect of AGPs on gut health improvement. *In vitro* free radical scavenging activity of flavophospholipol on DPPH (2,2 diphenyl-1-picryhydrazyl) radicals was investigated. Five concentrations of 4% flavophospholipol (50, 100, 150, 200, and 250 ppm.) were prepared by dissolution with methanol. The unpaired electron of DPPH radicals after reaction with AGPs was

detected by Electron Spin Resonance Spectroscopy. Results indicated that flavophospholipol had a free radical scavenging activity by decreasing the concentration of DPPH radicals. The 50% inhibition concentration (IC_{50}) of flavophospholipol was 154.8 ppm. or one ppm. of flavophospholipol was able to scavenge about 0.39 mole of DPPH radical. Furthermore, the *in vivo* study was conducted to confirm the anti-oxidative activity of flavophospholipol. Three hundred and twenty one-day old broilers (Ross 308) were divided into two groups with four replicates and consisted of 20 male and 20 female per each. The chickens were received one of the experimental diets (non-supplemented and supplemented with 5 ppm. flavophospholipol) for 42 days. The animals were kept under the housing condition recommended for the standard broiler production. Blood sampling were taken to measure the lipid peroxidation in serum in term of malondialdehyde (MDA) concentration. The *in vivo* result confirmed the anti-oxidative property of flavophospholipol, by decreasing the serum MDA concentration ($P = 0.051$) although the different was not significant.

Intensification of the Innovative Goat Production System for Sustainable Rural Enterprise Development in Region I, Philippines

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A development project implemented in Region I to transform goat raising from a subsistence type of farm activity into a profitable goat livelihood employing farmer participatory approach and technology based rural enterprises. One hundred ninety goat raisers served as farmer partners adopting housing, stall feeding and upgrading. A marked increase in growth and reproductive performance were registered. From an initial of 190 farmer partners, additional 271 additional raisers were encouraged to venture on goat enterprises. This covers 3 provinces, 14 municipalities and 45 barangays with nine (9) organized farmers association. Gender analysis accounted for 64.73% male farmer-partners and 35.26% farmer-partners. Farmers' knowledge, skills, attitude and social competence were enhanced. Increased farmers income was registered for a 10 doe level slaughter and 20 doe level breeder goat enterprise registered a monthly income of Php 1,836.33 and 5,899.33 with an ROI of 61.59% and 95.11% respectively. Beyond technology promotion thus, building sustainable goat enterprises through strengthened institutionalization effort of LGUs with organized and empowered rural communities, LGUs supported the expansion of the project and refocused their commodity priorities towards goat. As the project continues, goat raising is transformed from subsistence farming to vibrant and profitable enterprises.

Administration of Probiotics in Drinking Water on Growth Performance of Broiler

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Completely randomized design was conducted to investigate the effect of probiotics administration on the growth performance of broilers. Six hundreds one-day old chickens (Ross308) were divided into three groups with four replicates, which consisted of 25 male and 25 female per each. Broilers were kept in pen with 12 birds per square meter density in evaporative cooling house and were randomly received the experimental treatments. Effective microorganisms as probiotics such as *Lactobacillus* sp., *Bacillus* sp. *Pediococcus* sp. and *Saccharomyces cerevisiae* were used in two combinations, which were administrated through the drinking water at 1 ml/5 L compared with the non-treated group. Growth performance of broilers were studied in three period of growth (1-21, 22-35 and 36-42 day of age) and also in the whole period (1-42 day of age). In addition, the gut digesta were collected from at 10 and 21 day of age to measure the ammonia concentration as well as the

population of beneficial and pathogenic bacteria. Probiotics administration had the significantly effect on the body weight gain as well as the feed conversion ratio of broilers compared with the non-treated group. Especially in stress condition such as in period 1-21 and 36-42 day of age, the advantage of probiotics administration was clearly appeared by the highly significantly improvement of growth performance. The increasing of the beneficial microorganisms in gut as well as the reduction of ammonia concentration promoted the animal health and improved the nutrient utilization which caused the better growth performance in consequence.

Application of Lemongrass Volatile Oil Product for Controlling Mastitis in Dairy Cattle

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Mastitis, an udder bacterial infectious disease, is one of the most important diseases found in every dairy farm, causing high economical loss. One of the most important bacteria causing mastitis is *Staphylococcus* spp. Normally, treatment of this kind of bacterial mastitis is by intramammary infusion of appropriate antibiotics. However, to prevent the infection is advised and more practical. In Thailand, the prevention of infection in milking cows is performed by treat dipping with iodine solution after milking, which will be limited in the near future. The use of herbal product is common nowadays, not only for dairy farmers, but also for field crop farmers. Lemongrass (*Cymbopogon citrates* (DC.) Stapf) comprises 75.20% of citral, 9.82% of linalool and 4.37% of geraniol. The product of 1% lemongrass volatile oil is able to eradicate the prior bacteria causing mastitis, *Staphylococcus aureus*. Reducing antibiotics used through food safety concern, lemongrass volatile oil product for preventing infection of udders in milking cows is applied. The efficiency of bacteria eradication by using 1% of lemongrass volatile oil (product) is investigated *in vitro* using minimum inhibition concentration (MIC) and minimum bactericidal concentration (MBC) tests. Results revealed that lemongrass volatile oil product of 100%, 50%, 25%, and 12.5% can inhibit the growth of *Staphylococcus aureus*. In addition, *in vivo* study by swabbing the teats immediately after milking and 30 min. after post-milking teat dipping with lemongrass volatile oil solution was investigated. All swabs collected from 10 cows (40 teats) were negative. No *Staphylococcus aureus* was identified from all swabs. No significant difference was found between *Staphylococcus aureus* MPN in milk samples collected before and after the use of lemongrass teat dipping. Therefore, application of 1% lemongrass solution could be advised for controlling intramammary bacterial infection in dairy cattle.

Supplementation of Crude Extract Product from *Psidium guajava* L. Leaves in Broiler Diet

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One thousand-three hundreds and eighty one-day old broilers (Ross 308) were used to study the potential of crude extract product from *Psidium guajava* L. for using as the alternative for antibiotic as growth promoter. Feed additive product was prepared from ethanol extract of *Psidium*

guajava L. leaves and contained 1.17% quercitin. Completely randomized design was conducted and the animals were divided into six groups with five replicates, which consisted of 23 males and 23 females. The chickens were randomly fed one of these experimental diets for 42 days: basal diet, basal diet supplemented with 5 ppm. Flavo-phospholipol as positive control and basal diets supplemented with 20, 30, 40 and 50 ppm. crude extract product from guava leaves, respectively. The animals were kept in pen with 12 birds per square meter in evaporative cooling house, where feed and water were provided *ad libitum*. The body weight and feed intake were collected in three period of growth (1-21, 22-35 and 36-42 day of age). Results showed that dietary supplementation of crude extract product from guava leaves had significantly effect on the growth performance of broiler in period 22-35, 36-42 day of age (DOA) as well as the whole period of feeding (1-42 DOA). Weight gain as well as the feed conversion ratio were highly significantly improved ($P< 0.01$) by supplemented with 20 ppm guava leaves extract product compared with the non-supplemented group. However, the dose response was observed with more than 30 ppm inclusion rate of guava leaves extract product providing significantly detrimental effect ($P<0.05$) on the growth performance of broiler. Furthermore, comparing with the antibiotic as growth promoter group, the broilers fed diet containing 20 ppm extract product from guava leaves showed the better growth performance in period 22-35 and 36-42 DOA. Thus, the feed additive product from *Psidium guajava* L. leaves can be used as natural growth promoter for broiler and the proper inclusion rate is 20 ppm.

Screening of Plant Extracts on *In Vitro* Anti-Coccidial Sporulation of *Eimeria tenella*

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Eimeria tenella has recognized as a significant protozoan parasite disease in commercial broiler production. Due to the less effective against coccidia of chemical disinfectants, the coccidiosis is controlled with the preventive drugs. However, the drug residue issues in animal products lead to the preventive drugs banned in recently, so the new effective alternatives are necessary. Plant extracts can be a potential choice due to their antimicrobial property. The aim of this study was the evaluation of the anti-coccidial sporulation of some plant extracts, which their antimicrobial activities were reported. Efficacy of 15 different plant extracts as following *Boesenbergia pandurata* (Roxb) Schitr., *Ocimum basilicum* L., *Suaeda maritime* Dumort., *Acacia pennata* L., *Leptonycnia heteroclite* Kurz., *Basella alba* L., *Spenoclea zeylanica* Gaertn., *Neptunia oleracea* Lour., *Flagellaria indica* L., *Glinus oppositifolius* Ktze., *Trianthema portulacastrum* L., *Sesuvium portulacastrum* L., *Musa sapientum* L., *Cymbopogon citratus* Stapf. were preliminary screened and only the potentially plant extracts were further evaluated about the effective concentration. The results showed the strong anti-coccidial sporulation of oil extracts with steam distillation from fingerroot (*Boesenbergia pandurata* (Roxb) Schitr. and sweet basil (*Ocimum basilicum* L.), whereas the other plant extracts were no or less active against oeocysts sporulation. The exponential correlation between the oeocysts sporulation and the concentration of plant extracts were found and the 50% inhibition concentration (IC_{50}) of fingerroot and sweet basil oil extracts were 151.78 μg/ml and 66.79 μg/ml, respectively. These results may have significant implications for the future development of fingerroot and sweet basil oil as an anti-coccidial agent. However, the *in vivo* study should be further investigated to confirm effectiveness.

Study of Essential Oils Administration in Broiler

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Six hundreds one-day old broilers (Ross 308) were used to investigate the effect of essential oils contained eucalyptus oil, mint oil, thyme oil and L-menthol on the growth performance and feed efficiency during three periods of growth (1-21, 22-35, and 36-42 day of age). Besides the productive performance, the anti-oxidative as well as anti-inflammatory properties of essential oils were also evaluated. The animals were assigned to two groups with six replications which consisted of 25 male and 25 female per each. The chickens were randomly received the experimental treatment, which were the control group and the essential oils-administered through the drinking water at 1 ml/10 L. group. The stocking density was 12 birds per square meter and broilers were kept in the evaporative cooling house, where the inside temperature of 28-30 °C and a light/dark cycle of 23:1 were maintained throughout the 35 days experimental period (from 15-42 day of age). The feed and water were supplied *ad libitum*. Results showed that the growth performance and the feed efficiency of broiler in period 1-21 and 22-35 day of age were not affected by administration of essential oils ($P > 0.05$), whereas the body weight gain and feed conversion ratio of treated group in period 36-42 day of age were improved about 11.9 and 6.7 percentage compared with the non-treated group. Additionally, supplementation of essential oils provided the significantly improvement of health and height of villi from jejunum, especially at 15 day of age. However, the anti-oxidative and anti-inflammatory properties of essential oils in term of lipid peroxidation in serum (TBARs concentration) and the score of tracheal lesion, respectively, were not clearly found in this study.

In Vitro Anticoccidial Sporulation and Antibacterial Activity of Synthetic Camphor

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Coccidiosis is a parasitic disease that can cause severe losses in poultry production, caused by a one–celled parasite of the genus *Eimeria*. Besides, the pathogenic bacteria such as *Escherichia coli* and *Salmonella* spp. can be contaminated in animal products and cause the zoonotic disease. Normally, the chemical disinfectants in single or combination are used to control these microorganisms in animal housing and equipments, but they are not effective against coccidia because of their life cycle. Thus, the search for the effective anti-coccidial and anti-bacterial compound is needed. Due to the anti-microbial property of the essential oil such as synthetic camphor, the anti-coccidial and the anti-bacterial activity properties were evaluated. Camphor solution was prepared by dilution with ethanol, tween 80 and distillated water in ratio 1: 3: 2: 94. The result showed that synthetic camphor had a potential to inhibit the oeocyst sporulation from *Eimeria tenella in vitro* study and the 50 percentage inhibition concentration (IC_{50}) was 0.0245 mg/ml. Furthermore, camphor was active against all selected food related bacteria. The minimum inhibition concentration (MIC) against *Escherichia coli*, *Salmonella enteritidis*, *S. typhimurium*, *S. infantis*, *S. hadar* and *S. virchow* were 5 mg/ml. These results support the notion that synthetic camphor may be an effective disinfectant against coccidia and zoonotic bacteria for poultry production.

Native Chicken (*Gallus gallus domesticus*) Management Practices in Selected Upland Barangays of Tanay, Rizal, Philippines

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In the Philippine scene, native chicken is commonly raised in backyards. It is the farmers' main source of protein. It is preferred to serve in the table for its incomparable taste. Increase production through improved management practices was the objective of this study. Outputs are beneficial to different government agencies, chicken meat and by product processors, and the farmer-raisers himself. Farmers raised chicken for home consumption and sell for additional income. They had long experience in raising and bred own stocks. Chickens were kept in semi-range/confinement. Feeds given were corn, rice bran, *sapal ng niyog*, kitchen discards and grasses. Hens lay eggs 3 to 4 times per year and 11 to 15 eggs per laying. Naturally incubating eggs for 21 to 23 days and brooding chicks till weaning. Hens layed eggs somewhere in the area, then come back with newly hatched chicks, which was a unique observation. Their low production up to consumable-marketable age is because the fowls were stolen or eaten by astray animals; got sick and had parasites, since farmers do not vaccinate and deworm the animals. They fence the area to keep the animals away from the thieves and use herbal medicinal plant for treatment of diseases and parasites. Undergo training on the proper care and management of raising to enhance higher production of this indigenous fowl is recommended to the farmer-raisers.

Sustaining Anoa (Bubalus sp.) as Prospective Meat Resources by Using Feeding Technology Processing in the *Ex Situ* Area

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Anoa is a prospective animal that has the potential to developed as a meat-producing animal livestock. Anoa advantages include the ability of local resources' utilization, climate adaptation and resistance to disease. This animal has the potential to be a potential of germplasm stock in the future. The research aims to help *ex situ* conservation of anoa (*Bubalus sp*.) Particularly through an efficient feeding. The data obtained were used as supporting data in conservation and use of anoa as a livestock. Materials research is a common type of feed given at preservation locations (Ragunan Jakarta Wildlife Park [RJWP]) which was feeded in form of fresh crops, hay and wafer and also three anoa that belongs to RJWP. Alternative feed preferences known by the method of cafetaria feeding. The observed variable is the total amount of consumption of each feedstuff, total collection of faeces, the amount of nutrient intake, eating behavior including eating period, feeding preferences and the period of rumination. Data were analyzed descriptively. Wafer is the result of feed processing technology with feedstuffs nutrient measured that can be given to the anoa concerning *ex situ* conservation and cultivation. General conclusion recommended that technology of wafer processing can be applied for anoa *ex situ* conservation efforts and its utilization as an animal that can be cultivated. Feeding behavior of anoa showed the majority is used for eating and drinking (29.51%) and rumination (29.17%).

Growth and Feed Cost of Native Pigs Fed Trichantera (*Trichantera gigantea*) **in Partial Replacement of the Conventional Diets**

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The Philippine Native Pig maintains its niche in the demand for a Filipino delicacy called "lechon" because of taste and crunchiness. But commercializing native pigs is constrained by high cost of feeds. So, this study was conducted to evaluate the performance of Native Pigs fed Trichantera foliage replacing different levels of their commercial diets. Nine native pigs were used for three treatments and three replicates in a Completely Randomized Design: (Ti, 100% commercial rations; T2, 85% commercial rations+15% Trichantera and T3, 70% commercial rations+30% Trichantera). Replacing the commercial rations with different levels of Trichantera did not significantly affect the weight gains of native pigs. On the other hand, the feed efficiency improved significantly ($P < 0.05\%$) with the 15% and 30% replacement of Trichantera and were different between any two treatment means. The cost of feed per kilogram gain in weight was highly significant ($P < 0.01\%$) and were different between any two treatment means; the increasing level of replacement of Trichantera recorded a decreasing feed cost per kilogram gain in weight. It is concluded that Philippine native pigs can be grown with better feed efficiency and lower feed cost per kilogram gain using Trichantera to replace up to 30% of the commercial rations.

Avian Diversity in Agricultural Areas in North-East Luzon, Philippines

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Field surveys were conducted in agricultural areas in North-east Luzon, Philippines to infer species present in this type of ecosystem. Survey methods include transect walk, point-count, and mist-netting. A total of eighty four (84) avian species in thirty eight (38) families were identified, of which fifteen (15) species were endemic (28.84% end.). Extensive rice and corn farms interspersed with grassland areas lying in between communities and the forest accounts to the numerous representative species inhabiting this type of ecosystem. Lowland agricultural areas exhibit higher species richness but lower endemicity. Upland agricultural areas however have lower species richness but a higher percentage of endemic birds. As to the conservation status of birds as per listed in IUCN, a species is critically endangered (*Pithecophaga jefferyi*), one (1) is near-threatened (*Buceros hydrocorax*), one (1) is vulnerable (*Anas luzonica*) and the rest are of least concern. Though the present faunal species are still diverse, activities such as overhunting for food and pet trade impacts negatively on biodiversity in general. Other threats to bird diversity were swidden or slash-and-burn farming and small-scale logging due to the resulting habitat loss especially for site specific species. The effect of adopted agricultural practices by farmers in the area on bird diversity should be studied in detail. Biodiversity conservation should be taken into account when formulating and implementing management system especially for this type of ecosystem.

The Fishery for Macro-Invertebrate Gleaning in Catanduanes

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An assessment of the fishery for macro-invertebrates gleaning in Catanduanes side of Lagonoy Gulf was undertaken to document relevant information about gleaning fisheries. Rapid Resource Assessment (RRA) with survey questionnaire was used in the study. This was supplemented by data from actual gleaning field work and key informant's interview. Results showed

gleaning as traditional practice of women with other family members. It is a subsistence fishing activity in shallow reef flats, mud flats, sand and rocky areas, sea grass including mangrove areas. Species caught include mollusks, crustaceans and other invertebrates. Fishing methods employed are simple such as bolo plastic strainer, metal scraping tools and other improvised harvesting tools. From economic standpoint, gleaning is treated as food source and additional income. Monetary benefits derived reveal an estimated annual average production of 26.748 tons valued at PhP 534,960.00. This translates roughly to PhP 704.20 per month or Php 8,450.40 annual income per gleaner on the average. Since the activity use simple tools, exploited species are given time to regenerate with minimal impact. However, because invertebrates are lower down the food chain and are potential feed for larger species, the practice may result various forms of overfishing. In-depth studies along biodiversity conservation; management; health and safety hazards are recommended.

Socio-economic and Technological Assessment of Sustainable Agriculture

Factors Affecting Fluctiation of Exchange Rate: An Implication to Indonesian Trade Policy

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Managed floating exchange rate has been widely used by the Central Bank of Indonesia in a response to stong demand for more stable exchange rate. However rupiah recently experiences a strong position due to relatively high return in capital market as foreign investors change their investment portfolio by buying more assets in Indonesia. However this appreciation of rupiah would depress exports of agricultural products at the world market as a relative price of Indonesian product is percieved more expensive by foreign consumers. To investigate the factors affecting such rupiah appreciation, a Vector Error Correction Model is then applied for monthly data. A relative Gross Domestic Products of Indonesia to the United States reflecting a difference of demand potentials affect to what extent rupiah encounters appreciated or depreciated. Pro-long economic recession in the US would hamper Indonesian exports as rupiah appreciates. This is because rupiah appreciation leading to a change in relative interest rate in Indonesia would attract more foreign investors to re-allocate their investment.

Forecasting Methods of Spot Palm Oil Prices: Comparative Techniques

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The paper describes with a discussion of an outline of the research methodological issues of the short-term *ex-ante* forecasts of econometric models include single equation model and multivariate autoregressive–moving-average (MARMA) model (composite model), and the univariate model of autoregressive-integrated moving average (ARIMA) (Box-Jenkins model) of spot palm oil price using futures price in the Malaysian palm oil market. Both econometric models and the univariate model (ARIMA) were utilized using monthly data from January 1980-December 2010 as estimation period and data from January 2011-June 2011 was used as an *ex-ante* forecast. The time series model is estimated using vector error correction method (VECM) and co-integration method for residual error correction. The objective of the study is to compare the forecasting models accuracy between econometric models and the univariate model of ARIMA of spot palm oil price. Comparative forecasting models accuracy between single equation model, MARMA model and univariate model of

ARIMA, were made in terms of their estimation accuracy based on RMSE, MAE, RMPE and U-Theil criteria. The results revealed that MARMA model is more accurate and efficient measured in terms of its statistical criteria than single equation model and ARIMA model in forecasting the spot palm oil price using futures price in the next 6 months or so.

Foreign Trainees as Labor Force on Agriculture in Japan, The Characteristics and the Issues of the System for Foreign Trainees

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Japan had started the Industrial Training and Technical Internship Program System (ITTIPS) since 1993 in order to help the developing countries improve their human resource training and to let employers quit employing illegal immigrants. Japanese International Training Cooperation Organization (JITCO) managed contracts between farmers and trainees when farmers want to use foreign labor force. The system requires the farmers to deal with foreigners as not 'labor' but 'trainee.' The objectives of this study are, firstly, to overview the history of the system for foreign trainees on agriculture in Japan, and then secondly, to analyze actual activities of farmers who bring in foreign trainees. Finally, this study attempts to reveal the characteristics and the issues of the system for foreign trainees in Japan. The survey was conducted in Ibaraki prefecture where farmers bring in a lot of trainees for a long time and Yame district, Fukuoka prefecture where there is only short history about foreign trainees on agriculture. The main conclusions of this study are as follows. Firstly, this study came out some conditions for farmers to bring in foreign trainees. Secondly, this study revealed the advantages and disadvantages of the system for foreign trainees.

Economic Performance of Different Planting Density in Oil Palm Plantation

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A detailed farm management study was conducted on oil palm production under a Nucleus Estates Smallholders Scheme (NESS) and Non-NESS in Tembilahan and Sungai Piring Villages in Riau Province, Indonesia, in 2010. The number of farmers studied was 52 and 68 in both villages respectively. This paper presents an examination of financial returns from oil palm trees in relation to the planting density in order to determine the optimal planting density. Using the cases of four year old trees for both types of farmers, we compared the planting density, yield, cost, and income for oil palm production. Average planting density was 143.33 and 125.78 tress per ha for NESS and Non-NESS farmers respectively, which appeared to result in different yields. The NESS farmers obtained 8.53 tons of palm oil and 3,445,678 rupiah of net income per hectare basis, while the corresponding figures for non-NESS farmers were 7.92 tons and 2,589,005 rupiah. Our analysis revealed that the maximum income (3,952,250 rupiah/ha) was obtained from a planting density of 143 tress/ha for NESS farmers, and 2,910,375 rupiah from 124 trees/ha for non-NESS farmers. Therefore, it is clear that the planting density of 142-144 palms/ha should be introduced in order to maximize Net Present Value (NPV). The production cost of FFB (Fresh Fruit Bunches) by non-NESS farmers was higher than NESS farmers. For non-NESS farmers, the production cost was Rp 6,450,821/ha/yr whereas for the NESS farmers, the production cost was Rp 5,028,972/ha/yr for that year. The highest cost component for NESS farmers was fertilizer and its application, which amounted to Rp. 1,607,682/ha/yr. this constituting 32.8% of the total production cost. The second important cost item was transporting 21%, followed by upkeep 20%, harvesting 18% and other expenses 8%. The highest cost component for non-NESS farmers was harvesting and collecting, which consisting 30.9% of total cost. The second was fertilizer 30.2%, followed by upkeep 19%, transporting 18% and other expenses 2.9%. This study indicates that a lower or higher density than 143 trees/ha does not maximize income.

For production cost section, it is clear the farmers must be given extension services to educate them on the proper agronomic practice and extra fund with easy payment to encourage them.

Marketing Efficiency of Mangosteen: Case Study in Bogor, West Java, Indonesia

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Horticulture sector plays an important role in Indonesian economy, especially in agriculture sector. In horticulture sector, tropical fruits are prioritized as the export earning. Among the tropical fruits, mangosteen contributes high export value to tropical fruit export earning of the country. It is exported to some countries such as Taiwan, Japan, Hong Kong, French, Saudi Arabia, China, and Netherlands. As fruits can be categorized in the high growth export, thus, fruits, mangosteen in particular, can be one of the opportunities to increase export earning. Therefore, it is important to analyze current marketing efficiency of mangosteen in order to increase its competitiveness in the global market. The specific objectives of this paper are (1) to clarify the existing marketing channels of mangosteen in Bogor, West Java, Indonesia, and (2) to investigate the actual farmer's share, marketing margin, and profit-cost ratio of mangosteen in Bogor, West Java, Indonesia. Questionnaire survey was conducted to mangosteen farmers in in Karacak Village, Leuwiliang Subdistrict, Bogor District, West Java, where it is one of the most mangosteen producing areas in Indonesia, contributing around 37.58% of the total national mangosteen production. In-depth interview was also conducted to mangosteen traders and exporters in Bogor. The survey conducted from August to October 2011. This study has identified the marketing channels and marketing efficiency of mangosteen in terms of farmer's share, marketing margin, and profit-cost ratio in Bogor, West Java, Indonesia.

Socio-economic Determinants and Farmers' Perception on Land Degradation in Northern Laos

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The economy of Lao is based on agriculture. Land use has effected on the livelihood of rural populations through agricultural practices. Land degradation is regularly associated with land use practices and socio-economic factors. Without understanding farmers` perception on land issues, sustainable management of land resources is impossible because they have intimate knowledge on their land. Therefore, the objectives of this study are to find famers` perception on land degradation and to examine the socio-economic determinants of land degradation in the study area. The data was carried out during September 2010. Face to face interviews were conducted from a total of 98 maize farmers that were randomly selected from 8 villages identified as maize growing zones of Bokeo Province, Laos. The logistic regression analysis was used to estimate the socio-economic determinant on land degradation and farmers` perception on the status of land degradation in northern Laos. This study is the first to report to study on determinant of land degradation of maize farmers in Laos. The model predicted eight determinants of land degradation in the study area have positive significant and five determinants are negative significant with land degradation.

Impact of Agricultural Extension Education on Elementary School Level Cocoa Farmers: Acopagro Cooperative-Case Study

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Better education can improve the efficiency of agricultural production. In the Peruvian jungle, there are two main cocoa marketing channels: the cooperative and the intermediaries. The cooperative transfers agricultural technology to the members by means of their agents whilst the intermediaries do not offer any extension service to the farmers. This study analyzes 1) the effect of receiving agricultural extension education on the cocoa production volume and 2) the education level of farmers who are willing to leave the intermediaries as their usual marketing channel and shift to the cooperative. A survey of 140 farmers who commercialize through the intermediaries and 103 Acopagro cooperative members respectively was carried out between December 2009 and January 2010 in Juanjui, San Martin, the main cocoa production area in Peru. Results confirm that being a member of Acopagro cooperative impacts favorably on the cocoa production quantity due to the agricultural extension education they receive. Moreover, non-associated farmers who have elementary school level as the cooperative members are willing to belong to the cooperative in the future. The Acopagro cooperative should continue to support the adequate training and supervision of the communities' agents. Consequently, they can be highly motivated to provide research knowledge and technologies to the cocoa farmers for being competitive in the market.

On Improving the Triple Bottom Line Returns: The SAFEST Way

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The SAFEST project is the CFEM's "ride-on" Community Participatory Action Research project with overall aim to demonstrate the acceptability, viability and adoptability of some ecological farming systems (organic, natural and conservation farming) that can address upland farm households' concern for production of "safe" food and cash under "safe" agroecosystems on a sustainable basis. It is in response to the calls of the following: (1) The Kyoto Protocol: Reduction of Emission from Deforestation in Developing Countries (REDD) and Land-use, Land-use Change and Forestry Activities (LULUCF); (2) United Nations' Millennium Development Goals; (3) The Philippine Strategy for Sustainable Development (PSSD); (4) Order 481 of 2005, entitled "Promotion and Development of Organic Agriculture in the Philippines;" and other environmental laws of the Government of the Philippines. In each of the six 1-hectare mango-based crop-livestock integrated farm in marginal or sub-marginal farm land, the observable triple bottom-line returns include the following: 1) the socio-cultural aspect: transformation from subsistence farmers to business farmers, shift from unsustainable to sustainable practices, individual health being freed from exposure to disease-carrier animal manures, food safe from side effects of inorganic fertilizer, a shift from major to minor construction materials, a variety of nutritious food/feeds, safe potable water/farm irrigation water needs, and access to social services through road construction; 2) the economic aspect: transformation from consumerism and subsistence farming to entrepreneur-ship, increased income from crop-animal production, lower cost of inputs, income from conversion of agri-wastes and/or lesser-used resources into useful culture media & bio-organic fertilizer (BOF), increased soil productivity, increased effective land area, increased effective rainfall, efficient/effective production system, and, access to business/ finance/ marketing services; and 3) the ecological aspect: transformation from unsustainable/conventional agriculture to sustainable agriculture, reduction of serious nutrient use imbalance, environmental health with agroecosystems *safe* from toxic chemical

residues, solid waste management system, reduced CO2 from burning, reduced CH4 from decomposition, reduced emission from deforestation, carbon sequestration, reduced soil erosion/ landslide, and biotic balance and/or integrated pest management system.

Environmental Risks and Their Impact on Food Security

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The relationship between ecosystems and livelihoods is changing in fundamental but poorly understood ways as economic systems diversify across rural-mixed economy-urban spectrum. Intensification of industries and rapid processes of urbanization are leading to increasing demands on and decreasing quality of water- and forest-based ecosystems and limiting access of the poor to resources that are critical for them to meet their livelihood needs. The case study in the Silang-Sta.Rosa sub-watershed areas provides some understanding of the interactions between people and institutions within their given natural environment. The major issue confronting the people in the area is how they would be able to improve, protect and expand their current resource base or level of acquirement given the different types of risks facing them. The risks in the upstream areas include soil degradation and the inefficient farm production system that lead to low farm productivity. Given very limited sources of entitlements, the incidence of poverty and food insecurity as well as health risks are also high due to the unsafe or unhealthy environment associated with pollution from farm and household domestic practices. In the downstream areas, households face issues related to poverty such as low income from declining fishery resources, food insecurity, and pollution from upstream as well as downstream areas that threaten their livelihood and increase the incidence of water-borne diseases. To address these concerns, it would be important to engage the different stakeholders in coming up with an integrated development plan that would reflect their common interests and vision for the watershed area.

Understanding and Conserving Indigenous Knowledge on Sustainable Natural Resource Management in the Cordilleras Administrative Region of the Philippines

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The Cordilleras Region of the Philippines has a rich diversity of indigenous knowledge on sustainable resource management. It is the basis for agriculture, food preparation, health care and environmental conservation. This paper aims to integrate the lessons learned from the local people's knowledge on natural resource management. Strategic options on environmental communication and education will be drawn from these findings. Natural resource management strategies practiced by various communities were documented using a variety of Participatory Rural Appraisal (PRA) tools and literature survey. Some of the practices in the Cordilleras like *Muyong* by the Ifugao's and *Batangan* in Mountain Province have sustain the lives of the people by providing steady source of food, construction materials, firewood/fuel and medicine while maintaining forest biodiversity in the region. Shifting cultivation, known as *Uma* system or patch farming, is a traditional crop production system practiced in the Cordilleras to rejuvenate soil fertility. Another indigenous soil fertility management practice in the Mountain Province is *Payew* where sunflower cuttings is incorporated and allowed to decompose in the rice paddy fields during the rice growing season. Natural resource management practices in the Cordilleras have sustained the diversity of forest resources and lives of

the local people. Policy makers, scientists and researchers must recognize and include the role of local people's knowledge in management decisions of the country's fragile environmental resources. Development of information exchange campaign (IEC) materials translated into local dialects is vital so that other communities can learn from these indigenous practices.

Innovation Capacity of Entrepreneurial Farmers: A Case Study in West Java, Indonesia

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Emerging domestic and international markets for horticulture products in Asia provides opportunities for farmers to move from cultivating traditional products to produce high added-value products. This study investigates factors influencing the innovation capacity by vegetable farmers in West Java, Indonesia. We conducted in-depth interviews to focus on the case of the vegetable farmers who are linked to modern markets, such as export markets and local-modern retails. Our study shows that vegetable farmers do either innovation creation or innovation adoption to improve their product quality or to reduce their production costs. Entrepreneurial behavior underlying farmers' decisions on applying innovations are proactiveness and risk-taking behavior. These farmers show their proactiveness in searching new information, learning new knowledge, and being first in markets. Calculative risk-taking behavior is indicated by market diversification and collaboration with fellow farmers. These innovative and entrepreneurial farmers gain growth in farm assets and market sales as their business performance.The empirical case of the vegetable farmers in West Java suggests that working in a group allows farmers to create or adopt more innovations and to reach more markets.

Salt Farm Workers' Well-being as Influenced by the Nature of their Participation in Salt Production Enterprise

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The study was undertaken to determine the effects of participation on the productivity and well-being of salt farm workers in salt-based farming communities in San Jose, Occidental Mindoro, Philippines and its implications to policy formulation. Fifty-three salt farm workers were randomly selected from two barangays consisting of six (6) salt farms with an area of 115 hectares with 87 salt farm workers. Findings showed that the degree of participation of salt farm owners as stakeholders in salt farming was generally high in terms of administrative, technical, livelihood, advisory, extension, and financial support services. The nature of participation of salt farm workers in various management activities in salt farming was observed to be under a pseudo type of participation, particularly in the aspect of problem analysis, goal setting; decision-making and policy formulation with very slight inclination towards assistencialism. The salt farm workers perceived their state of well-being as generally moderate but were high in so far as domains of well-being such as employment and quality of working life, psychological health, information/knowledge, political participation and performance of the government in the maintenance of peace and order. The nature of participation of salt farm workers affected their productivity in terms of income, average yield and their well-being. Socio-demographic and economic factors such as years in farming, employment arrangement, annual income, technological factors such as source of technology, willingness to change technology, characteristics of technology, and skills and institutional factors namely policies, and employment arrangement influenced the degree of participation in the salt-based farming communities studied.

Land Tenurial Situation in Relation to Rice Production in Three Villages in the Red River Delta, Vietnam

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Red River Delta is one of the main rice producing regions in Vietnam. With large variations in natural conditions, the Red River Delta is suitable for development of different types of crops and animals. In recent years, the importance of fisheries, aquaculture and fruit trees have been increasing. With an average farming area per household in Red River Delta being 0.28 ha (2005), land is a limited factor to generate sufficient income. Most farmers resort to diversifying their farm to high quality crops such as vegetables, fruit trees, and livestock for urban markets, or engaging in non-farm activities. The result of this trend is the emergence of tenancy among farmers. This paper focuses on the clarification of the current land tenure systems and the existing tenancy contracts among farm household in agricultural production in relation to rice production of three villages in the Red River Delta, Vietnam. A series of questionnaire survey was conducted in 2010-2011 in village of Hung Yen, Bac Ninh, and Hai Phong Provinces which are located in Red River Delta in the North of Vietnam. Main finding of the research is the flexible of agricultural land tenurial situation. There is increasing area of non rice production with the appearance of difference kinds of tenurial status in difference village. The tenurial status changes as the age of farmers, indicating the life-cycle of farmer economic behavior. There is heavy dependence upon kinship ties in landlord-tenant relation. The production function analysis and marginal productivity analysis reveals that land and fertilizer are being used beyond its optimum level, while more labor and other material factor could profitably be employed in order to increase rice production.

Enhancing the Indigenous People's Capacity in Biodiversity Conservation and Sustainable Livelihood for Food Security in the Uplands

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The paper highlights the experience of Occidental Mindoro State College (OMSC) in working with the indigenous people (Buhid Mangyans) in a collaborative extension program, called the Poverty Alleviation Promotion thru Environmental and Livelihood Program for the Buhid Mangyans (PAPEL Buhid). The program was designed to help rehabilitate and conserve upland resources and generate alternative sustainable livelihoods. The program addressed the most pressing problems identified by the Buhids such as poor health, low farm productivity and income, and environmental degradation. The activities revolved around building the capacity of Mangyans in natural resource management and various livelihood options. These included establishment of a community nursery for forest and fruit-bearing trees and herbal plants; establishment backyard vegetable garden, and planting of mahogany, banana, and coconut trees in the periphery of the village. The Mangyans were also trained on handicraft making, organic fertilizer production, seedling grafting, and practical cooking. Seminars on health and nutrition, parenting, and values orientation were conducted. Jingle making and singing contest with a theme on biodiversity conservation for the Buhid school children was done in cooperation with their teachers. This paper proves that an academe-indigenous people partnership in development program is possible provided that it is people-initiated and urgent need-driven. In addition, cultural sensitivity and transparency help build trust and confidence with partners. Initial accomplishments of the program were the cultivation of idle lands, practice of organic agriculture, adoption of appropriate upland technologies, generation of livelihood, increased awareness on environmental conservation, and building of greener and healthier village.

Assessment on Durian GAP Development Participation in Eastern Cultivated Areas, Thailand

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This investigation aimed to determine 1) the participation of certified growers on durian good agricultural practice (GAP) development, 2) some factors affecting their participation on durian GAP development, and 3) constraints and recommendations on durian GAP development. The studied sample was selected 71 orchards certified durian growers in eastern cultivated areas, Thailand. In depth interview scheduled was obtained to collect data. Descriptive statistics was presented in percentage and arithmetic means. Inferential statistics to test the hypothesis was Pearson product moment correlation coefficient. The reliability discrimination measurements on durian GAP development participation were obtained in three aspects including making decision participation, implementation participation, and assessment participation. Discrimination of farmer capability on durian GAP development participation was determined through Cronbach's alpha with the reliability of 0.95, 0.96, and 0.97, respectively. The findings revealed that most respondents strongly agreed to participate in making decision, implementation and also assessment in all 13 proposed main items. In addition, most respondents moderate agreed in 2 main proposed items including pest management and record keeping. Testing hypothesis pointed out that there were positive statistically significant between cultivated areas, number of marketing channels, number of group belonging, number of household labor force, and farmers' knowledge in durian innovation with their participation on durian GAP development. Most constraints were limitation of their times. Implementation oriented promotion should be concerns in applicable guidelines through appropriate practices.

Promoting Good Management Practices in the Production of Local Banana Cultivars Among Small Scale Growers through Various Information, Education, and Communication Approaches

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There is much room for productivity improvements in local banana production of small hold growers. However, existing traditional practices need to be given up in favor of S&T-based technologies following a "best bet" banana package of technology (POT) developed by PCARRD-DOST and patterned after the plantation-type management of Cavendish cultivars. The project promoted the POT for farmers' adoption through interpersonal and mediated IEC approaches in the provinces of Quirino, Oriental Mindoro and Cavite. Traditional banana growing practices of chronic neglect and undermanagement promote the spread of pests and diseases, thus productivity in these important banana producing areas remain low and below the world average of 15t ha^{-1} yr^{-1}. A total of 30.5 ha of demonstration farms was established consisting of 15 hectares of Lakatan, 7 hectares of Latundan and 8.5 hectares of Saba involving 23 farmer-cooperators. Interpersonal IECs were provided to selected farmer cooperators (FCs) through training, technical and materials assistance in farm establishment, and regular technical support. The use of tissue-cultured planting materials, high-density, systematic planting system and fertilization were uniformly adopted by FCs. Almost all FCs were able to influence other farmers to practice various POT components. The mediated IEC strategies consist of six printed comics, a printed POT guidebook and its video version. The formats were decided based on the preferences of the respondents in the baseline survey while the contents

answered common problems and concerns experienced by the FCs. The comics were of two genres, a "fantaserye" featuring a superhero named "Super Saging" who helps farmers solve technical problems and "realistic" storylines inspired by the FCs dealing on the POT and on mite control. The banana guidebook in Filipino and its complementary video version contained the topics of interest to growers and would be useful in building local capacities on good management practices in other banana growing areas.

Capacity Building of the Buhid Mangyan Women in San Jose, Occidental Mindoro Through Community-Based Livelihood Options

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Poverty is a phenomenon among the country's indigenous peoples (IP's) like the Mangyans of Occidental Mindoro Many development interventions had been introduced in the past to help alleviate their living but most, if not all, had failed due todwindling funds, passive community participation and dole-out mentality. With the incessant desire to help uplift the Mangyan's economic state, the Occidental Mindoro State College (OMSC) in partnership with other government organizations, crafted a project specifically to build the Mangyan women's capacity to earn income. The paper highlights the strategies employed by the project to ensure smooth and successful implementation. The project recognizes the importance of making women feel they are both owners and managers of the project. A Buhid women organization "*Yame ngayan samahan Pagkasadiyan manga Ina Sayame Sitio Salafay*," in Tagalog "*Pagkakaisa ng mga Kababaihan sa Sitio Salafay*" was organized. This organization controlled the allocation and distribution of raw materials for the different community-based livelihood options. The initial interventions in "ono" (bead) and "abol" (weaving) making and design, and the quality control strategies had helped in improving the skills and the products of the Buhid women. The average monthly income had increased from PhP 86.80 to PhP 111.00. Aside from women's full control of their activities, experiences suggest that sustained partnership and implementation of need-driven projects can ensure success of any development endeavour.

Integrated Farming System Development in Ensuring Food Security and Sustainable Agriculture in Bali, Indonesia

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Integrated farming system, usually called as SIMANTRI, is one of food production technologies developed by Local Government of Bali Province since 2009. Until 2011, about 150 SIMANTRIs have established in Bali due to the success of some other ones development, previously. This paper aims to examine that it could be a holistic approach for food security and sustainable agriculture in Bali. An example one is the SIMANTRI operated by farmers group of Purna Gopala in Gianyar Regency, Bali. Based on survey in 2009, 24 farmers who were chosen by census integrated several crops such as paddy in Cropping Season 1 and 3, fodder grasses annually, corn dan peanut in Cropping Season 2, and cattle annually into the system. All of these farm enterprises were to produce food and feed commodities. An actual farm income from the average farm size of 0.45 ha was about Rp26,401,297.31/yr. Then, by using BLPX88 as a linear programming package program that acomodated 58 activities and 71 constrains of the system, it was found that the maximum farm income of Rp26,435,430.00/yr. This success indicated the system was optimally operated by local farmers. By defining sustainable agriculture as a holistic farming system which is economically viable, ecologically sound, socially just, and culturally and technically appropriate, so the system that producing food will potentially sustainable.

Food Household Consumption as Labor and Land Institutions in Gunung Kidul Regency

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This research aims to find out the effect of land and labor institution on food household consumptions in Gunung Kidul. This research conducted the survey in Gunung Kidul Regency South Zone, in one hamlet area which is relatively far away from the city or market, and one hamlet areas relatively close to the city or market. Totally, there are 225 farm households, the poor village area in the two hamlets all as respondents. The data was analysed by tabulations and regression. Food household consumptions of the owner-operator farmers are not different with the consumption of farmers in other land institution. Food household consumptions of forestry tenant land are lower than the consumption of farmers in other land institutions. Food consumptions of *LKP* tenant land is lower than the consumption of farmers in other land institutions. Food consumption based on labor institution of farming is not different. Proportion of household income to food consumption for the farmers who are relatively far from the city greater than the proportion of farmers who are relatively close to the city. Similarly, the proportion of carbohydrate intake for farmers who are relatively far from the city greater than the proportion of farmers who are relatively close to the city.

Factors Affecting Empowerment Process among Dairy Cattle Farmers in Semarang Regency, Central Java, Indonesia

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The study aimed to determine the factors affecting empowerment process among dairy cattle farmers in Semarang Regency, Central Java. It analyzed the effect of the socio-demographic factors (age, gender, occupation, family income, educational attainment, and length of membership in cooperatives) on the empowerment process (community organizing, training, and building network). The information gathered from the respondent's interview via questionnaire were coded and processed using the (SPSS) and were analyzed quantitatively to the possible extent by using descriptive statistics such as frequency distribution, mean, and percentage. Spearman Rank Order Correlation test was used to determine the relationship between independent and dependent variables. This study indicates that the is significant relationship between socio-demographic factors and the empowerment process. The indicators of socio-demographic factors could influence an organization and its members to improve the empowerment process. Although the respondents' knowledge on empowerment was still limited, hence, the goverment should provide empowerment promotion program for all dairy cattle farmers.

Technical Assessment on Commercial Sericulture Production in Northeastern Thailand

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The objectives of the study were to determine 1) commercial sericulture production condition, 2) cost and return in commercial sericulture production, 3) their constraints and recommendations in commercial sericulture production. The studied samples were selected 48 sericulture farmers in Hua Fai Village, PorDang sub district, Chonnabot district, Khon Kaen province through multistage sampling technique. Interview schedule was obtained to collect data. Descriptive

statistics used for analysis were percentage and arithmetic means. The findings revealed that average sericulture production experience was 32 years. Average mulberry cultivated area was 0.80 rai (0.12 ha) per household. The most popular variety is “BURIRUM 60” and irrigated by furrow method. Cultivation techniques were carried out through recommendations by extension officers. The most popular silkworm variety was “DOKBUA”, with 6-8 cycles per year. Rearing period was around 23-25 days. Farmers controlled silkworm disease with lime as regular application. Most of silk yarn product was first grade. Reeling apparatus was granted from The Queen Sirikit Institute of Sericulture. Almost of silk yarn and fabric products sold to sericulture group and middlemen. Average variable cost of sericulture production was 39,510 baht (US$ 1317; US$ 1 = 30 baht) per annum. Farmers got various income from sericulture production including cocoon 100 baht (US$ 3) per kg, silk yarn 1,200 baht (US$ 40) per kg, and silk fabric 500 baht (US$ 16.6) per meter. Silkworm disease and high cost were main production constraints. In addition, lack of marketing information and also uncertain marketing channels were serious constraints. A strategic policy for commercial sericulture promotion should focus on marketing channels and marketing information center.

Poster Abstracts

Adapting to Climate Change: Households' Food Security and Adaptive Strategies of Agricultural Communities in Upper Magat River Basin, North Luzon, Philippines

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This study was conducted to determine the adaptive strategies and food security conditons of households in agricultural communities in the Upper Magat River Basin as a consequence of environmental hazards. A structured interview schedule was developed and administered to 189 household-respondents residing within the hazard-prone areas of the Upper Magat River Basin, Philippines. Most of the households in the agricultural communities studied showed that they acquired loans from their cooperative for farm inputs. Correspondingly, the average amount of loan of the respondents in the study sites is about PhP 30,969.75 with the maximum amount of Php 500,000.00 and minimum amount of PhP 1000.00. Although typhoon provides the higher damage than flood, both of these climatic hazards destroyed the respondents properties like home garden, corn farms, fruit trees, houses, rice farms and animals. The average amount of damage to properties of the respondents in the study sites is about PhP 26,516.45 with the maximum amount of Php 500,000.00 and minimum amount of PhP 200.00. The most adaptive mechanism of households in the study sites can be viewed as traditional adaptations to annual flood events consisting of construction activities and a delay of the cropping cycle. The specific short-term coping mechanisms of households such as translocation, cleaning, supplementing, borrowing money, and precautionary savings, are performed before and after the occurrence of floods. The observed adaptive strategies influence the agricultural dependency, the level of exposure, land size, and income of the households. Likewise, the damage cost due to floods is positively correlated with income of the households, corn output, price of corn and loan money. However, there is a negative correlation of damage cost with new activities performed by the households after the flood and between current loan and income. The respondents' landownership in the study sites averaged about 1.15 hectare planting various crops such as rice, corn, vegetable and fruit trees and sell directly to the market or their neighbours. This study also shows that households in the Upper Magat River Basin, Philippines with higher damaged cost were inclined to borrow more.

Development of Model System of Sugar Cane Litter Management in Dry Land Sugar Cane Plantation

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The area of sugar cane plantation in Indonesia in 2010 reached 434,257 hectares with sugar production 2,694,227 tons. In sugar industry some by- products are also produced, such as sugar cane tops, sugar cane leaves, *blotong*, drops, and bagasse. Litter weight of cane harvesting area can reach 20-25 tons/ha. The research is being conducted in sugar cane plantations under PG Takalar, South Sulawesi, where there are problems on land preparation which is conventionally conducted so far by burning plant residues (sugar cane dry leaves) in the field. This method causes air pollution to the environment and leads to land degradation in the form of changes in physical properties, soil fertility, killing of soil biota, and global warming. This research aims to design a model system of sugar cane residue management on dry land sugar cane plantations with the purpose to increase the productivity of sugar cane production. The plant residue was used for compost, which is later be as organic

fertilizer. The compost produced here was standard compost according to SNI. The results showed that the application of compost fertilizers give significant influence on of sugar cane plant growth.

Effect of Heavy Metals Concentration in Soil Derived from Application of Raw and Composted Recycled Paper Mill Sludgeon *Orthosiphon stamineus*

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Increasing amount of disposed paper mill sludge from industries has recently attracted concern for an alternative environmentally sustainable application. Recycled paper mill sludge (RPMS) is an active organic material and has potential benefits to supply nutrients for crops growth. However, if excessive contaminants are introduced by application of low quality sludge, the practice may have an adverse effect of heavy metals in the contamination of food chain and the environment. Therefore, this study was carried out to investigate the heavy metals concentrations in soil applied with raw and composted recycled paper mill sludge. A study was conducted in the glasshouse unit of Faculty of Agriculture, Universiti Putra Malaysia. The soil used for this study was the Serdang Series and *Ortosiphon stamineus* was used as the test crop in 20 kg pots arranged in a complete randomized design. Application rates of raw and RPMS compost was based on the N content. Treatments were applied during transplanting for 3 weeks *O.stamineus* seedlings. The treatments were control, 100% N equivalent of the recommended rate of inorganic N fertilizer, 100%, 200% and 400% N eq. of raw and RPMS compost, respectively. This study indicates that raw and RPMS compost has potential to be a supplementary nutrient source as well as soil amendment for growing plants. After three months application of raw and RPMS compost, there was no significant difference in the concentrations of heavy metals in soil compared to the control except for Cd. However, foliar concentrations of all heavy metals were below the MPC value of the Malaysian Food Act 1983 and Food regulation 1985. Soil pH affected the total Cd in soil, meanwhile, available P were positively correlated with total Cd and Pb in soil.

Conservation Status and Utilization of Ethnobotanical Resources in Northern Cagayan Valley, Luzon, Philippines

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Throughout the world, people use many plant species for food, medicine, income generation and for the fulfillment of economic needs. In recognition to biological diversity, plants serve significant value to the present and future generations. However, pressure from growing populations and the adoption of modern life styles are threats to the existence of many of these species and the ecosystems that support them. Cagayan Valley, Philippines had an extremely rich diversity of ethnobotanical resources derived mainly from the environment as source of food and medicine**.** A total of 94 species, representing 92 genera and 60 families of potential wild food and 277 species, 202 genera and 82 families of useful medicinal plants, mostly at the least concerned status of conservation, were identified. Among the new findings are those ethnobotanical resources utilized for food by specific ethnic group, mostly unreported. Gardening and farming, are the major management practices preferred to maintain the existence of these resources. But richness in floral diversity do not exempt the region's resilience to climate change, hence the promotion of indigenous knowledge on the utilization of plant resources for food security and medicine is an effective strategy to minimize the

use of synthetic materials. Validation of pharmacological and nutriceutical efficacy of these plants should be done, for utilization of the growing population, thereby promoting ecological and biological diversity, and stability of IKS as well as in the upliftment of food security.

Sweetpotato (*Ipomoea batatas* l.) Varieties and Its Utilization in the Northern Philippines

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Sweetpotato (*Ipomoea batatas* L.) is locally known as 'dokto', 'lokto', 'ubi', 'bayading', in the cordillera region. It is known to be 'survival crop' 'famine crop', 'poor man's food', 'underutilized crop' and 'neglected crop' but are found nutritious food. It is a versatile crop and all plant parts are utilized as food and animal feed. It is nutritious food and could supplement or substitute rice which is a staple food among the Asean countries. It is also a crop that could resist our changing climate. Interventions has been made by the researchers of the Northern Philippines Root Crops Research and Training Center by selecting high yielding varieties and developing processing techniques in which they were made into candies, wine, yogart, inorder to increase its consumption. Likewise, dispersal of planting materials and IEC materials/publications as well as exhibition of products during trade fairs and hands on training is continuously being done in the region inorder to promote its importance and utilization.

Yam (*Dioscorea alata* L.) Minituber Seed Production from Vine Cuttings

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This study determined the practicability of vine cuttings as alternative technology for tuber seed increase in yam. Vine cuttings were severed from the 3 months old vine or 2 month old lateral vine disregarding the vine with undeveloped leaves. These were further cut into three different sizes of cuttings which are three-nodal cuttings, two-nodal cuttings and single node cutting. The result showed that the three-nodal cuttings developed an average of two tubers per cutting while the two-nodal cutting yielded 1 to 2 tubers per cutting while the single node cutting yielded one tuber per cutting. The average tuber size produced was of marble size or 7 to 13 g per tuber after four months. These yam minitubers were subsequently planted in the field after sprouting and its tuber yield or size increased from 3 to 7 folds with an average weight of 38 to 76 g per tuber.

Vermicompost Fertilization at Varying Rates of Application: Its Influence on the Growth of Okra (*Abelmoschus esculentus* (L.) Moench) and on the Soil Chemical Properties

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In responding to the call to sustain the efforts towards ensuring food security through environmentally-sound farming approach, this research on okra (*Abelmoschus esculentus* (L.) Moench) was conducted. Okra is a versatile plant and it is known as a powerhouse of valuable nutrients. Varying rates of vermicompost were utilized in the fertilization of the crop aimed at determining their effects on its growth and on soil chemical properties. The study was laid out in a randomized complete block design with five treatments: T1 = control (no fertilizer), T2 = inorganic Fertilizer (IF), T3 = 13 ton ha^{-1} vermicompost ($13tha^{-1}V$), T4 = 11 ton ha^{-1} vermicompost ($11tha^{-1}V$), T5 = 9 ton ha^{-1} vermicompost ($9tha^{-1}V$). Okra plants applied with $13tha^{-1}V$ increased in fruit weight and number of fruits than those in the control group. The same was observed on the plants treated

with lower rates of vermicompost. The result of application of 13tha^{-1}V was comparable to those plants treated with IF. The chemical properties of the soil had relatively improved as manifested by higher residual amount of nitrogen, phosphorous, potassium and organic matteron soil fertilized with 13tha^{-1}V. The soil pH became more acidic with the application of inorganic fertilizer while soil acidity declined with the use of vermicompost as fertilizer. Utilization of vermicompost is a good option over chemical-based fertilizer.

Bioactivity of Methanolic Seed Extract of *Barringtonia asiatica* L. (Kurz) (Lecythidaceae) on Biological Characters of *Spodotera litura* (Fabricius) (Lepidoptera: Noctuidae)

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Plants are known have various chemical compound that have potential to be developed as insecticides. One of the potential plants to be developed as insecticides is *Barringtonia asiatica* (Lecythidaceae). This research was conducted to determine toxicity of methanolic seed extract of *B. asiatica* to mortality and biological character of *Spodoptera litura*. The evaluation of toxicity was carried out using feeding method. Result of this research indicated that methanolic seed extract of *B. asiatica* had insecticidal activity with LC_{50} at concentration of 0.30% and LC_{90} at concentration of 0.80% in 13 days after treatment with LT_{50} at 4.8 days. In addition, Methanolic seed extract of *B. asiatica* coused decrease of larva's weight, time of development, reduced leaf consumption and decrease of egg amount oviposited by female of *S. litura*.

Edible Landscaping: A New Approach in Crop Production

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Edible landscaping (EL) is a new approach that merges science and creativity together to form a revolutionary crop production technology. It gives a twist in the conventional crop production as the basic tenets of landscape designing become its guiding principle. EL combines the basic crop production practices and the conventional landscaping processes which include design conceptualization, implementation and maintenance. Design phase incorporates edible plants like vegetables, fruits, and herbs with other plants and structures while taking into consideration the principles and elements of design to fit on the chosen design or style. Edible softscapes are arranged like ornamental plants to function as hedge, ground cover, accent or screen on the landscape. Trellises and other hardscapes are used to support crops and to provide additional attraction in the landscape. It also features different garden arrangements fit for both urban and rural areas like container gardening, verti-growing and themed gardens of Filipino favourite culinary dishes created through companion planting of crops. Implementation and maintenance phase of EL follow the practices used in the conventional landscaping, however focuses more on seedling and planting material production and modification of the environment to suit for the crops requirements. In general, EL integrates the science of crop production and the art of landscape design to create a more attractive and functional environment that answers the need for safe and nutritious food for the people.

Parasitoids Species of Bagworm *Pteroma pendula* Joannis and Its Abundance in Oil Palm Plantation

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Bagworm is known as one of the most destructive pests in Malaysia's oil palm plantations. There are three major species been recorded and one of them is the *Pteroma pendula* Joannis which was identified as dominant bagworm species in 69 oil palm estates in Peninsular Malaysia. Total of 100 larvae of this bagworm can caused about 133.68cm^2 of leaves area damaged. Numerous efforts have been considered in order to control the infestations including biological control using fungi, predators and parasitoids). Augmentation of natural enemies particularly parasitoids can be seen through planting of beneficial plants such as *Cassia cobanensis* surrounding the plantation areas. However, in order to ensure the capability of the parasitoids, detail information on species identification and its ecological aspect is still scarce and required to be explored further. Therefore, it is vital to investigate the parasitoids species parasitizing *P. pendula* and its abundance in oil palm area. In this study, the newly emerged parasitoids from collected bagworms larvae and pupae were identified and recorded. There were several species of parasitoids involved and most of them were the same parasitoids species of bagworm *Metisa plana*. The species were *Eupelmus catoxanthae*, *Eurytoma* sp., *Pediobius* sp., *Apanteles metesae*, *Tetrastichus* sp., and two other unknown species that have not been recorded which might be a new recorded species of parasitoids *P. pendula*.

A Study of the Mesofauna Diversity in the Park Land of Kelimutu National Park Ende-Flores, East Nusa Tenggara

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Soil organisms or soil biota as commonly referred to, have a role in the ecosystem as decomposers of organic matter. The process of decomposition in the soil is usually slow if not supported by the activities of decomposers which act as organic catalysts. The parkland of Kelimutu National Park in Flores has a topography, soils and vegetation that is so diverse so that there is need to support the management and development of the area with basic information on biodiversity found in the National Park and in particular soil fauna. This research was conducted in April 2010. Samples of soil were taken using a stratified random sampling technique from four different stations having different vegetations in the National Park. Identification of the mesofauna was performed at the Laboratory of the Faculty of Agriculture, University of Flores and soil analysis performed at the Laboratory of the Faculty of Agriculture, University of Udayana. The Shannon and Simpson index of vegetative analysis was used to analyze the vegetation and mesofauna. The results show that there are 16 kinds of mesofauna scattered in the four observation stations. The highest diversity (1.84) was found on station IV. Station IV had the highest mesofauna because the habitat on this station was made up of vegetation composed of a mixture of forest biomass meaning that the process of decomposition occurs continuously. This was further strengthened with a 23.14 ^{o}C temperature, an average soil pH of 6.22, very high organic C (8.42%) and available N being (0.23%) an indication high soil mesofauna activity in this habitat. The lowest diversity of mesofauna was found on the station I (0.35) this was a station with extreme conditions as indicated by the results of soil analysis from the station which showed a low organic C (1.62%), and very low N (0.04%). Since vegetation in an ecosystem are constituent of pioneer plants such as *Vasinium* spp., *Rododendron* spp., ferns and pines This is an indication of lack of soil mesofauna activity on that ecosystem. Thus, conservation measures need to be done by planting plants that are preceded by typical pioneer plants such as ferns

which are able to provide biomass relatively quickly when compared to other types of plants that will be used as sources of energy for soil mesofauna which are agents organic matter decomposition.

Use of Wild Plants and Animal Droppings as a Source of Manure for the Production of Organic Corn 'Pulut Putih'

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Productive optimal growth of corn "pulut putih" in open space is determined by the condition of soil fertility and organic materials present in the soil. Research results indicate that corn "pulut putih" which was grown with addition of organic materials from wild plants such as *Chromolaena* and *Tithonia* combined with 40% animal droppings showed better production components and growth. The crop grown under these conditions was found to be high in wet and dry weight and had wider leaves.

Toxicity of Plant Extracts from Black Pepper *Piper nigrum* and Physic Nut *Jatropha curcas* Against Rice Weevil *Sitophilus oryzae* (L.) and Rice Moth *Corcyra cephalonica* (Stainton)

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Laboratory studies on toxicity effects extracts of dried plant materials of black pepper and physic nut was made on adults of *S. oryzae* (7-14 days old) and 3rd instar larvae of *C. cephalonica*. On the basis of LC_{50}, results showed that the adults of *S. oryzae* were more susceptible than the 3rd instar larvae of *C. cephalonica* to petroleum ether (LC_{50}=1.6 and 12.5 mg/g) and chloroform extracts (LC_{50}=1.7 and 14.3 mg/g) from fruits of *P. nigrum*, respectively. However, the aqueous extracts from fruits of *P. nigrum* did not show any toxicity effect against both adults of *S. oryzae* and 3rd instar larvae of *C. cephalonica* at the calculated doses during 72 hours exposure. The petroleum ether extract from seeds of *J. curcas* was more toxic to the adult of *S. oryzae* (LC_{50}=6.8 mg/g) than 3rd instar larvae of *C. cephalonica* (LC_{50}=13.2 mg/g). Chloroform and aqueous extracts from seeds of *J. curcas* did not show any toxicity against adults of *S. oryzae* and 3rd instar larvae of *C. cephalonica*.

Preparation and Characterization of Encapsulated *Burkholderia S*train UPM B3

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The development of cost effective, user friendly and readily available commercial formulations for beneficial microbes has always been a constraint in sustaining the performance of the BCAs. Formulation of biological control agents for commercial use generally involves the mixing of viable BCAs cells with carrier-based materials in liquid or dry form and nutritional supplements such as glucose to develop fine formulations that not only can stabilize and enhance the growth of BCAs but also convenient for storage and user friendly. This study reports on the encapsulation of *Burkholderia* strain UPMB3 in sodium alginate (SA) as the matrix and montmorillonite (MMT) clay

to improve the viability and shelf life of the bioagent (SA-MMT). SA-MMT was characterized using Fourier Transform Infrared Spectroscopy, Thermogravimetric analysis and Scanning Electron Microscopy. FTIR results showed the interaction between the functional groups of SA and MMT in the SA-MMT beads. TGA analysis showed the incorporation of MMT in SA-MMT beads increased the thermal stability of the formulations due to the high thermal stability of the MMT and to the interaction between the MMT particles and the alginate matrix**.** SEM analysis revealed homogeneous distribution of the MMT particles throughout the SA matrix and the smooth surface of the SA-MMT compare to SA alone. *Burkholderia strain* UPM B3 was successfully encapsulated in the SA-MMT beads. Storage analysis of the encapsulated *Burkholderia strain* UPM B3 showed that lower storage temperature of 10 °C significantly gave better storage properties compared to room temperature (30°C).

Distribution of Root-knot Nematode Species, *Meloidogyne* spp., the Causes of Branched Tuber Disease at Different Altitudes in Indonesia

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Branched tuber disease is a raising problem in carrot cultivation. The disease is caused by infection of root-knot nematode (RKN) species, *Meloidogyne* spp. RKN distribution in Indonesia not cleary known, so needs a comprehesif research. The purpose of this research is to know the distribution of RKN based on altitude places. The identification of the nematodes were conducted at Laboratory of Plant Nematology, Department of plant pest and disease, faculty of Agriculture, Universitas Padjadjaran and Plant Virology, Department of Plant Protection, Faculty of Agriculture, IPB, involving conventional and moleculer techniques. The research was conducted from September 2009 until May 2011. Surveillance conducted in plain medium (700-1000 m asl) and highland (1000-1300 m asl; 1300-1600 m asl). The results of conventional and molecular identification is known that at an altitude of 700-1000 m asl there are four species of the NPA, *M. arenaria, M. hapla, M. incognita* and *M. javanica*. At an altitude of 1000-1300 m asl was found five species, namely *M. arenaria, M. falax, M. hapla, M. incognita* and *M. javanica*, while at an altitude of 1300-1600 m asl were found four species, namely *M. falax, M. hapla, M. incognita* and *M. javanica*.

Effectiveness of Leaf Extract of Teak (*Tectona grandis* L.f.) against *Arthrinium phaeospermum* (Corda) M.B. Ellis, the Causes of Wood Damage of *Albizia falcataria* (L.) Fosberg

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Arthrinium phaeospermum (Corda) M.B. Ellis is one of the causes of wood damage of *Albizia falcataria* (L.) Fosberg. The objective of this research was to investigate effectiveness of teak (*Tectona grandis* Lf) leaf extract in inhibiting the growth of *A. phaeospermum*. The purpose of this study was to test the potential of teak leaf extracts of teak as a biofungicide. Extraction was done by maceration method using methanol as solvent. Antifungal activity of teak leaf extract was done by a well-diffusion method on potato dextrose agar media. Five concentrations of the leaf extract, i.e. 0% (control), 0.5%, 1%, 2%, and 4% were tested in this study. The result of this study showed that the teak leaf extract significantly suppressed the growth of *A. phaeospermum* with minimum inhibitory concentration 0.1%. The extract inhibited fungal radial growth, total dry weight biomass, and spore formation of *A. phaeospermum*.

Prevalence of C*ucumber mosaic virus* Causing Mosaic Disease on Chilli Pepper in Bali and Collection of Mild Isolates for Cross Protection

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In Bali of Indonesia, chilli peppers (*Capsicum annum* L. and *C. frutescent* L.) are usually affected by two significant viral diseases having typical yellowing and mosaic symptoms, respectively. The yellowing disease had been known to be caused by infection of *Pepper yellow leaf curl virus* (PepYLCV), but the mosaic symptom may be caused by other viruses. In this study, by using enzyme-linked immunosorbent assay (ELISA), the mosaic disease was confirmed to be associated with infection of three viruses, *Tobacco mosaic virus* in the genus *Tobamovirus*, *Chilli vein mottle virus* (ChiVMV) in the genus *Potyvirus*, and *Cucumber mosaic virus* (CMV) in the genus *Cucumovirus*. No chilli pepper plants showing mosaic symptom was associated with infection of PepYLCV. The incidence of mosaic disease was more frequent (50%) than that of yellowing disease (8%) in all chilli pepper growing areas of Bali observed in 2010. Based on ELISA study, it was found that CMV was the main virus induced mosaic symptoms on the chilli pepper in Bali. Among plants showing mosaic symptoms, there were some plants expressed no or very mild symptoms that predicted to be infected by mild isolates of CMV. Double-stranded (ds) RNA analyses of 43 samples of chilli pepper plants naturally showing very mild symptoms suggested that four mild isolates of CMV contained satellite RNA (satRNA) of about 400 bp. Two of the satRNA-contained CMV isolates having significant protective effect against other CMV isolate naturally induced severe mosaic disease. These mild CMV isolates may be useful as biological control agent for mosaic disease management of chilli pepper in Bali or other area of Indonesia.

Forage Yield and Quality of Kenaf (*Hibiscus cannabinus* L.) for Consumption as Ruminant Feed

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Kenaf (*Hibiscus cannabinus* L.) which is usually utilized as a fiber crop can also be used as forage for feed of ruminants. Its early growth stage the plant possesses high protein content, making it a favorable forage for livestock. This study was carried out to evaluate 40 kenaf accessions for forage yield and quality at Universiti Putra Malaysia in 2009. Forage yield and quality traits were measured at the initial flowering stage. The kenaf accessions showed highly significant variation for fresh stem yield, plant dry matter (DM) yield, leaf and stem dry matter yield, leaf/stem ratio, crude protein (CP), acid detergent fiber (ADF) content and days to flowering. Plant dry matter yield ranged from 5286 kg/ha (Evarglade 41) to 16801 kg/ha (1X51). Crude protein content of the leaf ranged from 13.6% (G46) to 22.3% (75-71). Leaf ADF were significantly different among the accessions, where FDW 75-82 gave the highest (24.7%) while C74 gave the lowest (16%). Broad-sense heritability was highest for days to flowering (h_B^2= 97.6%) and lowest for fresh plant yield (h_B^2= 11.1 %). In conclusion 1X51, Cuba2032 (with high yield), 75-71 and Evarglade 41 (with high CP content), were the most superior among the 40 kenaf accessions evaluated and were found highly potential for forage. These accessions can therefore be utilized in further breeding programs to produce new kenaf varieties with high feed value for ruminant consumption.

Nutrient Digestibility and Growth Performance of Swine Fed Diet Supplemented with NSP-degraded Enzymes

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The effect of dietary non-starch polysaccharide (NSP)-degraded enzymes supplementation on the coefficients of total tract apparent digestibility (CTTAD) of nutrients and growth performance of growing-pigs were studied using completely randomized design. Thirty-six three-way crossbred piglets aging about 4 weeks were divided into three groups with three replicates, which consisted of two castrated-male and two female. The animals were kept in concrete pen where feed and water provided *ad libitum* until 16 week of age. The corn-soy based diet was used as the control diet and the other two experimental diets were control diets supplemented with NSP-degraded enzymes, mainly β-glucanase and β-xylanase from *Penicillium* sp. and NSP-degraded enzymes from *Aspergillus* sp. Body weight and feed intake of each group were collected during three periods of growth (4-7, 8-11 and 12-16 week of age) to evaluate the growth performance. The apparent digestibility assay was taken by using indicator method, which feed and feces sampling were collected at 5 and 12 week of age. Results showed that NSP-enzymes did not significantly improved the nutrient digestibility of young pigs (4-7 week of age) due to the low dietary crude fiber content, but the significantly improvement of nutrient digestibility such as dry matter, crude protein, crude fiber, energy and calcium were found at 12 week of age. The better nutrient digestibility provided the improvement of growth performance in term of body weight gain and feed conversion ratio, especially in period 7-11 week of age. Average improvement of average daily gain and feed conversion ratio were 3.55 and 4.05% by NSP-degraded enzyme supplementation. The different sources of NSP-degraded enzymes did not have the significant effect on the growth performance of growing-pigs.

Effects of Dietary Fenugreek Seed on the Growth Performance, Carcass Composition and Blood Parameters in the African Catfish

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An eight-week feeding experiment was conducted to assess the suitability of fenugreek seed meal (FSM; *Trigonella foenum-graecum*) as a replacement for fish meal (FM) in diets of the African catfish (*Claris gariepinus).* Five isonitrogenous (35% crude protein) and isoenergetic (3480 Kcal/kg) diets were formulated without (control) and with FSM concentrations of 10% (SFM-10), 18% (SFM-18), 26% (FSM-26) and 34% (SFM-34). The FSM replaced FM in the control diet in amounts of 25.3, 35.3, 45.3 and 54.7% in diets FSM-10, FSM-18, SFM-26 and SFM-34, respectively. Each diet was fed to three replicate groups of 30 fish kept in individual 100 *l* aquaria, organized in a completely randomized design. The fish fed diets FSM-26 and FSM-34 had lower hepatosomatic index, final body weight, body weight gain, feed intake and protein efficiency ratio, but higher feed conversion ratio than the fish in other dietary treatments, while the survival rate was not affected by any diet . The concentration of protein in the whole carcass decreased in fish fed the FSM-26 and FSM-34 diets compared with fish fed the other diets while lipid content of the whole carcass depressed in groups fed FSM-34 diet. The fish treated with the diets FSM-26 and FSM-34 showed lower ash content in the fillet compare to the others. Blood hemoglobin, hematocrit and red blood cells of groups fed up to 18% of FSM were higher than other groups. These results show that up to 18% FSM can be included

in the dietary dry matter to replace up to 35% of FM in the African catfish diet, without any negative effects on the growth performance or survival of the fish.

Making Goats RED

Cathy V. Balicat-Pastor

A development project entitled "Intensification of the Innovative Goat Production System for Sustainable Rural Enterprise Development in Region I, Philippines" was implemented to promote rural-based enterprises that would unlock business opportunities in transforming subsistence type of goat raising into profitable enterprises by employing farmer participatory approach and technology-based enterprise process. It has covered 3 provinces, 14 municipalities and 45 barangays with a total of 190 goat raisers and 271 spill-over farmers served as project partners by adopting innovative production systems on breeding, feeding and health management. A community-based selection and breeding system was established that resulted in significant improvements in the productive and reproductive performance of goats. Goat raisers have been organized into associations and were encouraged to venture into goat enterprises. Farmers obtained a monthly net value of incremental benefit of Php1,836.33 and PhP5,899.33 for a 10-doe level slaughter and 20-doe level breeder goat enterprise, respectively. Local government units (LGUs) supported the expansion of the project and refocused their priorities towards promotion of the goat industry. Beyond technology adoption thus, building enterprises through marked institutionalization and sustainability efforts of LGUs with organized farmers and empowered communities.

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