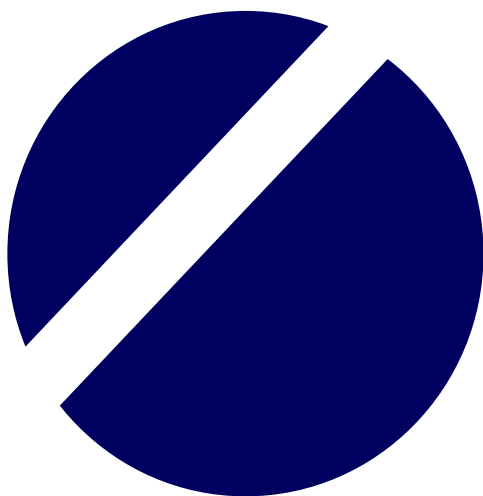


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IMPROVEMENT OF SOIL CARRYING CAPACITY FOR BETTER LIVING

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ABSTRACT

Soil is the most important resource for food production. The increase in world population puts pressure on the soil resource to continuously provide food security for the population. The per capita arable land is 0.22 ha per capita and it is expected to reduce due to population increase, land degradation processes and competition for non-agriculture land use. The agricultural sector has been successful to continuously supply food for the growing population. This is brought about by the green revolution resulting from technological improvement through advancement in scientific knowledge. With more constraints and greater challenges the agriculture sector requires more efficient and productive technology. Since horizontal increase through expansion of arable land is restricted the increase in food production has to be achieved vertically by increasing soil productivity. The use of fertilizer for improvement of soil productivity is one of the widely practices worldwide. The use of fertilizer has no doubt increased the soil productivity; however it has also created serious environmental problems. As an example, the efficiency of N fertilizer is often low due to losses and the N that leaks to the environment causes serious environmental problems such as ground water pollution, emission of greenhouse gases, eutrophication and nitrate pollution. For sustainable fertilizer management, the loss has to be minimized to subsequently increase fertilizer efficiency. Application of balanced plant nutrients had been shown to increase soil productivity. Addition of small amount of micronutrients in certain soils can result in tremendous yield increase. Other technologies that increase soil productivity and reduce its degradation will enhance the soil carrying capacity. The public awareness on the importance of soil resource for food production and human survival should be provided through the education system. Research for public good on sustainable soil management must be given top priority alongside the market driven research, to ensure the agriculture sector continues to supply us with food from the growing population.

Key words: Soil resource, food security, arable land, population carrying capacity

INTRODUCTION

Soil is the single most important resource required for food production. The early human civilization started in areas with deltas and valleys endowed with rich and fertile soil that enable agriculture for food production. The Mesopotamia civilization in the Tigris Euphrates, the Nile valley, Hwang Ho and Yang Tze Kiang in China and the Indus Valley are examples of these civilizations which owed their origin to fertile soil. The word agriculture originated from a Latin words *agre* and *cultura*, in which *agre* means land and *cultura* means cultivation, thus agriculture means cultivation of land. The significance of soil in agriculture and its role in food production cannot be disputed. Thus sound soil conservation and management are vital to support human lives on this planet. Its effect is not only relevant to the current inhabitants but also to the unborn in the future.

The performance of the agriculture sector has been very assuring, at every meal a variety of food in sufficient quantity can be found on our table. Can this situation be taken for granted? Will the soil resource continue to be sufficient to support agriculture so that our dinning table will continue to

be replenished with food indefinitely? It was however reported, famine did occur in certain part of the world due to food shortage.

Soil is nature's gift; it cannot be produced within human life span. Thus the available arable land area globally is fixed and cannot be extended. The arable land up till now can support the global population, which stands at 6.4 billion with 800 million of the world population undernourished (Eswaran et al 1999). The global population, however, increases at the rate of about 1.14% annually. At every one second 4.1 new babies are born. Thus with the increase in world population the per capita arable land decreases. The decrease in the per capita arable land is further aggravated by the process of land degradation and irreversible land use for non agriculture purposes brought about by population pressure. Both these factors i.e. land degradation and population increase threaten the ability of the soil resource to support agriculture for food supply. If population increase is unavoidable, serious effort should be focused to reduce land degradation and agricultural productivity has to increase to cope with the food demand of the growing population.

Soils are not created equal, some soils are fertile require little input while some are poor that require high input and special management. It is an irony that Asia and Africa being the most populous region of the world are provided with low quality soil, while the temperate regions of Europe, America and Australia are blessed with very productive soils that require minimal input. In addition to the presence of poor soils, the soils in the Asian and African regions are situated in the vulnerable climatic condition which exposes the soils to excessive land degradation processes. The Asian and African regions often referred to as the third world, will have to strive harder to provide food to the ever increasing population with low fertility soil and under adverse climatic condition favoring land degradation. Is it a coincidence; poor countries have poor soils?

This paper attempts to elucidate the significance of soil as a natural resource for food production that supports human life. It also examines the soil carrying capacity to support human life at the global and national level.

Food Security

The most important development in the twentieth century has been our ability to produce larger harvest, thereby ensuring food stability and security for the constantly growing population. This great achievement however was unnoticed, largely because most people do not realize how insecure and unstable agriculture was in the past. In Malaysia the 1997-98 economic crisis and the hike in food price in 2008 served as wake-up calls. It was suddenly realized that in 1998 Malaysia imported a hovering RM13 billion of food and the value keep on increasing. This is the result of the country bias towards the other more lucrative economic sectors and neglecting the agriculture, especially the food production sector. All countries in the world have no choice; they have to depend on agriculture for food supplies. The choice is whether domestic agriculture or the agriculture beyond the national border. This leads to the issue of food security, which has strong political, economic and sovereignty implications.

Food security is defined as "providing physical and economic access to balanced diets and safe drinking water to all people at all times" (Swaminathan,1986). Food produced domestically ensure stable long term supply and political sovereignty. It is less vulnerable to political, economic and military instability. It is the best option if the soil resource is available.

Learning from the Asian economic crisis Malaysia had declared agriculture as the third engine of growth, with creation of new wealth, improvement of the rural economy and ensuring food security as the main thrust. This simply means that while the country embarks on the industrial and service sector to fuel the economy the agriculture- food sector would not be neglected. In fact the

agriculture sector specifically the oil palm industry has proved to be resilient. In the Asian economic crisis it was the oil palm industry that provides the export earning to sustain the economy. Malaysia at present is one of the main palm oil producers, contributing about RM 50 billion to the country's export earning. It is the food production sector that requires the needed push to support the nation food security agenda.

Based on the available arable land, it is reported that China and India with a combined population of 2.3 billion and occupying more than 14 million km² of land will find difficulty in feeding their population unless these countries employ high level agricultural technology (Beinroth et al, 2001). Afghanistan, Bangladesh and Pakistan are other Asian countries that are facing food security problem due to limited arable land to support the ever increasing population. Base on the report Malaysia has a medium risk to food security at low level of technology and is classified as low risk with medium technology level. This means that Malaysia has sufficient soil resource to support its population up to 2020 with the expected population of 30 million, provided improved agricultural technology is being employed. In the Asian countries with the exception of Laos, Kampuchea and Papua New Guinea the region will have declined markedly in its capacity to sustain food security.

Arable land and global population

The distribution and area of land under different land use world wide are given in Table 1. The total area of land not covered by sea is 14.6 billion ha (Nat. Geog. Atlas of the world, 1981). Of this total area of land only 1.48 billion ha is arable land suitable for food production, a major portion of the land area are not suitable for agriculture either due to their unsuitable topography or adverse climatic condition. The arable land distributed in various continents where most of the arable land is in America, Canada, Europe and Australia. The arable land in Asia, however, is relatively less especially when the magnitude of the population is being taken into consideration.

Table 1. Major areas and water areas.

Earth	Tons or ha
Mass	5.974 x 10 ²¹ tons
Total Area	51,006,600,000 ha
Land	14,642,900,000 ha
Water	36,163,700,000 ha
Arable Land	1,480,000,000 ha

(Source: National Geography Atlas of the World, 1981)

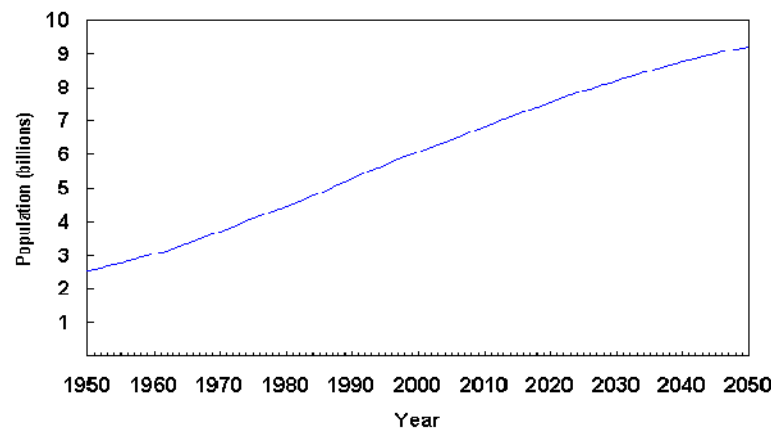
The number of the world population and its demography in relation soil resource is important to assess the distribution arable land per capita of the population. The world population at for the period 1950 to 2050 is given in Figure 1.

The current world population is 6.7 billion. In 2020 the world population is expected to increase to about 8 billion. The world population increase at the rate of 1.14 % per year. Most of the population increase occurs in the third world countries especially the Asian country. With current population the mean of arable land is 0.22 ha per capita. Each hectare of the arable land is expected to produce sufficient food for four persons. Based on the FAO land carrying capacity data the 0.22 ha per capita arable is above the critical value of 0.07 ha per capita considered sufficient for food production.

Although the world per capita arable land is above the critical level, a closer examination reveals that some of the countries such as China, Indonesia and Bangladesh have very low per capita arable land. The high per capita arable land is located in Australia, Canada and America. Thus the populous country of the world will have to depend on the west for their food supply in the future.

Given the increasing population, land degradation processing and urbanization the per capita available land for food production will continue to decrease. For the world to support the growing population on the decreasing soil resource tremendous advance in science technology is required to increase the soil productivity vertically as oppose to horizontal increase when soil resource is in abundance. The use of fertilizer, agro-chemical, machineries, precision farming and biotechnology will be the tools to bring about this needed change. The agriculture sector in the future should be knowledge and science driven not as in the past where it was land driven.

World Population: 1950-2050



(Source: U.S. Census Bureau, 2005)

Fig. 1. World population from 1950 to 2050

Population carrying capacity

The current world population is 6.7 billion. In 2025 the population is expected to reach 8 billion and about 97% of this increase will occur in the developing countries (Swaminathan, 1994; World Bank, 1992). The population of Malaysia now is 26 million and expected to increase to about 30 million in 2025. The urban population worldwide will increase from 1 billion to 4 billion in 2025.

With steady increase in the world population, there is a greater challenge for the agriculture sector to supply food. The increase in food production in the future has to come from increase in land productivity. The increase in food production through increasing land area is minimal because of limited land area is available. With population increase there is a tendency for more rapid land degradation process and the per capita arable is expected to diminish. Advances in science and technology in agriculture is required to sustain the increasing world population. Application high level technology is required for increasing the production capacity as to minimized land degradation.

Malthus in 1798 created awareness on global food supply in relation to the population increase. He stated that, with time the rate of population increase would be much greater than the rate of the world capacity to produce food. The pessimistic concept is controversial and has not been realized until today. The world continues to increase its food production (Table 2) and provides

sufficient food for the increasing population.

Table 2. The world total cereal production, average yield and area harvested from 1960 – 2004.

Year	Total production (metric ton x billion)	Average yield (ton/ha)	Area harvested (ha x 100 million)
1960	0.877	1.35	6.48
1970	1.19	1.77	6.76
1980	1.55	2.16	7.17
1990	1.95	2.75	7.08
2000	2.06	3.06	6.74
2004	2.25	3.30	6.81

(Source: FAOSTAT 2005 <http://faostat.fao.org>)

The ability of the world to supply food to the growing population until today is because of the advances in knowledge and science which manage to increase the agricultural productivity over less unit area of land. The discovery of new varieties, fertilizer, pesticides, machineries, irrigation system etc. as the results of R& D are responsible for the productivity increase. The advances in biotechnology are expected to increase the agricultural productivity higher to a magnitude beyond our imagination in the near future. Thus the Malthus prediction will never be fulfilled for a long time to come. As long as the human has the ability to discover new knowledge and technology for the agriculture system, the Malthus theory will not be realized.

The world ability to supply food for the growing population depends on the population carrying capacity. The population carrying capacity depends on the soil quality and the level of technology applied (Beinroth et al. 2001; Eswaran et al., 1999). The soil quality is based on its natural properties and the climate. The soil quality is classified into nine classes (from I to IX) in a descending order. The distribution of the soil based on the soil quality classification indicates that most of the class I and II soils are found in the temperate region, while the soil of class III, IV and V are found in the Asian region. In Malaysia no class I and II soils are found, thus Malaysia requires more inputs for food production as compared to the developed countries.

The level of technology used is important in determining the level of soil productivity. The soil productivity increases with higher level of technology. A combination of class I soil with high technology will give the highest productivity. While the poor class soil with low technology level will give the lowest productivity. The number of population that a hectare of land can support with different combination soil quality class and level of technology applied range between 0 to 10 person per ha. (Beinroth et al., 2001).

Other reports on the value of the carrying capacity did not consider the soil quality and technology level factors. The values of the number of person the land can support for food production range from 1 to 14 persons per ha. The reciprocal of the population carrying capacity gives the land area requires to provide food for one person. The carrying capacity value of 14 is being used by the FAO as the critical value. The accuracy of the value is sometimes doubtful thus further study is required to accurately determine the value. Based on the analysis by Eswaran et al 1999 the population carrying capacity of the world is 6.159 billion at low level of technology, 8.725 billion with medium level of input and 19.816 with high level of input.

Land degradation

Land degradation occurs when soil loses its quality, productivity and utility. The degraded land loses its ability to support crop production. The important physical processes resulting in land degradation are erosion, desertification and destruction of soil structure. Significant chemical processes include acidification, soil contamination, salinization, and nutrient mining. While biological processes involved are loss of organic matter and loss of soil biodiversity. Erosion and desertification are the most serious land degradation processes responsible for reducing the area of arable land for agricultural production.

Several reports have shown that land degradation reduced farm yield and resulted in loss of income (Lal, 1998, UNEP 1994, Pimental et al., 1995). In south Asia, annual loss in productivity is estimated at 36 million tons of cereal valued at US\$ 5.4 billion (UNEP 1994). On a global scale the annual loss of 75 billion tons of top soil cost the world about US\$400 billion per year (Lal, 1998) the economic impact of land degradation is extremely severe in the densely populated South Asia and sub Saharan Africa. In Malaysia perhaps soil erosion is the main cause for land degradation, especially in the areas with sloping land. Severe soil erosion occurs in Malaysia due to high rainfall.

With population pressure and limited land area excessive land degradation processes will reduce the capacity for food production. Thus globally land degradation issue is being given top priority in international forum and it is recognized as the important global agenda.

Improvement of soil productivity

The current issues on food security, population, land degradation and scarcity of arable land indicate that the land carrying capacity has to be maximized to ensure the world population to have sufficient food supply. Improvement of soil productivity through fertilizer use is a viable and reliable option. In modern agriculture the use of fertilizer to provide plant nutrients has increased crop yield and increased soil productivity. The increase in crop yield due to fertilizer application has provided more harvest per unit area with increasing land area. The use of fertilizer in crop production has put more food from the soil to the table. Nitrogen is the most required nutrient by plants and the demand cannot be sufficiently supplied by soil. Thus N fertilizer is the most common fertilizer used in crop production and it is used in large amount. Besides N, P and K are major plant nutrients applied as fertilizer. Other nutrients especially micronutrients are often neglected in most fertilization programs. In recent years more evidence has indicated that the micronutrients are required to sustain soil productivity for high crop yield. For sustainable crop production balanced fertilizer application is advocated. Other technologies that increase soil productivity and reduce its degradation will enhance the soil carrying capacity.

Excessive use of fertilizer has also been reported to cause environmental problems. High application of N fertilizer can result in groundwater contamination, N₂O emission and nitrate pollution. These problems can be minimized with sustainable management practices based on scientific knowledge and understanding.

CONCLUSION

The public awareness on the importance of soil resource for food production and human survival should be provided through the education system. Research for public good on sustainable soil management must be given top priority to ensure the agriculture sector continues to supply us with food for the growing population.

REFERENCES

- Beinroth, F.H., H. Eswaran and P.F. Reich. 2001. Land quality and food security in Asia. In: Bridges, E.M., I. Hannam, L.R. Oldeman, F.W.T. Pening de Vries, S.J. Sherr, and S. Sompaatnit (eds.). Responses to Land Degradation 2nd International Conference on Land Degradation, Khon Kean, Thailand, Oxford Press, New Delhi, India.
- Eswaran, H., F. Beinroth, and P. Relch. 1999. Global land resources and population supporting capacity. *Am J. Alternative Agric.* 14: 129-136.
- FAO, 1988. Food and Agriculture Production Yearbook : FAO, Rome.
- FAOSTAT 2005. <http://faostat.fao.org>
- Lal, R. 1998. Soil erosion impact on agronomic productivity and environmental quality. *Critical Reviews in Plant Sciences*, 17. 319 – 464.
- National Geographic Atlas of the World, 1981.
- Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. Macnair, S. Christ, L. Shpritz, L. Fitton, R. Saffouri and R. Blair. 1995. Environmental and economic costs of soil erosion. *Science*. 267. 1117 – 1123.
- Swaminathan, M.S. 1986. Building national and global nutrition security systems. In: M.S. Swaminathan and S.K. Sinha (Eds.) *Global Aspects of Food Production*. Tycooly Int., Oxford, England. 417-449.
- Swaminathan, M.S. 1994. International Conference on Population and Development. Issues in Agriculture, No 7, Cairo: CGIAR.
- U.S. Census Bureau. 2005. International Data Base, April 2005 version <http://www.census.gov/cgi-bin/ipc/pwc>.
- UNEP. 1994. Land degradation in South Asia: Its severity, causes and effects upon the people. INDP/ UNEP/FAO. World Soil Resources Report 78, Rome: FAO.
- World Bank. 1992. World Development Report 1992. New York: Oxford University Press.

THE AMAZING SWEET SORGHUM: PAMPANGA AGRICULTURAL COLLEGE'S INITIATIVES IN PROMOTING AND COMMERCIALIZING ITS UTILIZATION AS HUMAN FOOD, ANIMAL FEED AND BIO-FUEL

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ABSTRACT

Recognizing the potential of sweet sorghum, the Pampanga Agricultural College in Magalang, Pampanga, Philippines for the past three years has been conducting R&DE initiatives which include adaptability trials of different ICRISAT-bred varieties and processing of nutritious sweet sorghum food products, animal feed and as source of bio-fuel. Preliminary results were promising; hence, this paper describes the some strategies relative to its promotion and commercialization. From five varieties of sweet sorghum tested under Pampanga conditions, SPV422 showed the highest stripped stalk yield and percent sugar yield, which are very necessary in ethanol production. The expected income per hectare per year was computed at Php 125,000.00. Its grain was also found to have comparable performance as replacement for yellow corn in the diet of broiler chickens. About 486 persons benefited from the project from January 2006 to date. Promotional activities conducted included field days, exhibits, technology forum and demonstration. Participatory technology demonstrations at the farmers' field were also established to facilitate technology transfer among farmers in the countryside. Aside from various media exposures which include television, radio and print, a book was also developed and published containing various sweet sorghum-based food recipes. The book offers not only as a valuable guide for homemakers in the preparation and development of alternative food products for family consumption, but also to encourage stakeholders and entrepreneurs to develop a potentially viable cottage industry that could generate additional income for farming families. While its grains and stalk were also tested to evaluate its potential as alternative for corn in poultry feeds preparation and forage for ruminant animals, the juice can be processed into bio-ethanol for low-cost cooking fuel in the rural communities.

Key words: Commercialization, cottage industry, alternative food source.








INTRODUCTION

Sweet sorghum is versatile as a high value crop. The International Crop Research for Semi-Arid and Tropics International Crop Research for Semi-Arid and Tropics (ICRISAT) calls it a "smart crop". In the light of the oil and food crisis, several institutional partners agreed to push the program: the Philippine Commission on Higher Education (CHED), Department of Agriculture Bureau of Agricultural Research (DA-BAR), Philippine Council for Agriculture, Forestry and Natural Resources, Research and Development (PCARRD), and ICRISAT, among many others. The Pampanga Agricultural College (PAC), has been conducting R & D initiatives related to sweet sorghum since 2006 which consisted of (1) varietal trial (2) fertilizer trial (3) ethanol production (4) as animal feeds and (5) sweet sorghum-based food products. Among the five varieties (SPV- 422, NTJ-2, ICSV-93034, ICSV-700, and ICSV-93046) tested during the 2006 dry season at Pampanga Agricultural College, SPV-422 proved to be the best in terms of stalk production, grain yield and sugar content.

Sweet sorghum has an erect, solid stem and growth habit typical of any other grass species. Its stems vary in thickness because of cultivation techniques, competition from

surrounding plants, solar energy, availability of soil moisture, among many other factors. The basal stem diameter may reach one inch or more, and tapering towards its tip or inflorescence. Adventitious roots are found at each node and will develop if in contact with the soil. Prop (adventitious) roots may grow from lower nodes above the soil, especially in tall cultivars. A single bud is found at each node that may give rise to branches, called tillers or suckers, if these are from nodes at or near the soil surface. The Philippines is blessed with a climate in which sweet sorghum can be grown throughout the year or at least twice a year. Sweet sorghum is relatively easier to grow with minimal time and cost compared to other field crops. It is the only crop that both grains and juice can be processed into various food products that would substantially contribute to the food security program (ICRISAT, 2006). Moreover, the whole plant can be used as forage crop and the grain yield is also promoted to provide feed material for animals (De Jesus and Punzalan, 2007). Moreover, with the implementation of Bio-Fuels Act of 2006 (R.A.9367) that requires the blending of 5-10% ethanol to gasoline in order to minimize dependency on petroleum importation and attain 60% energy self-sufficiency by 2010, it is expected that the demand for sweet sorghum will expand, and must be met by local farmers to ensure the availability of supply in the future.

Conceptual Framework

INPUT	PROCESS	OUTPUT
Sweet Sorghum Varieties from ICRISAT	Varietal trial and development of production technology	⇒  Appropriate variety identified and production technology
Sweet Sorghum Juice	Fermentation technique	⇒  Bio-ethanol for low-cost cooking stove ⇒  Liquid sugar/jaggery
Sweet Sorghum Grain	Processing techniques	⇒  Flour ⇒  Food products ⇒  Non-food products
Technology on sweet sorghum	Technology dissemination through demonstrations, trainings, fora, exhibits, etc.	⇒  Increased awareness and appreciation of potential stakeholders

Project Objectives

In general, the project aims to promote the production and utilization of sweet sorghum for human food, animal feed and bio-ethanol purposes in Region-3.

Specifically, the project has the following objectives:

1. to establish technology demonstration on sweet sorghum at the farmer's field level;
2. to develop and package production technologies on sweet sorghum for dissemination and transfer;
3. to generate technologies on the utilization of sweet sorghum as forage and feed for livestock;
4. to develop fermentation technology for ethanol production and utilization; and,
5. to develop and package technologies on sweet sorghum food products.

Project Implementation

The team is composed of researchers with different fields of specialization: horticulturist and agronomist to take care of the production technology, food technologist and chemist to

undertake food and non-food products development, an engineer to test the bio-ethanol on a low-cost cooking stove and an agricultural economist to evaluate the profitability aspect of the project.

A. In-Campus and Off-Campus Varietal Trials – Five sweet sorghum varieties sourced from ICRISAT, India were tested for adaptability both at Pampanga Agricultural College experimental areas and at the farmer's field.

B. Technology Generation - There were three groups of scientists who worked on the following aspects: production, food and non-food products development, animal feed, forage, and bio-ethanol production and utilization.

C. Technology Demonstration on the Production of Sweet Sorghum-Based Food Products – The PAC Department of Home Economics, which is manned by competent food processing experts, has established a show case of various sweet sorghum-based food products. Proper packaging and labeling of such products were done to encourage women, OSYs (Out-of-School-Youths), entrepreneurs, among others.

D. Packaging and Development of POT (Package of Technologies) – POTs from previously generated information by PAC and other agencies involved in sweet sorghum R&D were developed in various forms. Such materials developed are made available for distribution to increase awareness generate interest among potential users.

E. Conduct of Training – Potential technology takers/adopters were identified, organized and afforded with technical training on sweet sorghum production and processing of sweet sorghum-based food products.

F. Promotional and Media Mileage Activities – To enlarge the promotion of sweet sorghum, radio and print media were tapped. Slogans and other forms of articles were advertised.

G. Monitoring and Evaluation of the Project - A pool of expert-extensionists from PAC and partner-LGUs of the region were assigned to monitor and evaluate the progress/performance of the project based on its set of objectives.

RESULTS AND DISCUSSION

There were about 486 individuals who benefited from the project which composed of the following; 136 farmers, 108 mothers, 185 LGUs and professionals and 57 out of school youths and students. Of the 136 farmers, four were tapped as farmer-cooperators, who demonstrated the technology on sweet sorghum production. They also served as the venue for the conduct of field days (Fig. 1).

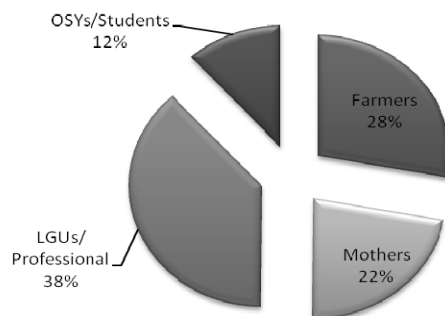


Fig. 1. Percent distribution of persons who benefited from this project.

Yield Performance

From the five varieties sourced from the International Crop Research Institute for Semi-Arid and Tropics (ICRISAT), India in 2006 and Mariano Marcos State University (MMSU) in 2007, SPV422 consistently gave the highest stripped stalk yield and percent sugar yield (Table 1). Although grain yield is also of economic importance in sweet sorghum production, for bio-ethanol purposes juice and sugar content are given emphasis in selecting the variety to grow. It is worthy to mention that sweet sorghum under Pampanga conditions can be ratooned up to three times, hence there would be four croppings including the seed crop.

Table 1. Comparative performance of five varieties of sweet sorghum under Pampanga conditions (Dry and wet season, 2007-2008).

Variety	Stripped Stalk Yield (t/ha)		Grain Yield (t/ha)		Percent Sugar yield, % Brix Matter
	Seed Crop	1 st Ratoon	Seed Crop	1 st Ratoon	
MM2	47.5	55.1	3.62	4.40	18.5
SPV422	57.5	61.0	3.28	3.92	19.0
ICSW700	45.5	47.5	3.46	4.11	18.0
ICSW9304	52.0	51.5	3.40	4.08	15.0
ICSW93084	49.0	50.0	3.46	4.25	18.0

Note: Mean of two cropping seasons/year

Profitability of Sweet Sorghum Production

In growing sweet sorghum, farmers have several options for additional income such as selling of harvested grains, cane stalks with leaves as forage for animals, stripped cane stalks to produce juice extracts, boiled sweet sorghum juice (jaggery) to produce liquid sugar and distilled jaggery to produce ethanol. The farmers, therefore, could earn more by selling sweet sorghum cane stalks in addition to the income from grain harvest. Sweet sorghum cane stalks are main raw materials for the production of ethanol. A cost and return analysis of sweet sorghum production per hectare is presented in Table 2 to indicate the profitability. As sweet sorghum is not a plant intended to replace other crops grown by target farmers, it can be planted during the dry season in irrigated areas and during wet season in idle rain fed areas where it can survive and thrive well. Net income from a rain fed area during the wet season (P127,129.40) is estimated to be higher by P8,669.80 per hectare than that generated from an irrigated area during the dry season (P118,458.60). Gross revenue derived from irrigated area during the dry season (P174,250) is higher by P5,500 than that realized from rainfed areas during the wet season (P168,750). However, this profit advantage is not enough to compensate for the higher production cost incurred during the dry season in the irrigated area brought about by the need for labor, fuel and oil for irrigating the crop. Pesticides and the labor cost is doubled in the irrigated area during the dry season.

Harvesting, threshing and drying costs are also relatively bigger during the dry season in an irrigated area due to its greater production (especially grains) as these expense items are largely dependent on the volume of harvests. Total cost of sweet sorghum production per hectare, therefore, is much higher (by P14,169.80) in the irrigated area during the dry season (P55,790.40) than in the rainfed area during the wet season (P36,620.60).

Table 2. Cost and return analysis for one hectare (dry and wet seasons).

Items	Dry Season Production from Seed and Ratoon Crops (Irrigated)	Wet Season Production from Seed and Ratoon Crops (Rainfed)
Grain	93,750.00	81,250.00
Fresh cane	80,500.00	87,500.00
Variable costs		
Material cost	14,110.00	9,400.00
Seeds	800.00	800.00
Fertilizer	8,100.00	8,100.00
Pesticides	1,000.00	500.00
Fuel and oil	4,210.00	
II. Labor cost	28,250.00	22,723.33
Tractor plowing	2,500.00	2,500.00
Tractor harrowing	2,500.00	2,500.00
Furrowing	1,200.00	1,200.00
Planting	1,000.00	1,000.00
Basal Fertilizer Application	600.00	600.00
Side dressing fertilizer application	800.00	800.00
Hilling-up	2,100.00	2,100.00
Irrigation	3,000.00	
Pesticide application	1,600.00	800.00
Harvesting	8,000.00	6,933.33
Threshing	3,750.00	3,250.00
Drying	1,200.00	1,040.00
III. Interest on operating capital	5,930.40	4,497.27
Total Variable Cost	48,290.40	36,620.60
Total Fixed Cost (land rental)	7,500.00	5,000.00
Total Cost (B+C)	55,790.40	41,620.60
Total Net Income (A-D)	118,459.60	127,129.40
Returns above variable cost	125,959.60	132,129.40
Return on Investment	212.33%	305.45%

The returns above variable cost for the two farms planted at different production periods are more than P125,000 per hectare which show a high level of profitability as compared with those derived from rice and corn farming. In the short run, the farmer must at least cover total variable costs or production should be discontinued. The returns on investment (ROIs) in all

production seasons (dry and wet) and ecosystems (irrigated and rainfed) have positive values from 212.33% to 305.45%. This means that a farmer would earn more than twice or even thrice for every peso invested in sweet sorghum production, depending on the type of production ecosystem and cropping season. ROI is a performance measure used to evaluate the efficiency of an investment. It is a very popular measure of profitability because of its versatility and simplicity. That is, if an investment does not have a positive ROI, then such investment should not be undertaken.

Sweet sorghum grain yield from seed crop is the same at 3,500 kilograms per hectare, regardless of cropping season and production ecosystem. Ratoon crop grain yield is 4,000 kilograms from irrigated area during dry season and 3,000 kilograms from rainfed area during the wet season. Fresh cane yield from seed crop is 55,000 kilograms per hectare from irrigated area during dry season and 60,000 kilograms from rainfed area during the wet season (De Jesus and Punzalan, 2007). Sweet sorghum ratoon crop yield of fresh cane is 60,000 kilograms from irrigated area during dry season and 65,000 kilograms from rainfed area during the wet season. Quantities or volume of production inputs and outputs from sweet sorghum growing were based from the recommendations of the International Center for Research in the Semi-Arid Tropics (ICRISAT) located in India where the crop originated. Data on land rental, loan interest and prices of outputs and inputs were based on prevailing market rate in the project area taken through personal interviews. The prices of outputs (grains and fresh canes) are the same across cropping seasons and production ecosystems. The cropping period from land preparation to marketing of harvest or output is three and a half (3.5) months for all three (3) crops. The production period for two (2) croppings is 7 months while the interest rate is 24% per annum

As Animal Feed

It was generally observed that the performance of broilers fed with sweet sorghum grain in terms of growth, was comparable in all the treatment groups (Table 3). The weight gain of broilers is almost the same since the birds consumed nearly equal amount of feeds. The gain in weight conforms to the principle that growth rate of the birds is correlated with the level of feed intake (Ackar and Cunningham, 1991).

Table 3. Performance of birds fed with corn and sweet sorghum based diet.

Item	Dietary Treatments			SEM	P - value
	Corn	Sorghum	Corn + Sorghum		
Initial weight (g/bird)	279.17	268.76	263.20	5.63	.567
Final weight (g/bird)	1,568.33	1,575.00	1,566.67	8.45	.934
Gain in weight (g/bird)	1,289.17	1,306.25	1,303.47	6.70	.601
Average Daily Gain (g/bird)	37.74	38.28	38.14	0.24	.835
Feed consumption (g/bird)	2848.33	2756.67	2773.33	21.12	.170
Feed Conversion Ratio	2.23	2.14	2.15	0.02	.135

Pooled SEM, n=36

Palatability and acceptability of the diets, regardless of the based ingredient, was the same as manifested by similar feed consumption rate. It was noted that broilers fed with corn-based

diet consumed more feeds. However, the difference was not enough to elicit remarkable improvement in weight gain and accordingly in feed efficiency. The result would imply that sweet sorghum can replace corn without causing adverse effects on performance and this is in agreement with previous studies conducted comparing low tannin sorghum with maize (Ackar and Cunningham, 1991). Analysis showed that the net income per kilogram liveweight was highest in sorghum-fed diets regardless of the levels of inclusion (Table 4). The rate of feed consumption and the cost of diet (Php21.86/kg) contributed to the highest cost of feed/kg live weight which was calculated to be Php2.00 to 3.00 higher in corn-based diet that eventually reduces the return of income from this group. Also, it is worth mentioning that the cost of diet in treatments 2 (sweet sorghum) and 3 (sorghum + corn) were almost the same (Treatment 2 = Php20.49, Treatment 3 = Php20.70). However, it should be pointed out that this was Php1.00 cheaper than the corn-based diet. The protein contribution coming from sweet sorghum reduces the inclusion rate of other protein-rich ingredients like soya and fish meal, which ultimately lessens the cost of diet per kilogram (Richert, et al., 1991). Considering that the supply of sweet sorghum will become more available in the future and the price as estimated to be Php13.00/kg will remain or even decrease, it is therefore highly beneficial to replace corn with sweet sorghum in the broiler diet (Pineda and Pineda, 2008).

Table 4. Cost and return analysis of broiler birds fed with sweet sorghum and corn.

Particulars	Corn	Sweet Sorghum	Corn+ Sorghum
<i>Expenses</i>			
Stocks	1944	1944	1944
Feeds			
CBM	971.26	971.26	971.26
Experimental Feeds ¹	4299.80	4097.13	4117.68
MVE	80	80	80
Vaccine (NCDB ₁ B ₁)	80	80	80
Miscellaneous	200	200	200
Total Expenses	7575	7372	7392
<i>Return</i>			
Total LW produce, kg	100.9	103.1	101.7
Selling Price/kg LW	90	90	90
Gross Income	9081	9279	9153
Net Income	1505	1906	1760
Cost to produce kg LW	75.07	71.51	72.69
Feed Cost/kg LW	52.24	49.16	50.04
Net Income/kg LW	14.93	18.49	17.31

¹Diet cost per kilogram: Corn-based = Php21.86, Sweet Sorghum-based = Php20.49, Corn + Sweet sorghum 3 = Php20.70 and Traditional Sorghum-based = Php20.51.

Food and Non-Food Products Developed

The general preparation of the sweet sorghum grains for processing is shown in Figure 2. Sweet sorghum grains ready for processing were tested with the different processing techniques such as: toasting, boiling, milling and some other techniques that were used in combination, such as boiling and addition of sugar, milling and drying.

PREPARATION OF THE SWEET SORGHUM GRAIN AND JUICE



TESTING WITH FOOD PROCESSING TECHNIQUES



IDENTIFY THE RECIPE/PROCEDURE



SWEET SORGHUM FOOD PRODUCTS AND DELICACIES

Fig. 2. Framework of the study on the utilization of the sweet sorghum plant for human food (Zabala et al., 2009).

Food Products

Various food and non-food products were developed from sweet sorghum-derived flour and grains. To enhance technology adoption, said food products were packaged into a compendium book and published through the funding assistance of Bureau of Agricultural Research of the Department of Agriculture of the Philippines.

Food and non-products developed are the following:

1. Several sorghum-based food products developed, include: burger, pastilles, porridge in various flavors like chicken or chocolate, native rice cakes with squash, soup with mushroom or various vegetables,
2. Non-food products included hair remover, soap, spa salt, hair remover, body scrub, and liniment oil.

Bio-Ethanol Production and Utilization

Ethanol derived from crops other than corn would increase farm diversity and sustainability. Sweet sorghum, which is biologically competitive to corn, has a more beneficial energy balance than corn. To produce comparable ethanol yields, 190, 140, and 90 kilograms N per hectare, respectively, are required for corn, grain sorghum, and sweet sorghum production.

Sweet sorghum extract contains about 8 to 10 percent sugar (w/w). Fermentable sugars present are mainly fructose, sucrose and glucose. Not all sugars in the sweet sorghum extract were fermentable. Every liter of sweet sorghum extract yields 40 to 50 ml (4-5%) of ethanol upon distillation (about 100 ml of 50% ethanol solution) after three days of fermentation. Fermentation efficiency ranges from 40 to 45 percent after three days of fermentation using yeast. Varietal study on the type of yeast used in the fermentation has not yet to be done.

Unmodified commercially available kerosene stove was tested and was able to produce a steady blue flame while utilizing a low grade ethanol (50% ethanol) made out of sweet sorghum extract. Modifications will be done to further increase the efficacy and safety of the stove while using ethanol as fuel.

Promotional Activities

Aside from proper coordination with various stakeholders and partners, different promotional activities were also undertaken to ensure technology diffusion among target end-users. These activities include: video shooting and TV telecasts, radio broadcasts, posters and primers production, training, technology fora, trade fair and exhibits, among others.

SUMMARY AND CONCLUSIONS

Sweet sorghum variety from ICRISAT, India, particularly SPV422, was found productively growing under Central Luzon, Philippines conditions. It requires lesser inputs like fertilizer and irrigation vis-a-vis corn and rice. Its grains were tested and found effective as alternative to corn in the diets of broiler chicken, hence higher net returns not only for grain growers but also for broiler producers. Juice extracted from sweet sorghum, which contains about 8 to 10 percent sugar (w/w), was found highly feasible to ferment and produce blue-colored flame ethanol when used in a modified low-cost cooking stove. A very interesting array of low cost and nutritious food developed from sweet sorghum grains and stalks were packaged into a book, in a manner people in the countryside can easy to follow, to hasten its utilization.

There were about 486 persons who benefited from the project from January 2006 to December 2009 from activities such as; farmer's field days, exhibits and technology fora. Technology demonstrations at the farmers' field level were also undertaken.

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REFERENCES

- Ackar, D. and M. Cunningham. 1991. *Animal Science and Industry*. 4th edition. Prentice Hall, Engle Wood Cliffs, New Jersey.
- De Jesus, N. G. and J. Punzalan. 2007. Varietal trial of six varieties of sweet sorghum under Pampanga conditions. Pampanga Agricultural College, Magalang, Pampanga
- Pineda, L. M. and E. B. Pineda. 2008. Utilization of Sweet Sorghum as Animal Feed for Poultry. Pampanga Agricultural College, Magalang, Pampanga.
- Zabala, E. C., Z. M. Battad and N. De Jesus. 2009. *Sweet Sorghum Food Products: A Compendium*. 2009. Quezon City, Philippines: Pampanga Agricultural College and Bureau of Agricultural Research.

USING TRICHODERMA SPECIES FOR BIOLOGICAL CONTROL OF PLANT PATHOGENS IN VIET NAM

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ABSTRACT

Trichoderma spp. are fungi that occur worldwide. Recent studies show that they are not only parasites of fungal plant pathogens but also can produce antibiotics. In addition, certain strains can induce systemic and localized resistance to several plant pathogens. Moreover, some strains may enhance plant growth and development. The potential of *Trichoderma* species used as biological agents of plant diseases have been known since the 1930s, however these were introduced in Vietnam about two decades. Surveys conducted on food crops, industrial crops, vegetable crops and fruit crops in the north and south of Vietnam indicate that *Trichoderma* are common and can be isolated easily from soil, root and plant organic matters. *Trichoderma viride*, *T. harzianum*, *T. hamatum* were predominant species in Viet Nam. Laboratory and field trials in Viet Nam also proved that *Trichoderma* species had ability to suppress growth of fungal plant pathogens and enhance plant growth and development. Experiments conducted on several crops such as: peanut, tomato, cucumber and durian indicate that selected *Trichoderma* strains could reduce significant diseases caused by fungal pathogens including: *Phytophthora palmivora*, *Rhizoctonia solani*, *Fusarium* spp., *Sclerotium rolfsii* and *Pythium* spp. The efficacy of *Trichoderma* species on soil borne fungal disease is higher than fungicides and maintain longer. The value obtained through development, exploitation and use of *Trichoderma* products are not only plant disease control but also gave the local people opportunities to reduce health risks, costs and environmental damage due to over fungicide usages. Moreover, crop treated with *Trichoderma* grown better and had higher yields to compare with the one without application. There have been extensive efforts to commercial *Trichoderma* products for managing plant diseases in the field in Viet Nam. *Trichoderma* products have been developed by several companies, institutes and universities such as: BIMA, Trico-ĐHCT, Promot Plus WP, Vi – ĐK, NLU-Tri, Bio – Humaxin Sen Vang and Fulhumaxin are available commercially now. *Trichoderma* product can be used in many ways including: seed treatment, applied direct to the soil before planting and added to organic fertilizers.

Key words: fungal plant pathogens, resistance

INTRODUCTION

Members of the *Trichoderma* genus are known as imperfect fungi, fast growing in culture and produce numerous green spores. These occur worldwide and are commonly associated with root, soil and plant debris (Howell *et al*, 2003). These have long been recognized as biological agents to control plant diseases. Since the first application in 1930s, *Trichoderma* species became popular biological agents to protect crops against plant pathogens all over the world. Past research indicated that *Trichoderma* can parasitize fungal pathogens and produce antibiotics. Weindling (1932) described in detail the mycoparasitism of a fungal pathogen causing damping off disease (*Rhizoctonia solani*) by the hyphae of *Trichoderma*, including coiling around the hyphae, penetration, and subsequent dissolution of the host cytoplasm. He also described an antibiotic which was toxic to both *R. solani* and *Sclerotinia americana*, and named it gliotoxin. In the year following

this study, many similar results were reported by other plant pathologists. The mechanism of antibiosis was demonstrated in several studies. An antibiotic, gliovirin, from *Trichoderma virens* demonstrated strong inhibition of *Pythium ultimum* and the *Phytophthora* species (Howell and Stipanovic, 1995). More recent research indicated that certain strains of *Trichoderma* can induce systemic and localized resistance to several plant pathogens. Plants treated with *Trichoderma* in the root zone can produce higher levels of peroxidase, chitinase activity, deposition of callose-enriched wall appositions on the inner surface of cell walls and pathogenesis-related proteins. Moreover, some strains may enhance plant growth and development. These phenomena was observed by several researchers who treated plants with *T. harzianum* resulting in large increases in root area and cumulative root length, as well as significant increases in dry weight, shoot length, and leaf area over that of the untreated control (Howell, 2003). Due to effective control of plant diseases, several commercial biological products based on *Trichoderma* species are manufactured and marketed in Asia, Europe and USA for use on a wide range of crops. These can be efficiently used as conidia, mycelium and chlamydospores which are produced in either solid state or liquid fermentation (Harman *et al*, 2004).

The use of *Trichoderma* as a biological agent of plant diseases has long been known, however, these were introduced to Vietnam only in the last two decades (Tran, 1998). Research has been done on biological control potential of *Trichoderma* spp. against several pathogens attacking vegetables, fruits, field and industrial crops. Surveys conducted in the north and south Vietnam on several type of crops showed that *Trichoderma* have been isolated from soils, root, leaves and plant debris (Table 1).

Table 1. *Trichoderma* species isolated from several crops in Viet Nam.

No	Species	Crop	Location
1	<i>T. atroviride</i>	Coffee, tea	Central Highland
2	<i>T. hamatum</i>	Peanut, soybean	South, North
3	<i>T. harzianum</i>	Tomato, pineapple, peanut	South, North
4	<i>T. koningii</i>	Rubber	South, North
5	<i>T. reesei</i>	Rice, maize	South, North
6	<i>T. virens</i>	Peanut, soybean, tomato	South, North
7	<i>T. viride</i>	Peanut, soybean, tomato, durian	South, North

Trichoderma viride, *T. harzianum*, *T. hamatum* are predominant species in Viet Nam. After identification, *Trichoderma* isolates were preserved, tested and selected based on their efficacy on growth inhibition of fungal pathogens in *in vitro*, *in vivo* and green house as well as under field conditions. The first successful use of a *Trichoderma* product to control fungal diseases of rice and peanut was demonstrated by researchers at the National Institute of Plant Protection in 1995.

Trichoderma species, which were grown on solid media, were screened at different doses to determine the efficacy of the antagonists. Disease incidence decreased significantly when *Trichoderma* was used to treat soil and seeds compared with untreated controls. After that *Trichoderma* species became the most common fungal biological agents that have been extensively researched and deployed throughout Viet Nam. The number of research projects on *Trichoderma* on various crops are presented (Fig. 1).

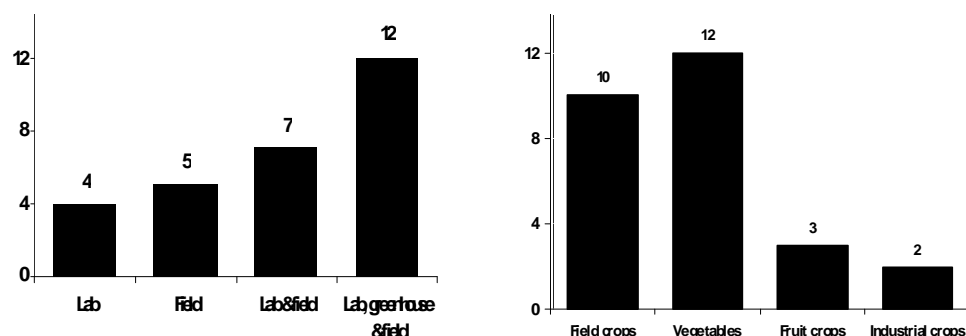


Fig. 1. Number of *Trichoderma* research projects grouped by site and by crops

For last twenty years, a total of 28 research projects on *Trichoderma* was conducted in Viet Nam which included laboratory, greenhouse and field works. These projects were carried on most of economical important group of crops such as field, vegetable, fruit and industrial crops. Results came out from the projects proved that *Trichoderma* spp. could be used to control several fungal pathogens causing plant diseases. Several plant diseases caused by fungi can be potentially controlled by *Trichoderma* species (Table 2).

Table 2. Plant diseases controlled by *Trichoderma* species.

Name of disease	Crop	Fungal pathogens	<i>Trichoderma</i> species
Wilt	Tomato, Chili, Peanut, Potato, Coffee, Black pepper, Lychee	<i>Fusarium</i> spp.	<i>T. hamatum</i> , <i>T. harzianum</i> , <i>T. viride</i> , <i>T. virens</i>
Root rot	Citrus, Tobacco, Pineapple, Durian, Rubber, Black pepper, Lychee	<i>Phytophthora</i> spp.	<i>T. harzianum</i> , <i>T. viride</i>
Damping off	Tomato, Chili, Peanut, Potato, Soybean, Maize, Cabbage, Chinese cabbage	<i>Pythium</i> spp., <i>Rhizoctonia solani</i>	<i>T. hamatum</i> , <i>T. harzianum</i> , <i>T. viride</i> , <i>T. virens</i>
Southern stem rot	Tomato, Chili, Peanut, Potato, Soybean,	<i>Sclerotium rolfsii</i>	<i>T. hamatum</i> , <i>T. harzianum</i> , <i>T. viride</i> , <i>T. virens</i>
Cottony rot	Cabbage, Chinese cabbage, Soybean	<i>Sclerotinia sclerotiorum</i>	<i>T. harzianum</i> , <i>T. viride</i>
Sheath blight	Rice, Maize	<i>R. solani</i>	<i>T. harzianum</i> , <i>T. viride</i>

The application of *Trichoderma* species can control a large number of foliar and soil borne fungi i.e. *Fusarium* spp., *R. solani*, *Pythium* spp., *S. sclerotium*, *S. rolfsii*, in vegetables, field, fruit and industrial crops (Tran, 1998; Ngo et al, 2006). These results were similar to previous studies in other countries where *Trichoderma* spp. was used successfully to control fungal pathogens.

Therefore, farmers have reduced their use of chemical fungicides.

Further studies were conducted to find techniques for mass multiplication and development of a bioformulation of the biological control agent. Several growth media and protocols for *Trichoderma* spp. spore production were reported as mass scale production would have great potential for commercial use. At the beginning, *Trichoderma* propagules, in the form of conidia, mycelium and chlamydospore, were mass produced on conventional synthetic media. However the cost of these materials was too high. To overcome cost limitation, alternative substrates such as rice husks, coffee, sugarcane waste, rice bran, corn meal were used. *Trichoderma* products can be applied to the soil, used as seed treatment, seedling root dip or added to organic fertilizers/or compost.

The use of *Trichoderma* product has both short term effects: immediate control of diseases and growth enhancement of crops as well as long-term effects which are demonstrated by the decrease in fungal pathogen inoculum in the field. Health plants mean less contamination from chemicals. Presently, *Trichoderma*-based products are considered as relatively novel biological control agents which can help farmers to reduce plant diseases and increase plant growth.

Several commercial *Trichoderma* based products were registered and sold in Vietnam market (Table 3).

Table 3. *Trichoderma* based products commercialized in Viet Nam.

Trade name	Company	Active ingredients
Promot PlusWP Promot PlusDD	Tan Quy	<i>Trichoderma</i> spp. <i>Trichoderma koningii</i> <i>Trichoderma harzianum</i>
TRiB ₁	National Institute of Plant	<i>Trichoderma</i> spp.
TRICÔ-ĐHCT	Can Tho University	<i>Trichoderma</i> spp.
Vi = ĐK	Pesticide Corp.	<i>Trichoderma</i> spp.
NLU-Tri	Ho Chi Minh University of Agriculture and Forestry	<i>Trichoderma virens</i>
Biobus 1.00WP	Nam Bac	<i>Trichoderma viride</i>
Bio = Humaxin Sen Vàng 6SC,	An Hung Tuong	<i>Trichoderma</i> spp.
Fulhumaxin 5.15SC	An Hung Tuong	<i>Trichoderma</i> spp.

It is interesting to note that *Trichoderma* based products in Viet Nam were developed and commercialized by companies, institutes and universities (Table 3). This provides more opportunities for farmers to multiply and use fungi. The successful application of *Trichoderma* spp. to control soil borne fungal diseases were reported by farmers around Viet Nam. Soon after short time training, the farmers can understand and do it by themselves.

CONCLUSION

Trichoderma species play an important role in controlling fungal plant pathogens, especially soil borne fungal pathogens. The use of *Trichoderma*-based products is not only safe for the farmers and consumers but it is also good for the environment. However, much more work needs to be done to develop stable, cost effective, easy to produce and easy to apply formulations.

REFERENCES

- Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., Lorito, M. 2004. *Trichoderma* species opportunistic, avirulent plant symbionts. Nat Review Microbiol. 2 (1): 43-56.
- Howell, C. R. 2003. Mechanisms employed by *Trichoderma* species in the biological control of plant diseases: The History and evolution of current concepts. Plant Dis.: 87, 4-10.
- Howell, C.R., and Stipanovic, R. D. 1995. Mechanism in the biocontrol of *Rhizoctonia solani* induced cotton seedling disease by *Gliocladium virens*: Antibiosis. Phytopathology 85:469-472
- Ngo, B. H., Vu, D. N., Tran, D. Q. 2006. Analyze antagonist effects of *Trichoderma* spp. for controlling southern stem rot caused by *Sclerotium rolfsii* on peanut. Plant Protection 1: 12-14.
- Tran, T. T. 1998. Antagonistic effectiveness of *Trichoderma* against plant fungal pathogens. Plant Protection 4: 35-38.
- Weindling, R. 1932. *Trichoderma lignorum* as a parasite of other soil fungi. Phytopathology 22, 837-845.

THEOBROXIDE AND DAY-LENGTH EFFECTS ON THE GROWTH OF YAM (*DIOSCOREA* SPP.)

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ABSTRACT

The effects of theobroxide (a novel compound isolated from the fungus *Lasiodiplodia theobromase* culture) and day length on flowers, tubers, and bulbils development at the primary and rapid growth stages of yam tubers were investigated in four varieties of water yam (*Dioscorea alata*) and one variety of Chinese yam, cv. Nagaimo (*D. opposita*) in 2005 and 2007. The yam plants were exposed to 10 h day length (short-day) and theobroxide application, with natural day length serving as control. Flower development was not influenced by the treatments in all the varieties evaluated. The effects of theobroxide and short-day to tubers and bulbils development were varied, depending on the varieties tested and the growth stage of the plant. Theobroxide or short-day treatment did not affect the growth of tubers and bulbils in *D. opposita*. The treatments promoted tubers and bulbils development in *D. alata*, but some varieties were inhibited. The short-day treatment tended to promote tuber growth at the primary tuber growth stage of the plant, and bulbil development at the rapid tuber growth stage in most varieties. The short-day length was the important environmental factor for bulbil development in *D. alata*. The short-day treatment in *D. alata* first induced the thickening growth of the tubers and then the development of bulbils with some time lag. The theobroxide application was most effective during the tuber enlargement period in encouraging the development of bulbils. However, the effectiveness of theobroxide on the development of flowers, tubers, and bulbils was not very clear in this study. Further study is necessary to identify the optimum treatment period for each yam species and variety. This is the first reported use of theobroxide in yam.

Key words: Bulbils, flower development, short-day, tuber growth

INTRODUCTION

Yam (*Dioscorea* spp.) is one of the important starchy tuberous crops in the tropics. Yam propagation in tropical Asia and Africa has utilized traditional techniques and methods. Yam breeding is constrained by some factors especially low levels of flowering that limit the development of new varieties. Several environmental factors affect the growth of yam (*Dioscorea* spp.), in particular, the development of the flowers, tubers and bulbils. Tuber growth in yam is slow immediately after initiation; then it becomes very rapid at full canopy formation and finally slows down during maturation with a loss in dry matter (Onwueme, 1978). However, details of the tuber growth pattern differ, especially the start of rapid growth depending on the species or varieties (Shiwachi *et al.*, 1999, 2001). The enlargement of the tuber in yam is known to be affected by photoperiod. Short days stimulate tuberization, while long days inhibit it in water yam (*D. alata*). The translocation of photosynthetic product is encouraged under short-day condition. However, *D. opposita* is more sensitive to the short-day treatment than *D. alata* (Shiwachi *et al.*, 1999). The

difference in the response is noticeable at the beginning of the rapid growth of the tuber and seems related to the maturity period of tubers and to the geographic distribution of *Dioscorea* species (Shiwachi *et al.*, 2000, 2002). Knowledge of the relations between photoperiod and tuber growth would be useful for varietal selection and the breeding program in yam.

Bulbils in *D. opposita* proliferate under short-day conditions (Yoshii, 1949) that encourage their growth (Sato, 1974). However, little is known about bulbil development in tropical and subtropical yams, and the physio-ecological profiles are almost unknown. The environmental factors for the development of inflorescences in yam are also not well defined. The characteristics and eco-physiologies on flowering vary among species and varieties in yam. For example, flowering is frequent in white Guinea yam (*D. rotundata*) and *D. opposita*, but very rare in *D. alata* (Asiedu *et al.*, 1998). The effects of photoperiod on the development of inflorescences in yam were complicated by differential responses by the varieties (Shiwachi *et al.*, 2005). More knowledge about this could provide options for manipulating flowering periods and thus enhance the efficiency of yam hybridization program.

Yoshihara *et al.* (2000) reported that theobroxide; a novel compound isolated from the fungus *Lasiodiplodia theobromae* culture, induces flowering of potato (*Solanum tuberosum*) under non-induced long-day condition. And more, potato tubers were produced under non-induced long-day condition by the theobroxide treatment (Arimoto *et al.*, 2005). Theobroxide is the trigger for jasmonic acid production to induce potato tuberization (Xiquan *et al.*, 2005). Several plant hormones affect tuber growth in yam (Chang *et al.*, 1995). The enlargement of tubers in *D. alata* was promoted by jasmonic acid (Kikuno *et al.*, 2002a, 2002b). Thus, it is expected that theobroxide application would induce the flower and tuber development in yam. But this has not been tested yet. In this study the influences of theobroxide and day-length on the development of flowers, tubers and bulbils at primary and rapid growth stages of the tubers in yam were investigated.

MATERIALS AND METHODS

Two experiments were carried out at the Tokyo University of Agriculture (TUA), Tokyo, Japan, from March to December, 2005 and 2007. Four varieties of *D. alata* and one variety of *D. opposita* were obtained from the germplasm collection at TUA. Yam seed-sets, each weighing about 50g, were planted in plastic pots (30 cm diameter × 30 cm depth) that had been filled with topsoil for the experiments at the end of March, 2005 and 2007. 23.8 g of ammonium sulfate, 26.3 g of calcium super-phosphate, and 25.0 g of potassium silicate were initially applied in each pots. These pots were kept under plastic cover, air temperature controlled at 20 - 22 °C from planting in March to April, and under natural air temperature conditions from May. The plants were staked with a stick 2.0 m long. The pots were kept under natural day-length conditions until specific day-length treatments were imposed.

Effect of theobroxide and day length at the rapid growth stage on tubers

The varieties Obukosumbori, Basmi and Malaysia-A were used in this experiment. Fifteen plants from each variety were randomly selected on 4 th August 2005. Ten plants were kept under 10 hr day length (short-day treatment: ST) imposed by shielding the plants from light from 1800 hr each day using a rectangular plastic canopy. The rest were kept under natural day-length (control) during the experiment. The foliage of five plants from each variety was sprayed with 100 mlplant⁻¹ of 250 mgL⁻¹ of theobroxide (short-day-theobroxide treatment: STT) every 7 days from 16 th August to 13 th: September. The concentration of theobroxide was specified in a previous report (Yoshihara *et al.*, 2000). Control and short-day treatment plants of the same varieties were sprayed with water on the same date. Natural day-length during treatment was from 13 hrs 30 min to 12 hrs 30 min. Flower and bulbil development was observed every 7 days from planting.

The plants from each variety were harvested in December. The roots were washed with

water and each plant was divided into leaves (petioles included), vines, roots, and tubers. The fresh weights of these portions were recorded and their dry weights were estimated following oven drying at 90°C for 4 days.

Influence of theobroxide and short-day length at the primary growth stage of tubers

The varieties Basmi, Malaysia-A and Taiwan local (*D. alata*), and Nagaimo (*D. opposita*) were used in this experiment. These were obtained from the germplasm collection at TUA (Table 1). Forty plants of each variety were randomly selected on 20 th July 2007. Twenty plants of each variety were exposed to a ten-hr day-length as in experiment 1. The other 20 plants were kept under natural day-length throughout the experiment. Foliage of the 10 plants of each variety from the short-day treatment (ST), short-day-theobroxide treatment (STT) and natural day-length theobroxide treatment (TT) was sprayed with 100 ml plant⁻¹ of 250 mg l⁻¹ of theobroxide every 7 days from 3 rd to 24 th August. The concentration of theobroxide was used as same as in experiment 1. The rest were kept under natural day-length during the experiment. Natural day-length during treatment was from 13 hrs 54 min. to 13 hrs 17 min. Flower and bulbil development were observed as in experiment 1, and these were sprayed with water on the same date. The yam plants were harvested in December.

Table 1. Yam species, maturity class and origin of the yam varieties used in the study.

<i>Dioscorea</i> species	Variety	Maturity class	Origin
<i>D. alata</i>	Obukosumbori	Unknown	Papua New Guinea
	Basmi	Early maturing	Papua New Guinea
	Malaysia-A	Early maturing	Malaysia
	Taiwan Local	Unknown	Taiwan
<i>D. opposita</i>	Nagaimo	Early maturing	Hokkaido, Japan

RESULTS

Air temperature in Tokyo during the experimental period 2005 and 2007 is shown (Table 2).

Table 2. Air temperature in Tokyo during the 2005 and 2007 experiments.

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2005										
Max.	12.4	18.9	21.4	26.2	28.5	31.3	27.8	22.2	16.5	9.8
Min.	4.9	10.9	14.0	20.1	22.6	24.8	21.8	16.5	9.1	2.5
Avg.	8.6	14.9	17.7	23.2	25.5	28.0	24.8	19.4	12.8	6.2
2007										
Max.	14.4	25.8	29.0	31.5	32.7	37.5	32.9	26.5	21.2	15.8
Min.	6.8	4.0	13.0	15.7	18.2	23.1	15.7	12.8	4.6	2.7
Avg.	10.6	13.7	19.8	23.2	24.4	29.0	25.2	19.0	13.3	9.0

Effect of theobroxide and day length at the rapid growth stage on tubers

Flower development was not observed in the three tested varieties. The effects of theobroxide and day-length treatments on the growth of yam at the rapid growth stage of the tuber are shown (Table 3). Most vigorous growth of leaves and vines in three varieties was observed in the control. In cv. Obukosumbori, the dry weight of leaves and vines was higher in the control than in ST and STT. The dry weight of ST and STT were not significantly different from one another while the best growth was observed in the control; there was no significant difference between ST and STT.

Theobroxide treatment reduced tuber growth and varietal response was observed. In cv. Obukosumbori, the smallest tuber weight was observed in ST. The difference between the control and STT was not significant. The least tuber growth was observed in cv. Malaysia-A where better tuber growth was observed in the control; there was no significant difference between ST and STT.

Table 3. Effect of daylength and theobroxide on the growth of *D. alata* at rapid tuber growth stage, 2005.

Variety		Control	Short day length (SE)	Short day length• theobroxide
Obukosumbori	Leaf and vine (g)	98.7 (5.2)	43.5 (6.8)	46.7 (4.1)
	Tuber (g)	392.5 (37.3)	276.6 (32.7)	392.5 (30.1)
Basmi	Leaf and vine (g)	107.7 (3.9)	53.3 (1.0)	46.7 (2.4)
	Tuber (g)	397.2 (21.5)	272.9 (44.3)	248.5 (42.5)
Malaysia-A	Leaf and vine (g)	89.0 (8.9)	56.0 (2.1)	52.0 (2.1)
	Tuber (g)	427.3 (15.1)	256.5 (36.7)	238.3 (46.1)

Influence of theobroxide and short-day length at the primary growth stage of tubers

Bulbil development was affected by theobroxide treatment and varietal response was observed in this experiment (Table 4). In cv. Obukosumbori, bulbils did not develop or only a few were observed in the control, ST and STT, however some bulbils were recorded in the other varieties in all treatments. The highest number of bulbils developed was demonstrated in cv. Basmi at short day length while the number of bulbils of cv. Malaysia increased significantly in ST and STT treatments. In cv. Basmi, the weight of bulbils in ST and STT was consistently greater than in the control.

Table 4. Effect of daylength and theobroxide on the development of bulbils in *D. alata* at the rapid tuber growth stage, 2005.

Variety		Control	Short day length (SE)	Short day length• theobroxide
Obukosumbori	Number	0	0.2	0.4
	Weight (g)	0	0.4	0.8
Basmi	Number	12.4 (3.8)	23.2 (5.3)	33.0 (4.2)
	Weight (g)	27.8 (11.6)	69.7 (20.0)	86.2 (15.4)
Malaysia-A	Number	10.6 (3.0)	26.2 (7.3)	25.4 (4.5)
	Weight (g)	43.5 (13.7)	96.7 (21.6)	73.7 (13.6)

Experiments on Taiwan local and cv. Nagaimo

Taiwan local and cv. Nagaimo varieties both have female and male flowers that are varieties setting used for the flowering effects observation in the theobroxide treatment. The variety cv. Obukosumbori was not used in this experiment, because bulbil formation was not observed in any of the treatments. Flowers were not observed on the *D. alata* varieties in experiment 1. Flowering was observed in cv. Nagaimo, however the number of flowers and date of emergence on the flower spike did not differ among treatments and control.

The effects of theobroxide and day-length treatments on the growth at the primary growth stage of tuber are shown on Table 5. In cv. Nagaimo, a low dry weight of leaves and vines was recorded in the control and TT, while ST and STT treatments, were heavier than the control. For Taiwan local, the largest weight was in the TT treatment while ST was the same as the control.

For cv. Basmi the biggest growth of leaves and vines was observed in the TT treatment. The growth in ST and STT was smaller than in the control. For cv. Malaysia-A the TT treatment did not differ from the control; results in ST and STT were smaller than in the control.

For cv. Nagaimo, the dry weight of tubers was smaller in TT and larger in ST and STT treatments compared with the control. Taiwan local had lower tuber weight in TT than in ST and STT, which were heavier than in the control. For cv. Basmi, the biggest tuber growth was in TT and the smallest in control. There was no difference in tuber weight between ST and STT treatments. For cv. Malaysia-A, the biggest tubers were observed in STT, followed by ST, and least was control and TT.

Table 5. Effect of daylength and theobroxide on the growth of *D. alata* and *D. opposita* at the primary growth stage of tuber, 2007 (SE).

Variety		Control	Theo-broxide	Short day length	Short day length + theobroxide
Nagaimo	Leaf and vine (g)	7.2 (1.6)	5.5 (0.7)	12.5 (1.2)	12.6 (0.9)
	Tuber (g)	91.4 (19.3)	42.6 (7.2)	132.6 (10.7)	152.7 (16.5)
Taiwan Local	Leaf and vine (g)	25.8 (2.1)	34.4 (2.4)	24.0 (2.3)	19.4 (1.6)
	Tuber (g)	76.8 (5.4)	49.7 (4.3)	113.1 (9.9)	115.6 (12.1)
Basmi	Leaf and vine (g)	30.8 (3.4)	38.4 (2.2)	21.0 (2.0)	21.0 (0.7)
	Tuber (g)	117.6 (9.7)	162.8 (28.3)	149.1 (9.7)	135.5 (11.7)
Malaysia-A	Leaf and vine (g)	46.7 (3.4)	48.4 (4.7)	26.0 (2.4)	21.6 (1.7)
	Tuber (g)	240.4 (15.5)	184.2 (16.1)	104.8 (15.3)	89.0 (7.1)

The effect of theobroxide and day length treatments on the development bulbils at the tuber initiation stage are shown in Table 6. Bulbils developed in all tested varieties. More of bulbil development was observed in cv. Nagaimo compared with *D. alata* varieties. Less bulbils formation and enlargement was observed in cv. Basmi and Malaysia-A compared with results from experiment 1 in 2005. The number and enlargement of bulbils were not significantly different among treatments. Bulbil development in cv. Nagaimo started before theobroxide and day-length treatments in June. The physiology of bulbil formation in cv. Nagaimo was different from that in the *D. alata* varieties.

Table 6. Effect of daylength and theobroxide on the weight of bulbils in *D. alata* and *D. opposita* at the primary growth stage of tubers, 2007 (SE).

Variety		Control	Theo-broxide	Short day length	Short day length - theobroxide
Nagaimo	Number	14.8 (3.8)	12.8 (5.4)	19.8 (5.1)	18.7 (5.9)
	Weight (g)	1.7 (0.6)	2.2 (0.9)	3.6 (1.2)	2.5 (0.8)
Taiwan	Number	2.9 (1.4)	2.7 (1.2)	2.4 (1.2)	1.1 (0.6)
Local	Weight (g)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.1 (0.1)
Basmi	Number	0.8 (0.4)	0.4 (0.3)	1.9 (1.8)	0.2 (0.1)
	Weight (g)	-	-	0.1 (0.1)	-
Malaysia-A	Number	2.1 (1.0)	2.3 (0.9)	1.0 (0.6)	1.5 (0.5)
	Weight (g)	0.1 (0.1)	0.1 (0.1)	-	0.1 (0.1)

-: weight was observed less than 0.1 g.

DISCUSSION

Flower development

Flower development did not occur under natural day-length in Tokyo in all of the *D. alata* varieties. Flowering and non-flowering types of *D. rotundata* and *D. alata* are found, and there are a few flowering varieties of *D. alata* (Asiedu *et al.*, 1998). The results shows that the three varieties used in experiment 1 were non-flowering types, because none of them developed flower bud. The flowering variety of *D. opposita* and a Taiwan local variety of *D. alata* which were used in experiment 2 had been observed to develop flowers in Tokyo and Okinawa, Japan. However, Taiwan local, a flowering variety, did not develop flowers in this experiment. *D. rotundata* and *D. alata* have been described as short-day plants for flowering (Bai and Ekanayake, 1998). But Taiwan local, a female flowering variety did not develop flower buds under the short-day treatment. The short day period did not affect the number of flowers and the date of emergence on the flower spike in cv. Nagaimo (experiment 2).

Varieties of *D. rotundata* developed flower spikes under long-day period (Shiwachi *et al.*, 2005). Flower development in *D. rotundata* was caused by combination and rate of change of photoperiod (Ile *et al.*, 2007). It suggests that *D. alata* and *D. opposita* have similar flowering behavior in the flower bud development. Theobroxide induces the flowering of potato (*Solanum tuberosum*) and morning glory (*Ipomoea purpurea*) under non-induced long-day conditions (Yoshihara *et al.*, 2000). Theobroxide had no influence on yam flowering at the rapid and primary

growth stages of tubers in these experiments. The usefulness of theobroxide in yam flowering would be tested to determine the appropriate treatment time and concentration.

Plant growth and tuber development

The growth of tested yam plants was smaller in 2007 than in 2005. The experiment was conducted in less sunny conditions with the cooler minimum air temperatures in June and July and this had a negative effect on their growth. The short-day length stimulates tuberization in yam (Shiwachi *et al.*, 2002). The short-day treatment inhibited leaves, stems, and tuber growth at the rapid growth stage of tuber (experiment 1). In the primary growth stage of tubers, plant and tuber growth varied among the varieties under the short-day treatment (experiment 2). These results were in line with those of Shiwachi *et al.* (2000). The short-day treatment applied at the primary growth stage of tubers promoted the enlargement of tubers, but when applied after the rapid growth stage of the tubers it tended to inhibit tuber enlargement. When the short-day treatment was applied to plants in experiment 2, it seemed that the tubers of cv. Nagaimo, Taiwan local, and cv. Basmi had already changed to the rapid growth stage. The *D. opposita* variety had a very low sensitivity to short-day length; tubers continued to enlarge slowly, even under long-day length conditions (Yoshida and Kanahama, 1999; Shiwachi *et al.*, 2000).

D. opposita is an early maturing plant. Low sensitivity to short-day length was related to the maturity level of plants in *D. rotundata* and *D. alata* (Shiwachi *et al.*, 2002). Taiwan local and cv. Basmi could be considered to have an early maturity level compared with cv. Malaysia-A.

Theobroxide treatment did not affect yam tuber growth at the rapid growth stage. Tuber growth was inhibited in cv. Nagaimo, Taiwan local, and cv. Malaysia-A, but promoted in cv. Basmi at the primary growth stage of tubers. Theobroxide treatment influenced potato yield in a field experiment; tuber yield in most of tested varieties increased but was decreased in one variety (Yoshihara and Murai, 2008). To increase yield, theobroxide treatment should be at the stolon formation period and this should be identified in each variety. The usefulness of theobroxide in increasing yam tuber yield was not clear in this study. The tuber growth characteristics of specific yam varieties would be limited by the need to determine the appropriate treatment time.

Bulbil development

Bulbil formation varies among species and varieties in yam. *D. bulbifera* produces a large number and size of bulbils; it is used for food. Bulbil setting and non-setting types are found in *D. opposita* and *D. alata* although the latter has few bulbil setting species in yams (Coursey, 1967; Inagaki *et al.*, 1985). Bulbil formation was observed in all varieties tested in this study. However, bulbil setting rate (number and weight) varied in varieties and years. Less or no formation of bulbils was observed in cv. Obukosumbori (experiment 1). This variety was considered a non-setting type. Less bulbil formation in cv. Basmi and cv. Malaysia-A was observed in 2007 compared with 2005. It seemed that the cool minimum air temperature affected bulbil formation as well as tuber growth.

Short-day treatment promotes bulbil formation at the rapid growth stage of tubers, but does not affect the bulbils formation at the primary growth stage. Theobroxide promoted bulbils setting in cv. Basmi. When yam seed-setts were planted in April, bulbil development was observed from June in cv. Nagaimo (*D. opposita*), and from September in *D. alata* varieties in Japan. Development of tubers in *D. alata* was earlier than the development of bulbils. Bulbil development would be started after the rapid growth tuber stage. Therefore, the short-day or theobroxide treatment at the primary growth stage of tubers did not affect bulbil development. Bulbil development started under long-day period in *D. opposita*, but under short-day period in *D. alata*. Results showed that short-day stimulated the development of bulbils in *D. alata*.

The usefulness of the theobroxide treatment in bulbil development was not as clear as for

tuber development in this study. Theobroxide is the triggers for jasmonic acid production to induce potato (*Solanum tuberosum*) tuberization (Xiquan *et al.*, 2005). The enlargement of tubers in *D. alata* was promoted by jasmonic acid (Kikuno *et al.*, 2002a, 2002b). There is evidence that bulbils development would be promoted by jasmonic acid. Further study is expected of the theobroxide treatment in yams. Since bulbils are used for seed-setts in *D. opposita* (Inagaki *et al.*, 1985) and could be used for seed-setts in *D. alata*, the short-day or theobroxide treatment would be effective for bulbil production. The short-day or theobroxide treatment should be done after the rapid growth stage of tuber, that is the period of bulbil development in *D. alata*. This is first report of the use theobroxide in yams.

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REFERENCES

- Arimoto, H., T. Shimano and D. Uemura. 2005. Concise synthesis of the plant growth regulator Theobroxide. *Journal of Agricultural and Food Chemistry* 53:3863-3866.
- Asiedu, R., S.Y.C. Ng, K.V. Bai, I.J. Ekanayake and N.M.W. Wanyera. 1998. Genetic Improvement, pp 63-104. In G.C. Orkwor, R. Asiedu and I.J. Ekanayake (eds.). *Food Yams: Advances in Research*. NRCRI and IITA, Ibadan, Nigeria.
- Bai, K.V. and I.J. Ekanayake. 1998. Taxonomy, Morphology and Floral Biology, pp 13-37. In G.C. Orkwor, R. Asiedu and I.J. Ekanayake (eds.). *Food Yams: Advances in Research*. NRCRI and IITA, Ibadan, Nigeria.
- Chang, K., H. Shiwachi and M. Hayashi. 1995. Ecophysiological studies on growth and enlargement of tubers in yams (*Dioscorea* spp.). II. Detection of effect of plant growth regulators on the growth and enlargement of microtubers of yams. *Japanese Journal of Tropical Agriculture* 39:69-75.
- Coursey, D.G. 1967. *Yams, Modes of yam propagation*, Longmans, London. 223 p.
- Ile, E.I., P.Q. Craufurd, R. Asiedu and N.H. Battey. 2007. Duration from vine emergence to flowering suggests a long-day or rate of change of photoperiod response in white yam (*Dioscorea rotundata* Poir.). *Environmental and Experimental Botany* 60:86-94.
- Inagaki, N., S. Komatsubara, Y. Oka, S. Maekawa and M. Terabun. 1985. Clonal Propagation through Bulbils in *Dioscorea opposita* Thunb. cv. Yamatoimo. *Journal of the Japanese Society for Horticultural Science* 54:66-74.
- Kikuno, H., M. Onjo, K. Kusigemati and M. Hayashi. 2002a. A Relationship between the initiation of tuber enlargement and endogenous plant hormones in water yam (*Discorea alata* L.). *Japanese Journal of Tropical Agriculture* 46: 39-46.
- Kikuno, H., M. Onjo, K. Kusigemati and M. Hayashi. 2002b. A Relationship between the initiation of tuber enlargement and changes in the content of endogenous jasmonic acid in water yam (*Discorea alata* L.). *Japanese Journal of Tropical Agriculture* 46: 109-113.
- Onwueme, I.C. 1978. *The tropical tuber crops -Yams, Cassava, Sweet potato and Cocoyams*, John Wiley & Sons, New York. 223p.

- Sato, I. 1974. "Nagaimo: Shokubutsu to shitenō Tokusei (Water Yam: Characteristics as a Plant)," *Nogyo Gijutsu Taikei Yasai Hen (Agricultural Technology Almanac: Vegetables)*. Rural Culture Association: Tokyo. 56 p.
- Shiwachi, H., M. Onjo and M. Hayashi. 1999. Comparison of ecological characters of water yam (*Dioscorea alata* L.), Chinese yam (*D. opposita* THUNB.) and Jinen-jo (*D. japonica* THUNB.). *Japanese Journal of Tropical Agriculture* 43: 149-156.
- Shiwachi, H., M. Onjo and M. Hayashi. 2000. Photoperiodic response of water yam (*Dioscorea alata* L.), Chinese yam (*D. opposita* THUNB.) and Jinen-jo (*D. japonica* THUNB.). *Japanese Journal of Tropical Agriculture* 44: 107-114.
- Shiwachi, H., M. Onjo and M. Hayashi. 2001. Growth patterns of water yam (*Dioscorea alata* L.) introduced from high altitude areas of Nepal in Temperate Zone. *Japanese Journal of Tropical Agriculture* 45: 16-21.
- Shiwachi, H., T. Ayankanmi and R. Asiedu. 2002. Effect of day length on the development of tubers in yams (*Dioscorea* spp.). *Tropical Science* 42:162-170.
- Shiwachi, H., T. Ayankanmi and R. Asiedu. 2005. Effect of photoperiod on the development of inflorescences in white Guinea yam (*Dioscorea rotundata*). *Tropical Science* 45:126-130.
- Xiquan, G., F. Wang, Q. Yang, H. Matsuura and T. Yoshihara. 2005. Theobroxide triggers jasmonic acid production to induce potato tuberization. *Plant Growth Regulation*. 47:39-45.
- Yoshida, Y. and K. Kanahama. 1999. Effect of photoperiod and temperature on the development of spikes and new tubers in chinese yam (*Dioscorea opposita* THUNB. cv. Ichpimo). *Journal of Japanese Society for Horticultural Science* 68: 124-129.
- Yoshihara, T., F. Ohmori, K. Nakamori, M. Amanuma, T. Tsutsumi, A. Ichihara and H. Matura. 2000. Induction of plant tubers and flower buds under noninducing photoperiod conditions by a natural product, Theobroxide. *Journal of plant growth regulation* 19: 457-461.
- Yoshihara, T. and N. Murai. 2008. A study on the increased yield of potato by theobroxide. *The journal of the Women's Junior College. Asahikawa University.* 38:63-69.
- Yoshii, Y. 1949. *Shokubutsu no Koshusei (Photoperiodicity of Plants, in Japanese)*. Yokendo. 149 p.

**UPTAKE ABILITY OF TOMATO PLANTS (*SOLANUM LYCOPERSICUM* L.)
GROWN USING NUTRIENT FILM TECHNIQUE (NFT) BY ASCENDING
NUTRIENT CONCENTRATION METHOD**

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ABSTRACT

A simple but precise method was developed to measure the amount of nutrient and water uptake. The nutrient uptake ability of tomato plant in NFT culture was investigated by using this method. All the treatments started with rainwater and then six different concentrations of nutrient solution were added to each system according to solution consumption. The concentration of each mineral element in the nutrient solution increased with the addition of the supplement solution until the 3rd day and thereafter leveled off until the 7th day. This indicates that when absorption concentration became in stable state, except for the ion in the highest strength solution (1 U) for potassium and magnesium elements, and that most of the newly added ions were absorbed stably by plants from low to high concentration of nutrient solution. At that point when each ion concentration in the nutrient solution reached a critical level, the tomato plants were no longer able to uptake ions from the solution, and the minimum uptake concentration was evaluated. The critical concentration for tomato obtained in our experiment was 0.01-0.02 me/L for NO₃-N, 0.20 me/L for PO₄-P, 0.05-0.10 me/L for K, 0.40-0.50 me/L for Ca and 0.10 me/L for Mg. Tomato seedlings were able to uptake nutrients even from nutrient solutions with extremely low concentrations. These findings further suggest that cultivation using a low nutrient concentration could be attained if each nutrient was properly supplied.

Key words: absorption concentration, hydroponics, minimum concentration, NO₃-N

INTRODUCTION

In the Philippines and in other Southeast Asian countries, there are many problems associated with the conventional way of growing vegetables in the soil. The soil may be acidic, contain exceptionally low amount of nutrients, or harbor pests or disease inoculum that would greatly reduce the chance of profitable crop production (Resh, 1989). Also, in urban areas, area for conventional crop production may be limiting. An alternative way of growing vegetables that would overcome many of these constraints is hydroponics. In hydroponics there are many advantages, but the precise control of nutrient solution has not been established (i.e. waste of fertilizers and water, damage to environment from run-off of fertilizers etc. And minimizing the waste of fertilizers is one of the urgent problems in hydroponic technology. Therefore, this publication attempts to investigate, the precise value of the lowest critical concentration using improved experiment system.

Hydroponics is regarded as one of the most advanced growing techniques not only for environmental protection but also for high efficiency of vegetable production. Since plant growth in hydroponics is generally faster than in the conventional soil culture, more intensive and successive cropping production is carried out all year round (Savvas, 2002). Generally a conventional management of nutrient solution for soilless culture is based on the maintenance of relatively high ion concentrations. However, this method reduces the efficiency of nutrient application and has serious

environmental impact due to the solution exchange and run-off in the system (Böhme 1995; Os 1995). Also it can lead to luxurious nutrient uptake that would caused excessive vegetative growth and reduce yield especially for fruit vegetables or those with high nitrate concentration like in leafy vegetables (Pardossi et al., 1995). Therefore, it is important to investigate the precise pattern of the availability of water and nutrients in plants.

In a closed type hydroponic method, the amount of nutrient solution per plant largely affects the changes in concentration and/or composition during the cultivation period. In general, the smaller the quantity of the nutrient solution, the more variable the quality of the nutrient solution. Thus, the management system for nutrient solution is very important. It is therefore necessary to measure the nutrient and water uptake rate of the plant for better management of nutrient solution.

The relationship between the hydroponic nutrient concentration and mineral uptake has been well studied. However, most of the studies use Wagner pots or containers, showed that there is a change in the concentration and the amount of water uptake for a certain period. However under low mineral concentration in hydroponic solution, it is difficult to get exact values because solution concentration changes within a short period of time. In the NFT system, the root system of the plant can contact water and nutrients frequently, and this method was thought to be better to measure the minimum absorption concentration compared with other growing systems. Hence, NFT was adopted in this study.

In this study, nutrient absorption was studied by examining the uptake of nutrients in the solution in comparison to the nutrients from the water supply. Nutrient absorption per volume water consumption was used as an indicator of nutrient uptake concentration. If we have the above data, we can get the minimum absorption concentration and this can be estimated using the lowest values of each element grown in lower nutrient concentration as what we had in this study.

MATERIALS AND METHODS

Preparation of Tomato plants

The experiments were carried out in the plastic greenhouse at the Graduate School of Horticulture, Chiba University (Matsudo City, Chiba, Japan). Tomato (*Solanum lycopersicum* L. cv. Reiyo; Sakata Seed Co. Japan) was used as the test plant in this experiment. Seeds were sown in cell trays filled with fine granulated rockwool on December 23, 2006. After emergence, the seedlings were irrigated once a day with a 1/4 strength nutrient solution (Enshi-formula: Table 1).

On January 2, 2007, when the seedlings had two true leaves, they were potted to a 9.5 cm plastic pots filled with 300 ml fine granulated rockwool and grown with a 1/2 strength nutrient solution until transplanting. The air temperature in the plastic greenhouse was kept at about 12 °C using a heating system and ventilation windows opened when temperatures reached 25 °C.

Experimental design

A NFT system with 180 cm long channels and a 1% slope were used (Fig. 1-a). Total volume of the nutrient solution in the tank and culture bed was 20 L. Nutrient solution for each channel was controlled independently. Rainwater (EC: 0.029 dS/m) was used for making nutrient solution because it was almost mineral free and thought to be the best water quality. Six beds were used, each bed contained 12 plants for a total of 72 plants.

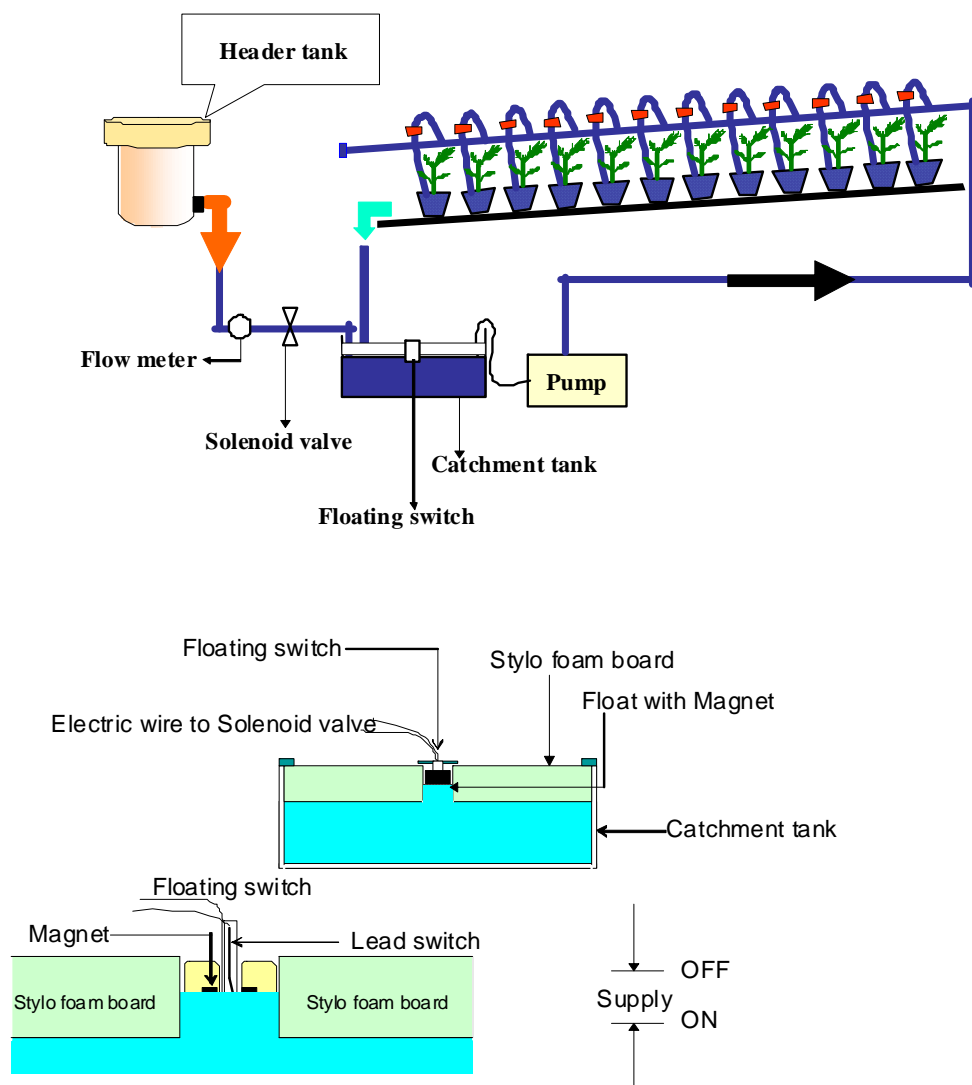


Fig. 1-a. Overview of the Nutrient Film Technique (NFT) system
1-b. Floating switch with controller

Seventy two seedlings with four fully expanded true leaves were prepared two days before transplanting. Roots and substrates in the pot were washed with rainwater until the EC value of the drained solution was similar to the rainwater. Seedlings were transplanted to beds on February 3, 2007, with a planting distance of 15 cm between plants in the NFT system and a flow rate of 2 L/h per plant.

Initially, only rainwater was supplied to the NFT system including the channels. Six concentrations of nutrient solution according to the treatments (1, 1/2, 1/4, 1/6, 1/8, and 1/10 strength) were kept in the header tank and supplied to each treatment system according to the solution consumption. The nutrient composition of treatment is shown in Table 1.

Table 1. Nutrient composition of treatments used.

Chemicals	Concentration, mM	Elements	Composition (me/L)
$\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	4.00	$\text{NO}_3\text{-N}$	16
KNO_3	8.00	$\text{PO}_4\text{-P}$	4
$\text{NH}_4\text{H}_2\text{PO}_4$	1.33	K	8
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	2.00	Ca	8
		Mg	4

Twenty ml of nutrient solution was sampled every

afternoon to analyze its nutrient concentration. After sampling, 20 ml of the same solution was added to the system to compensate for the volume sampled. There was no replication in the treatment because the environmental condition of the top and root system was uniformly controlled and the measurement of the solution was very precise as described below.

Measuring system

In this study, we needed to measure the solution consumption precisely and thus we designed a special device using the floating switch and its way of actions are shown in figure 1-b. A floating switch has a small switch (lead switch) and float with a built-in ring magnet. When the float moves downward in connection with the solution level of the catchment tank, the switch turns on and the nutrient solution supply begins from the header tank to the catchment tank. When the float returns to the original solution level of the catchment tank, the switch turns off, stopping the solution supply. The stylo foam board with a small hole was fixed tightly on top of the catchment tank (19.5 cm x 39 cm) to amplify the change of the water level. With this set up, accurate information of water consumption can be obtained. To estimate the sensitivity and accuracy of the floating switch, the supply volume was checked several times. The distance between the on and off position of the switch was 1.03 mm and is equal to a volume of 4.06 ml (means the minimum accuracy of the volume measured). The count of on- off was recorded to obtain the volume of the added solution. The nutrient uptake amount was calculated by subtracting the residual amount of nutrients from the total amount of given nutrients. Since the water and nutrient content in the substrate could hardly change throughout the experiment, it was considered that the decrease in the amount of nutrient in the solution during the experiment corresponded to the amount of nutrients absorbed by the plants.

The cations (potassium, calcium and magnesium) were analyzed using the atomic absorption spectrophotometry (Z-6000, Hitachi Ltd., Japan) and anion contents (nitrate and phosphate) of the solutions were analyzed using spectrophotometry (U-2000, Hitachi Ltd., Japan).

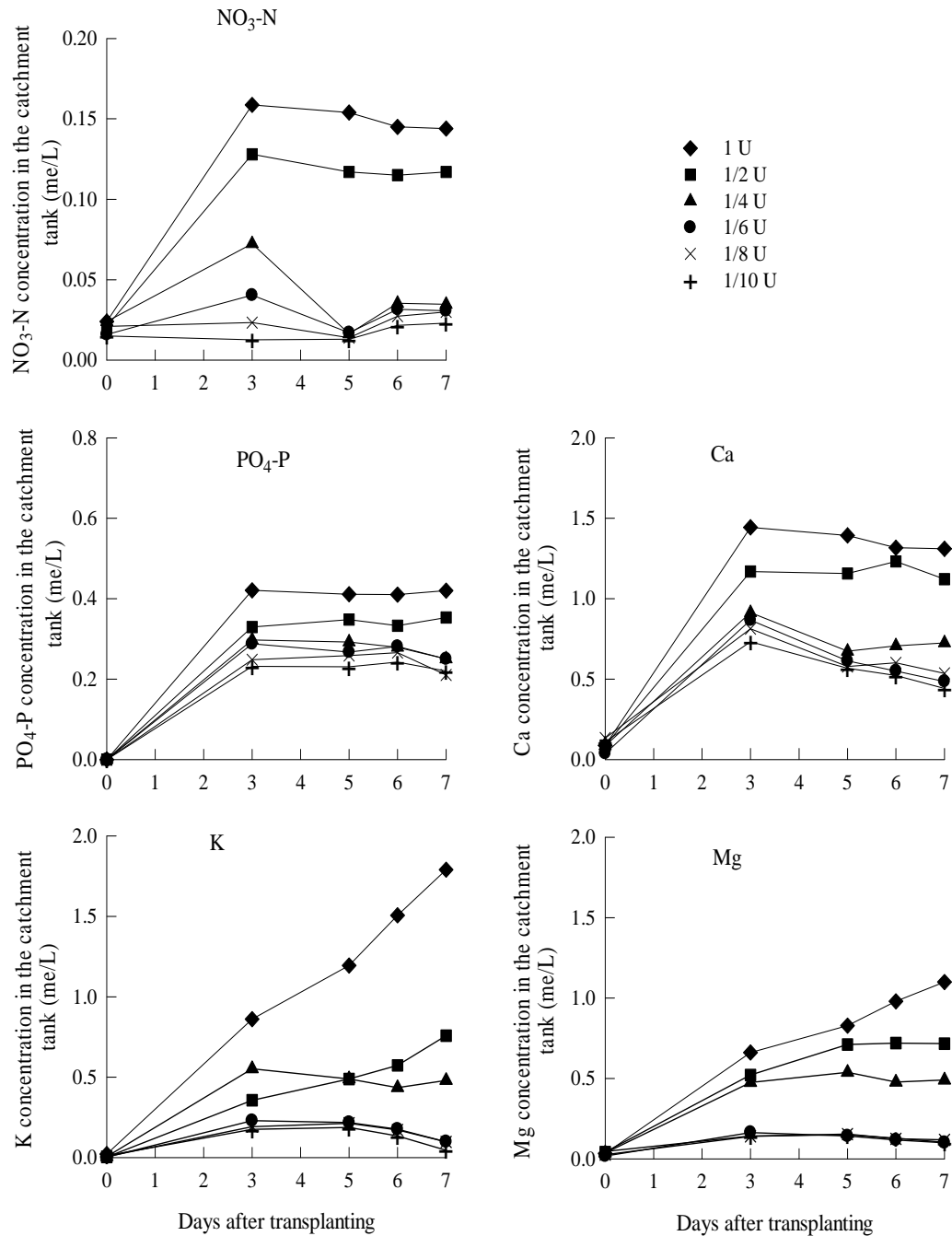
RESULTS AND DISCUSSION

The concentration of $\text{NO}_3\text{-N}$, $\text{PO}_4\text{-P}$, K, Ca and Mg in the system changed during the experimental period (Fig. 2). The concentration of each ion in the system increased immediately after the start of the experiment. From the 3rd day it leveled off until the end of the experiment, except for the highest strength solution (1 U) of potassium and magnesium. Before the solution in the system became stable, more nutrients from the header tank were supplied than the plant could take up. So the nutrient concentrations in the system increased. After the third day, the supplied amount of nutrient elements was nearly equal to the absorption amount. In the case of nitrate, when 1/10 to 1/4 strength solutions were added, the concentrations in the system remained low (about 0.01-0.02 me/L). Even when 1/2 or 1 strength solution was added, the solution concentration in the system became stable at slightly high concentrations (0.13-0.16 me/L). This indicates that almost all newly added ions into the system were immediately absorbed by the plants. However, even the same

tendency was obtained in potassium and magnesium, not all of the ions were absorbed when 1 strength solution was added, the concentration in the system continuously increased until the end of the experimental period.

Fig. 2. Effect of supplemented solution concentration of nutrient solution on $\text{NO}_3\text{-N}$ absorption rate.

If we try to find the lowest concentrations of each element, we can get them from 1/10 U treatment at 7 days. This indicates that when the ion concentration in the nutrient solution reached the critical level, the tomato plants could no longer uptake ions from the solution. The critical concentrations



obtained in our experiment were, 0.01-0.02 me/L for NO₃-N, 0.20 me/L for PO₄-P, 0.05-0.10 me/L for K, 0.40-0.50 me/L for Ca and 0.10 me/L for Mg. Maruo et al. (2004) determined that the critical nutrient concentrations for water convolvulus were as follows, 0.20 me/L for NO₃-N, 0.05 me/L for PO₄-P, 0.07 me/L for K, 0.03 me/L for Ca.

The critical concentrations of NO₃-N and K were higher and lower in PO₄-P and Ca, in water convolvulus than those in tomato determined in this study. Abe et al. (1999) reported the influence of N and P concentration on the absorption concentration of Italian ryegrass, papyrus and kenaf, and concluded the nutrient uptake at minimum absorption concentrations were 0.20-0.30 mg/L for N and 0.01-0.60 mg/L for P. These values are similar to our results in tomato. In addition, plants are able to uptake nutrients for optimum development at relatively low concentration in the root environment (Ingstad, 1970; Clement et al., 1978; Massey and Winsor, 1980; Wild and Breeze, 1978; Siddiqi et al., 1998). These references also well agree with our results.

The total water consumption and average absorption concentration of each ion during the experiment is shown in Table 2. Results showed that there were no differences in the water consumption among six treatments. In each ion the absorption concentration increased with the increasing concentration of the added nutrient solution. Within the condition of this experiment, absorption of a given ions was not affected by the presence and concentration of other ions. This means that the plant absorbed almost all newly added ions by adjusting the amount of absorption.

Table 2. Water uptake and absorption concentration of mineral elements by tomato plants during the experiment.

The nitrate showed the highest absorption rate among the measured elements (Fig. 3). The NO₃-N supplied was absorbed by the plants following a similar pattern, regardless of the strength of the nutrient solution. There is a tendency that the amount of nitrate absorbed is almost equal to that of

Treatment (U)^z	1 U	1/2 U	1/4 U	1/6 U	1/8 U	1/10 U
Total water uptake(L/plant)^y	0.18	0.18	0.17	0.15	0.14	0.13
Absorption Concentration (me/L) ^x						
NO ₃ -N	15.06	7.31	3.04	2.66	2.06	1.82
PO ₄ -P	4.71	1.54	1.48	1.06	1.05	0.56
K	5.77	4.30	4.02	2.44	2.12	1.95
Ca	6.24	3.09	2.38	1.83	1.34	1.02
Mg	3.63	2.46	1.57	1.26	0.76	0.71

^xAbsorption concentration was computed: total ion uptake (me/plant / total water uptake (L/plant)

^yTotal water uptake was computed: water consumption (L) / no. of plants

^zU (strength)

added solution, and this explains why the concentration in the catchment tank finally became stable.

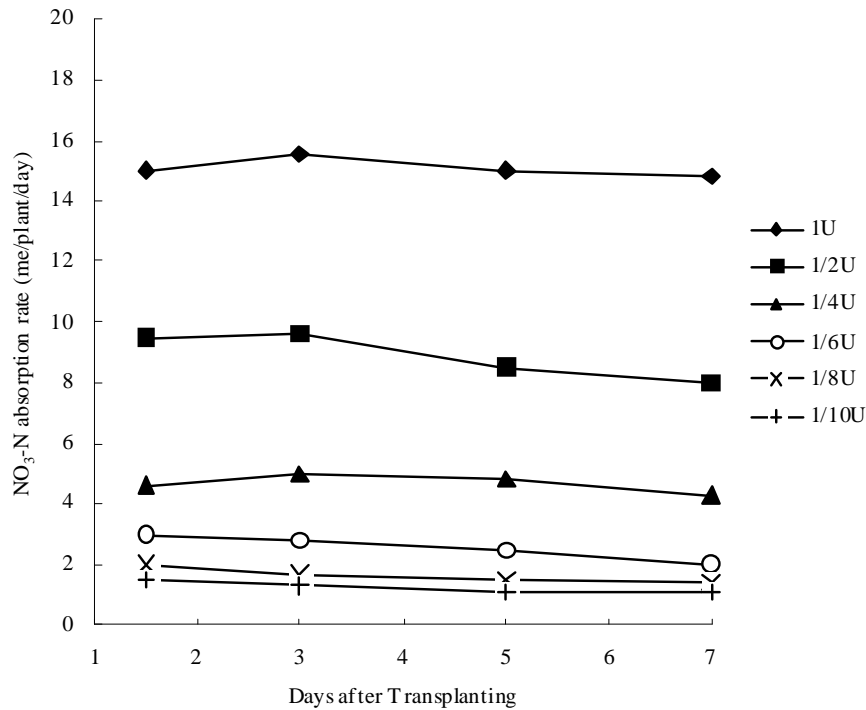


Fig. 3. Effect of supplemented solution concentration in the nutrient on the changes in NO₃-N absorption rate during the experiment.

Figure 4 showed the relationship between the absorption concentration of nitrate by the plant and solution concentration of nitrate in the catchment tank for 6th-7th days (taken from figure 2). At this period, the solution concentration was stable and it indicates that the added amount of nutrient in the system equalizes to the uptake amount by the plant. In this figure, when 1/10 to 1/4 U solutions were added, absorption concentration by plants were 2-3 me/L and solution concentrations in the system were kept at very low concentration, 0.01-0.02 me/L. Also, even when 1/2 or 1 U solutions were added, solution concentrations in the system were still kept very low at 0.13-0.16 me/L. The critical absorption concentration of nitrate was estimated in the lowest values as shown in figure 4. From this result, the critical absorption concentration of nitrate was estimated at about 0.01-0.02 me/L. This result suggests that cultivation with low nutrient concentration could be applicable when each of the nutrients was properly supplied.

In the present experiment, when a certain amount of nutrient was added to the plant, initially the plant could not adapt and thus a temporary increase in the concentration was observed. The uptake amount by the tomato plant gradually increased with increasing concentration of the nutrient solution. Our result suggests that the higher the strength of the added nutrient solution the higher the absorption concentration of each mineral element.

Changes in the concentration of each element in the nutrient solution have considerable effects on growth, nutrient uptake and, in some cases, on the distribution of nutrients within the plants (Sonneveld and Voogt, 1990). Since the concentration of the re-circulating solution in conventional systems is kept at relatively high concentration for most vegetables (Ikeda et al., 1995), hydroponic cultures employing low nutrient concentrations can be appealing for commercial growers from the standpoint of both plant physiology and pollution prevention.

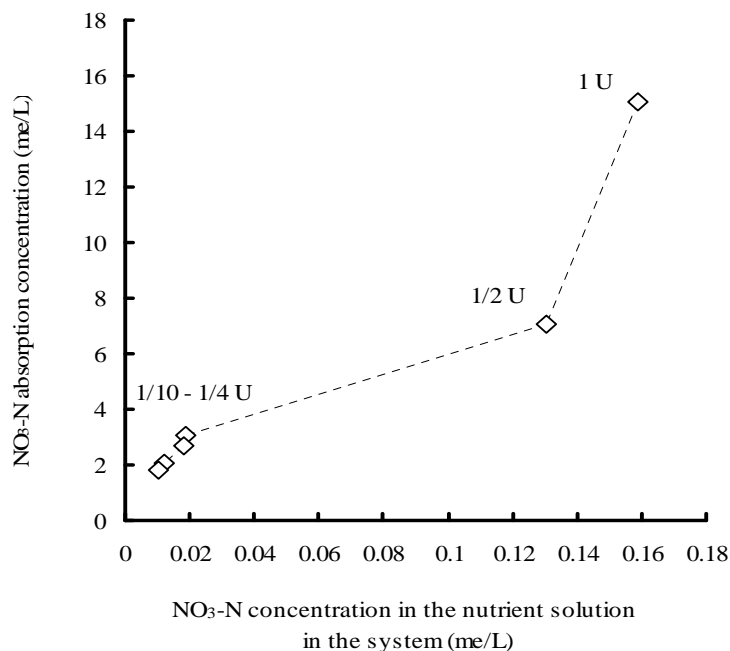


Fig.

NO₃-N concentration in the catchment tank and concentration of tomato plant.

4. The relationship between the NO₃-N absorption

CONCLUSION

These precisely controlled methods could be applied for measuring the absorption concentration of the amount of water and nutrients, and the uptake ability of tomato plants. Tomato plants can uptake nutrients even from extremely low nutrient concentrations. These results suggest that cultivation with low nutrient concentration could be applicable if each nutrient element was stably supplied and balanced with the absorption. However, further studies should be conducted on the uptake ability from low nutrient solution concentration and evaluate at different growth stages of the plant of a specific variety at a given season.

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REFERENCES

- Abe, K., Y. Ozaki and K. Mizuta. 1999. Evaluation of Useful Plants for the treatment of Polluted Pond Water with Low N and P Concentrations, *Soil Sci. Plant Nutr.*, 45(2), 409- 417.
- Böhme, M. 1995. Effects of closed system in substrate culture for vegetable production in greenhouses. *Acta Hort.* 396: 45-54.
- Clement, C. R., M. J. Hopper and L. P. H. Jones. 1978. The uptake of nitrate by *Lolium perenne* from flowing nutrient solution. *J. Exp. Bot.* 29: 453-464.
- Ikedo, H., T. Wada., T. Mirin., K. Okabe., A. Tazuke and H. Furukawa. 1995. Year-round production of spinach by NFT and DFT in the greenhouse. *Acta Hort.* 396: 257-264.
- Ingestad, T. 1970. A Definition of Optimum Nutrient Requirements in Birch Seedlings. *I. Physiol.*

Plant, 23: 1127-1138.

- Maruo, T., M. Takagaki and Y. Shinohara. 2004. Critical nutrient concentration for absorption of some vegetables. *Acta Hort.* 644: 493-499.
- Massey, D. M. and G. W. Winsor. 1980. Some responses of tomatoes to nitrogen in recirculating solutions. *Acta Hort.*, 98: 127-137.
- Pardossi, A., F. Malorgio and F. Tognoni. 1995. Control of mineral nutrition in melons plants grown with NFT. *Acta Hort.* 396:173-180.
- Resh, H. M. 1989. *Hydroponics Food Production. A Definite Guidebook of Soilless Food Growing Methods* (the fourth edition). Woodbridge Press Publishing Co. pp. 426.
- Savvas, D. 2002. Nutrient solution recycling, pp.299-343. In: Savvas, D and H. Passam (eds). *Hydroponic Production of Vegetables and Ornamentals*. Embryo Publications, Athens, Greece.
- Sonneveld, C. and W. Voogt. 1990. Responses of Tomatoes (*Lycopersicon esculentum*) to an unequal distribution of nutrients in the root environment, In: Van Beusichem, M.L. (ed). *Plant Nutrition-Physiology and Applications*. Kluwer Academic Publishers. pp 509-514.
- Siddiqi, M. Y., H. J. Kronzucker, D. T. Britto and A. D. M. Glass. 1998. Growth of a tomato crop at reduced nutrient concentrations as a strategy to limit eutrophication. *J. Plant Nutr.* 1:1879-1895.
- Van Os, E. A. 1995. Engineering and environmental aspects of soilless growing system. *Acta Hort.* 396:25-32.
- Wild, A. and V. G. Breeze. 1981. Nutrient uptake in relation to growth, In *Physiological processes limiting plant productivity* (ed). C.B. Johnson, pp.331-343. London: Butterworths.

VARIETAL DIFFERENCE OF NEGATIVE GRAVITROPISM IN RICE SEEDLINGS AND INVOLVEMENT OF ETHYLENE PRODUCTION IN ITS MECHANISM

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ABSTRACT

This study aimed to investigate the varietal difference in lodging recovery of rice seedling (negative gravitropism), which might be related to the suitability for seedling establishment in direct-seeding cultivation. Characteristics of general features of rice varieties which were collected from different countries were studied, focusing on the comparison of lodging recovery. The results obtained are as follows:

1. The 18 rice varieties tested in this experiment (17 Asian rice and one African rice) showed a wide range of variation in grain shape, phenol reaction and alkali degradability according to their ecotypes such as Japonica, Indica, and Javanica. African rice exhibited the Indica like characteristics in general.
2. A wide variation in negative gravitropism was found when tested with seedlings sown on agar media. The degree of negative gravitropism is not common within the ecotypes.
3. Kasalath (Indica) and Shinriki (Japonica) showed very strong lodging recovery and they were considered to be desirable breeding materials to introduce high negative gravitropism to direct-seeding oriented new varieties.
4. Calrose76 and Nongan, which are semi-dwarf varieties bred for direct seeding in USA and Korea respectively, were found to exert high lodging recovery.
5. The degree of lodging recovery of seedlings was observed to be well correlated with ethylene production rate of horizontally placed seedlings when tested with Nongan, WO492 and Daorenqiao.

Key words: direct sowing, seedling establishment, semi-dwarf variety, lodging recovery

INTRODUCTION

Since the practice of rice cropping is now decreasing under an aging agricultural society and outflow of rural population in Asian countries including Japan, it is highly important to produce rice of high quality and high value by developing new technologies for extending operation scale or saving labour and cost. The monsoon Asian countries, for instance, are starting to introduce the direct-seeding technology to extend operation scales although they have preferred transplantation for weed control (Savary *et al.*, 2005). The establishment of the direct-seeding technique calls for urgent attention in Japan as well, especially after the GATT Uruguay Round agreements, to decrease labour with lower cost of seedling raising and transplanting (Fujimaki, 1997).

There are two types of direct-seeding techniques; the seeding on well-drained paddy fields

followed by water logging; and the seeding on submerged paddy fields. The former has a number of advantages such as the high efficiency of seeding operation, but this technique can be applied only in warm-temperature regions and seedlings can be damaged by birds. The latter, on the other hand, can be applied in broader areas but the seedling height can be unequal, and due to bad rooting, seedlings can be easily suffered from lodging. Although there is a technique using Calper-coated seeds for stabilization of emergence and seedling erection, establishment of such technologies is not yet sufficient for steady spread of the direct-seeding techniques. It is therefore essential to develop varieties suitable for direct-seeding. Such varieties are expected to excel in the following characteristics: low-temperature germination, low-temperature emergence/seedling direction, hypogeal germination, and resistance against lodging (Miura, 2003).

Under submerged conditions, the lodging recovery of a seedling plays an important role. Mishima (1938) found that the characteristics of seedlings to re-rise vertically after being kept horizontal differ according to varieties. He also suggested that this difference might be related with the recovery ability of rice plants after lodging. However, to date, few studies have been done on varietal difference for lodging recovery in rice seedlings among ecotypes such as Indica, Japonica and Javanica. Thus, we carried out research on varietal difference of the lodging recovery ability of rice seedlings in relation to the negative gravitropism.

In this study, we investigated the difference in lodging recovery among rice varieties using 17 *Oryza sativa* varieties including the ecotypes of Indica, Japonica, and Javanica and one *Oryza glaberrima* variety, and the involvement of ethylene production in its mechanism was also discussed.

MATERIALS AND METHODS

At first, the characteristics of 17 varieties of Asian rice (*Oryza sativa*) and one variety of African rice (*Oryza glaberrima*) which have the potential to head panicles in the Kanto region were checked for their phenol reaction, alkali digestibility, husk shape and color, and grain color, shape, and size. The original place of origin for *Oryza sativa* tested in this experiment varies from India, China, Laos, Thailand, USA, Japan, to Korea and consisted of 8 Indica, 2 Javanica, and 7 Japonica ecotypes.

The seeds were germinated for 2 days under dark conditions at 30°C, and sown on a 1/5000a Wargner's pot on May 5, 1998. The pot was filled with 3 kg red Kanto loam soil, mixed with 2 g ammonium sulfate, 7 g superphosphate lime, and 1.2 g potassium chloride, as N, P, K fertilizer, respectively. Two seeds were planted and grown in a pot for each variety with two replications in the net field of the Tropical Crop Science laboratory, Tokyo University of Agriculture located in Setagaya ward. The seeds were harvested in the end of October, 1998 and the characteristics were investigated for phenol reaction, alkali digestibility, husk shape and color, and grain color, shape and size. The phenol reaction was carried out by soaking the seeds in 1.5% phenol solution for 24 hours, and the results were described as positive or negative, when grain was dyed black or not, respectively. The alkali digestibility was evaluated 24 hours after soaking in 1.7% KOH solution, using 10-grade decomposition index of Ebara's method (Ebara, 1968).

Negative gravitropism of the tested 18 rice varieties were compared by a newly developed method using an agar medium as follows. First, seeds of the 18 varieties were cultured at 30°C under dark conditions for two days to stimulate germination. Then fifteen germinated seeds were sown on the 1% agar medium filled in a plate and were cultured at 30°C under bright conditions in a climate chamber for two days. Thereafter, the plates were inclined at a 90° angle so that the first leaf would bend down its head and whole plants would be kept horizontal. Then, as an indicator of negative gravitropism, the angle of the uprising plant body was measured with a protractor for 48 hours at every 3 hours interval. The typical three varieties that is, Nong-an for its high negative gravitropism, WO492 (*Oryza glaberrima*) for its moderate negative gravitropism and Daorenqiao for its low negative gravitropism were selected to measure their lodging recovery ability and ethylene evolution

pattern during uprising process at 30 °C.

After one day incubation at dark condition (30 °C), five seeds were placed on 1% agar medium in 100 ml Erlenmeyer flask and kept at 30 °C under dark condition after sealed with silicon cap. The half was kept vertically, and the other half was placed horizontally. The lodging recovery pattern was measured with a protractor for 48 hours at every 3 hours interval and ethylene evolution in the atmosphere of the flask was analyzed after 24 hour incubation using GC14A (Shimadzu) equipped with flame ionization detector (FID). The analysis conditions were as follows: carrier gas was N₂ (6kg/cm²), column: Sunpack A (porous polybeads), and the temperatures of injector, column, and detector were 120 °C, 80 °C, and 140 °C, respectively. The experiment was carried out on April 30, 2002 with three replications.

RESULTS

The 18 rice varieties were classified as Japonica, Indica, and Javanica based on their phenol reaction and alkali digestibility (Table 1). The grain shape showed a wide range of variation and it was found a typical characteristics according to the ecotypes; relatively round in Japonica type, long in Indica type, and big and wide in Javanica type. As for phenol reaction, all the Indica except Surjamkhi showed a positive reaction and all the Japonica and Javanica except Owarihatamochi showed a negative reaction. WO492, an African rice of *Oryza glaberrima*, indicated a positive phenol reaction as same as most of the Indica varieties.

In the case of alkali digestibility, Japonica varieties showed relatively higher digestibility. Indica varieties indicated lower alkali digestibility comparing to Japonica varieties and Javanica varieties showed intermediate values. The alkali digestibility of WO492 was rather low, indicating a similarity with the Indica type. This variety exerts Indica like characteristics in general, except for the peculiar trait of *Oryza glaberrima* such as short and round ligule, lesser secondary spikelets, and rarely observed pubescence of glumes and leaves.

The varietal difference of negative gravitropism which was indicated by the time to rise up to 50, 70 and 90 degree angle from horizontal position, was shown in Table 2. Observing the ability to rise to a 30 degree angle, Kasalath (Indica), Hunanxian (Indica), and Shinriki (Japonica) showed strong lodging recovery.

The rising pattern shown in Figure 1, indicates the relationship between the time taken to rise to a 50 degree angle and the one from a 50 degree angle to a 70 degree angle. Most of the varieties rise quickly to a 50 degree angle, and thereafter shows relatively slow pace of getting upward to a 70 degree angle, as typically shown in Dular (Indica), Kasalath (Indica), Liuzhoubaoyacao (Indica), Calrose76 (Japonica), Shinriki (Japonica) and Nong-an (Japonica). On the other hand, the varieties such as Hunanxian (Indica), Dam Ngo (Javanica), Asahi (Japonica), and WO492 (*Oryza glaberrima*) showed a rather constant rising speed, and in case of Daorenqiao, it showed a very slow rising pattern.

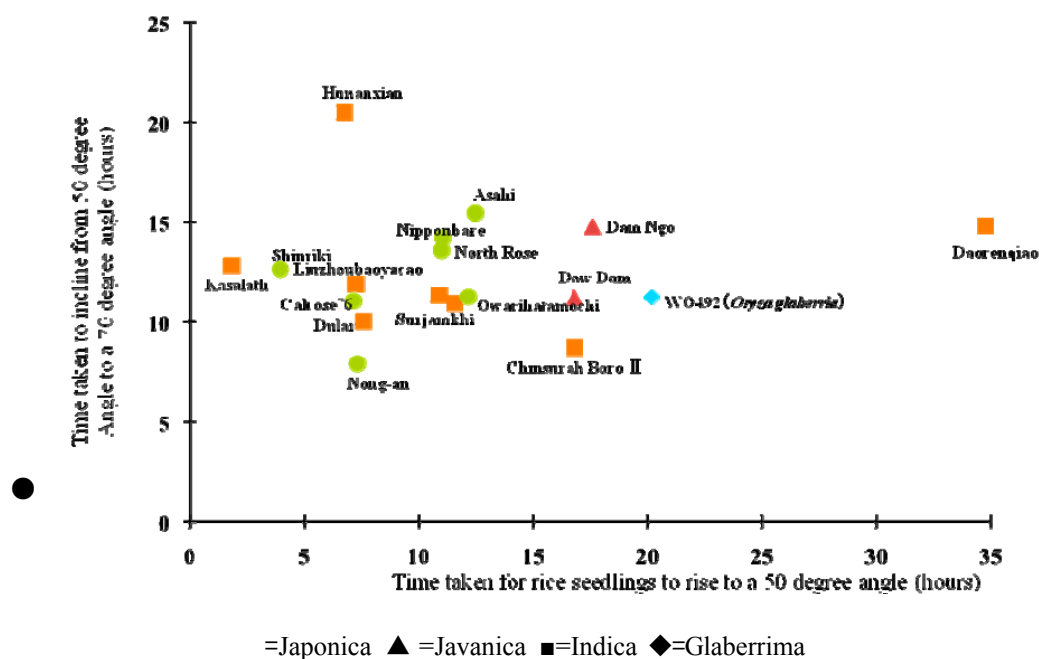
The lodging recovery pattern of typical three varieties (Nong-an for strong, WO492 for intermediate, and Daorenqiao for weak variety) and their ethylene evolution were well coordinated; the stronger the lodging recovery ability, the higher the ethylene evolution, especially when placed horizontally (Fig. 2 and 3).

Table 1. Selected chemical and morphological characteristics of husks and grains of 18 rice varieties of various origins and ecotypes.

	Variety Name	Origin	Ecotype	Phenol reaction	Alkali digestibility	Grain length (mm)	Grain width (mm)	Grain length/width
<i>O. sativa</i>	1 Surjamkhi	India	Indica	—	0	8.77	2.64	3.3
	2 Dular	India	Indica	+	0	8.83	2.82	3.1
	3 Kasalath	India	Indica	+	1	7.5	2.7	2.8
	4 Chinsurah Boro II	India	Indica	+	1	7.9	3.01	2.6
	5 Liuzhoubaoyacao	China	Indica	+	3	8.01	3.23	2.5
	6 Hongxuenao	China	Indica	+	1	9.07	3.16	2.9
	7 Hunanxian	China	Indica	+	2	7.55	3.12	2.4
	8 Daorenqiao	China	Indica	+	0	7.41	3.35	2.2
	9 Dam Ngo	Laos	Javanica	—	5	8.86	3.81	2.3
	10 Daw Dam	Thailand	Javanica	—	4	8.37	3.81	2.2
	11 North Rose	U.S.A	Japonica	—	5	7.84	3.08	2.5
	12 Calrose76	U.S.A	Japonica	—	5	6.96	3.34	2.1
	13 Asahi	Japan	Japonica	—	8	7.13	3.49	2
	14 Shiriki	Japan	Japonica	—	7	6.9	3.47	2
	15 Nipponbare	Japan	Japonica	—	6	6.85	3.3	2.1
	16 Owarihatamochi	Japan	Japonica	+	5	8.1	3.68	2.2
	17 Nong-an	Korea	Japonica	—	7	7.16	3.24	2.2
<i>O. glaberrima</i>	18 WO492	Africa		+	2	7.84	2.93	2.7

Table 2. The time taken for rice seedlings to rise up to 50, 70, and 90 degrees from the horizontal position.

		Variety Name	Time to rise to 50 degrees (hr)	Time to rise to 70 degrees (hr)	Time to rise to 90 degrees (hr)
<i>O. sativa</i>	1	Surjamkhi	11.6	22.5	42.9
	2	Dular	7.6	17.6	39.0
	3	Kasalath	1.8	14.7	41.6
	4	Chinsurah Boro	16.8	25.5	45.2
	5	Liuzhoubaoyacao	7.3	19.2	47.7
	6	Hongxuenuo	10.9	22.2	47.3
	7	Hunanxian	6.8	27.2	53.4
	8	Daorenqiao	34.7	49.6	60.7
	9	Dam Ngo	17.6	32.4	47.9
	10	Daw Dam	16.8	28.0	42.7
	11	North Rose	11.0	24.6	46.4
	12	Calrose76	7.2	18.2	42.9
	13	Asahi	12.5	27.9	49.4
	14	Shinriki	4.0	16.6	45.1
	15	Nipponbare	11.1	25.3	47.8
	16	Owarihatamochi	12.2	23.4	49.2
	17	Nong-an	7.3	15.2	29.7
<i>O. glaberrima</i>	18	WO492	20.2	31.4	44.6

**Fig. 1.** Relationship between time taken for rice seedlings to rise from 0 to 50 degrees angle and from 50 to 70 degrees angle.

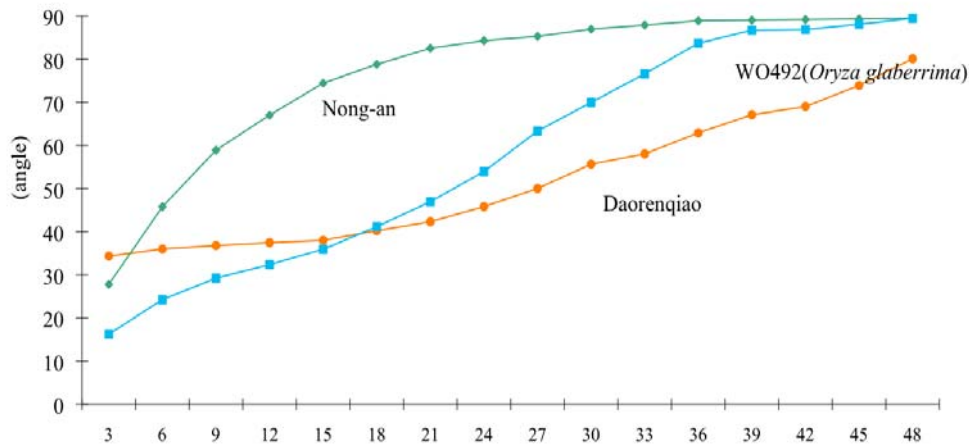


Fig. 2. Changes in rising pattern of horizontally placed rice seedlings on Nong-an, WO492 and Daorenqiao.

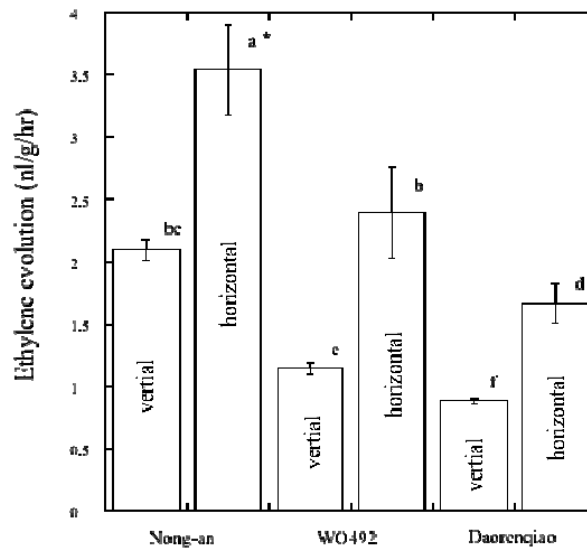


Fig. 3. Ethylene evolution of vertically or horizontally placed rice seedlings. Different letters shows significant difference at 5% level by t-test.

DISCUSSION

The development of new varieties has supported the extension of direct seeding method of rice in USA, Italy, and Australia (Kushibuchi, 1997). The main characteristics noticed for breeding direct seeding rice varieties were germinability, seedling establishment ability and lodging tolerance, and the varietal differences or genetical characteristics have been studied on the elongation of mesocotyl and coleoptile (Katsuta, 1998). The study on varietal differences in lodging recovery of rice seedlings, which might well correlate with lodging recovery of lodged seedlings, however, are very rare.

In the present study, a wide range of lodging recovery of rice seedlings was observed, and there seemed no clear tendency within and among Japonica, Indica, and Javanica ecotypes. The strongest lodging recovery performance was observed in Kasalath (Indica) and Shinriki (Japonica). Though they are not presently applicable for direct-seeding since they have a longer stem, they can be

useful as breeding materials to produce direct-seeding oriented varieties.

Interestingly, it was found that the semi-dwarf varieties, such as Calrose76 (American) or Nong-an (Korean), which were both bred for direct-seeding, showed high negative gravitropism. The result indicates that the semi-dwarfing characteristics of these varieties are intentionally or unintentionally accompanied with high ability of negative gravitropism. Semi-dwarfing genes of practical use were clarified to be located on the identical locus (Kikuchi *et al.*, 1985; Ashikari *et al.*, 2002), and it was shown that they had no adverse effect on direct-seeding regardless of dried or submerged, Calper-coated or not-coated, deeply or shallowly sown conditions (Koshio *et al.*, 2008). The fact that the horizontally placed Nong-an produced much ethylene compared with the other two tested varieties indicates the possibility that the semi-dwarfing gene has some effect both on ethylene production and lodging recovery. It was also found that Daorenqiao, a Chinese-origin Indica rice, has extremely low negative gravitropism accompanied with low ethylene production. Mesocotyl elongation of this variety was shown extremely low (Katsuta, 1998), and here also suggested the involvement of the lower ethylene production both in the lower lodging recovery ability and the lower mesocotyle elongation. The characteristics of Daorenqiao can be useful as a crossing material for genetic analysis to clarify the effect of mesocotyl elongation or lodging recovery.

The involvement of ethylene production in expressing gravitropism of rice or other plants (Abe *et al.*, 1998; Blancaflor and Masson, 2003, Horton R. F., 1993; Lu BW *et al.*, 2001) has been reported as well as enhancing flooding tolerance (Fukao *et al.*, 2006) and low temperature stress (Gao *et al.*, 2008). We suggest that ethylene production ability can be an indicator of negative gravitropism which may contribute to improve rice seedling establishment in direct seeding, with enhanced tolerance against environmental stresses.

CONCLUSION

In this study, we investigated the difference of the lodging recovery of 17 *Oryza sativa* varieties including the ecotypes of Indica, Japonica, and Javanica and one *Oryza glaberrima* variety. A wide range of negative gravitropism was observed among tested varieties, and the involvement of ethylene production was suggested. The knowledge obtained in this paper may contribute to breeding new varieties which are suitable for direct sowing cultivation method in the future.

REFERENCES

- Abe K., Takahashi H. and Suge H. 1998. Gravimorphism in rice and barley: promotion of leaf elongation by vertical inversion in agravitropically growing plants. *J. Plant Research* 111: 523-530.
- Ashikari M., A. Sasaki, M. Ueguchi-Tanaka, H. Itoh, A. Nishimura, S. Datta, K. Ishiyama, T. Saito, M. Kobayashi, G. S. Khush, H. Kitano and M. Matsuoka. 2002. Loss-of-function of a rice gibberellin biosynthetic gene, GA20 oxidase (GA20ox-2), led to the rice 'Green Revolution'. *Breeding Science* 52: 143-150.
- Blancaflor E. B. and P. H. Masson. 2003. Plant gravitropism. Unraveling the ups and downs of a complex process. *Plant Physiology* 133: 1677-1690.
- Ebata Morie 1968. Studies on Alkali Decomposition of Rice Kernel : 1. On the alkali test of milled white rice kernel. *Japanese Journal of Crop Science* 37: 499-503.
- Fujimaki H. 1997. Situation changes and strategy for technology development of rice cultivation in Japan. *Agriculture and Horticulture* 72: 71-78.
- Fukao T. K. Xu, P. C. Ronald and J. Bailey-Serres. 2006. A variable cluster of ethylene response factor-like genes regulates metabolic and developmental acclimation responses to

- submergence in rice (W). *The Plant Cell* 18:2021-2034.
- Gao S, Haiwen Zhang, Yun Tian, Fang Li, Zhijin Zhang, Xiangyang Lu, Xiaoliang Chen and R. Huang. 2008. Expression of TERF1 in rice regulates expression of stress-responsive genes and enhances tolerance to drought and high salinity. *Plant Cell Report* 27: 1787-1795.
- Horton R. F. 1993. Gravitropism in rice seedlings: the effects of anoxia and N-1-naphthylphthalamic acid. *Plant Science* 95: 41-47.
- Katsuta-Seki Masumi 1998. Genetic diversity and control of mesocotyl elongation ability on rice. *Bull. Natl. Inst. Agrobiol. Resour.* 12: 55-98.
- Kikuchi, F., N. Itakura, H. Ikehashi, M. Yokoo, A. Nakane and K. Maruyama 1985. Genetic analysis of semidwarfism in high yielding rice varieties in Japan. *Bull. Nat. Inst. Agr. Sci., Ser. D* 36: 125-145 (*in Japanese*).
- Kuhsibuchi K. 1997. Future and problems of non-tilled rice culture on paddy field. *Journal of Agricultural Science* 52: 267-273 (*In Japanese*).
- Koshio K, T. Osaka, K. Irie, H. Toyohara, F. Kikuchi, and H. Fujimaki 2008. Effects of semi-dwarfing *sd-1* alleles on emergence and establishment of rice seedlings under different sowing conditions in the direct sowing cultivation. *Japanese Journal of Tropical Agriculture* 52:63-68.
- Lu BW., Pei LK, Chan WK., Zhang H., Zhu G., Li JY., and Li N. 2001. The dual effects of ethylene on the negative gravicurvature of *Arabidopsis* inflorescence, an intriguing action model for the plant hormone ethylene. *Chinese Science Bulletin* 46: 279-283.
- Mishima T. 1938. Varietal difference in the degree of uprising ability expression of rice seedlings (*in Japanese*). *Agriculture and Horticulture* 13: 2238-2240.
- Miura K. 2003. Genetic studies on germination of seed and seedling establishment for breeding of improved rice varieties suitable for direct seeding culture. *Misc. Publ. Natl. Inst. Agrobiol. Sci.* 2: 1-44.
- Savary, S., N. P. Castilla, F.A. Elazegui and P. S. Teng 2005. Multiple effects of two drivers of agricultural change, labour shortage and water scarcity, on rice pest profiles in tropical Asia. *Field Crops Research* 91: 263-271.

**CRITICAL NUTRIENT UPTAKE ABILITY OF TOMATO PLANTS (*SOLANUM LYCOPERSICUM* L.) GROWN USING THE NUTRIENT FILM TECHNIQUE (NFT)
BY DESCENDING NUTRIENT CONCENTRATION METHOD**

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ABSTRACT

The critical nutrient uptake ability of each element in tomato plants (*Solanum lycopersicum* L. cv. Reika) grown using the Nutrient Film Technique (NFT) was investigated by descending nutrient concentration method using three seedling sizes. All the cultures started from different concentrations of nutrient solution and supplemented only with rainwater. The changes in NO₃-N concentration of nutrient solution decreased right after the start of the experimental period in all the different seedling stages. The bigger plants absorbed the nutrient elements very fast and reached the final concentration faster than younger plants, but uptake by all plant stages reached almost the same final concentration. The changing patterns of the concentration of other elements were similar to those of nitrate. The uptake rates of each element were measured to determine the points for the critical uptake rate to become zero. A zero value means that the plants can no longer absorb the nutrient from the solution. The critical nutrient concentrations for tomato obtained in our experiment were, 0.01-0.04 me/L for NO₃-N, 0.02-0.09 me/L for PO₄-P, 0.03-0.10 me/L for K, 0.02-0.20 me/L for Ca, and 0.01-0.09 me/L for Mg. These concentrations were lower than those of the ascending method in our previous study. The differences in the values of the critical nutrient concentration of each element are discussed.

Key words: uptake concentration, hydroponics, critical concentration

INTRODUCTION

In a closed type soilless culture system, nutrient management has been based on the maintenance of relatively high ion nutrient concentrations. Considerable attention has been given to the change in absorption of water and nutrient uptake at different growth stages of crops (Van Goor et al., 1988). Likewise, several studies were performed on the suitable nutrient concentration for the growing plant (Gomez-Lepe et al., 1974; Moustafa and Morgan, 1983; Larouche et al., 1989), however there are still differences in the recommended concentrations.

The minimum critical nutrient concentrations measured by Maruo et al. (2001 and 2004) and in our previous paper (Gonzales et al., 2010) were much lower than the concentrations commonly used in nutrient solution. In principle, the critical nutrient concentration of each element should not be different. There are two methods which can be used to measure the critical nutrient concentration in each element. One is the ascending method which we used in the previous study. In this method all treatments started with rainwater and different strengths of nutrient solution were supplemented according to the consumed solution. The absorption concentrations were measured under the concentration ascending condition. The other method is the descending method in which the culture starts from higher concentrations and supplemented only with rainwater. The critical nutrient concentration of each element can be measured according to the given nutrient conditions under the concentration descending method and can be estimated using the average concentration of the

nutrient solution which gave zero values in the absorption concentration.

Therefore, this study adopted the descending method to grasp more precisely the critical concentration for tomato plants. Results for the ascending and the descending methods were compared, and the differences in the values of the critical nutrient concentration of each element are discussed. In this study, three different seedling stages of tomato plants were used to further clarify the critical nutrient concentrations of each element more accurately.

MATERIALS AND METHODS

Preparation of Tomato plants

Tomato (*Solanum lycopersicum* L. cv. Reika; Sakata Seed Co. Japan) was used as the test plant in this experiment. Seeds were sown in cell trays filled with fine granulated rockwool on October 23, 2007. After emergence, the seedlings were irrigated once a day with a 1/4 strength nutrient solution (Enshi-formula). On November 28, 2008, when the seedlings had two true leaves, they were potted to 9.5 cm plastic pots filled with 300 mL fine granulated rockwool and grown with 1/2 strength nutrient solution until transplanting. Seedlings were transplanted to the NFT system when they reached at the stage of 4 true-leaves (December 8-14, 2008), 8 true-leaves (December 23-31 2008), and 11 true-leaves (January 3-14, 2008). Plants were spaced 15 cm apart and the flow rate was 2 L/h per plant. The air temperature in the plastic greenhouse was kept at above 12°C by a heating system and ventilation windows were opened when temperatures reached 25°C.

Experimental design

In both methods, i.e. ascending and descending nutrient concentration method, the system was principally the same but the volume of nutrient solution in the system was different. The total volume of the solution was reduced. A NFT system with, 180 cm long channels and a 1% slope were used. Total volume of the nutrient solution in the tank and culture bed was 6.5 L. Nutrient solution for each channel was controlled independently. Six beds were used, each bed contained 12 plants for a total of 72 plants. The details of the system used were described fully in our previous paper (Gonzales et al., 2010).

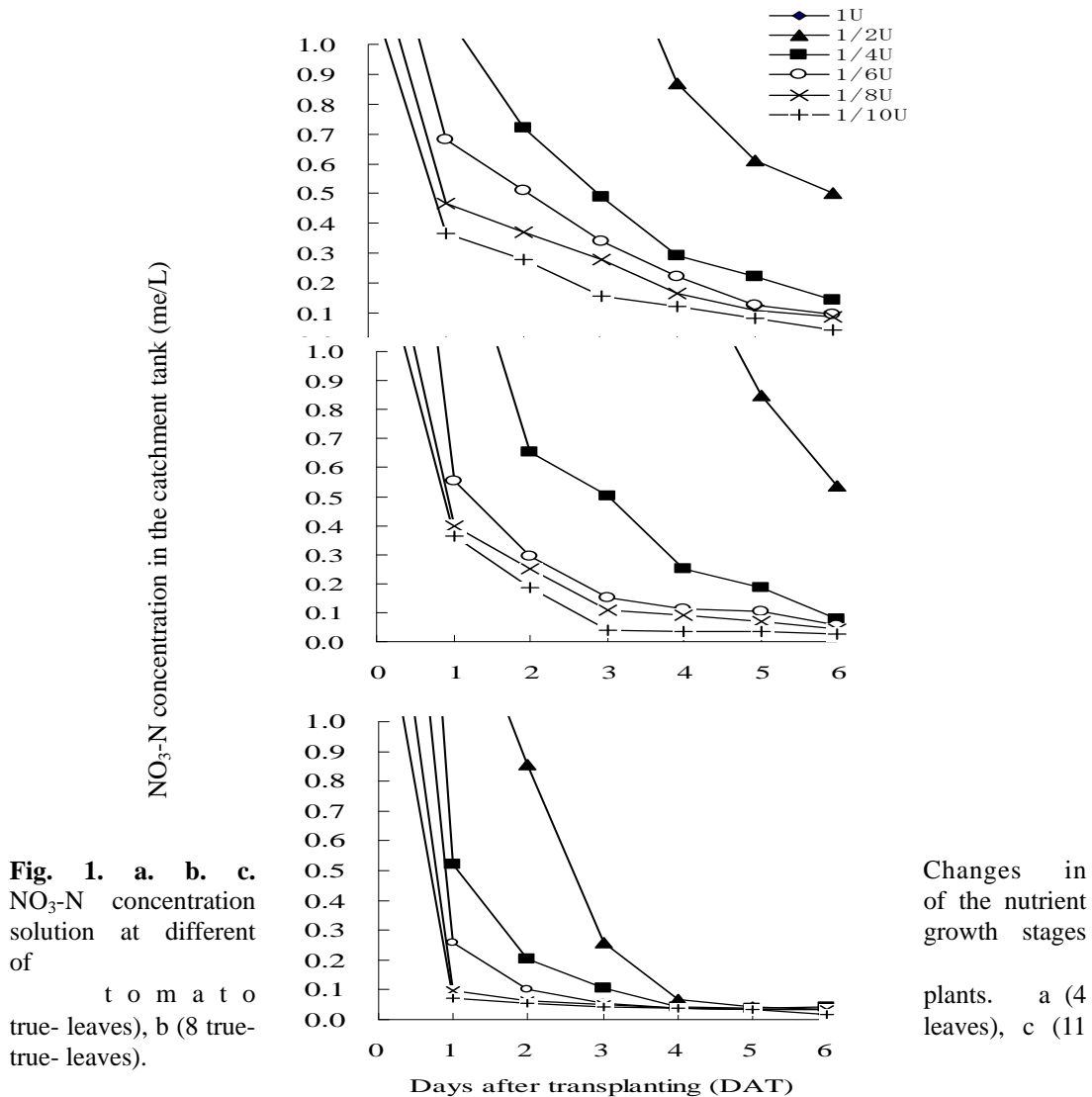
Seventy two seedlings in each stage (4 true- leaves, 8 true-leaves, and 11 true- leaves) were prepared. Roots and substrates in the pots were washed with sufficient rainwater until the EC value of the drained solution was similar with rainwater. We started six concentrations of nutrient solution according to the treatments (1, 1/2, 1/4, 1/6, 1/8, and 1/10 strength) and were supplemented with only rainwater which was kept in the header tank. The nutrient composition of the treatments and the method of the measurement of the solution were described in the previous paper.

RESULTS AND DISCUSSION

The changes in the nitrate concentration in the nutrient solution at different growth stages of tomato seedlings are shown in Figure 1. The highest concentration of the nutrient solution started from 16 me/L. The vertical axis of the graphs must be drawn full scale to 16 me/L, but the difference in the decreasing pattern can not be shown clearly because the concentration of each treatment decreased quickly. Therefore, the vertical axis was changed to 1 me/L in full scale. As a result, the data of the highest strength (1 U) treatment could not be plotted because it is out of range in the graph. The concentration of nutrient solution decreased rapidly right after the start of the experiment. Once the nutrient solution reached a certain concentration, the speed slowed down and continuously decreased until finally reaching a plateau, except for the treatments of smaller size plants. Although the duration needed to reach the plateau differed depending on the size of the plants, the final concentration was almost the same value.

For small plants, the nitrate concentrations decreased slower than the bigger plants (Fig. 1-a). Therefore, we can grasp the dynamic change more clearly. In treatment 1/10-1/6 strength, nitrate

concentrations decreased faster until the 1st day and the speed slowed down until the 3rd day. On the 3rd day it slowed down again and then continuously decreased until the end of the experiment. The decreasing pattern was similar to the other treatments but the slopes are not completely parallel. This means that there was a difference in the uptake rate of NO₃-N depending on the strength of NO₃-N solution. A continuous decrease suggested that the final concentration of nitrate did not reach the critical minimum uptake of this plant size within the experimental period.



The plants with the biggest size absorb NO₃-N faster than those of other sizes (Fig. 1-c). In treatment 1/10-1/4 strength, the plant quickly reached close to the plateau of the graph on the 1st day or 2nd day. Even at 1/2 strength, the concentration leveled off on the 5th day. In figure 1-b, the response of nitrate concentration in the plant was in the middle of the two plant sizes. As shown in the figure, the concentration at the flat points can be used to estimate the critical uptake concentration of tomato plants. The final concentration of the other elements on the 6th day, including the nitrate, is shown in Table 1.

Table 1. a. b. c. Final concentration of selected mineral elements remaining in the nutrient solution

six days after treatment using tomato plants at different growth stages. a (4 true-leaves), b (8 true-leaves), and c (11 true-leaves).

a. 4 true-leaves stage

Nutrient concentration left in the catchment tank (me/L) ^y					
Treatment (U) ^z	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	2.88	0.63	2.15	1.85	0.29
1/2 U	0.58	0.47	2.07	0.57	0.24
1/4 U	0.18	0.15	0.94	0.31	0.15
1/6 U	0.13	0.09	0.58	0.21	0.06
1/8 U	0.11	0.07	0.34	0.18	0.05
1/10 U	0.05	0.04	0.11	0.08	0.05

b. 8 true-leaves stage

Nutrient concentration left in the catchment tank (me/L) ^y					
Treatment (U) ^z	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	2.10	0.48	1.72	1.25	0.68
1/2 U	0.77	0.16	1.02	0.69	0.32
1/4 U	0.23	0.12	0.27	0.48	0.13
1/6 U	0.05	0.06	0.06	0.07	0.03
1/8 U	0.04	0.03	0.05	0.05	0.03
1/10 U	0.01	0.02	0.03	0.04	0.02

c. 11 true-leaves stage

Nutrient concentration left in the catchment tank (me/L) ^y					
Treatment (U) ^z	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	2.04	0.54	0.42	1.16	0.47
1/2 U	0.13	0.17	0.15	0.25	0.21
1/4 U	0.03	0.09	0.10	0.20	0.09
1/6 U	0.01	0.07	0.05	0.05	0.03
1/8 U	0.01	0.04	0.03	0.02	0.02
1/10 U	0.01	0.03	0.02	0.03	0.01

^zU (strength)

^ynutrient concentration left in the catchment tank was computed:
concentration of element in the tank (me/L) * total volume in the system / no. of plant

The changing patterns of the concentration of the other elements were similar to those of nitrate. Bigger plants absorbed the nutrient elements faster than the younger plants, the values of the final concentration became smaller than those of the other sized plants within the limited experimental period. Therefore, we can estimate the critical absorption concentration of each element using the values of bigger sized plants grown in lower nutrient concentration.

The uptake rates of each element from 4 to 6 days after treatment are shown in Table 2. In

each plant stage, treatments started with higher concentrations (1/2 or 1 strength), the uptake rate was higher compared to lower concentration treatments in which the values were already very low or nearly zero. The number of value zero increased according to the plant size. As there were differences in uptake rates and /or uptake concentrations by different plant sizes, the time needed for the uptake of each element was also different.

Therefore, the critical concentration of each nutrient can be estimated using the average concentration of the nutrient solution which gave zero values in the uptake rate. From these results, we can estimate the critical uptake concentration of each element using the values obtained from the bigger sized plants grown in the treatment using lower nutrient concentration as a starting point.

Table 2 a. b. c. Uptake rate of each element from 4th to 6th days after treatment. a (4 true-leaves), b (8 true-leaves) and c (11 true-leaves).

a. 4 true-leaves stage

Treatment (U) ^z	Uptake rate (me/plant/day) ^y				
	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	0.11	0.14	0.12	0.09	0.07
1/2 U	0.09	0.10	0.09	0.07	0.06
1/4 U	0.04	0.03	0.07	0.03	0.02
1/6 U	0.02	0.02	0.05	0.03	0.01
1/8 U	0.02	0.02	0.05	0.03	0.02
1/10 U	0.02	0.02	0.05	0.02	0.02

b. 8 true-leaves stage

Treatment (U) ^z	Uptake rate (me/plant/day) ^y				
	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	0.09	0.11	0.06	0.09	0.07
1/2 U	0.08	0.05	0.03	0.06	0.04
1/4 U	0.05	0.02	0.02	0.04	0.01
1/6 U	0.02	0.02	0.00	0.00	0.00
1/8 U	0.00	0.00	0.00	0.00	0.00
1/10 U	0.00	0.00	0.00	0.00	0.00

c. 11 true-leaves stage

Treatment (U) ^z	Uptake rate (me/plant/day) ^y				
	NO ₃ -N	PO ₄ -P	K	Ca	Mg
1 U	0.07	0.04	0.05	0.05	0.06
1/2 U	0.01	0.02	0.01	0.03	0.02
1/4 U	0.00	0.00	0.00	0.00	0.00
1/6 U	0.00	0.00	0.00	0.00	0.00
1/8 U	0.00	0.00	0.00	0.00	0.00
1/10 U	0.00	0.00	0.00	0.00	0.00

^zU (strength)

^yUptake rate was computed: amount of nutrient in the tank (me) [4th-6th day] / 12plants / 2 days.

The zero value means that the plants can no longer uptake the nutrient and the concentrations of the nutrient solution do not decrease further. Therefore, the critical concentration of each nutrient can be estimated using the average concentration of the nutrient solution which gave zero values in the uptake rate. From these results, we can estimate the critical uptake concentration of each element using the values obtained from the bigger sized plants grown in the treatment using lower nutrient concentration as a starting point.

The critical nutrient uptake concentrations of each element are compared between the results of the previous ascending method (Gonzalez et al 2010) and those of the present descending method (Table 3). In both methods, all the values are extremely low concentrations in comparison to common cultural sense. However, the values of $\text{PO}_4\text{-P}$, Ca and Mg in the present study were much lower than those of the previous result, while the values of $\text{NO}_3\text{-N}$ and K are nearly the same in both methods.

From these data, there might be two groups of ions. For the first group (i.e. $\text{PO}_4\text{-P}$, Ca and Mg), the nutrient uptake is easily influenced by the surrounding solution concentration under steady feeding condition. For the second group (i.e. $\text{NO}_3\text{-N}$ and K), the nutrient uptake is hardly affected by the surrounding solution concentration. It was suggested that the amount of nutrient solution per plant was influenced more strongly in the ascending method because it was about three times higher in the previous study. Therefore, the different values between the two methods can be minimized, if the amount of the solution per plant could be reduced properly. As sufficient amount of the solution was used in the commercial culture, a substantial critical uptake concentration of each ion for practical culture is considered to be near to those of the ascending method. However the value in the descending method is thought to be near to the real uptake ability of plants in view of plant physiology.

	Critical concentration (me/L)				
	$\text{NO}_3\text{-N}$	$\text{PO}_4\text{-P}$	K	Ca	Mg
Ascending concentration ^z	0.01 - 0.02	0.2	0.05 - 0.10	0.4 - 0.50	0.10
Descending concentration	0.01 - 0.04	0.02 0.09	- 0.02 - 0.10	0.02 - 0.20	0.01 - 0.09

^z Data from Gonzales et al. (2010).

Table 3. Comparison of the mineral element in the nutrient solution using ascending and descending nutrient concentration method.

CONCLUSION

The results from a previous study and the present results agree with the observation of Maruo and co-workers (2001, 2004) which demonstrated that the critical nutrient concentrations were much lower than those used in the commercial nutrient solution. The values of the critical nutrient concentration in the present study were lower than those found in Maruo's report for each element. The difference is due to an improved system used in this experiment which was able to obtain more accurate measurements for volume and the mineral element in the solution. The critical nutrient concentration in this study seems to be more precise and nearer to the real values. These findings suggest that cultivation using low nutrient concentration could be attained if each nutrient is properly supplied. Growers can not only save the use of fertilizer but by doing so, environmental impact can also be lowered.

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REFERENCES

- Gonzales, J. A., T. Maruo and Y. Shinohara. 2010. Measuring the uptake ability of tomato plants (*Solanum lycopersicum* L.var. Reiyō) by ascending nutrient concentration method. J. International Soc. Southeast Asian Agric. Sci. Vol. 16, No.1.
- Gomez-Lepe, B.E. and A. Ulrich. 1974. Influence of nitrate on tomato growth. J. Amer. Soc. Hort. Sci.99:45-49.
- Larouche, R., A. Gosselin and V. Louis-Philippe. 1989. Nitrogen concentration and Photosynthetic photon flux in greenhouse tomato production: I. Growth and development. J. Amer. Soc. Hort. Sci. 114:462-465.
- Maruo T., H. Hoshi, M. Hohjo, Y. Shinohara and T. Ito. 2001. Quantitative Nutrient Management at Low Concentration Condition in NFT Spinach Culture. Acta Hort. 548: 133-140.
- Maruo T., M. Takagaki and Y. Shinohara (2004). Critical Nutrient Concentration for Absorption of Some Vegetables. Acta Hort. 644: 493-499.
- Moustafa, A. T. and J. V. Morgan. 1983. Influence of solution concentration on growth, flower quality and nutrient uptake in spray chrysanthemum. Acta Hort.133:13-24.
- Van Os, E. A. 1995. Engineering and environmental aspects of soilless growing systems. Acta Hort. 396:25-32.
- Van Goor, B. J., A. de Jager and W. Voogt. 1988. Nutrient uptake by some horticultural crops during the growing period. ISOSC. Proc. pp. 163-176.

UTILIZATION OF BROILER LITTER PELLETS TO SUBSTITUTE MIXED FEED PELLETS IN FATTENING STEERS

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ABSTRACT

Thirty crossbred steers of Thai indigenous and Brahman cattle were used in an experiment for a 120 day period to determine effects of dietary broiler litter (BL) level on growth performance, carcass and meat quality, sensory grading, chemical composition of *Semitendinosus* (ST) and microbial contamination in carcass and beef. BL was provided as pellet. Six treatments substituted 0, 10.0, 20.0, 30.0, 40.0, and 50.0% BL pellet (total dietary level). At the end of the fattening period, all animals were slaughtered. After the experiment, productive performance in terms of weight gain, daily gain, dry matter (DM) rice straw intake, DM pellet diet intake, total DM feed intake and feed conversion ratio were found not to be influenced by diet ($P>0.05$). At slaughter, carcass and meat quality, sensory grading and chemical composition of ST did not differ significantly among treatments ($P>0.05$). All treatments of muscle, purge, and ground beef were culture-negative for *Escherichia coli*, *Salmonella* spp. and *Campylobacter* spp. These results indicated that 50.0% BL pellets may be used effectively as a feedstuff for cattle; beef cattle may consume properly handled pelleted BL without increasing the likelihood of carcass/meat contamination with pathogenic bacteria. However, a 15-day withdrawal time for exclusion of BL from diets of cattle before slaughter is suggested in order to avoid drug residue in meat.

Key words: feedstuff, manure, nutrient, pathogen, pelleting

INTRODUCTION

Rapid expansion within the broiler chicken (*Gallus gallus domesticus*) industry has resulted in critical environmental concerns in several areas of Thailand, due to excesses of substances entering groundwater (Suppadit, 2002). However, broiler litter (BL) has economic value associated with its nitrogenous and mineral components (Suppadit, 2005). Recycling BL as a ruminant feed could be beneficial for individual farmers and the broiler industry (Van Ryssen and Mavimbela, 1999; Suppadit *et al.*, 2002b; Jackson *et al.*, 2006). BL contains 12.0-35.0% crude protein (CP) (Davis *et al.*, 2002). Most of the CP are true protein and non-protein nitrogen (Pongpiachan, 1996), which ruminants can metabolize into essential amino acids for growth and maintenance (Guseva, 1993; Owoigbe *et al.*, 1998). BL also contains up to 22.5% digestible carbohydrates (Tanco, 1997). Given its potential as a source of nutrition, it is worthwhile to study how the litter can be processed and used as a feed source for cattle. This could reduce cattle feed costs, increase feed conversion efficiency and increase daily weight gain (Rossi *et al.*, 1999). However, fresh BL added directly to cattle feed can lead to unacceptable problems associated with worms, insects, parasites, palatability and odor (Suppadit *et al.*, 2002a). This has an adverse impact on the health of cattle and farm workers; in addition can be a source of odor pollution (Suppadit, 2009).

To overcome these problems, pelleting the BL is being proposed. Pelleting is a process used to eliminate the worm, insect, microorganism, noxious odor, antibiotic residue and hormone in BL (Suppadit, *et al.*, 2008). Furthermore, pelleting can support the feeding, handling, storing and transporting management (John *et al.*, 1996). Developing a process of converting a voluminous waste byproduct into a valuable, environmentally safe feed could be very beneficial (Suppadit, 2004). Therefore, the present experiment aims to access the effectiveness of BL pellet to substitute the mixed feed (MF) pellet for steer at ~18 months of age in order to indicate the differences in terms of productive performance, carcass and meat quality, sensory grading, chemical composition of *Semitendinosus* (ST) and microbial contamination in carcass and beef.

MATERIALS AND METHODS

Comparison of Productive Performance

Data on productive performance, carcass and meat quality, sensory grading, chemical composition of ST and microbial contamination were assessed in six treatments with five replications in a completely randomized design. The mixture of six ratios of BL pellets and MF pellets as follows: control (without BL pellets) (T₁), BL pellets mixed with MF pellets at substitution level of 10.0% : 90.0%, (w/w) (T₂), 20.0% : 80.0%, (w/w) (T₃), 30.0% : 70.0%, (w/w) (T₄), 40.0% : 60.0%, (w/w) (T₅) and 50.0% : 50.0%, (w/w) (T₆). Thirty steers were used in the experiment. The SAS program version 6.12 (SAS Institute, 1996) was used to calculate the analysis of variance and Duncan's New Multiple Range Test, to compare the experimental treatments.

Twenty broiler farms were randomly chosen from 200 farms, all located in Saraburi province, Thailand in November, 2008 that had broilers of the same age (45 days), duration, bedding materials (rice husks), area ratio (9 broilers per square meter) and open-housing system. From each broiler farm, 500 kilograms of BL was collected for the study. Collected BL were mixed together. Next, they were mixed with sugarcane molasses at the ratio (% BL: % sugarcane molasses; w/w) as 92.0: 8.00. After mixing, the BL were pelleted by Siriwan Model machine using the Suppadit and Panomsri (2009) method. The pelleting process produced heat up to 90.0 C and pellet size was 6.00 mm in diameter and 1.50-2.00 cm in length. After pelleting, BL pellets were sampled, crumbled and sent to the laboratory at Thailand Institute of Scientific and Technological Research for analysis of nutrient contents (AOAC, 2000).

The MF components were calculated for steer feedlot-type requirements according to National Research Council (1996) by the feed formulation software (FeedLive 1.00) (Live Informatics Co., Ltd., 2009). Next, MF were pelleted by Siriwan Model machine according to the Suppadit and Panomsri (2009) method. These were randomized, crumbled and analyzed for nutrient content at the laboratory at Thailand Institute of Scientific and Technological Research (AOAC, 2000).

From each 300-gram sample of the rice straw, BL pellet and MF pellet, the CP content was determined using the Kjeldahl method (6.25 x N) (model TLE 230, behr Labor-Technik, Dusseldorf, Germany). Dry matter (DM) (drying method; model Sharp IEC, Tokyo, Japan), crude fat (CF) (ether extraction method; Tecator Ltd., Haganas, Sweden), crude fiber (CFI) (ceramic fiber filter method; model Labconco, Missouri, USA), ash (dry ash method; ICP-AES, St. Pual, MN), calcium (Ca) (dry ash method; ICP-AES, St. Pual, MN) and phosphorus (P) (photometric method; model Hirama, Kanagawa, Japan) contents were analyzed according to the procedure described in the Association of Analytical Chemists manual. Gross energy (GE) content was determined in a Parr adiabatic oxygen bomb calorimeter (model RSBI, Dew Delhi, India) (AOAC, 2000).

Thirty crossbred steers of Thai indigenous and Brahman cattle obtained from local farmers

located in Nakhon Ratchasima province, Thailand with an average initial weight of 250 ± 10.0 kg at ~18 months of age were used. The steers were divided into six equal groups, containing five steers per group by random selection. Each steer was then allocated to an individual pen and remained in the pen for 120 days of the study. The steers were vaccinated (hemorrhagic septicemia and foot and mouth disease) and dewormed (ivermectin drug) by the veterinarian, adapted to the environment and conditions and fed the experimental feed for 20 days prior to the trial. The steers were fed the BL pellets and MF pellets in each treatment at 1.00% of initial body weight each morning. They were weighed every 15 days and the ration was adjusted to 1.00% of the new body weight. The rice straw was provided *ad libitum* daily in the afternoon. Prior to providing rice straw, all leftover feed pellets were weighed and recorded. The leftover rice straw was weighed and recorded the next morning. The production efficiency of the growing cattle including weight gain, daily gain, DM rice straw intake, DM pellet diet intake, total DM feed intake and feed conversion ratio was calculated and analyzed.

Measurement of Carcass and Meat Quality

After the experiment, the steers in each treatment were slaughtered randomly within three days at the Duangkamol slaughterhouse, Nakhon Ratchasima province, Thailand, following procedures outlined in Allingham *et al.* (1998). All experimental procedures were carried out following the animal welfare standards of Department of Livestock Development, Ministry of Agriculture and Cooperatives, Royal Thai Government. The carcass weight and fat depth at the P8 site for each side was measured before chilling. The left side of each carcass was electrically stimulated with a low voltage application (2.00 mA; model LF 196, WTW, Weilheim, Germany) for 40.0 s immediately after exsanguinations, and chilled according to conventional abattoir procedures. The ST was removed from the left side of each carcass at 48 hr *post mortem*, weighed, blast frozen and stored at -20.0°C until required for analysis.

The tenderness of cooked ST samples was determined objectively by way of measurements of a modified Warner-Bratz shear (model 5565, Instron Co., Ltd., UK), compression (CO) and adhesion strength (ADH), following the established methods of Bouton *et al.* (1977). The parameters measured from shear force deformation curves were (i) peak force (PF), (ii) initial yield (IY) and (iii) the peak force minus initial yield (PFIY) (Bouton *et al.*, 1975; Harris and Shorthose, 1988). All measurements were made on samples taken from cooked (70.0°C for 1 hr) 250 g blocks cut from the proximal section of the ST. Shear force was also measured on pressure-heat treated samples (60.0°C and 1,500 psi for 1 hr prior to the normal shear protocol). Samples taken from the distal section of the ST were used for measurement of sarcomere length (Bouton *et al.*, 1973), ultimate pH (pH_u : pH meter model no. 250A, Orion Research Inc., USA) and meat surface color (L, 'a' and 'b' values; Minolta CR-300, Osaka, Japan). Samples were allowed to bloom for 1 hr at 4.00°C prior to the color measurements. Cooking loss was also measured.

For sensory evaluation, a test panel was selected from a number of Siriwan Co., Ltd. Staff, Saraburi province, who had undergone sensory evaluation training following the methods of Viriyajare (1992). Grilled 2.50-cm slices of ST were cut into pieces of $1.30 \times 1.30 \times 1.90$ cm and served warm. Panelists were asked to grade samples for tenderness, juiciness, flavor and overall acceptability by a scale ranging from 1 (low) to 9 (high). Samples were served subsequently in a randomized order with respect to group and animal. The 30 samples (from 30 animals) were tested by 6 persons each.

Samples of the ST were minced and analyzed in duplicate for moisture, fat and protein contents (Kjeldahl; $6.25 \times \text{N}$) according to AOAC (2000). Cholesterol concentrations were determined in samples after extraction of the fat (Folch *et al.*, 1957) and its saponification (Abell *et al.*, 1951). In the residual extract cholesterol was measured colorimetrically according to Jung *et al.* (1975).

Isolation of Microbial Contamination

The comparison of microbial contamination followed the procedures outlined by Davis *et al.* (2002). After steers were slaughtered carcass quality was compared. The right sides of carcass were thoroughly washed with cool (8.00 C) water. The right side of each carcass received a 2.00% lactic acid rinse to simulate a post-harvest sanitation step possibly employed by small-scale meat processors. Muscle and fat samples from the neck and bung areas (incision samples) of the carcass were taken from right side, placed in individually identified bags (Whirl-Pak), and immediately cultured for *Escherichia coli* (*E. coli*), *Salmonella* spp. and *Campylobacter* spp. Approximately 5.00 kg of pre-rigor beef trimmings from the external surfaces of the round, loin, rib, chuck, flank, plate and brisket were removed from this side, packaged in individual sterile plastic bags and refrigerated at 2.00 C. After six days of refrigerated storage, samples of purge (moisture that collects in the bottom of packages of meat) were collected for microbial analyses, and trimmings were then ground twice through a grinder (model 310, Hobart, Troy, OH) with a 3.20-mm plate. All parts and equipment were washed with hot (79.0 C) water and commercially available detergent (Ecolabs, St. Paul, MN), and sanitized with a 4.00% chlorine solution between sample grindings. Random samples of ground beef, as well as purge samples, were subsequently cultured for the presence of *E. coli*, *Salmonella* spp. and *Campylobacter* spp.

The isolation of *E. coli* from purge and meat samples followed the procedure outlined by Hitchins *et al.* (1998). Approximately 25.0 g of meat (either neck and bung incision samples or ground beef) were placed in Stomacher bags (Seward, London, UK) with 225 ml of buffered peptone water, stomached for 1 min in a Model 400 Lab Stomacher (Seward, London, UK), and subsequently incubated for 6 h at 37.0 C. One milliliter of stomached solution or purge was placed into an 8.00-ml tube containing lauryl sulfate tryptose broth with 4-methylumbelliferyl- β -D-glucuronide (MUG, REMEL, Lenexa, KS), and incubated at 37.0 C for 24 h. After incubation, samples were streaked for isolation on MacConkey agar (MAC, REMEL, Lenexa, KS) and MacConkey agar with sorbitol (SMAC, REMEL, Lenexa, KS), and incubated for 24 h at 37.0 C. Colony morphology was examined, and typical round, light-colored, smooth colonies were picked from SMAC plates and tested for indole production with Kovacs reagent (REMEL, Lenexa, KS). Indole positive colonies were selected from SMAC plates and transferred to tubes with lauryl sulfate tryptose broth containing 4-methylumbelliferyl- β -D-glucuronide (MUG, REMEL, Lenexa, KS) and a Durham tube. Tubes were observed for gas production and phosphorescence after 24 h of incubation at 37.0 C. Gas positive-phosphorescence negative isolates were agglutinated with O157 antisera (REMEL, Lenexa, KS), and O157-positive isolates were streaked on blood agar (REMEL, Lenexa, KS) and incubated at 37.0 C for 24 h. One colony was picked from the blood plate and tested for agglutination with H7 antisera (REMEL, Lenexa, KS). The relative specificity of the serotyping procedures was greater than 99.0%.

Procedures for the isolation of *Salmonella* spp. followed those outlined by Andrews and Hammack (1998). Briefly, 25.0 g of meat were stomached with 225 ml of buffered peptone water as described previously (*E. coli* isolation). One millimeter of solution (from stomached/incubated meat samples) or purge was placed into a 10.0-ml tube of tetrathionate broth (REMEL, Lenexa, KS) for *Salmonella* enrichment and incubated at 42.0 C for 24 h. After incubation, samples were streaked for isolation on brilliant green agar with novobiocin and XLT-4 agar (REMEL, Lenexa, KS). Colony morphology was compared, and three typical round, black ("bull's-eye") colonies were selected from XLT-4 plates and stab-streaked into Kingler's iron agar slants (Edge Biologicals, Memphis, TN). Then, H₂S-positive isolates from Kingler's iron agar slants were selected and re-streaked on MacConkey agar and agglutinated with *Salmonella* O polyvalent (A-E, Vi) antisera (REMEL, Lenexa, KS). Isolates, which were agglutinated with the *Salmonella* O polyvalent antisera, were further agglutinated with *Salmonella* group B and D antisera (REMEL, Lenexa, KS). Again, the relative specificity of *Salmonella* isolation was greater than 99.0%.

The isolation of *Campylobacter* spp. from purge and meat samples followed the procedure

by Zweifel *et al.* (2004). Approximately 25.0 g of meat were inoculated into 250 ml of selective enrichment broth (*Brucella* bouillon [(Difco 0495-17-3) with *Campylobacter* growth supplement (Oxoid SR84) and Skirrow *Campylobacter*-selective supplement (Oxoid SR69), Oxoid]) and incubated at 42.0°C for 24 h under microaerobic conditions (5% O₂, 10% CO₂, 10% N₂) provided by commercial gas packs (BBL 271045). The enrichment samples were streaked onto selective agar media (*Brucella* agar [(Difco 0964-17-5) with 6.00% horse blood (Oxoid SR48) and Butzler *Campylobacter*-selective supplement (Oxoid SR8) and incubated at 42.0 C for 36 h under microaerobic conditions. Suspect colonies were identified by typical morphology, gram-negative stain, catalase and oxidase reactions, characteristics motion, hippurate hydrolysis and intrinsic resistance to cephalotin. The relative specificity of *Campylobacter* isolation was greater than 99.0%.

RESULTS AND DISCUSSION

The chemical composition of rice straw, MF pellet and BL pellet, including the dietary ingredients of MF are shown in Table 1.

Table 1. Chemical composition of rice straw, MF pellet and BL pellet.

Feed composition (DM basis)	Rice straw	MF pellet ¹	BL pellet
DM (%)	89.1	89.4	84.6
Moisture (%)	10.9	10.6	15.4
CP (%)	4.20	18.5	26.0
CF (%)	1.45	6.50	1.10
CFI (%)	34.7	15.8	15.4
Ash (%)	16.6	9.10	19.9
Ca (%)	0.220	1.33	3.72
P (%)	0.0840	0.690	1.68
GE (kcal/g)	3.96	4.26	3.99

Composition of MF pellet: cassava meal, 42.4%; rice bran, 12.4%; palm kernel meal, 3.00%; coconut meal, 24.2%; bone meal, 2.00%; salt, 1.00%; cattle premix, 0.500%²; ipil-ipil meal, 12.5%; urea, 2.00%.

² Cattle premix composition per kg: vitamin: A 2,400,000 IU, D₃ 500,000 IU, E 500 IU, B₁₂ 2.00 mg; mineral: Mn, 8.00 g; Zn, 8.00 g; Fe, 10.0 g; Cu, 2.00 g; Co, 400 mg; I, 400 mg; Mg, 26.4 g; Se, 40.0 mg; food preservative, 40.0 mg; carriers, add wholly, 1.00 kg.

In general, moisture content of BL is not an important measure of nutrient value (Suppadit, 2000). The CP in BL is usually a very inexpensive source of protein for cattle. Most of the CP is true protein and non-protein nitrogen (Pongpiachan, 1996). The non-protein nitrogen is mostly uric acid that is excreted by poultry (Biely *et al.*, 1980). Young or steer cattle do not utilize non-protein nitrogen as readily as more mature beef cattle (Davis *et al.*, 2002). The CF and GE of BL is fairly low in comparison to grain (Ruffin and McCaskey, 1991). The fiber in BL cannot effectively meet the cattle's need for fiber, because cattle also need long roughage to properly maintain their digestive systems (Boyles and Golden, 2000). Ash content is one of the important measures of a quality of BL because ash contents of over 28.0% are too high and should not be fed to beef cattle (Davis *et al.*, 2002). The BL pellet analyzed contained an average of 19.9% ash. BL is an excellent source of Ca and P. But the excess minerals are not a problem except under specific conditions (Boyles and Golden, 2000).

The addition of BL pellet in the steer diet did not significantly affect the weight gain, daily

gain, DM rice straw intake, DM pellet diet intake, total DM feed intake and feed conversion ratio ($P>0.05$) (Table 2) due to the cattle having a unique digestive system that enables them to use a number of non-conventional feedstuffs having high CF (cellulose and hemicelluloses) such as BL (Tancho, 1997). Cattle have many microorganisms in the digestive system that can digest the true protein and non-protein nitrogen compounds (Pongpiachan, 1996). Microorganisms will use protein in nitrogen form to expand and enrich their cells. When microorganisms move into the digestive system, they will be digested by gastric juices in the real stomach. Cattle can get essential and non-essential amino acids from the cells of microorganisms in this way (Ruffin and McCaskey, 1991). Suppadit *et al.* (2002b) found similar results when they compare a control feed which diets containing 15.0 and 30.0% BL. Mekasha *et al.* (2004) and Jackson *et al.* (2006) found that organic matter, CP, acid detergent fiber and neutral detergent fiber digestibilities were not affected by the addition of 40.0 -60.0% BL in the goat diet. It is possible that low residues of growth promoters, unidentified growth factors and drugs support a positive impact on growth rate and feed efficiency (Webb and Fontenot, 1975). Lactic acid and ethanol-producing bacteria, that occur naturally in BL, produces lactic acid and acetic acid. The two acids produce a sour smell and taste which cattle favor (Suppadit *et al.*, 2002a) although, during the pelleting process, heat was produced from pressure at the BL (~90.0 C) (Suppadit and Panomsri, 2009). The nutrient content was affected slightly by the heat and pressure (McCaskey *et al.* 1989). The nitrogen becomes insoluble (bound), the amount of bound nitrogen increases, and the DM digestibility decreases which cattle can digest less easily (McCaskey and Martin, 1988). Besides, heat from the pelleting process destroyed some useful microorganisms and lactic acid (Wenger, 1997). However the high temperature from the pelleting process over a short period of time gave no adverse influence on nutrient content of BL pellet clearly (Suppadit *et al.*, 2008).

Table 2. Performances of cattle fattened with MF pellets substituted by various ratios of BL pellets.
¹ Standard error of the mean.

Performance	Percent of Substitution						SEM ¹	P - value
	0 (T ₁)	10 (T ₂)	20 (T ₃)	30 (T ₄)	40 (T ₅)	50 (T ₆)		
No. of steers (head)	5	5	5	5	5	5	-	-
Initial weight/head (kg)	252	251	253	250	251	252	6.10	0.400
Final weight/head (kg)	313	310	313	313	314	313	10.8	0.320
Weight gain/head (kg)	61.0	59.0	60.0	63.0	63.0	61.0	2.10	0.180
Daily gain (kg/head/day)	0.508	0.492	0.500	0.525	0.525	0.508	0.01	0.660
DM rice straw intake/head/day (kg)	4.12	4.12	4.13	4.16	4.18	4.15	0.11	0.280
DM pellet diet intake/head/day (kg)	2.32	2.32	2.33	2.35	2.36	2.30	0.045	0.910
Total DM feed intake/head/day (kg)	6.44	6.44	6.46	6.51	6.54	6.45	0.074	0.340
Feed conversion ratio (kg DM of feed/kg weight gain)	12.7	13.1	12.9	12.4	12.4	12.7	0.080	0.850

Carcass qualities are summarized in Table 3. Mean final live weight, hot carcass weight, dressing, ST weight, ST as a percent of side and P8 fat depth of six treatments were not significantly different ($P>0.05$). Meat color (L^* , a^* and b^*) of ST, cooking loss, pH_u and sarcomere length of samples were not significantly different ($P>0.05$). Including shear PF and PF1Y values gave no

significant difference ($P>0.05$). After pressure-heat treatment, shear PF and PFIY values of ST were not significantly different ($P>0.05$) as pre-treatment results. ADH values showed a similar trend with CO values and were not significantly different ($P>0.05$). The ST muscles from the steers of six treatments were all acceptably tender as determined by PF shear. PF values which ranged from 4.50-4.65 kg, a shear force below the value that Thai consumer studies have shown that consumers consider tough (Jaturasitha *et al.*, 2009). In the USA, Huffman *et al.* (1996) have shown that a shear force below 4.60 kg was required to ensure high levels of consumer acceptance (98.0%).

All grilled 2.50-cm slices of ST in each treatment were similarly accepted by consumers in all palatability attributes (tenderness, juiciness, flavor, overall acceptability) and differences in consumer acceptance, based upon palatability attributes were not observed ($P>0.05$) (Table 4). Chemical compositions of ST did not differ due to treatment in moisture, protein, fat and cholesterol ($P>0.05$).

Table 3. Carcass and meat quality of cattle fattened with MF pellets substituted by various ratios of BL pellets.

Items	Percent of Substitution						SEM ³	P-value
	0 (T ₁)	10 (T ₂)	20 (T ₃)	30 (T ₄)	40 (T ₅)	50 (T ₆)		
Carcass quality								
Live weight (kg)	313	310	312	313	314	313	4.80	0.32
Hot carcass weight (kg)	171	170	172	172	174	170	1.70	0.88
Dressing (%)	55.2	54.1	54.4	55.5	55.6	54.0	0.200	0.24
ST weight (kg)	1.98	1.98	1.99	2.00	2.02	2.01	0.010	0.95
ST as a percent of side (%)	0.490	0.460	0.460	0.470	0.490	0.480	0.020	0.01
P8 fat depth (mm)	5.50	5.55	5.62	5.70	5.80	5.70	0.020	0.70
Meat quality								
Meat color of ST								
Lightness (<i>L</i> *)	46.0	46.5	47.0	47.0	47.2	45.8	0.0500	0.23
Redness (<i>a</i> *)	20.5	20.6	20.6	20.9	21.0	20.2	0.0700	0.87
Yellowness (<i>b</i> *)	14.7	14.7	15.0	15.1	15.1	14.8	0.0400	0.64
Cooking loss (%)	22.4	22.4	22.5	22.8	22.8	22.5	0.0900	0.84
pH _u	5.50	5.50	5.50	5.60	5.60	5.60	0.0200	0.10
Sarcomere length (μm)	2.10	2.10	2.10	2.10	2.20	2.10	0.0500	0.28
PF ¹ (kg)	4.50	4.50	4.60	4.65	4.65	4.60	0.100	0.53
PFIY ² (kg)	1.30	1.40	1.40	1.50	1.50	1.45	0.120	0.45
PF (pressure heated samples) (kg)	4.70	4.75	4.80	4.90	4.95	4.80	0.200	0.89
PFIY (pressure heated samples) (kg)	2.50	2.55	2.55	2.60	2.60	2.60	0.200	0.90
CO (kg)	2.30	2.40	2.50	2.50	2.50	2.45	0.100	0.56
ADH (kg/cm)	0.600	0.610	0.650	0.670	0.670	0.640	0.0400	0.24

¹ Shear PF.

² Numerical difference between shear PF and IY.

³ Standard error of the mean.

Carcass and meat quality, sensory grading and chemical composition of ST of cattle fattened with MF pellets substituted by various ratios of BL pellets were not distinguished from the control treatment in the present study, which is consistent with previous reports (Gomez *et al.*, 1995; Jeremiah and Gibson, 2003). Although fat content tended to decrease with increasing BL pellet in diet there was no significant difference ($P>0.05$). Addition of BL pellet in feedlot diets for cattle does not decrease the carcass yield and meat quality of cattle and without compromising either palatability or consumer acceptance.

Table 4. Sensory grading and chemical composition of ST of cattle fattened with MF pellets

Items	Percent of Substitution						SEM ₂	P-value
	0 (T ₁)	10 (T ₂)	20 (T ₃)	30 (T ₄)	40 (T ₅)	50 (T ₆)		
Sensory grading (1-9)								
Tenderness score ¹	5.88	5.90	5.90	5.92	5.94	5.92	0.013	0.078
Juiciness score ¹	5.55	5.60	5.68	5.90	5.90	5.70	0.051	0.20
Flavor score ¹	6.65	6.60	6.64	6.65	6.64	6.64	0.016	0.45
Overall acceptability score ¹	6.44	6.48	6.45	6.44	6.40	6.50	0.014	0.30
Chemical composition (g/100 g meat)								
Moisture	72.4	72.5	72.4	72.0	72.3	72.6	0.060	0.12
Protein	22.6	22.6	22.8	22.9	23.0	22.7	0.040	0.19
Fat	3.40	3.39	3.35	3.33	3.32	3.30	0.024	0.10
Cholesterol	42.4	42.5	42.9	43.1	42.6	42.0	0.300	0.24

substituted by various ratios of BL pellets.

¹ 1= low, 5 = moderate and 9 =high.

² Standard error of the mean.

In the experiment, no *E. coli*, *Salmonella* spp. and *Campylobacter* spp. were detected from neck and bung incision samples, purge samples and ground beef samples (Table 5). Results from this experiment support the contention that beef cattle, especially those destined for ground beef production, may be fed BL pellet without substantially increasing the likelihood of carcass and meat, contamination with *E. coli*, *Salmonella* spp. and *Campylobacter* spp. Result of this study concur with those from the studies of Martin *et al.* (1998) and Davis *et al.* (2002), although fresh BL showed harboring several pathogenic bacteria (Kelley *et al.*, 1998; Davis *et al.*, 2002; Suppadit *et al.*, 2002a; Suppadit *et al.*, 2008). However, within a short time period of pelleting the BL, the temperature of pelleting process reached 90.0 C, thus, producing an inhospitable environment for *E. coli*, *Salmonella* spp. and *Campylobacter* spp. survival. Suppadit (2005) found that, when BL inoculated with pathogenic bacteria was pelleted, heat generated within the chamber was sufficient to kill almost all bacteria.

Suppadit *et al.* (2008) reported that there were no parasites (roundworms, flatworms, tapeworms and flukes) and *Salmonella* spp. detected in the BL after pelleting process. Kelley *et al.* (1998) also showed that the heat reached 51.0 C in BL reduced *Salmonella* spp., *Listeria monocytogenes*, *Staphylococcus aureus*, and *Clostridium perfringens* well below their respective detection limits, and *E. coli* was non-culturable in the BL. However, McCaskey *et al.* (1997) reported that BL is not normally used in diets for cattle destined for slaughter and feeding the BL within 15

days of slaughter should be stopped so as to avoid potential drug residues.

Table 5. Frequency of isolation of *E. coli*, *Salmonella* spp. and *Campylobacter* spp. from carcasses and ground beef of cattle fattened with MF pellets substituted by various ratios of BL pellets.

Pathogens	Sources	Percent of substitution					
		0 (T ₁)	10 (T ₂)	20 (T ₃)	30 (T ₄)	40 (T ₅)	50 (T ₆)
<i>E. coli</i>	<i>Cold water-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5
	<i>Lactic acid-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5
<i>Salmonella</i> spp.	<i>Cold water-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5
	<i>Lactic acid-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5
<i>Campylobacter</i> spp.	<i>Cold water-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5
	<i>Lactic acid-rinsed (# positive/# cultured)</i>						
	Neck	0/5	0/5	0/5	0/5	0/5	0/5
	Bung	0/5	0/5	0/5	0/5	0/5	0/5
	Trim purge	0/5	0/5	0/5	0/5	0/5	0/5
	Ground beef	0/5	0/5	0/5	0/5	0/5	0/5

CONCLUSIONS

Growth, feed efficiency, carcass and meat quality, sensory grading and chemical compositions in ST are similar for fattening steers fed diets containing 0, 10.0, 20.0, 30.0, 40.0 or 50.0% BL pellet. Beef cattle fed 50.0% in the diet through pelleting process did not show incidence of *E. coli*, *Salmonella* spp. and *Campylobacter* spp. on beef carcasses, beef trimmings, and in ground beef. The pelleting process contributes to the development of an environment not optimal for the survival and reproduction of pathogenic bacteria. Therefore, the BL diets tested in this study provided an adequate source of digestible nutrient and may be effective as a feedstuff for cattle feedlot diets. However, the recommended 15-day withdrawal period for exclusion of BL from diet of cattle destined for market provides an additional safety measure.

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REFERENCES

- Abell, L.L., Brodie, B.B. and F.E. Kendall. 1951. A simplified method for the estimation of total serum cholesterol in serum and demonstration of its specificity. *J Biol Chem.* 195 : 357-366.
- Allingham, P.G., Harper, G.S. and R.A. Hunter. 1998. Effect of growth path on the tenderness of the *semitendinosus* muscle of Brahman-cross steers. *Meat Sci.* 48 : 65-73.
- Andrews, W.H. and T.S. Hammack. 1998. *Salmonella*. In: FDA Bacteriological Analytical Manual, 8 ed., Revision A. AOAC International, Gaithersburg, MD. pp.5.01-5.20.
- AOAC. 2000. Official Methods of Analysis. 17th (Ed.). Association of Official Analytical Chemists, Gaithersburg, MD. 2214 p.
- Biely, J.W., Kitts, D. and N.R. Bully. 1980. Dried poultry waste as a feed ingredient. *World Anim Rev.* 34 : 35-42.
- Bouton, P.E., Fisher, A.L., Harris, P.V. and R.I. Baxter. 1973. A comparison of the effects of some post-slaughter treatments on the tenderness of beef. *J Food Technol.* 8 : 39-49.
- Bouton, P.E., Ford, A.L., Harris, P.V., MacFarlane, J.J. and J.M. O'Shea. 1977. Pressure heat treatment of post-rigor muscle : Effects on tenderness. *J Food Sci.* 42 : 132-135.
- Bouton, P.E., Harris, P.V. and W.R. Shorthose. 1975. Changes in shear parameters of meat associated with structural changes produced by ageing, cooking and myofibrillar contraction. *J Food Sci.* 40 : 1122-1126.
- Boyles, S. and P. Golden. 2000. Feeding Broiler Litter to Beef Cattle. OSU Extension, Coshocton County Agriculture & Natural Resources. Oklahoma State University, Oklahoma, USA.
- Davis, J.R., Apple, J.K., Hellwig, D.H., Kegley, E.B. and F.W. Pohlman. 2002. The effects of feeding broiler litter on microbial contamination of beef carcasses. *Bioresource and Technol.* 84 :

191-196.

- Folch, J., Lees, M. and G.H.S. Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissue. *J Biol Chem.* 226 : 497-509.
- Gomez, C., Sugronez, R. and V.A. Vera. 1995. Recycling chicken litter for ruminant feed II. Nutritional experiments. *Adv Alimen Major Anim.* 35 : 3-7.
- Guseva, K. 1993. Diced poultry manure as a feed supplement. *Ptitsevodstvo.* 2 : 31-31.
- Harris, P.V. and W.R. Shorthose. 1988. Meat texture. *In: Development of Meat Science* 4. Elsevier Applied Science, London, England. pp.245-296.
- Hitchins, A.D., Feng, P., Watkins, W.D., Rippey, S.R. and L.A. Chandler. 1998. *E. coli* and the coliform bacteria. *In: FDA Bacteriological Analytical Manual*, 8 ed., Revision A. AOAC International, Gaithersburg, MD. pp.4.21-4.29.
- Huffman, K.L., Miller, M.F., Hoover, L.C., Wu, C.K., Brittin, H.C. and C.B. Ramsey. 1996. Effect of beef tenderness on consumer satisfaction with steaks consumed in the home and the restaurant. *J Anim Sci.* 74 : 91-97.
- Jackson, D.J., Rude, B.J., Karanja, K.K. and N.C. Whitley. 2006. Utilization of poultry litter pellets in meat goat diets. *Small Rumin Res.* 66 : 278-281.
- Jaturasitha, S., Norkeaw, R., Vearasilp, T., Wicke, M. and M. Kreuzer. 2009. Carcass and meat quality of Thai native cattle fattened on Guinea grass (*Panicum maxima*) or Guinea grass-legume (*Stylosanthes guianensis*) pastures. *Meat Sci.* 81 : 155-162.
- Jeremiah, L.E. and L.L. Gibson. 2003. The effect of dietary poultry litter supplementation on beef chemical, cooking, and palatability properties and consumer acceptance. *Food Res Int.* 36 : 943-948.
- John, N.M., Adeoye, G.O. and M.K.C. Sridhar. 1996. Compost pelletization eases end use in Nigeria. *Biocycle.* 37 : 55-56.
- Jung, D.H., Biggs, H.G. and W.R. Moorehead. 1975. Colorimetry of serum cholesterol with use of ferric acetate, uranyl acetate and ferrous sulfate/sulfuric acid reagents. *Clin Chem.* 21 : 1526-1530.
- Kelly, T.R., Pancorbo, O.C., Merka, W.C. and H.M. Barnhart. 1998. Antibiotic resistance of bacterial litter isolates. *Poultry Sci.* 77 : 243-247.
- Live Informatics Company. 2009. The feed formulation software by live informatics (internet edn). [cited 3 January 2009]. Available from URL: <http://www.liveinformatics.com/eng/feedlive/>
- Martin, S.A., McCann, M.A. and W.D. Waltman. 1998. Microbiological survey of Georgia poultry litter. *J Appl Poultry Res.* 7 : 90-98.
- McCaskey, T.A. and J.B. Martin. 1988. Evaluation of a process for improved quality and microbial safety of broiler litter. *Biol Waste.* 25 : 209-218.
- McCaskey, T.A., Sandhu, K.S., Das, A.M., George, M.C. and A.H. Stephenson. 1997. Effect of deep

- McCaskey, T.A., Stephenson, A.H. and B.G. Ruffin. 1989. Good management necessary to cash in broiler litter resource. *Agr Res.* 36 : 14.
- Mekasha, Y., Merkel, R.C., Goetsch, A.L., Sahl, T. and K. Tesfai. 2004. Effects of method of offering broiler litter and level of prairie hay intake on growth of Boer x Spanish wethers. *Small Rumin Res.* 55 : 123-133.
- National Research Council. 1996. Nutrient Requirements of Beef Cattle. 7th (Ed.). National Academy Press, Washington, DC, USA.
- Owoigbe, G.A., Bartko, P., Mudron, P., Nagy, O., Vajda, V., Paulikova, I. and R. Link. 1998. The effect of fermented broiler poultry litter on the ruminal environment in bulls. *Folia-Veterinaria.* 42 : 53-58.
- Pongpiachan, P. 1996. Feed Production. Department of Animal Husbandry, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand. 294 p.
- Rossi, J.E., Loerch, S.C. and M.L. Borger. 1999. Poultry manure as a supplement in high concentrate diets limit-fed to beef cows. *Prof Anim Sci.* 15 : 258-263.
- Ruffin, B.G. and T.A. McCaskey. 1991. Feeding Broiler Litter to Beef Cattle. Circular ANR-557, Alabama Cooperative Extension Service, Auburn, AL 36848, USA.
- SAS Institute. 1996. SAS User's Guide: Statistics. SAS Institute, North Carolina, USA. 956 p.
- Suppadit, T. 2000. Poultry waste pelleting : Villager Technology. *Livest Prod J.* 18 : 51-54.
- Suppadit, T. 2002. The recycle of broiler litter as a feed ingredient for cattle to reduce environmental pollution I. Impact of broiler litter on environmental states and community health. *Thai Environ Consult J.* 6 : 12-17.
- Suppadit, T. 2004. Capitalizing on chicken litter. *Feed & Livest.* 1 : 24-25.
- Suppadit, T. 2005. The recycle of broiler litter as a feed ingredient for cattle to reduce environmental pollution III. Safe use of broiler litter as a feed ingredient source. *Thai Environ Consult J.* 9 : 22-34.
- Suppadit, T. 2009. Environmental Health Management in Livestock Sector. 2nd. Tippanate Printing Press, Bangkok, Thailand. 783 p.
- Suppadit, T. and S. Panomsri. 2009. Broiler litter pelleting using Siriwan model machine. *KMITL Sci Tech J.* (Submitted)
- Suppadit, T., Kitikoon, V., Key, J.P., Chaicumpa, W., Pongpiachan, P. and S. Jaturasitha. 2002a. Utilization of broiler litter as a source of crude protein for cattle I. The nutritional effect of different feed modification. *Thai J Agric Sci.* 35 : 427-436.
- Suppadit, T., Kitikoon, V., Key, J.P., Chaicumpa, W., Pongpiachan, P. and S. Jaturasitha. 2002b. Utilization of broiler litter as a source of crude protein for cattle II. Productive performance aspects. *Thai J Agric Sci.* 35 : 437-449.
- Suppadit, T., Parukatpichai, K. and N. Talakhun. 2008. Dietary quality and safety in the reuse of

broiler litter as a feed ingredient through fermentation and pelleting. *J Appl Anim Res.* 33 : 109-112.

Tancho, A. 1997. Poultry Production. Department of Animal Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, 507 p.

Van Ryssen, J.B. and D.T. Mavimbela. 1999. Broiler litter as a source of selenium for sheep. *Anim Feed Sci Technol.* 78 : 263-272.

Viriyajare, P. 1992. Experiment and Analysis of Organoleptic Test. Department of Food Science and Technology, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand. 275 p.

Webb, K.E. and J.P. Fontenot. 1975. Medicinal drug residues in broiler litter and tissues from cattle fed litter. *J Anim Sci.* 41 : 1212-1217.

Wenger, E. 1997. Pelleted feed production. *Kraftfutter.* 11 : 467-475.

Zweifel, C., Zychowska, M.A. and R. Stephan. 2004. Prevalence and characteristics of Shiga toxin producing *Escherichia coli*, *Salmonella* spp. and *Campylobacter* spp. isolated from slaughtered sheep in Switzerland. *Int J Food Microbiol.* 92 : 45-53.

DECISION MAKING BY UPLAND FARMERS ON FOREST MANAGEMENT IN THE NORTHWEST MOUNTAINOUS REGION OF VIETNAM

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ABSTRACT

In Vietnam, especially in the northwest mountainous regions, deforestation remains unabated in spite of the national reforestation and forest management programs of the government that started as early as the 1990s. This is of particular importance to the country because many of its poor people are dependent on forest and forest products for their livelihood. One objective of the study was to determine the major factors affecting the decision of upland farmers to participate in forest management programs in the northwest mountainous region of Vietnam.

The results of the study show that the important factors affecting the decision of upland farmers to participate in forest management programs include the age of upland farmers which is reflective of their farm experience, their ethnicity, availability of family labor, access to forest resources and income earned from forest-related activities. To encourage the participation of upland farmers in forest management programs, it will be important to increase the level of awareness of upland farmers who are mostly poorly educated ethnic minorities about the benefits of improved management of the forest. It will be important also to modify existing forest management policies to ensure that upland farmers are adequately compensated for their efforts in forest management and promote eco- and community tourism.

Key word: deforestation, watershed protection, binary logit model, ethnic upland farmers

INTRODUCTION

Forests play a very important role in human society. They provide many useful ecological services and benefits for society such as wood products, watershed protection, biodiversity conservation, carbon storage, landscape beauty preservation, boundary protection, and natural disaster prevention. Moreover, forests also prevent and reduce the greenhouse gas (GHG) emissions that are the main culprits of the climate change (Malmsheimer, et al., 2008).

In recent years, deforestation has become a serious global problem. Increasing deforestation is one of the major causes of global climate change. It caused the release of 16 billion metric tons of carbon into the atmosphere. It would need about 450 million hectares of forest to sequester the 29 billion metric tons of carbon that have accumulated in the atmosphere as a result of all past emissions (Ramirez et al., 2000). Due to the negative effects of climate change on the social and economic development of all countries, forest management is considered to be very important by most countries in the world, especially those with large forest areas like Vietnam.

Vietnam is directly affected by global climate change given its long shoreline and location. To mitigate its effects, the Vietnamese government launched several upland reforestation and afforestation programs. These include the PAM program (1992), program 327 (a nationwide

reforestation program), and Five Million Hectares Reforestation Program (National Reforestation Program - a continuation of program 327). The objective of this program is to increase the existing forest cover from about 28 to 43 % by the year 2010 (The and Ngoc, 2006). In addition, the National Assembly of Vietnam promulgated a number of laws such as the Law on Environmental Protection (1991); the Land Law (1993), and the amended versions (1998, 2001, 2003); and the Law on Forest Protection and Development (2004). These are intended to encourage farmers to participate in its reforestation and afforestation programs. In addition, the Vietnamese Government defined the obligations of farmers participating in these programs and the corresponding payments for their participation. The provisions of these policies are contained in the Prime Minister Decision No. 178/2001/QĐ-TTg (Bien, 2006) and its amended version (2006), and Prime Minister Decision No. 308/QĐ-TTg (2008).

However, despite these programs and policies, deforestation in Vietnam remains unabated. This is especially true in the northwest mountainous regions where the livelihood of many poor people is dependent on the forest and forest products. One major reason given is that only a few upland farmers are participating in its forest management programs because the remuneration is quite low although there are no studies to support this contention. This paper discusses the major findings relating to the factors affecting the decisions of upland farmers to participate in forest management programs in the northwest mountainous region of Vietnam.

Forest Management

Forest management includes a range of human interventions that affect forest ecosystems. These interventions include both conservation and economic activities (Wikipedia, undated). The economic activities of forest management include the extraction of timber (Wikipedia, undated), maintenance of forest property (About.com, undated), planning forest utilization for wood production (Eionet, undated), and manipulation of tree and forest stands to meet landowner objectives (University of Wisconsin Stevens Point, undated). The conservation activities related to forest management consist of planting and replanting of various species, cutting roads and pathways through forests, and techniques for preventing or reducing outbreaks of fire (Wikipedia, undated); control of wooded land to maintain health, vigor, product flow, and other values such as soil condition, water quality, wildlife preservation, and beauty (About.com, undated); making forest healthier, protecting forests and related resources against disease and disaster and promoting sound ecology and management practices (North Carolina State University, undated); protection of fauna and flora, recreation and water supply (Eionet, undated); and fulfilling relevant ecological functions including biological diversity (Natural Resources Canada, undated).

A study conducted by the NGA Center for Best Practices – Natural Resources Policy Studies Division (2000) found that the three major forms of forest management in the world include collaboration, rules and regulation, and institutions. There are three types of collaboration in forest management in the USA - the state/federal, state/state, and state/local areas collaboration. In addition, there are collaborations between private companies and government agencies, and those between companies and public interest groups. Findings of the study showed that collaboration and compromise could address the primary concerns of all parties and enhance forest health. Wollenberg, et. al. (2004) mentioned that millions of the rural poor now participate in collaborative forest management schemes under a variety of tenurial and organizational arrangements. They mention also that governments around the world tap the participation of people living nearby these forests. The government forestry agencies oblige local people to cooperate in the protection and replanting of existing forest. The forest “co-management” programs have improved formal access of rural people to the forests although there is great difficulty in assigning the roles, rights and responsibilities especially among groups with highly divergent interests.

In Ghana, the forest environment has a significant impact on the social life of many of its tribes and exercises a profound influence on social organization. The forests are considered very

important culturally, economically, and ecologically. The traditional natural resources management is shaped around local rules and regulations (Mensah and Oduro, 2007). These rules and regulations are most often enshrined in religious or cultural beliefs and superstitions and enforced by prohibitions. These have no legal basis but the beliefs have been strong enough in the past to make people obey the regulations. Traditional natural resources management includes the protection of particular ecosystem habitats, and animals or plant species, and regulation of the exploitation of some natural resources.

“Institutions” is another form of forest management. In Pakistan, the management of forest resources is generally considered the exclusive domain of the Forestry Department, especially since the state is the formal owner of all forest resources (Kruseman and Pellegrini, 2008). There are two strategies for the sustainable forest management in Pakistan. First is the organizing by local groups of citizens to defend some stretches of forest from exploitation. Second is the joint management of the local communities with the Forest Department. While this has been found to be a successful approach, the success depends very much on the willingness of the Forestry Department to endorse such process.

Forest Management in Vietnam

In Vietnam, the policy of the government is to encourage everyone to participate in the management and protection of the forest. Since participation is voluntary, the approach of the government is to inform everyone especially upland farmers who settle close to the forest about its importance and the benefits to be derived by participating in the program. Individuals, organizations or communities may sign a contract with the government to participate in the reforestation, management, and other protection activities. For this study, participating upland farmers are persons who sign a contract with the local government to manage the natural forest near their area.

Studies show that there are five major forms of forest management in Vietnam. The first is by households who as private entrepreneurs manage the allocated forestlands, mainly bare lands and lands intended for production forests (Bien, 2001). Nam, et al. (2001) however mentioned that commercially managed forests are best for households with large farms. Smallhold upland farmers however have very little incentive to engage in forest management activities because forest products contribute very little to their income. The second is community-based management where the Commune’s People Committee is the basic administrative unit that has authority within a commune’s boundary to manage the forests and forestlands (Bien, 2001). There are three major models of this form (Mai, 2002). The first is where communities manage the forest through conventional ownership. The second model is co-management where the village community signs a contract for forest protection and management with the state organization. The third is where the village community manages forest allocated by local authorities. Nam et al. (2001) suggests that community-based management (or strict protection forest management) is suitable for the management of reserved Melaleuca forest. This form of management contributes to the improvement of the economic status of the community. However, the development of community forest management involves changes that can only be achieved through a strong collaborative effort.

The process of devolving community-based forest management however has been facing some significant challenges. The first challenge is the lack of capacity in participatory methodology to support forest allocation, community forest assessment and planting. The second is the vagueness of the policy on benefit sharing for land recipients as well as the administrative procedures for harvesting forest products which are too complicated. Also, there is a need to include changes in the policy framework, as well as the introduction of new management procedures and technologies (Huy, undated).

The third form of forest management is joint management. Joint management is the cooperation between forest enterprises and household-based management in forestry (Bien, 2001).

Joint venture management is the best option for state production forest (Nam et al., 2001). Another form of forest management is by forest enterprises. As state representative, forest enterprises manage forestlands covered with natural forests and state-funded plantation forests (Bien, 2001). And the last is the contract-based management. According to Bien (2001), contract-based management is implemented with commitments to a contract signed by both forest enterprise and households or village.

METHODOLOGY

Conceptual Framework

Four groups of factors are hypothesized to be affecting the decisions of upland farmers to participate in forest management programs. These include the physical, social, economic and institutional factors (Fig. 1).

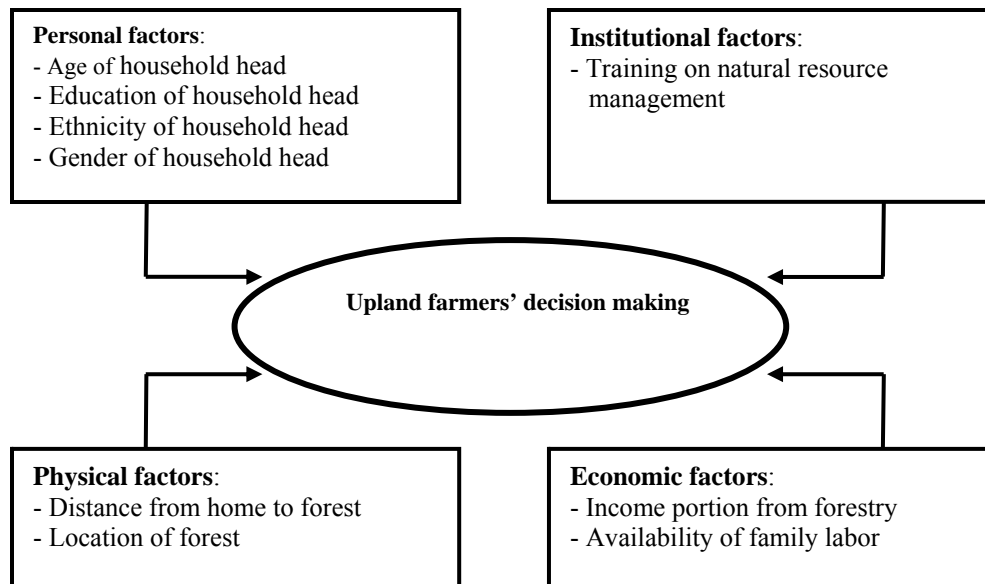


Fig. 1. Factors affecting decisions of upland farmers to participate in forest management

Personal factors refer to individual characteristics of farmers such as age, level of education, gender and ethnicity of household heads. Institutional factors include access to training services on natural resource management and extension services that provide information related to the importance of forest management for human life and activities. State offices such as the Extension Center and Department of Natural Resources and Environment administer these services. The physical factors include the physical characteristics of the forest such as its location and distance from the farmers' home. Lastly, the economic factors include the availability of family labor and share of income from forest activities as a proportion of total household income.

Both primary and secondary data were used in this study. The primary information was gathered thru direct interview of 200 farmers in two communes, It Ong and Nam Pam using a structured questionnaire that was pre-tested before being used. A total of 200 households that was 6.5% of total households of the two communes in the study site were chosen using stratified random sampling. The total sample included 90 participants and 110 non-participants of the forest management program.

The primary data collected included information on: (1) the age, education level, gender and

ethnicity of farmer-household head; (2) decision of farmers to participate or not in forest management; (3) location of forest and distance from residence of family; (4) access to training services on natural resources management and extension services on sustainable agricultural development; and (5) economic condition of households such as annual total income of household, availability of family labor and household's income from forest activities.

The secondary data on the other hand was collected from general reports, and summary records of the state offices in the study region such as the Muong La Statistics Department, Muong La Natural Resource and Environment Department, and other state offices in the study site. The secondary information collected included data on the natural and socio-economic conditions, the forest management status and other relevant information.

Analytical Tools

Some descriptive statistics were used to characterize and compare the different farming households across the two groups of farmers – the participating and non-participating farmers in the government forest management program. A quantal response or choice model, specifically the binary logit model, was used to determine the factors affecting decisions of farmers to participate in the forest management programs in the study site. The empirical model is:

$$\text{DECISION} = \text{Ln} \left(\frac{P_i}{1 - P_i} \right) = \alpha_0 + \alpha_1 \text{AGE} + \alpha_2 \text{EDU} + \alpha_3 \text{GEN} + \alpha_4 \text{ETHN} + \alpha_5 \text{INPOR} + \alpha_6 \text{LAB} + \alpha_7 \text{DIST} + \alpha_8 \text{LOCA} + \alpha_9 \text{TRAIN} + u_i \dots \dots \dots (\text{Eqn. 1})$$

Where:

- P_i is the probability of participating in forest management program, and $(1-P_i)$ is the probability of non-participation in forest management program.
- α_0 is intercept of the model
- α_i ($i = 1$ to 9) are coefficients of dependent variables in the binary logit model.
- u_i is the error term of the model.

The marginal effects explain the probability of upland farmers participating in forest management programs. The marginal effect is the change in predicted probability associated with changes in explanatory variables of the binary logit model (Anderson and Newell, 2003). Marginal effect or the probability of farmers' participation in forest management programs of government can be determined given the coefficients of the binary logit model for the different personal, institutional, physical and economic factors. According to Green (2003), the marginal effect is estimated as follows:

$$ME = \frac{\partial \Lambda(X'\beta)}{\partial X} = \Lambda(X'\beta) [1 - \Lambda(X'\beta)] \beta \dots \dots (\text{Eqn. 2})$$

Where:

X is matrix of independent variables in logit model
 β is matrix of parameters in logit model

Both coefficients of the binary logit model and marginal effects were estimated using the STATA 8.0 program.

Table 1 shows a description of both the dependent and independent variables of the empirical logit model.

Table 1. Definition of variables in the empirical logit model.

Variable	Description	Unit of Measure
Dependent variable		
DECISION	Decision of upland farmers to participate or not in forest management	1: participating; 0: non-participating
Independent variables		
AGE	Age of farmers	Years
EDU	Education level	Years
GEN	Gender of farmer (dummy)	1: male; 0: female
ETHN	Ethnicity of farmers (dummy)	1: Kinh group; 0: Minority groups
INPOR	Income portion from forest activities	%
LAB	Availability of family labor	Person
DIST	Distance from home to forest	Kilometers
TOPO	Topography of the forest (dummy)	1: if steep; 0: otherwise
T R A I N (dummy)	Participation in natural resource management training courses	1: yes; 0: no

RESULTS AND DISCUSSION

The Study Area

Muong La is a mountainous district of Son La province, which is 41 kms away from Son La city toward the northeast side. The district has 15 communes and 1 town, with a total area of 142,924 hectares. Muong La district is 500 to 700 meters above sea level and located at 21°15' to 21°42' north latitude, and at 103°45' to 104°20' east longitude. It borders on Lao Cai province in the north, Son La city and Mai Son district in the south, Yen Bai province in the east, and Thuan Chau district in the west. Toward the east and northeast side of the district are high mountain chains and in the south side are the lowlands. The forest is especially important in this district because of the presence of 27 hydroelectric plants, especially the Son La hydroelectric plant, the biggest hydroelectric plant in Vietnam.

There are two distinct seasons in a year in Muong La district, the rainy and dry season. The rainy season starts in April and ends in September. The dry season starts October and ends in March the following year. Annual average temperature ranges from 20 to 26 degrees. The highest temperature is 41 degrees in June and July. The average rainfall is 1347 mm/year. There are dry and hot winds in March and April. There are many rivers and streams that include the 50 km. Da river, the longest river in the North that flows across the district and 5 big streams that are 200 kilometers in length namely Nam Mu, Nam Chien, Nam Trai, Nam Pan, and Nam Pia. The district therefore is an ideal location for hydroelectric plants because of the large number of river and stream systems in the area. At present, there are a total of 27 hydroelectric plants (General Report of Muong La Committee, 2009). In April 2009, its total population was around 91000 of which 78000 or about 85% belong to a minority ethnic group (Table 2). The labor force comprises 51% of its population that is mostly employed in agriculture and the forestry sector.

Table 2.

ITEMS	No.	%	Population and labor force of Muong La district, Son La province, Vietnam, 2008.
Total Population	91,234	100	
Distribution by gender			
Male	48,988	54	
Female	42,246	46	
Distribution by ethnicity			
Kinh group	13,290	15	
Minority group	77,944	85	
Total Labor Force	46,204	100	
Distribution by gender			
Male	23,564	51	
Female	22,640	49	
Distribution by area			
Urban	4,310	9	
Rural	41,894	91	

Source: Muong La Statistic Department, 2009

The total land area of Muong La district is around 142,924 hectares of which 60% is classified as agricultural/forestry land. Of the agricultural/forestry area, 79.5% is classified as forestry land while 19.2% is planted to crops such as rice, corn, soybean and others (Table 3).

Table 3. Land use in Muong La district, Son La province, Vietnam, 2008.

Type of Land	AREA (has.)	%
Agricultural/Forestry land	86,374	60.0
Annual crops area	16,605	19.2
Perennial trees area	925	1.2
Forestry land	68,707	79.5
Surface water area	137	0.2
Non-agricultural land	5,710	4.0
Other lands	50,840	36.0
Total Area	142,924	100.0

Source: Muong La Natural Resources and Environmental Department, 2009

The Muong La district is one of the 63 poorest districts of Vietnam. The income per capita

of only 5,340,000 VND (equivalent to US\$330) per year is very low compared with the national per capita income of US\$1,030/year (Chau, 2008). The economy is very dependent on the agro-forestry and aquaculture sector that in 2008 contributed 43% to gross income of the whole district. The contribution of this sector to total income of the district is even higher than that of industry and construction that contributed only 27%.

Item	Amount	%	
Gross income (billion VND)	487	100	
Agro- forestry and aquaculture	211	43	
Industry and construction	133	27	
Commerce and services	143	30	
Income per capita ('000VND/year)	5,340	-	

(Table 4).

Table 4. Economic structure and income per capita of Muong La district, Son La province, Vietnam, 2008.

Source: Muong La Statistic Department, and General Report of Muong La People's Committee, 2009

Forest Management

Type of Forest	Muong La District		It Ong Commune		Nam Pam Commune		Of the
	(has.)	(%)	(has.)	(%)	(has.)	(%)	
Total Area	68,707	100	534	100	5,022	100	
Natural forest	59,202	86	454	85	95		
Planted forest	5,339	8	27	5	0		
Bare land	4,166	6	53	10	5		
Protection forest	61,437	89	219	41	5,022	100	
Production forest	7,191	11	315	59	0	0	

68,707 has. of forested land of the Muong La district, 59,202 has. (86%) is classified as natural forest. By function, 89% of the forested land is classified as a protection forest with the rest intended for production of timber (Table 5). Similarly, of the 534 hectares of the It Ong commune, 454 hectares (85%) is classified as natural forest, 315 hectares (59%) as production forest and 219 hectares (41%) as protection forest area. In Nam Pam commune however, the entire forested area is classified as protection forest of which 95% is natural forest. The forested area plays a very important role in the socio-economic development of the whole district. It is a buffer area that also serves to mitigate if not prevent natural disasters, supply wood, firewood and non-timber products for its inhabitants. However, majority of the forest in the whole district is natural forest that provides a limited source of income for the farmers. It is very difficult therefore to encourage farmers to join the forest management programs of the government.

Table 5. Forest and forestry land of Muong La district, Son La province, Vietnam, 2008.

Source: Muong La Natural Resources and Environment Department, 2009

Forest management and payment. Forest management in Vietnam includes activities such as reforestation, protection, and other management activities. The Vietnamese Government is very keen on encouraging individuals and organizations alike to participate in these programs especially in the

Management Groups	Area (has.)	%	high mountainous regions where the livelihood of the residents depends on the forest.
Household	13,741	20	There are four groups managing the forest in La district. The area managed by the local
Household group	4,810	7	
Local community	32,919	48	
Organization	17,177	25	community is the largest with 32,919 hectares or 48 percent of the entire forest area followed by organizations with 17,177 has. or 25% of the total forested area. This is followed by households that manage 13,741 has. or 20% of the total forested area. Household groups manage the smallest area with 4,810 has. or 7% of the total forested area. The local minority groups living in nearby communities manage the largest forested areas. These minority groups can be considered as the best managers especially in the high mountainous regions because they follow very strict, culturally-based rules for managing the forest.
Muong La Whole district	68,707	100	

community is the largest with 32,919 hectares or 48 percent of the entire forest area followed by organizations with 17,177 has. or 25% of the total forested area. This is followed by households that manage 13,741 has. or 20% of the total forested area. Household groups manage the smallest area with 4,810 has. or 7% of the total forested area. The local minority groups living in nearby communities manage the largest forested areas. These minority groups can be considered as the best managers especially in the high mountainous regions because they follow very strict, culturally-based rules for managing the forest.

Table 6. Forest land areas managed by different management groups in Muong La district, Son La province, Vietnam, 2008.

Regulations	Provisions	Fees ('000VND/ha/year)
Prime Minister Decision No.178/2001/QD-Ttg (2001)	It provides for the rights and obligations of households or individuals who have been allocated forest land for benefit sharing	50 (US\$3)
Revision of Prime Minister Decision No.178/2001/QD-Ttg (2006)		100 (US\$6)
Prime Minister Decision No. 380/2008/QD-Ttg (2008)	Still a pilot program, it provides that hydroelectric plants, local water utility and tourist agencies should pay providers of environmental services	-
Government Resolution No. 30a/2008/NQ-CP (2008)	Pilot program being implemented in sixty one poor districts in Vietnam	200 (US\$12)

Source: Muong La Forest Protection Department, 2009

It is worthwhile noting the reasons why households are only managing 20% or 13,741 hectares of the total forested area in Muong La district. The first is that payments for activities related to managing the forests are not as attractive as other economic activities. The level of payment to upland farmers for participating in the government forest programs is regulated. For example, the highest amount that can be paid to upland farmers is only 200,000 VND (around US\$12) per hectare per year (Table 7). This amount is much less than those paid for other jobs such as construction work that pays at least 80,000 VND (around US\$5) per day.

Table 7. Government policies regulating payments for management of forest areas in Vietnam.
Source: Vietnam Government (2001, 2008)

The second reason is that most of the forest management programs are located in high mountainous areas and are usually natural forests that provide very little opportunity for upland farmers to earn additional income. The difficult terrain of the forests makes it difficult for them to raise crops or livestock. Table 8 shows the level of income for It Ong and Nam Pam communes of the Muong District by sources for both participating and non-participating households from forest management. In both communes, the level of income from the forest of both participants and non-participants in the forest management program of the government is very low. In It Ong Commune, the income from the forest for participants is 2,047,000 VND (US\$117) per household per year while income from the forest of non-participants is only 1,452,000 VND (US\$83) per household per year. In Nam Pam commune, the income from the forest of participants is 2,876,000 VND (US\$164) per household per year while those of non-participants is only 1,769,000 VND (US\$101) per household per year. The reason is that the sources of income from the forest of participants in forest management programs include the payment from government, firewood, and non-timber products while income from the forest of non-participants comes from only firewood and non-timber products. However, the quantity and value of non-timber products in the study site are quite low. The non-timber products that can be harvested from the forest are only bamboo sprouts and some kinds of vegetables.

Table 9 shows the sources of income from the forest of households participating in the

Source of Income	It Ong				Nam Pam			
	P_H (n=45)		NP_H (n = 55)		P_H (n=45)		NP_H (n =55)	
	Amt.	%	Amt.	%	Amt.	%	Amt.	%
Crop production	3,778	28	4,411	23	3,867	32	4,898	31
Livestock activity	5,335	40	8,487	45	4,213	35	6,826	42
Forestry	2,047	15	1,452	8	2,876	23	1,769	11
Non-agricultural	2,238	17	4,463	24	1,162	10	2,570	16
Total Income	13,398	100	18,813	100	12,118	100	16,063	100

government forestry program. About 84 % of the income is from firewood, about 8% from non-timber products and only about 6% from government payment for forest management. The non-timber products include bamboo sprout and some kinds of vegetables. However, it is very difficult to harvest these non-timber products because they are found in the high mountainous areas which are very difficult to access. A comparison of income from forest activities of participants in forest management programs however shows that those from Nam Pam commune earn much more than those in It Ong Commune. This is because the size of the forest areas managed by farmers in Nam

Sources of Income	It Ong		Nam Pam		DIFF (t-stat)
	Amount ('000VND)	%	Amount ('000VND)	%	
Forest management payment	108	5	189	7	5.87***
Firewood	1,804	88	2,422	84	4.05***
Non-timber product	135	7	265	9	2.16**
TOTAL	2,047	100	2,876	100	4.15***
Average forest area (hectare)	1.1	-	1.9	-	5.86***

much larger than those in It Ong Commune. The average forest area managed by participating

households in Nam Pam commune is 1.9 hectares while those managed by participating farmers of the It Ong commune is only 1.1 hectares.

Table 8. Sources of income of participating and non-participating households in It Ong and Nam Pam Communes, Muong La district, Son La province, Vietnam, 2008.

Variables	P_H (n = 90)	NP_H (n = 110)	DIF. (t-stat)	All (n = 200)	
				Mean	Std
GEN (Gender)	0.68	0.80	-	0.75	0.44
Age	50.81	42.64	6.46***	46.32	9.51
ETHN (Ethnicity)	0.19	0.53	-	0.38	0.49
EDU (Educational level)	5.13	4.19	4.16***	4.62	1.68
LAB (Labor)	3.72	3.03	5.01***	3.34	1.03
DIST (Distance)	2.79	6.39	6.24***	4.77	4.43
LOCA(Location of forest)	0.47	0.35	-	0.40	0.49
INPOR (Income from forest)	25.17	7.99	12.48***	15.72	12.31
TRAIN (Training attendance)	0.72	0.35	-	0.52	0.50

Note: P_H and NP_H are participating and non-participating households in forest management program, respectively; Amt is amount ('000 VND/household/ year).

Table 9. Average forest area and percentage of income of participating households from forest resources in the forest management program in It Ong and Nam Pam Communes, Muong La district, Son La province, Vietnam, 2008.

Note: DIFF is difference; *** and ** are significant at 1% and 5% level, respectively

Empirical Results

Upland farmers participating in the forest management program of the government tend to be older, more educated, have more family labor, derive a larger percentage of income from forest activities and live nearer the forest than those not participating in the program (Table 10). This is indicative of the greater dependence of participating households on the forest for their livelihood than non-participating households.

Table 10. Descriptive statistics of participating and non-participating farmer respondents, Muong La

district, Son La province, Vietnam, 2009.

Note: P_H and NP_H are participating household and non-participating household, respectively

Std is standard deviation;

*** significant at 1% level

The Estimated Participation Logit Model

Variable	Coefficient	z-TEST	ME (dy/dx)	z-Test	The estimated
Intercept	-12.185***	5.12	-	-	
GEN	0.533 ^{ns}	0.84	0.1211 ^{ns}	0.88	
AGE	0.150***	3.91	0.0355***	3.86	
ETHN	-1.058*	-1.67	-0.0237*	-1.83	
EDU	0.151 ^{ns}	0.89	0.0356 ^{ns}	0.90	
LAB	0.434*	1.67	0.1025*	1.67	
DIST	-0.148*	-1.93	-0.0348*	-2.01	
TOPO	0.626 ^{ns}	1.18	0.1489 ^{ns}	1.19	
INPOR	0.211***	4.31	0.0497***	3.86	
TRAIN	0.738 ^{ns}	1.38	0.1722 ^{ns}	1.37	
LR chi2(9) = 166.93			Log likelihood = -52.26		
Prob > chi2 = 0.0000			Pseudo R ² = 0.6149		

participation logit model is significant given an LR chi2 (9) of 166.93 and p-value of 0.0000. Based on the Pseudo R², the model is able to explain 61.49 % of the change in the probability of upland farmers participating in forest management programs (Table 11). There are 5 factors that clearly affect the decision of upland farmers to participate in the forest management programs. These are age and ethnicity of upland farmers, availability of family labor supply, distance from house of farmer to the forest, and percentage of income derived from the forest.

Results show that older farmers are more likely to participate in the forest management program, *ceteris paribus* because their opportunities to be employed or engaged in other livelihood activities such as driving taxis, working in construction projects or as porters is more limited than younger people who tend to have more employment choices. The marginal effect shows that the probability of upland farmers to participate in forest management programs increases with age. The younger upland farmers who have more options do not usually participate in the forest management program because the pay is lower than their other economic activities.

Kinh upland farmers are also less likely to participate in forest management programs than their counterparts in minority groups because they are better educated and have more opportunities to be employed or engaged in other livelihood activities than the other minority groups. In contrast, the other minority groups are less educated and have more limited employment opportunities. In addition, upland farmers in minority groups whose livelihood depends so much on forest resources have to follow very strict rules of their community regarding the use of forest resources.

Table 11. Estimated coefficients of logit model for decision of upland farmers to participate in Forest Management Program, n=200.

Note: *** and * significant at 1% and 10%, respectively;
ns is non-significant

Results show that there is an inverse relationship between distance of the house (DIST) of the farmer from the forest area to be managed and probability of participation. This is because the transportation cost increases with distance and thus becomes more expensive, especially because their activities related to protection of the forest require more of their regular presence. Households of upland farmers with more family labor are also more likely to participate in the forest management programs. This factor shows the greatest effect on decisions of farmers to participate with a 10.25% increase in probability of participating with a unit increase in family labor supply, *ceteris paribus*. This is important because the management of the forest is labor intensive and would require an adequate supply of household labor for the different activities such as reforestation, protection and others. It is also not surprising to find that households that get more benefit from participating in the forest management activities are more likely to participate in the forest management program. Households that are very dependent on the forest products for their livelihood are more willing to participate in forest management programs than other households. The higher income derived from the forest helps farmers recognize the benefit from protecting the forest and are therefore more willing to participate in forest management programs. Gender, level of education, location of forest, and training were not significant factors affecting the decision of upland farmers to participate in the forest management programs for the study areas.

CONCLUSION AND RECOMMENDATIONS

The availability of family labor and unattractive remuneration are the major reasons why very few upland farmers participate in the forest management program of the Vietnamese government. There are three major recommendations to encourage their participation. The first is to generate enough funds to adequately compensate farmers for their services. These can come from taxes imposed on environmental service users such as hydroelectric plants, ecotourism agents, etc. Involving upland farmers in various ecotourism programs that may be developed can also help augment their income. The second is to simplify the contents and language used in these training programs on natural resources management to ensure that the topics discussed are readily understood and appreciated by the target audience, the upland farmers. In addition, some members of these minority groups may be trained as trainers because they have a better understanding of the behavior of members in their communities. And lastly, increase the income of upland farmers from forest activities by (1) providing appropriate technologies to encourage households especially those located closer to the forest to cultivate annual crops like corn, bean, etc. in the buffer zone; (2) providing training in the production of animals such as goats, local pigs, etc. that can adapt to the high mountain conditions; (3) undertake research on medicinal plants adapted to high mountain conditions that upland farmers can cultivate as a source of additional income, and (4) educate people who live in the lowlands about the importance of the forest for them and encourage them to contribute to a fund that can be used by the government to provide compensation for forest management activities of upland

- Mai, T. D. 2002. Models on Public Participation in Forest Resource Management at Village Level in Vietnam. Research Paper. Vietnam Environment Administration (VEA). Ministry of Natural Resources and Environment (MONRE). Available (online) http://www.nea.gov.vn/html/tintuc/ASEM_16-9-02/Reports [December 11, 2008]
- Malsheimer. R.W, Patrick Heffernan, Steve Brink, Douglas Crandall, Fred Deneke, Christopher Galik, Edmund Gee, John A. Helms, Nathan McClure, Michael Mortimer, Steve Ruddell, Matthew Smith, and John Stewart. 2008. Forest Management Solutions for Mitigating Climate Change in the United States. Journal of Forestry. Society of American Foresters, pages 115-173.
- Mensah, P. S. and W. Oduro. 2007. Traditional Natural Resources Management Practices and Biodiversity Conservation in Ghana: A Review of Local Concepts and Issues on Change and Sustainability. Fondazione Eni Enrico Mattei.
- Muong La Forest Protection Department. 2009. Forest Management Situation. Data base. Muong La district. Son La province. Vietnam.
- Muong La Natural Resources and Environment Department. 2009. Forest and forestry land situation. Data base. Muong La district. Son La province. Vietnam.
- Muong La People's Committee. 2009. General Socioeconomics Report. Muong La People's Committee, Muong La district, Son La province, Vietnam.
- Muong La Statistic Department. 2009. Data of Population and Economic Status. Data base. Muong La district. Son La province. Vietnam.
- Kruseman, G and L. Pellegrini. 2008. Institutions and Forest Management: A Case Study from Swat, Pakistan. Fondazione Eni Enrico Mattei. Available (online) <http://ageconsearch.umn.edu/simple-earch?sort=date&SortDirection=descending&query=forest+management&start=70> [March 29, 2009]
- Nam, M. V, N. T. Nhan, B. V. Trinh, and P. L. Thong. 2001. Forest management systems in Mekong River Delta, Viet Nam. Research Report. Economy and Environment Program for Southeast Asia (EEPSEA). Available (online) http://www.idrc.ca/eeepsea/ev-8196-201-1-DO_TOPIC.html [January 5, 2009]
- Natural Resources Canada. Undated. Forest Management Definition. Available (online) http://carbon.cfs.nrcan.gc.ca/presentations/Kurz_COP8_e/sld025.htm [March 20, 2009]
- NGA Center for Best Practices. Natural Resources Policy Studies Division. 2000. Partnerships for Progress in Sustainable Forest Management. Available (online) www.nga.org/Files/pdf/005020FOREST.dpf [December 9, 2008]
- North Carolina State University. Undated. Forest Management. Available (online) <http://cnr.ncsu.edu/fer/under/formgmt.html> [March 20, 2009]
- Ramirez, O. A, C. Carpio, R. Ortiz, B. Finnegan. 2000. Economic Value of the Carbon Sink Services of Tropical Secondary Forests and its Management Implications. Department of Agricultural and Applied Economics. Texas University. Available (online) <http://ageconsearch.umn.edu/simple-earch?sort=date&SortDirection=descending&query=forest+management&start=70> [March 29, 2009]
- The, B. D and H. B. Ngoc. 2006. Payment for Environmental Services in Vietnam: Assessing An Economic Approach To Sustainable Forest Management. Research Report. Economy and

Environment Program for Southeast Asia (EEPSEA). Available (online) http://www.idrc.ca/eeepsea/ev-8196-201-1-DO_TOPIC.html> [November 8, 2008]

University of Wisconsin Stevens Point. Undated. Forest Management. Available (online) http://www.uwsp.edu/natres/nres743/Definition/Forest_management.htm>[March 20, 2009]

Vietnam Government. 2001. Prime Minister Decision No.178/2001/QD-TTg dated November 12, 2001 on the benefits, rights and responsibilities of households and individuals with allocated, leased, and contracted forest land. Vietnamese Official Gazette No. 47, December 22, 2001. Socialist Republic of Vietnam, pages 3128-3136.

Vietnam Government. 2008. Prime Minister Decision No.380/2008/QD-TTg dated April 10, 2008 on the Pilot Policies on Payment for Environmental Services. Vietnamese Official Gazette No. 239+240, April 22, 2008. Socialist Republic of Vietnam, pages 1347-1351.

Vietnam Government. 2008. Resolution No. 30a/2008/NQ-CP dated December 27, 2008 on Support Programs to reduce poverty for 61 poor districts in Vietnam. Vietnamese Official Gazette No. 73+74. January 24, 2009. Socialist Republic of Vietnam, pages 3903-3914.

Wikipedia. Undated. Sustainable Forest Management. Available (online) http://en.wikipedia.org/wiki/sustainable_forest_management> [March 20, 2009]

Wollenberg. E, B. Campbell, S. Shackleton, D. Edmunds, and P. Shanley. 2004. Collective Action and Property Rights for Sustainable Development. Collaborative Management of Forest. IFPRI. Washington, DC, USA.

**SPECIES DISTRIBUTION OF *TRICHOGRAMMA* AND
TRICHOGRAMMATOIDEA GENUS
(*TRICHOGRAMMATOIDEA*:HYMENOPTERA) IN JAVA.**

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ABSTRACT

Trichogramma and *Trichogrammatoidea* are the most studied egg parasitoids in biological control programs. Information on geographical distribution and status of those genus are limited in Indonesia. The research sought to study community and species distribution of these genus across the island of Java. Egg parasitoids were surveyed by collecting host eggs from various agricultural crops across the island. Approximately five species of Trichogrammatidae were recorded, *Trichogrammatoidea armigera*, *Trichogramma flandersi*, *Trichogramma cojuangcoi*, *Trichogramma japonicum* and *Trichogramma minutum*. *T. japonicum* was the only egg parasitoid species recorded to be associated with yellow stem borer, *Scirpophaga incertulas*. *T. 'oidea armigera*, *T flandersi*, and *T cojuangcoi* were found to attack *P. xylostella* and *T. minutum* was recorded to parasitize eggs of Pieridae. Results showed that *T. flandersi* and *T. minutum* are habitat specific, while the rest have a much more wider distribution, and can be found across the Java Island. *T'oidea armigera* was the most cosmopolite species that occurs across the island by parasitizing various host species including Dipteran eggs.

Key words: Egg parasitoid, community, host, parasitization, biological control

INTRODUCTION

Trichogrammatids are the common group of egg parasitoid used for biological control and parasitoid modelling across the world. The genus *Trichogramma* are the most studied and successful taxa used in biological control programs (Li, 1994). They have been used in more than 30 million ha worldwide to control lepidopteran pests in agriculture and forestry (Hassan, 1988; Li, 1994). Many species of Trichogrammatidae (Hymenoptera) are known to attack various lepidopteran host species on various agricultural crops (Alba, 1988). The Trichogrammatids also attack eggs of Hymenoptera, Neuroptera, Diptera and Hemiptera (Nagarkatti and Nagaraja, 1977), Coleoptera and Megaloptera (Clausen, 1940). Today, those parasitoids are reared usually under laboratory conditions using alternative Lepidopteran hosts (Hassan, 1993; Housewear *et al.*, 1983; Herlinda, 1995; Van Bergeijk *et al.*, 1989).

In Indonesia, the evaluation of *Trichogramma* and *Trichogrammatoidea* as biological control agents have been conducted through many studies (Nurindah *et al.*, 1993; Herlinda, 1995; Marwoto and Supriyatin, 1999, Marwoto and Saleh 2003). Most of these studies focused on the fitness of the parasitoids, mass rearing, and mass release (Nurindah *et al.*, 1993; Marwoto and Supriyatin, 1999; Marwoto and Saleh, 2003), while very limited information are available on the

taxonomic distribution and occurrence of those genus in the field. As a tropical country, Indonesia is expected to harbour large numbers of insect species, including trichogrammatids. Unfortunately, the large extent of land use change and pesticide applications may lead to species extinction, including those which have not yet been discovered. Since information on species list, distribution, niche breadth (generalist versus specialist) is very important to support biological control program, studies on the taxonomic distribution and population status of trichogrammatids are crucial.

Java is the most populated island in Indonesia and suffers the highest rate of habitat destructions, hence investigation on the population density of Trichogrammatid's species is necessary. This research was conducted to investigate the status of trichogrammatids across different regions in Java which also include the species list and egg distribution of *Trichogramma* and *Trichogrammatoidea* collected from various host species and host plants in Java.

METHODOLOGY

Study Area and Sites

Ecological samplings were conducted in different locations in East and West Java from July 1998 to June 1999 (Table 1). Egg parasitoids were collected from various agricultural crops including vegetables, paddy, and sugar cane. All collected specimens were identified in the Department of Crop Protection, Bogor Agricultural University.

Table 1. Study site of egg parasitoid survey across Java Island.

Geographical Region	District	Sites
West Java	Karawang	Jatisari, Amansari, Rengas Dengklok,
	Cianjur	Sindang Asih, Ciloto, Cipeyeum, Ciranjang
	Bogor	Darmaga, Jalan Baru, Cisarua, Cibogo, Ciampea, Leuwiliang, Sindangbarang
	Tangerang	Cengkareng
	Cirebon	Sumber , Losari, Ciledug, Kemantren
	Lembang	Cikole
	Palimanan	Beberan
	Phumbon	Kenanga
Central Java	Yogyakarta	Umbul Harjo
	Bantul	Ringroad Selatan
	Kulon Progo	Sentolo, Wates,
	Sleman	Moyundan, Godean
	Tawangmangu	Blumbangan,
	Karanganyar	Jaten
East Java	Brebes	Wonosari,
	Situbondo	Asembagus
	Malang	Pujon

Egg Parasitoid Surveys

Egg parasitoids were surveyed by collecting plants from 20% of the crop areas. Eggs from the collected plants were then temporarily stored in glass tubes containing honey solution for emerging parasitoids. These were incubated under room temperature until the parasitoids emerged and subsequently reared in *Corcyra cephalonica* eggs to produce enough progeny for identification purposes. The parasitization level was estimated by using the following formula:

$$\text{Parasitization (\%)} = ((\text{total parasitized eggs} / \text{total collected eggs}) \times 100\%)$$

Mass rearing of *C. cephalonica* and Trichogrammatidae

C. cephalonica eggs used for rearing were collected from livestock feed storages located in Ciawi and Karawang, West Java. Adult moths were kept in a cylinder container made of cardboard paper (8x20cm) and covered by a 25 mesh nylon for oviposition. Eggs attached on the nylon were then harvested daily to serve as hosts of trichogrammatids. Some of the *C. cephalonica* eggs were left to hatch and the larvae were reared in plastic boxes (35x25x7 cm) for maintenance of *C. cephalonica* cultures. For parasitoid rearing, host eggs were attached on a 1x10 cm paper using gum arabic and exposed to female parasitoids in 3x15 cm diameter glass tubes containing 20% honey solution. Females were exposed to the host eggs for 24 hours and the eggs were replaced with new ones while parasitized eggs were incubated under room temperature until emergence.

Identification

A dry collection, embedded in object glass, was prepared for identification using morphological characters. The genus level was distinguished based on wing pairs and the species level was identified from differences found in the male genitalia (Alba, 1988; Pinto, 1995; Nagarkatti and Nagaraja, 1977).

RESULTS

Collection of Herbivorous Insect Eggs

The survey was conducted for seven months by collecting eggs of herbivorous insects attacking various agricultural crops across regions in Java. There were many eggs collected, among others *Scirpophaga incertulas* on paddy, *Plutella xylostella* and *Crociodolomia pavonana* on cabbage and cauliflower, *Spodoptera litura* on shallot and red onion, *Etiella zinckenella* on soybean, and *Helicoverpa armigera* on various agricultural crops (Table 2).

Table 2. Eggs of herbivorous insects collected from various host plants and location.*

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/Species
1	29-07-98	Jatisani, Karawang, West Java	Paddy	RBPH, YSB	28	Paddy	>100 YSB
2	18-08-98	Sindang Asih, Cianjur, West Java	Paddy	Golden snail, rat	-	Paddy, corn + pepper	-
3	22-08-98	Amansani, Rengas dengklak, Karawang, West Java	Paddy	RBPH, golden snail, YSB	-	Paddy	7 YSB

Species distribution of Trichogramma and Trichogrammatoidea genus.....

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/ Species
4	22-08-98	Pabrik es, Karawang, West Java	Paddy	RBPH , YSB	-	Paddy	13 YSB
5	25-08-98	Darmaga, Bogor, West Java	Paddy	RBPH, GLH	-	Paddy	-
6	29-08-98	Cengkareng, Tangerang, West Java	Paddy	RBPH, GLH	-	Paddy	-
7	04-09-98	Ciloto, Cianjur, West Java	Shallot	<i>Spodoptera exigua</i>	1315	Mixed Crop, cabbage	>100 <i>S. exigua</i>
8	04-09-98	Ciloto, Cianjur, West Java	Cabbage	<i>Plutella xylostella</i>	1325	Cabbage, tomato, shallot	26 <i>P. xylostella</i>
9	05-09-98	Jalan Baru, Bogor, West Java	Corn	<i>Mithymna sp, Heliothis sp</i>	220	Corn	-
10	05-09-98	Jalan baru, Bogor, West Java	Taro	<i>S. litura, Spingidae</i>	220	Mixed crop, cassava	-
11	09-09-98	Tugu, Cisarua, Bogor, West Java	Cabbage, mustard greens	<i>P. xylostella</i>	1120	Cabbage, small red bean + lettuce	74 <i>P. xylostella</i>
12	09-09-98	Tugu, Cisarua, Bogor, West Java	Cabbage, mustard greens	<i>Crocidolomia pavonana</i>	1120	cabbage + small red bean+ lettuce	3 <i>C. pavonana</i>
13	10-09-98	Cipeyeum, Cianjur, West Java	Soybean	<i>S. litura, Lamprosema, Chrysodeixis</i>	-	Soybean	1 <i>S. litura</i> , 1 <i>Piezodoros</i>
14	14-09-98	Cibogo, Bogor, West Java	Paddy	RBPH, WSB, YSB, X1	-	Paddy, banana	3 YSB, 5 eggs X1
15	14-09-98	Batulayang, Cisarua,Bogor, West Java	Paddy	RBPH	-	Paddy, banana	-
16	16-09-98	Cubungbulan, Ciampea, Bogor, West Java	Paddy	RBPH, YSB	210	Paddy	3 YSB
17	16-09-98	Leuwiliang, Bogor, West Java	Paddy	Stink bug, YSB	230	Paddy	4 YSB
18	16-09-98	Karehkel, Leuwiliang, Bogor	Paddy	RBPH + YSB	145	Paddy	1 YSB

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/ Species
19	07-10-98	Umbul harjo. Central Java	Paddy	RBPH + golden snail +YSB	110	Paddy	2 YSB
20	07-10-98	Bantul, Central Java	Paddy	YSB +golden snail	80	Paddy	5 YSB
21	07-10-98	Ringroad Selatan, Bantul, Central Java	Soybean	<i>Piezodorus</i> <i>sp</i>	40	Soybean, corn, peanut.	2 <i>Piezodorus</i>
22	08-10-98	Sentolo, Kulon Progo, Central Java	Corn	<i>Mithymna sp</i>	80	Corn, + Caper bush (<i>Capparis sp</i>)	-
23	08-10-98	Sentolo, Kulon Progo, Central Java	Paddy	YSB + rat	65	Paddy	2 YSB
24	08-10-98	Wates, Kulon Progo, Central Java	Paddy	YSB + rat	35	Paddy	2 YSB
25	08-10-98	Wates, Kulon Progo, Central Java	Red Onion and Shallot	<i>S. exigua</i>	35	Paddy, cabbage, Shallot	-
26	08-10-98	Wates, Kulon Progo, Central Java	Cabbage	<i>P. xylostella</i> + <i>C.</i> <i>binotalis</i>	35	Paddy +cabbage +Shallot	-
27	09-10-98	Moyundan, Sleman, Central Java	Paddy	YSB + rat	150	Paddy	1 YSB
28	09-10-98	Godean, Sleman, Central Java	Paddy	YSB + rat	160	Paddy	3 YSB
29	10-10-98	Blumbangan, Tawang Mangu, Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1465	Mixed crop: carrot +cabbage +shallot	157 <i>P. xylostella</i>
30	10-10-98	Blumbangan, Tawang Mangu, Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1420	Mixed crop: carrot +cabbage +shallot	108 <i>P. xylostella</i>
31	10-10-98	Blumbangan, Tawang Mangu, Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1465	Mixed crop: carrote +cabbage +shallot	12 <i>C. pavonana</i>
32	10-10-98	Blumbangan, Tawangmangu , Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1420	Mixed crop carrot +cabbage +shallot	16 <i>C. pavonana</i>

Species distribution of Trichogramma and Trichogrammatoidea genus.....

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/ Species
33	10-10-98	Blumbangan, Tawangmangu, Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1465	Mixed crop: carrot +cabbage +shallot	9 <i>S. exigua</i>
34	10-10-98	Blumbangan, Tawang Mangu, Central Java	Cabbage	<i>P. xylostella</i> , <i>C. binotalis</i> , <i>S. exigua</i> , <i>S. litura</i>	1420	Mixed crop: carrot +cabbage +shallot	12 <i>S. exigua</i>
35	10-10-98	Jaten, Karang anyar, Central Java	Paddy	YSB + rat	170	Paddy	3 YSB
36	11-10-98	Tegal Catak, Umbul Harjo, Central Java	Paddy	YSB + Snail + RBPH	110	Paddy	1 YSB
37	16-10-98	Raja Baluh, Sumber, Cirebon	Paddy	Golden snail + rat	160	Paddy	-
38	16-10-98	Kramat Jati, Sumber, Cirebon	Paddy	Golden snail + rat + RBPH	110	Paddy	1 <i>S. litura</i>
39	16-10-98	Dukupuntang, Sumber, Cirebon	Paddy	X2	95	Paddy	1 cluster X2
40	17-10-98	Wonosari, Brebes, Central Java	Red Onion	larvae of <i>S. exigua</i>	10	-	-
41		Losari, Cirebon	Paddy	<i>Lepidopteran</i> larvae	75	Paddy, sugar cane	-
42		Pabuaran Lor, Ciledug, Cirebon	Red Onion	<i>Larvae of S. exigua</i>	90	Red onion	-
43	18-10-98	Kemantren, Cirebon Selatan	Paddy	-	85	Paddy	-
44	18-10-98	Kenanga, Phumbon	Paddy	YSB, eggs (X2), <i>S. litura</i>	105	Paddy	1 <i>S. litura</i> , 3 YSB, 4 X2
45		Palad, Sumber, Cirebon	Paddy	<i>Golden snail</i> + rat	150	Paddy	2 <i>Nezara</i> , 1 Egg X2
46		Beberan, Palimanan	Paddy	YSB, WSB	40	Paddy	1 YSB
47	02-11-98	Sindang Barang Bogor	Paddy	YSB + RBPH		Paddy	1 YSB
48	11-11-98	Cikole, 1 Lembang	Cauliflower	<i>P. xylostella</i>	1305	Cauliflower	26 Eggs <i>P. xylostella</i>
		Cikole, 1 Lembang	Cauliflower	<i>C. pavonana</i>	1305	Cauliflower	3 clusters <i>C. pavonana</i>
		Cikole, 1 Lembang	Cauliflower	<i>S. litura</i>	1305	Cauliflower	3 clusters <i>S. litura</i>

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/ Species
49	11-11-98	Cikole, 2 Lembang	Cabbage Cauliflower	<i>P. xylostella</i>	1305	Cauliflower +cabbage +shallot +lettuce	49 eggs <i>P. xylostella</i>
		Cikole, 2 Lembang	Cauliflower	<i>C. binotalis</i>	1305	Cauliflower + cabbage +shallot +lettuce	28 clusters <i>C. binotalis</i>
		Cikole, 2 Lembang	Cauliflower	<i>S. litura</i>	1305	Cauliflower +cabbage +shallot +lettuce	1 cluster <i>S. litura</i>
		Cikole, 2 Lembang	Cauliflower	Diptera	1305	Cauliflower +cabbage +shallot +lettuce	31 Dipteran eggs
50	17-11-98	Ciranjang, Cianjur	Paddy	Stinkbug + grasshopper	390	Paddy	-
		Ciloto 1, Cianjur	Cauliflower	<i>C. binotalis</i>	1410	Mixed crop: cabbage +carrot +corn	49 clusters <i>C. binotalis</i>
		Ciloto 2, Cianjur	Cabbage	<i>C. binotalis</i>	1390	Mixed crop: cabbage +shallot	1 cluster <i>C. binotalis</i>
		Ciloto 2, Cianjur	Cabbage	Diptera	1390	Mixed crop: cabbage +shallot	13 Dipteran eggs
		Ciloto 2, Cianjur	Shallot	<i>S. exigua</i>	1390	Shallot	5 clusters <i>S. exigua</i>
51	27-02-99	Ciloto, Cianjur	Cabbage	<i>P. xylostella</i>	1350	Cabbage	96 eggs <i>P. xylostella</i>
52	-	Cianjur	Soybean	<i>Etiella zinckenella</i>	-	Soybean	-
53	-	Cianjur	Kassod tree (Cassia)	<i>Pieridae</i>	-	-	-
54	24-3-99	Asembagus, Situbondo, Jatim	Sugar cane	<i>S. incertulas</i>	0	Sugar cane	-
55	24-3-99	Asembagus, Situbondo, Jatim	Cotton	<i>Helicoverpa armigera</i>	0	Cotton	-
56	24-3-99	Malang, Jatim	Cotton	<i>Helicoverpa armigera</i>		-	-
57	25-03-99	Mantung, Pujon, Malang	Cabbage	<i>P. xylostella</i>	1090	Cabbage	85 eggs <i>P. xylostella</i>

Species distribution of Trichogramma and Trichogrammatoidea genus.....

No	Date	Location	Host Plant	Pests/hosts	Altitude (masl)	Plantations	Egg cluster/ Species
57	25-03-99	Mantung, Pujon, Malang	Cabbage	<i>P. xylostella</i>	1090	Mixed crop: cabbage	168 eggs <i>P. xylostella</i>
58	26-3-99	Malang	Soybean	<i>Etiella zinckenella</i>	370	-	-

(YSB=Yellow stemborer; RBPH=rice brown planthopper; GLH=green leafhopper, WSB=white stemborer.)

Egg parasitoid community

In total, there were approximately five species of egg parasitoids recorded from various hosts by surveying 20% of observed agricultural crops. All of the recorded egg parasitoids belong to the family Trichogrammatidae and have been identified to belong to the genus *Trichogramma* and *Trichogrammatoidea* (*T'oidea*). *T'toidea armigera*, recorded to be the most generalist species, adapts to various host species and attacks various host plants. In contrast, *T. flandersi* and *T. minutum* were only found in certain host species in a certain location (Table 3).

Table 3. Species list of *Trichogramma* and *Trichogrammatoidea* recorded from the survey.

No	Species	Hosts	Host Plant	Distribution
1	<i>T. flandersi</i>	<i>P. xylostella</i>	Cabbage	Tawangmangu
2	<i>T. japonicum</i>	<i>S. incertulas</i>	Paddy	Karawang, Bantul, Kulonprogo, Sleman, Umbul harjo
3	<i>T. minutum</i>	Pieridae	Kassod tree (Cassia)	Cianjur
4	<i>T' t o i d e a</i> <i>cojuangcoi</i>	- <i>Plutella xylostella</i> -Diptera -unknown	Cabbage, Cauliflower -	Lembang, Ciloto- Cianjur, Cisarua- Bogor, Tawangmangu, Pujon-Malang Plumbon-Cirebon
5	<i>T'toidea armigera</i>	- <i>P. Xylostella</i> <i>Crociodomia binotalis</i> - <i>Helicoverpa armigera</i> - <i>S. incertulas</i> - <i>Etiella zinckenella</i>	Cabbage Cabbage, Cauliflower Cotton Sugar cane Soybean	Cisarua-Bogor Lembang, Cianjur, Malang, Situbondo

Geographic distribution and parasitism.

Not all collected eggs were parasitized (Table 4). *Spodoptera* eggs were occasionally free of parasitism and parasitism varied from low to medium (1% to 60%). There was also host specific parasitoid species recorded from the survey. *T. japonicum* was the only species recorded to be associated with eggs of *S. incertulas* with low-medium parasitization level, between 13.60 and 33.82%, across selected locations and altitude. *T. flandersi* and *T. cojuangcoi* were two species found to parasitize eggs of *P. xylostella* on highland brassicaceae. *T. cojuangcoi* was found to occur in the highlands, attacking Brassicaceae across Java. In contrast, *T. flandersi* was only recorded in highland area in Tawangmangu-Central Java. *T. minutum* was recorded from Pieridae eggs in cabbage plantations. A single female *T'oidea cojunagcoi* was collected from rice paddy in West Java.

T'oides armigera was found to be a cosmopolitan species, attacking various host species across Java. It attacks not only Lepidopteran eggs but also Dipteran eggs.

Table 4. Distribution and parasitism by egg parasitoids attacking various hosts from various plant hosts across Java.

Region	Sites	Host plant	Hosts	Altitude	% Parasitism	Species
West Java	Jatisari, Karawang	Paddy	<i>Scirpophaga incertulas</i>	28	-	<i>Trichogramma japonicum</i>
West Java	Tugu, Cisarua, Bogor,	Cabbage, lettuce	<i>P. xylostella</i>	1120	9.50	<i>T'oides cojuangcoi</i> <i>T'oides armigera</i>
West Java	Cikole, 1 Lembang	Cauliflower	<i>P. xylostella</i>	1305	11.50	<i>T'oides cojuangcoi</i>
West Java	Cikole, 2 Lembang	Cabbage + Cauliflower	<i>P. xylostella</i>	1305	42.90	<i>T'oides cojuangcoi</i> <i>T'oides armigera</i>
West Java	Cikole, 2 Lembang	Cauliflower	Diptera	1305	22.60	<i>T'oides cojuangcoi</i> <i>T'oides armigera</i>
West Java	Ciloto 1, Cianjur	Cauliflower	<i>C. binotalis</i>	1410	1.29	<i>T'oides armigera</i>
West Java	Ciloto, Cianjur	Cabbage	<i>P. xylostella</i>	1350	55.20	<i>T'oides cojuangcoi</i>
West Java	Cianjur	Soybean	<i>Etiella zinckenella</i>	1200	-	<i>T'oides armigera</i>
West Java	Cianjur	Kassod tree (Cassia)	Pieridae	1250	-	<i>T. minutum</i>
West Java	Kenanga,	Paddy	<i>Scirpophaga incertulas</i>	105	Single female	<i>T'oides cojuangcoi</i>
Central Java	Umbul harjo.	Paddy	<i>Scirpophaga incertulas</i>	110	33.82	<i>T. japonicum</i>
Central Java	Bantul,	Paddy	<i>Scirpophaga incertulas</i>	80	25.30	<i>T. japonicum</i>
Central Java	Sentolo, Kulon Progo,	Paddy	<i>Scirpophaga incertulas</i>	65	21.15	<i>T. japonicum</i>
Central Java	Wates, Kulon Progo,	Paddy	<i>Scirpophaga incertulas</i>	35	26.49	<i>T. japonicum</i>
Central Java	Moyundan, Sleman,	Paddy	<i>Scirpophaga incertulas</i>	150	13.60	<i>T. japonicum</i>

Region	Sites	Host plant	Hosts	Altitude (M asl)	% Parasitism	Species
Central Java	Blumbangan, Tawang Mangu,	Cabbage	<i>P. xylostella</i>	1465	4.50	<i>T. flandersi</i>
Central Java	Blumbangan, Tawang Mangu,	Cabbage	<i>P. xylostella</i> ,	1420	2.80	<i>T'toidea cojuangcoi</i>
Central Java	Tegal Catak, Umbul Harjo,	Paddy	<i>Scirpophaga incertulas</i>	110	25.86	<i>T. japonicum</i>
East Java	Asembagus, Situbondo,	Sugar cane	<i>S. incertulas</i>	0	-	<i>T'toidea armigera</i>
East Java	Asembagus, Situbondo,	Cotton	<i>Helicoverpa armigera</i>	0	-	<i>T'toidea armigera</i>
East Java	Malang,	Cotton	<i>Helicoverpa armigera</i>		-	<i>T'toidea armigera</i>
East Java	Mantung, Pujon, Malang	Cabbage	<i>P. xylostella</i>	1090	49.41	<i>T'toidea cojuangcoi</i>
East Java	Mantung, Pujon, Malang	Cabbage	<i>P. xylostella</i>	1090	62.50	<i>T'toidea cojuangcoi</i>
East Java	Malang	Soybean	<i>Etiella zinckenella</i>	370	-	<i>T'toidea armigera</i>

Table 5 shows the diversity of trichogrammatids found in Java. This table was compiled to assess the overall trichogrammatids that has been recorded thus far. There is one species of trichogrammatids (*T'toidea cojuangcoi*) found in this study that is a new record for Java.

Table 5. Trichogrammatid species recorded from various host plants in Indonesia.

No.	Species	Hosts	Host plant	Reference
1	<i>Trichogramma japonicum</i>	<i>Scirpophaga incertulas</i> <i>Tryporyza nivella</i> <i>Chillo auricilius</i> <i>S. innotata</i>	Paddy Sugar cane Sugar cane Paddy	Mahrub (1993), Soejitno (1989), Meilin et al. (2000) Samoedi, et al., (1988) Samoedi, et al., (1988) Kalshoven (1981)
2	<i>T. chilonis</i>	<i>Helicoverpa armigera</i>	Soybean Shallot	Herlinda, Pudjianto and Winasa (1996) Shepard dan Barrion (1998)
3	<i>T. australicum</i>	<i>Nivella</i> <i>Auricilius</i> <i>Chillo</i> spp.	Sugar cane Sugar cane Sugar cane/ Paddy	Samoedi et al., (1988) Samoedi et al., (1988) Kalshoven (1981)

No.	Species	Hosts	Host plant	Reference
4	<i>T. chilotraeae</i>	<i>H. armigera</i> <i>Suppresalis</i> <i>Ostrinia furnacalis</i> <i>C. infuscatellus</i> <i>C. sacchariphagus</i> <i>Etiella zinckenella</i>	Corn Corn Corn Sugar cane Sugar cane -	Nurindah and Bindra (1989) Uintah and Bindra (1989) Nurindah and Bindra (1989) Nagarkatti and Nagaraja (1977) Nagarkatti and Nagaraja (1977) Nurindah and Bindra (1989)
5	<i>T. minutum</i>	<i>Heliothis</i> spp. <i>Agrius convolvuli</i> Pieridae	Tobacco Sweet potato Soybean Cabbage	Kalshoven (1981) Shepard and Barrion (1998) Meilin <i>et al.</i> (2000)
6	<i>Trichogramma</i> sp.	<i>Cricula trifenestrata</i>	Cashew	Djuarso dan Wikardi (1977)
7	<i>Trichogramma</i> sp.	<i>Milionia basalis</i>	Pinus	Nagarkatti and Nagaraja (1977)
8	<i>Trichogrammatoid</i> <i>ea</i> <i>Bactrae bactrae</i>	<i>Etiella</i> sp.	Soybean	Marwoto, Supriyatin dan Djuarso (1997) Shepard and Barrion (1998)
9	<i>T'toidea bactrae</i>	<i>C. sacchariphagus</i> <i>Straminellus</i>	Sugar cane	Nagarkatti and Nagaraja (1977)
10	<i>T'toidea thoseae</i>	<i>Setora nitens</i> <i>Setothoseae asigna</i> <i>Darna trima</i>	Oil Palm Oil Palm Oil Palm	Sipayung, Chenon dan Sudharto (1989) Sipayung, <i>et al.</i> , (1989) Sipayung, <i>et al.</i> , (1989)
11	<i>T'toidea armigera</i>	<i>H. armigera</i> <i>D. zinckenella</i> <i>P. xylostella</i>	Cotton Sugar cane Cabbage	Nurindah and Bindra (1989), Meilin <i>et al.</i> (2000) Nagarkatti and Nagaraja (1977) Meilin <i>et al.</i> 2000
12	<i>T'toidea guamensis</i>	<i>H. armigera</i>	Corn	Nurindah and Bindra (1989)
13	<i>T'toidea nana</i>	<i>C. sacchariphagus</i> <i>Straminellus</i> <i>C. infuscatellus</i> <i>Tetramoera schistaceana</i>	Sugar cane Sugar cane Sugar cane	Nagarkatti and Nagaraja (1977) Kalshoven (1981) Kalshoven (1981)

DISCUSSION

In this survey, five species of trichogrammatids from seven hosts were collected across geographic regions in Java. The parasitization rate varies, from no parasitism at all to medium parasitism. Interestingly, all eggs of *Spodoptera* spp. were not parasitized by Trichogrammatid even though these occurred in the same habitat of parasitized eggs of other species. This indicates that *Spodoptera* may not serve as a promising host for Trichogrammatid. This was supported by Djuwarso *et al.*, (1997) who identified that under laboratory conditions, *S. litura* eggs can be

parasitized by *T'toidea bactrae bactrae* (with parasitization level up to 80.3%) however the survival of the parasitoid reared on *Spodoptera* was very low, i.e. only reached 0.80%. The most common herbivorous insects attacked by trichogrammatids were *P. xylostella* and *S. incertulas*, common pests of cabbage and rice paddy. The differences in parasitism rate may reflect various factors, i.e the use of pesticides (which resulted in low parasitism rate), differences in population size of the parasitoids, differences in ability of parasitoids to find and parasitize their hosts, and differences in landscape structure. Complex landscape, whereby various vegetation can be found within a landscape has been found to be correlated with high incidence of parasitism (Buchori *et al.*, 2008, Hunter, 2002, Marino *et al.*, 2006). This finding suggests that for parasitoid conservation, landscape structure that harbors high diversity of vegetation is crucial in maintaining parasitoid presence.

From five trichogrammatid species, three species were recorded to attack eggs of *P. xylostella*. Meilin *et al.*, (2000) reported that *Trichogramma flandersi*, *T'toidea cojuangcoi*, *T'toidea armigera* were three species found to be associated with *P. xylostella* in Indonesia. This finding was different with several studies on Trichogrammatid attacking *P. xylostella* in other countries. In Thailand, species that were found to be associated with this pest are *T'toidea bactrae* Nagaraja and *T. confusum* Viggiani, in Japan were *T. chilonis* Ishii (Keinmessuke *et al.*, 1992; Klemm *et al.*, 1992) and in Philippine were *T. evanescens* and *T'toidea armigera* (Alba 1988). In this study, *T'toidea cojuangcoi* was recorded to parasitize eggs *P. xylostella*, however in the Philippines, this species was reported to attack *Acrocercops cramerella*, a cocoa pod borer and rambutan pest (Alba, 1988).

T'toidea armigera was the only species found to attack several host species including *P. xylostella*, *C. binotalis*, *H. armigera*, *S. incertulas* and *E. zinckenella*. This species was also found across geographic regions and host plants. Previous studies reported that *T'toidea armigera* attacks *H. armigera* on cotton plantations (Nurindah and Bindra, 1989) and tomato (La Daha, 1997), *Etiella zinckenella* in sugar cane plantations (Nagarkatti and Nagaraja, 1977). An interesting result was that *T'toidea armigera* survived in eggs of *C. pavonana* with low level parasitism. This was the first finding reported the association of *T'toidea armigera* and *C. pavonana* in Indonesia. These findings suggested that *C. pavonana* may serve as potential alternative hosts in the field. Further research is needed to evaluate the ability of the species to control *C. pavonana* in the field. Since *C. pavonana* has not been controlled using biocontrol agents, it is very important for biocontrol measures against *C. pavonana* be developed.

T. japonicum Ashmead is the only species found to be associated in paddy fields by parasitizing yellow stem borer (*S. incertulas*). This was confirmed by Nagarkatti and Nagaraja (1977) who reported that *T. japonicum* was associated with paddy field. Further research supports the results that the species was found to attack *S. incertulas* in paddy field (Soejitno, 1989; Mahrub, 1993).

In the research, *T. minutum* was reported to parasitize eggs of Pieridae on Kassod tree (*Cassia seamea*), however some research reported different results, this species attacks *Heliothis* spp. on tobacco (Kalshoven, 1981) and *Agrius convolvuli* on sweet potato and soybean (Shepard and Barrion, 1998). Our results are new findings for Indonesia, i.e *T. minutum* can be found in perennial trees.

CONCLUSIONS

Three species of *Trichogramma* and two species of *Trichogrammatoidea* were recorded in this survey. *T. flandersi* and *T. japonicum* were found to be more host species specific, compared to other trichogrammatids. A new record of Trichogramma was found in *Crocidolomia pavonana*, a very important pest of cabbage. *T'toidea armigera* and *T. cojuangcoi* are found to be able to survive in alternative species. These findings are valuable information for biological control programs. Further field investigation and laboratory tests are needed to verify the effectiveness of those

identified species for biological control agents.

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REFERENCES

- Alba, M.C. 1988. Trichogrammatids in The Philippines. Philipp. Ent. 7(3): 253-271.
- Buchori, D, Sahari B. Nurindah. 2008. Conservation of Agroecosystem through Utilization of Parasitoid Diversity: Lesson for Promoting Sustainable Agriculture and Ecosystem Health. Hayati, Journal of Bioscience 15:165-172.
- Clausen, CP. 1940. Entomophagous Insects. New York :McGraw-Hill Book Company Inc.
- Djuwarso T, Wikardi EA. 1997. Perbanyakkan *Trichogramma* sp. Parasitoid Telur *Cricula trifenestrata* Helf. pada Jambu Menté. Jurnal Littri. 3 (3): 78-86.
- Djuwarso. T, W.Tengkano, D. Koswanudin, D.Damayanti . 1997. Potensi *Trichogrammatoidea bactrae bactrae*, Parasitoid Telur Penggerek Polong Kedelai, pp.29-45. In Proc. Seminar Nasional Perhimpunan Entomologi Indonesia, Tantangan Entomologi Abad XXI, Bogor.
- Hassan, S.A. 1993. The mass rearing and utilization of *Trichogramma* to control Lepidoptera pests: Achievements and Outlook. Pestic. Sci. 37 : 387-391.
- Herlinda S. 1995. Kajian *Trichogrammatoidea bactrae bactrae* Nagaraja (Hymenoptera: Trichogrammatidae), Parasitoid Telur *Etiella zinckenella* Treitschke. (Lepidoptera: Pyralidae). Master. Thesis, Program Pascasarjana Institut Petanian Bogor, Bogor.
- Houseweart, M.W., D.T.Jennings, C.Welty, and S.G.Southard. 1983. Progeny production by *Trichogramma minutum* (Hymenoptera:Trichogrammatidae) utilizing eggs of *Choristoneura fumiferana* (Lepidoptera : Tortricidae) and *Sitotroga cerealella* (Lepidoptera : Gelechiidae). Can. Ent. 115 (10): 1245-1252.
- Hunter M.D. 2002. Landscape structure, habitat fragmentation, and the ecology of insects. *Agric. Forest. Entomol.* 4:159-166.
- Kalshoven, L.G.E. 1981. Pests of Crops in Indonesia. Revised and Translated by Van der Laan., PT. Ichtiar Baru van Hoeve. , Jakarta. 701p.
- Keinmeesuke, P., A.O Vattanatangun, Sarnthoy, B. Sayampol, T. Myata, T. Sait, F. Nagasuji, and N.Sinchaisri. 1992. Life table of Diamond back moth and its egg parasite, *Trichogrammatoidea bactrae* in Thailand, pp. 309-315. In Takelar, N. S. (Ed.). Diamondback Moth and Other Cruciferae Pests : Proc. 2nd Int. Workshop. AVRDC , Shanhua, Taiwan.
- Klemm, U., M.F. Guo, L.G. Lai and H. Schmutterer. 1992. Selection of effective species or strain of *Trichogramma* egg parasitoids of diamondback moth, pp. 317-323. In “Diamondback Moth and Other Cruciferae Pests : Proc. 2nd Int. Workshop” (Takelar, N. S., Ed.), AVRDC, Shanhua, Taiwan.

- La Daha. 1997. Ekologi *Helicoverpa armigera* (Hubner) (Lepidoptera : Noctuidae) pada Pertanaman Tomat. Doctor. Program Pascasarjana Institut Pertanian Bogor, Bogor.
- Li, L. 1994. Worldwide use of *Trichogramma* for biological control on different crops: A survey pp 37-53. In E. Wajnberg, S.A.Hassan (eds.). *Biological control with egg parasitoids*. International Organization for Biological Control. UK.
- Mahrub, E. 1993. Peranan Parasitoid Telur dan Varietas Padi dalam Pengendalian Hama Terpadu Penggerek Batang Padi Kuning (*Scirpophaga incertulas*). Ilmu Pertanian 5 (3) : 645-656.
- Marwoto, Supriyatin and T. Djuarso . 1997. Prospek Pengendalian Hama Penggerek Polong Kedelai (*Etiella* spp.) dengan parasitoid *Trichogrammatoidea bactrae* *bactrae*. Jurnal Litbang Pertanian. XVI (3) : 71-76.
- Marwoto and N. Saleh. 2003. Peningkatan parasitoid telur *Trichogrammatoidea bactrae* *bactrae* dalam pengendalian hama penggerek polong kedelai *Etiella* spp. Jurnal Litbang Pertanian. 22(4):141-149.
- Meilin, A., P. Hidayat, D. Buchori and U. Kartosuwondo U. 2000. Parasitoid telur pada *Plutella xylostella* (L).(Lepidoptera:Yponomeutidae). Bull. Hama Penyakit Tanaman. 12(1):21-26
- Marino PC, Landis DA and BA Hawkins. 2006. Conserving parasitoid assemblages of North American pest Lepidoptera: Does biological control by native parasitoids depend on landscape complexity? Biological Control 37: 173–185
- Nagarkatti S, H. Nagaraja. 1977. Biosystematics of *Trichogramma* and *Trichogrammatoidea* Species. Ann. Rev. Entomol. 22: 157-176.
- Nurindah and O.S Bindra. 1989. Studies on *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) in the Control of *Heliothis armigera* (Hubner) (Lepidoptera Noctuidae). Biotrop. Spec. Publ.. 36: 165-173.
- Pinto, J.D. 1995. Hand Out of *Trichogramma* Identification Workshop. Brisbane, Australia. (Unpublished).
- Samoedi D, B. Wirioatmodjo, D. Santoso. 1988. Evaluation of *Trichogramma* liberation to control the sugarcane moth borers *Chillo auricilius* Dudgeon and *Tryporyza nivella intacta* SN on sugarcane in West Java. Biotrop Spec. Publ. 32:177-181.
- Shepard, B.M and A.T. Barrion. 1998. Parasitoids of insects associated with soybean and vegetable Crops in Indonesia. J. Agric. Entomol. 15(3) : 239-272.
- Sipayung A, R. Desmier De Chenon, P. Sudharto . 1989. Natural enemies of leaf eating lepidoptera in the oil palm plantations north Sumatra. *Biotrop Spec. Publ.* 36: 99-120.
- Soejitno, J. 1989. The biological aspects of egg parasitoids of rice stem borer. Biotrop. Spec. Publ. 36: 141-147.
- Van Bergeijk, K.E, F. Bigler, N.K. Kaashoek and G.A.Pak. 1989. Changes in host acceptance and host suitability as an effect of rearing *Trichogramma maidis* on factitious host. Entomol. Exp. Appl. 52: 229-238.

**FISH AND VEGETABLES DIVERSIFICATION IN IRRIGATED RICE FIELDS
IN SUMATRA, INDONESIA: A STUDY OF TWO VILLAGES IN THE
KOMERING IRRIGATION DEVELOPMENT AREA**

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ABSTRACT

Although crop diversification has been one of the major government policies in Indonesia since the late 1980s, it is still not widely practiced by most farmers. This paper aims to analyze the diversification in the rice-based farming system, specifically to (a) identify the existing cropping patterns, (b) examine the factors affecting diversification, and (c) examine optimal crop combination in Karang Sari and Tambak Boyo villages in Komering irrigation area.

In addition to double rice cropping of rice, farmers in Karang Sari and Tambak Boyo have diversified into fish culture and vegetable cultivation, respectively. There are a number of factors affecting fish diversification. They include the level of knowledge, market access and income sources. Results of the study show that level of knowledge is positively related to fish diversification while market accessibility and income sources are negatively related. In Tambak Boyo, the factors influencing farmers to diversify into vegetable production include availability of irrigation water which is reflective of the stability of water supply, availability of family labor, and availability of manure for fertilizer, respectively. These three factors have a positive influence on vegetable diversification. In Karang Sari, the optimal combination was rice-fish-rice-fish which gave the highest annual net income while in Tambak Boyo, the optimal combination was (rice+spinach)-rice. Results of the study show that diversification into fish and vegetables production provided additional employment and made a positive contribution to household economy.

Key words: Cropping pattern, logit function, and linear programming.

INTRODUCTION

The crop and food diversification program was one of the major programs of the Fifth Five-Year Development Plan (1989-1994) of Indonesia. This encouraged the planting of a wider range of commodities which was considered important in attaining rice self-sufficiency, (MA, 1994). The calorie and protein intake from rice can be reduced and substituted by increasing the consumption of other foodstuff such as fruits, vegetables, meat, eggs, fish, etc. However, it appears that diversification is still not practiced by most farmers. The Komering Irrigation Project is one of the most important irrigation projects in South Sumatra. It aims to improve people's welfare by providing a constant supply of irrigation water from Komering River to the rainfed rice fields in Ogan, Komering, and Tulang Bawang Basin (DPPW, 2004). The first phase of the project was in 1991 and continued to the second phase in 1996. In addition to increasing cropping intensity, some farmers had diversified their farm businesses by cultivating vegetables and raising fish in their rice fields.

A farm household survey was conducted from June to October 2005 in three villages: Hamlet I of Karang Sari village, Hamlet I of Tambak Boyo village, and Hamlets I and II of Rasuan Baru village with 105, 105, and 102 farmer-respondents interviewed, respectively. The villages of Karang Sari and Tambak Boyo villages were chosen as the study sites because diversified rice farming is commonly practiced in the area given its relatively stable water supply. Among the farmers

interviewed, only 72 farmers were considered as they had access to irrigation in Karang Sari. In Tambak Boyo, only 49 farmers were considered because the rest still planted rice once a year due to the condition of new irrigation system. The existing cropping patterns, factors affecting diversification, and optimal crop combination were identified and examined.

CHARACTERISTICS OF THE VILLAGES SURVEYED

Two villages were chosen for the study, Karang Sari representing a well-irrigated rice field in Stage I and Tambak Boyo representing a newly-irrigated rice field in Stage II Phase 1. In Karang Sari which is located in the Stage I area of the Komerang Irrigation Project, there are still some rainfed rice fields. A river divides the village area into two distinct ecosystems, irrigated and rainfed rice fields. Karang Sari is located 290 kms. from Palembang, 95 kms. from the capital city of OKU district, and 15 kms. from the capital city of Belitang sub-district. The village consists of 5 hamlets and 14 neighborhoods. The total land area is 1,246 has., with 850 has. considered as agricultural. The area for the well-irrigated, semi-irrigated and rainfed rice fields are 336 has., 56 has. and 270 has., respectively. At the time of the survey, there were 984 households with a total population of 3,830 people, of which 2,929 people were engaged in agriculture. There were 1 KUD (village unit cooperative), 12 Kelompok Tani (farmers groups) and 1 P3A (water users' organization). The P3A in Karang Sari was well organized and considered to be one of the best in the country.

The second study area, Tambak Boyo, is one of the villages in the Stage II Phase 1 area of the Komerang Irrigation Project. It is located 225 kms. away from the capital city of Palembang, 85 kms. from the capital city of OKU Timur district and 26 kms. from the capital city of Buay Madang sub-district. During the time of survey, there were 3 hamlets and 6 neighborhoods. The total land area was 600 has., in which the irrigated rice fields occupied 353.5 has. The total population was 2,692 people or around 659 households, who mostly transmigrated from Java. There were 16 farmers groups, one KUD, and one P3A. However, the KUD and the P3A did not work well.

The Farmer Respondents

The profile of interviewed farmers is presented in Table 1. The average family size was rather small, 3.79 and 3.73 persons in Karang Sari and Tambak Boyo, respectively, indicating the success of the country's family planning program. The average age of household heads was 45.79 and 46.63 years in Karang Sari and Tambak Boyo, respectively, indicating a general trend of aging farmers in the country.

Table 1. Profile of farmer respondents in Karang Sari and Tambak Boyo, Sumatra, Indonesia in 2005.

Items	Karang Sari	Tambak Boyo
N	72	49
Age (years)	45.79	46.63
Education (years)	7.10	7.65
Rice farming experience (years)	24.08	21.54
Non-farming experience (years)	2.13	2.64
Family member (persons)	3.79	3.73
Family member above 16 years old	2.79	2.69
Average land area (ha)	0.62	0.51

s o m e
f r o m

Source: Survey June-October 2005

Although farmers graduated college, the

majority of farmers completed elementary school, which was the basic formal education until 1994. The average number of years of rice farming experience were 24.08 and 21.54 years in Karang Sari and Tambak Boyo, respectively, reflecting engagement in rice farming since their twenties. The average non-farming experience was 2.13 and 2.64 years in Karang Sari and Tambak Boyo, respectively. Non-farming experience refers to trading or business, tailor, carpenter, driver, etc. Lastly, the average operated land area which on the average was 0.62 ha and 0.51 ha per household in Karang Sari and Tambak Boyo, respectively was relatively small.

CROPPING PATTERNS

There are 3 common patterns of rice-fish production, namely: (1) fish production in between two paddy cultivations, at land preparation until the seedlings are ready for the transplanting, usually around 20-30 days; (2) fish production in the third season, usually around 80-90 days; and (3) combination of fish and rice production, usually called “Mina Padi” (Sudirman and Iwan, 2000). The recommended rice varieties to be planted for the Mina Padi pattern are IR64, Citanduy, Dodokan, Cisadane and Ciliwung which most farmers cultivated.

Rice-fish cropping patterns in Karang Sari Village

Some farmers in Karang Sari raised carp (Ikan Mas) in their rice fields because it has the ability to adapt to the rice field environment. It grows relatively fast and has high economic value leading to higher profitability (Sudirman and Iwan, 2000). The patterns of rice-fish production in Karang Sari are shown in Figure 1. There were 13 farmers who raised fish after double rice cropping (rice-rice-fish), 6 farmers with rice-fish-rice-fish pattern, 3 farmers with rice-fish-rice pattern, and the majority of farmers practiced double rice cropping. For double rice cropping, depending on the rice field location and timing of the water distribution which was decided by the water users’ organization, farmers planted the first rice crop from June to September, July to October, and August to November. The second rice crop was cultivated from early November to February, end of November to early March, or December to March.

Source: Survey June-October 2005

Notes: R = Rice; F = Fish

Cropping Pattern	No. of Farmers	2004					2005							
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
R-R-F	13	R					R					F		
R-F-R-F	6	R					F	R					F	
R-F-R	3	R					F	R						
R-R	50	R					R							

Fig. 1. Rice-fish production patterns in Karang Sari, Sumatra, Indonesia in 2004-2005.

Rice in the rice-rice-fish (R-R-F) pattern, is usually planted first between June and November, with a second cropping between November and March, and fish was raised between April and May. Second, in rice-fish-rice-fish (R-F-R-F) pattern, the first rice crop was planted from June to November, first fish raised from November to December, second rice planting from December to March, and second fish introduction from April to May. Finally, in rice-fish-rice (R-F-R), farmers cultivated first rice crop from June to September, raised fish from October to November, and planted the second rice crop from November to March. By adjusting the timing of the rice farming activities, farmers were able to avoid the shortage during transplanting and harvesting which is labor intensive.

Farmers also tried to raise fish at different periods to get better market prices that also consequently led to a more stable supply of fish.

Rice-fish-vegetables cropping patterns in Tambak Boyo Village

In Tambak Boyo village, 22 out of 49 farmers practiced double rice cropping (Figure 2). There were two farmers who practiced rice-(rice+fish) and (rice+vegetables)-(rice+fish) systems in which farmers raised fish (carp) together with rice (Mina Padi) in the rainy season. The dry season rice in the village was planted from May to August, June to September, and July to October, while the rainy season rice was cultivated from October to January, November to February, and December to March, depending on the location of the rice fields. Vegetables were commonly planted in the rice fields during the dry season from May to August following the patterns of (rice+vegetables)-(rice+fish) and (rice+vegetables)-rice. There were some farmers who cultivated vegetables during the rainy season from December to March in the pattern of rice-(rice+vegetables). Some farmers who planted longer growing vegetables such as string beans (kacang panjang) and tomato, cultivated vegetables from May to November under a cropping pattern of (rice+vegetables)-vegetables-rice. One farmer planted vegetables between the dry and rainy season from September to November under cropping pattern of rice-vegetables-rice while another farmer planted vegetables between the rainy and dry season from March to June, in the pattern of rice-rice-vegetables.

Fig. 2. Rice, vegetable and fish production patterns in Tambak Boyo, Sumatra, Indonesia in 2004-2005

Cropping Pattern	No. of Farmers	2004				2005										
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		
R-(R+F)	1	R						R+F								
(R + V) - (R+F)	1	R+V						R+F								
(R+V)-R	15	R+V						R								
R-V-R	1	R				V				R						
R-(R+V)	5	R						R+V								
(R+V)-V-R	3	R+V				V				R						
R-R-V	1		R					R				V				
R-R	22	R						R								

Source: Survey June-October 2005

Notes: R = Rice, V = Vegetables, F = Fish

Farmers in the village have been cultivating vegetables since the 1970s. Although there is a market near the village where some farmers sell their vegetables, most farmers would sell their products to middlemen or the village collectors.

DIVERSIFICATION

Variables and Empirical Models

Logit function analysis was used to examine the factors affecting farmers' decision to diversify to rice-fish production and rice-vegetables production. Two logit functions were estimated. First is the diversification to fish function in Karang Sari. Second is the diversification to vegetables function in Tambak Boyo. The dependent variable is the natural logarithm of the odds ratio, $L_i = \ln(P_i/(1-P_i))$. The P_i is the probability that each farmer will diversify his rice land to fish in Karang Sari and to vegetables in Tambak Boy.

The empirical model is specified as follows.

$$\ln (P / (1-P)) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$

Where: X_1 = irrigation condition score, ranging from 2 to 6
 X_2 = educational attainment of farmer in years
 X_3 = no. of family members above 16 years old (available family labor)
 X_4 = distance of the rice field from the road in meters
 X_5 = dummy variable, 1 for having other jobs, 0 for otherwise
 X_6 = dummy variable, 1 for raising cows, 0 for otherwise

In addition, marginal effects were also computed in order to determine the quantitative effects of the independent variables on each diversification (Banerjee and Martin, 2009). Marginal effects (Anderson and Newell (2003); Greene (2003)) measure the changes in probability of adopting each diversification due to given changes in the relevant independent variables. Marginal effects of continuous variables were calculated at the mean of the data and for the dummy variables, a value of 0 was used if the mean less than 0.5 and a value of 1 was used if the mean was greater than or equal to 0.5 (Banerjee and Martin, 2009).

Lowland vegetables were evaluated since the study villages are located in the lowland areas. Linear programming was used to determine the optimum rice-fish combination in Karang Sari and rice-vegetables combination in Tambak Boyo that would maximize net income of farmers with land area and family labor serving as constraints.

The Study Model

In this study, linear programming was used to maximize a linear objective function subject to the constraints (Vajda, 1958) where the objective function to be maximized was net income of farmers and the constraints were the land area and family labor (Pitipunya, 1995). The mathematical representation of the linear programming (LP) problem is:

Objective function: Maximize $Z = \sum C_j X_j$

Subject to

$$\begin{aligned} A_{ij}X_{ij} &\leq b_i \\ X_j &\geq 0 \end{aligned}$$

Where: Z is total net income (Rp)
 C_j is net income of j^{th} crop or activity (Rp/0.1ha)
 X_j is size of j^{th} crop or activity (0.1ha)
 A_{ij} is technical coefficient of i^{th} input for j^{th} activity (unit/0.1ha)
 b_i is available amount of i^{th} input (constraints)

RESULTS AND DISCUSSION

The results of logit analysis of factors affecting the probability of rice field diversification to fish production in Karang Sari are shown in Table 2. The deviance statistic is frequently used to determine whether or not the current model provides a good fit to the data under consideration (Berenson et al, 2002). The model has a good fit given a chi-square coefficient of 19.470 which is significant at 1% level. Three factors namely education, distance from the road and other jobs are significant at 5% level. The remaining two factors, irrigation condition and family members above 16 years old or available family labor, are significant only at 15% level.

The regression coefficient of education is equal to 0.250, implying it has a positive correlation with fish diversification. It indicates that with higher level of education, reflecting the level of knowledge, farmers will be more open to diversify their rice fields to fish production. The estimated marginal effect of 0.039 implies that an increase of one year formal education will increase the probability of fish production by 0.039 percent. Second, the regression coefficient of distance of

rice field from the road is equal to -0.003, reflects a negative correlation to fish diversification. It suggests that the nearer the rice field's location to the road, the higher the probability of farmers to diversify into fish production. Having an estimated marginal effect of -0.001, it indicates that one meter increase in the distance of the rice fields to the road will decrease the probability of farmers to choose fish diversification by 0.001 percent. The buyers usually purchase the fish at farmers' fields, thus the proximity of the rice fields to the road will attract buyers to come. Third, the regression coefficient of other jobs is equal to -1.290, implies a negative correlation to fish diversification. The estimated marginal effect is -0.228, indicates fish diversification is estimated to decrease by 0.228 percent for a farmer who has another job compared to a farmer without one. Since raising fish is a source of income, farmers without other jobs have a higher probability to choose fish diversification than farmers with other jobs. It must be noted that irrigation condition and available family labor had a positive correlation to fish diversification and were significant at 15% level. This implies that in fish diversification, water and labor supply are also factors to be taken into consideration.

Logit analysis of factors affecting the probability of diversification to vegetables in Tambak Boyo village are shown in Table 2. There are three important factors affecting farmers to diversify their rice farming to fish production in Karang Sari, namely education, proximity of the rice field to the road, and other jobs or source of income. Meanwhile, in Tambak Boyo the important factors include irrigation conditions, available family labor and cow raising for manure in vegetable cultivation.

Table 2. Logit analysis and estimated marginal effects of factors affecting the probability of rice fields diversification in Karang Sari and Tambak Boyo, Sumatra, Indonesia in 2004-2005.

OPTIMAL COMBINATION OF CROPS

Enterprise Budget of Fish

Farmers in Karang Sari usually raise fish for one to two months. Fish culture can be divided

Variables	Karang Sari				Tambak Boyo				into two
	b	Marginal Effects			b	Marginal Effects			
Constant	-4.614				-4.507				
Irrigation condition	0.422		0.066		0.486	*	0.112	*	
Education	0.250	**	0.039	**	-0.003		-0.001		
Family members above 16 years old	0.409		0.064		0.907	*	0.209	*	
Distance from the road	-0.003	**	-0.001	**	0.002		0.001		
Other Jobs (Yes=1, No=0)	-1.290	**	-0.228	**	-0.795		-0.174		
Raised cow (Yes=1, No=0)					1.597	**	0.372	**	
N	72				45				
Chi-square	19.470	***			12.170	*			

Source: Survey June-October 2005

Notes: *** denotes significant at the 1% level.

** denotes significant at the 5% level.

* denotes significant at the 10% level.

seasons, i.e. after the dry season rice between September and December and after the rainy season rice between March and May. Table 3 presents the average cost and returns of fish production per 0.1 ha in Karang Sari village. In the first season, the gross return was Rp 154,377/0.1 ha with a total cost that includes family labor of Rp 102,301/0.1 ha and net profit of Rp 52,076/0.1 ha. In the second season, the gross return was Rp 138,341/0.1 ha, with a total cost that includes family labor,

of Rp 116,700/0.1 ha, and net profit of Rp 21,640/0.1 ha.

The biggest percentage of production costs was due to family labor followed by fingerlings and fertilizers. Farmers bought the fingerlings at Rp 6,000/bowl on the average. Fertilizers were applied during land preparation to enhance the growth of microorganisms that serve as the natural feed for the fish. Farmers feed the fish with rice bran that they purchase from the rice mill or from their own production. During land preparation and harvesting, hired labor were paid in kind (e.g. fish).

Table 3. Average cost and returns of fish production per 0.1 ha in Karang Sari, Sumatra, Indonesia in 2004-2005.

Items	Dry season rice		Rainy season rice	
	Rp/0.1 ha	%	Rp/0.1 ha	%
N	5		14	
Gross Return (A)	154,377		138,341	
Production Costs				
Fingerlings	33,033	32.3	39,974	34.3
Fertilizers	2,494	2.4	2,588	2.2
Feed	15,041	14.7	20,018	17.2
Hired labor	560	0.5	5,599	4.8
Imputed family labor	51,173	50.0	48,521	41.6
Total Costs (B)	51,128		68,180	
Total Costs (C)	102,301	100.0	116,700	100.0
Net Return (A-B)	103,249		70,161	
Net Return (A-C)	52,076		21,640	
			Enterprise	Budget of

Source: Survey June-October 2005

Crops

Notes:

Total Costs (B) refers to cash cost of fingerlings, fertilizers, feed and hired labor.

Total Costs (C) includes the imputed cost of family labor.

Based on market demand and profitability, lowland vegetables can be divided into three groups (Nazaruddin, 2000). The first group consists of chili, a main commodity which Indonesians eat almost daily. The second group consists of shallot and beans, such as string beans while the third group consists of eggplant, spinach, kangkung, and other vegetables that are not so profitable. In Tambak Boyo, farmers cultivate the third group of vegetables while some farmers plant string beans. The average costs and returns of vegetables per 0.01 ha in Tambak Boyo are shown in Table 4. The number of farmers who planted spinach, Indian mustard, string beans and tomato was 19, 11, 7, and 3 farmers, respectively. If the imputed or non-cash costs of manure and family labor were included in the computation, farmers were actually incurring losses from their production. However, if only cash costs were considered, the highest cash returns was from producing spinach (Rp 107,609/0.01 ha), followed by Indian mustard (Rp 97,563/0.01 ha), string beans (Rp 85,865/0.01 ha), and tomato (Rp 42,843/0.01 ha). It was observed that the vegetable cultivation was labor intensive in the study villages where all farmers used family labor. Therefore, vegetable cultivation is considered as an employment provider for farmers in the village. In Tambak Boyo, farmers initially cultivated vegetables in the 1970s for their own consumption but later on sold some of their vegetables to generate income.

Spinach, *Amaranthus* sp. is the most common vegetable eaten not only in the study area but the entire country as well. Thus most farmers would grow them. Within a month of planting, these vegetables can be harvested and sold in the market. Indian mustard, *Brassica juncea* is the second most commonly planted vegetable in the village that can be harvested around two months after planting. string beans (*Vigna sinensis*) and tomato (*Solanum lycopersicum*) can be harvested for the first time two months after planting and then once a week until it reaches four months.

Table 4. Average cost and returns of vegetables per 0.01 ha in Tambak Boyo, Sumatra, Indonesia in 2004-2005.

Labor Requirement and Net Income

Items	Spinach		Indian mustard		String beans		Tomato	
	Rp/0.01 ha	%	Rp/0.01 ha	%	Rp/0.01 ha	%	Rp / 0.01 ha	%
N	19		11		7		3	
Gross Return (A)	121,019		114,436		95,434		53,157	
Production Costs								
Seed	4,333	0.8	3,136	0.7	1,286	0.5	1,296	0.8
Fertilizer	6,636	1.3	8,340	1.7	5,790	2.1	8,237	4.9
Pesticides	2,441	0.5	5,396	1.1	2,493	0.9	781	0.5
Manure	18,830	3.7	39,606	8.3	9,542	3.5	11,157	6.6
Imputed Family Labor	478,978	93.7	420,895	88.2	250,573	92.9	146,829	87.2
Total Costs (B)	13,411		16,873		9,569		10,315	
Total Costs (C)	511,219	100.0	477,374	100.0	269,684	100.0	168,301	100.0
Net Return (A-B)	107,609		97,563		85,865		42,843	
Net Return (A-C)	(390,199)		(362,938)		(174,250)		(115,144)	

Source: Survey June-October 2005

Notes: Total Costs (B) refers to cash cost of seed, fertilizer and pesticide.

This section presents the family labor input and net income from fish and crops by month in the two study villages. In terms of rice cultivation in Karang Sari, most family labor was utilized in July, August and September in the rainy season and in January during the dry season. In terms of fish production, the average raising period was one and a half months. The highest family labor requirement was in October in the first season and in April in the second season (Table 5).

Farmers gained a net income of Rp 236,829/0.1 ha. and Rp 302,415/0.1 ha. on the average from rice during the dry and rainy seasons, respectively. In terms of fish production, farmers earned a net income of Rp 103,249/0.1 ha. and Rp 70,161/0.1 ha. on the average during the first and second seasons, respectively.

Table 5. Family labor requirement, gross return, cash expenses and net income per 0.1 ha of rice and fish in Karang Sari, Sumatra, Indonesia in 2004-2005.

	Dry Season		Rainy Season		Fish 1	Fish 2
	Rice 1	Rice 2	Rice 1	Rice 2		
Labor (hours)						
June	7.29	5.85	0	0	0	0
July	12.80	5.64	0	0	0	0
August	10.31	13.51	0	0	0	0
September	3.09	7.98	0	0	0	0
October	0	0	0	0	15.15	0
November	0	0	5.69	4.50	5.50	0
December	0	0	9.37	4.20	0	0
January	0	0	10.15	12.51	0	0
February	0	0	4.28	6.99	0	0
March	0	0	0	1.30	0	0
April	0	0	0	0	0	12.11
May	0	0	0	0	0	7.30
Gross Return (Rp)	580,191	580,191	656,438	656,438	154,377	138,341
Cash Expenses (Rp)	343,362	343,362	354,023	354,023	51,128	68,180
Net Income (Rp)	236,829	236,829	302,415	302,415	103,249	70,161

Source: Survey June-October 2005

family labor requirement, gross return, cost and net income per 0.1 ha. of rice and per 0.01 ha of vegetables in Tambak Boyo are shown in Table 6. For rice cultivation, most family labor was utilized in July during the dry season and from November to January during the rainy season. The family labor requirement for spinach cultivation was 191.6 hours/0.01 ha/month; Indian mustard cultivation family labor requirement was 92.41 and 75.94 hours/0.01 ha. for the first and second months, respectively; string bean cultivation family labor requirement was 35.60, 20.91, 25.12, and 18.56 hours/0.01 ha. for the four consecutive months, respectively; and for tomato cultivation it was 20.60, 13.12, 9.63, and 15.33 hours/0.01 ha for the four consecutive months. For rice production, farmers earned a net income of Rp 136,132/0.1 ha. and Rp 231,595/0.1 ha. on the average during the dry and rainy seasons, respectively. From vegetables, farmers earned a net income of Rp 107,608/0.01 ha. from spinach, Rp 97,563/0.01 ha. from Indian mustard, Rp 85,865/0.01 ha. from string beans and Rp 42,842/0.01 ha. from tomato.

Constraints

In this study, land and family labor were taken as limited resources. The limitation of land and family labor were based on the average operated land area and the number of family members older than 16 years old. The average operated land area was 0.622 ha. in Karang Sari and 0.514 ha. in Tambak Boyo. In both study villages, the average number of family labor was 3. Given a 30-day working period with one day off a week or 4 days off a month, and 8-working hours a day, the total is 624 hours per month.

Optimal Combination of Fish and Crops

The results of the linear program to determine the optimal combination of rice-fish production in Karang Sari and rice-vegetables production in Tambak Boyo are presented in Table 7. The combination of rice-fish-rice-fish (R-F-R-F) gives the highest net income of 4.4 million rupiah with the largest operated land area of 2.488 has. and family labor of 637.8 hours. By diversifying their rice farming into rice-fish culture, farmers would be able to increase their net income by 13 % (R-F-R) to 32 % (R-F-R-F). Although fish diversification would increase family labor absorption, it was still much lower than the availability of family labor of 624 hours per month or 7,488 hours per year. It is clear that fish diversification would absorb family labor and also contributes to increased the net income of households.

Based on the crops combination results in Tambak Boyo, (rice+spinach)-rice pattern would occupy the largest planted area, followed by rice-Indian mustard-rice, and rice-spinach-rice (Table 7). In terms of family labor, (rice+spinach)-rice combination would utilize the most family labor, followed by (rice+Indian mustard)-rice and rice-spinach-rice. There are several interesting points that can be observed from these findings. Vegetable diversification would absorb a larger amount of family labor than double rice cropping although it would utilize only around 17% to 35% of the total available family hours per year. It is clear that vegetable cultivation is more labor-intensive than rice cultivation; therefore development of vegetable cultivation would provide more employment for the village. Lastly, vegetable diversification can increase the farm household economy by 24% (rice+rice+Indian mustard) to 68% (rice+spinach)-rice) compared to double rice cropping only.

From the crops-fish combinations in Karang Sari and Tambak Boyo, it is clear that fish and vegetable diversification would provide more employment in the village. In addition, fish and vegetable diversification would contribute a higher net income to the household economy.

CONCLUSIONS

In line with the government program to increase farmers' income, fish and vegetables diversification can be one of the options for increasing income. Through fish diversification, farmers would be able to increase their net income by 13 to 32 % higher than the common rice double cropping in Karang Sari. In Tambak Boyo, farmers would be able to increase their income by 24 to 68 % through vegetable diversification than rice double cropping. Moreover, it would also provide more employment to farmers and villagers in these areas. More effort should be exerted to enhance the educational level of farmers. This is especially true in Karang Seri where the results show that higher educational attainment allows farmers to be more open and receptive to new technologies and improves the chances of deciding to diversify their rice farming into fish culture. Poor farmers especially in the rural areas should at least be given an opportunity to get nine years of basic formal education. Another is the improvement and maintenance of infrastructures like irrigation and road systems which will ensure a stable water supply for the crops while good farm-to-market roads will reduce transport costs for farm products and improve access to the market.

In Tambak Boyo, a good irrigation system is very important to encourage farmers to diversify to vegetable production. The water users' organization should be assisted in the operation and maintenance of the irrigation system. Farmers should be encouraged to raise cows to augment farm income and provide manure for vegetable production, which is in line with the governments integrated crop management program. Farm households with more available family labor will have a higher probability to decide to diversify to vegetable production.

Overall however, there is excess labor in these farm areas possibly because the farms are too small to absorb all of the farm labor and different options should therefore be explored to absorb surplus labor. The agrarian reform program, for example, can be explored as a means of increasing the farm holdings of farmers and absorbing more farm labor.

Table 6. Family labor requirement, gross return, cash expenses and net income per 0.1 ha of rice and 0.01 ha of vegetables in Tambak Boyo, Sumatra, Indonesia in 2004-2005.

	Dry Season		Rainy Season		Spinach	Indian mustard	String beans	Tomato
	Rice 1	Rice 2	Rice 1	Rice 2				
Labor (hrs)								
May	9.27	0	0	0	0	0	35.60	20.60
June	6.09	10.5	0	0	191.6	92.41	20.91	13.12
July	9.37	10.09	0	0	0	75.94	25.12	9.63
August	4.19	6.63	0	0	0	0	18.56	15.33
September	0	2.05	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0
November	0	0	11.20	0	0	0	0	0
December	0	0	5.50	11.30	0	0	0	0
January	0	0	12.12	10.69	0	0	0	0
February	0	0	3.56	7.93	0	0	0	0
March	0	0	0	2.47	0	0	0	0
April	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0
Gross Return (Rp)	442,214	442,214	556,063	556,063	121,019	114,436	95,434	53,157
Cash Expenses (Rp)	306,082	306,082	324,469	324,469	13,411	16,873	9,569	10,315
Net Income (Rp)	136,132	136,132	231,595	231,595	107,608	97,563	85,865	42,842

Source: Survey June-October 2005

Note: Labor requirement in this table is for one planting period only.

Source: Survey June-October 2005

Notes: R = Rice; F = Fish; C = Indian mustard; SB = String Beans; S = Spinach; T = Tomato

REFERENCES

Anderson, S. and R. Newell. 2003. Simplified Marginal Effects in Discrete Choice Models. Discussion Paper 03-38, October 2003. Resources for the Future, Washington D.C.

Items	G r o s s Income (Rp)	C a s h Expenses (Rp)	N e t Income (Rp)	Total Planted Area (ha)	Total Labor Input (hours)
Karang Sari					
R-F-R-F	9,512,538	5,079,830	4,432,708	2.488	637.8
R-R-F	8,652,057	4,655,751	3,996,306	1.866	517.1
R-F-R	8,552,313	4,761,814	3,790,499	1.866	512.5
R-R	7,691,832	4,337,735	3,354,097	1.244	391.7
Tambak Boyo					
(R+S)-R	6,476,805	3,307,783	3,169,022	1.119	2,621.0
(R+SB)-R	5,982,402	2,891,289	3,091,113	1.028	1,932.5
(R+C)-R	6,296,986	3,258,017	3,038,969	0.976	2,390.2
R-S-R	6,313,572	3,372,059	2,941,513	1.061	2,145.7
(R+T)-R	5,392,909	2,646,495	2,746,414	1.028	1,949.5
R-C-R	5,903,869	3,354,963	2,548,906	1.096	1,412.4
R-(R+C)	5,495,861	3,144,467	2,351,394	1.028	1,305.5
R-R	5,131,143	3,241,028	1,890,115	1.028	273.6

Banerjee, S. B. and S. W. Martin. 2009. "A Binary Logit Analysis of Factors Impacting Adoption of Genetically Modified Cotton AgBioForum, 12(2):218-225.

Berenson, M. L., D. M. Levine and T. C. Krehbiel. 2002. Basic Business Statistics Concepts and Application. Prentice Hall.

Departemen Pemukiman dan Prasarana Wilayah (DPPW) 2004. Uraian Singkat Proyek Irigasi Komering di Sumatra Selatan, Progasi Kompres, Dep Kimpraswil Sumatra Selatan. Dep Kimpraswil Sumatera Selatan.

Greene, W. H. 2003. Econometric Analysis. Fifth Edition. Prentice Halll.

Ministry of Agriculture (MA), Republic of Indonesia. 1994. Indonesian Agriculture: The Experience in Achieving and Sustaining Rice Self-Sufficiency. Ministry of Agriculture, RI, Jakarta.

Nazaruddin. 2000. Budi Daya dan Pengaturan Panen Sayuran Dataran Rendah. Penebar Swadaya, Jakarta.

- Pitipunya, R. 1995. The Economics of Rice Farming and Crop Diversification in Central Plain, Thailand. Unpublished PhD Dissertation, Tokyo University of Agriculture, Tokyo.
- Sudirman S.P. and Ade Iwan S. 2000. Mina Padi: Budi Daya Ikan Bersama Padi. Penebar Swadaya, Jakarta.
- Vajda S. 1958. Readings in Linear Programming. John Wiley & Sons, inc. New York.

FACTORS AFFECTING YIELD PERFORMANCE OF BANANA FARMS IN ORIENTAL MINDORO, PHILIPPINES

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ABSTRACT

This paper aims to determine the factors affecting yield performance of banana farms located in Oriental Mindoro, identify the problems/constraints encountered by banana growers, and provide policy directions that would enhance the productivity of banana in the province. Based on survey data of 80 banana growers from the municipalities of Bansud, Socorro, Pinamalayan and Bacu in Oriental Mindoro in 2007, multiple regression analysis was conducted. The Cobb-Douglas production function was estimated using the Ordinary Least Squares (OLS) method. Explanatory variables included in the model on a per hectare basis were fertilizer, labor, planting material cost, number of stalks, tenurial status, types of banana cultivar grown, intercropping, topography, soil type, distance between hills, education, farming experience, age and gender of the banana grower, household size and distance of farm to residence of the banana grower. Results of the multiple regression analysis revealed that increased fertilizer and labor usage, tenurial status in favor of owner-operators, adoption of diversified banana farming and establishment of ideal farm characteristics (i.e., clay loam or sandy clay loam soil, distance between hills of $\geq 20\text{m}^2$ and shorter distance from farm to residence of grower) significantly and positively affect banana yield in Oriental Mindoro.

The sum of the production elasticities (0.76) is significantly different from one as verified by the t-test results. The function coefficient of the OLS model implies decreasing returns to scale where a one percent increase in all production inputs would raise banana yield by 0.76 percent. Problems and constraints cited by the banana grower-respondents in Oriental Mindoro include: (1) limited supply of high-yielding and disease-free banana planting materials; (2) high incidence of pests and diseases; and (3) inadequate knowledge on proper production practices/technologies in banana farms. Hence, the following policy directions are recommended: (1) provision of technical and budgetary support to the propagation and distribution of banana cultivars which are better yielding and highly resistant to virus and other systemic diseases; (2) adoption of site-specific IPM and dissemination of information on banana pests and diseases and their control; (3) conduct of training on good agricultural practices (GAP); and (4) formation of banana cluster to effectively forge strong linkages between banana growers and suppliers of quality planting materials and production technologies.

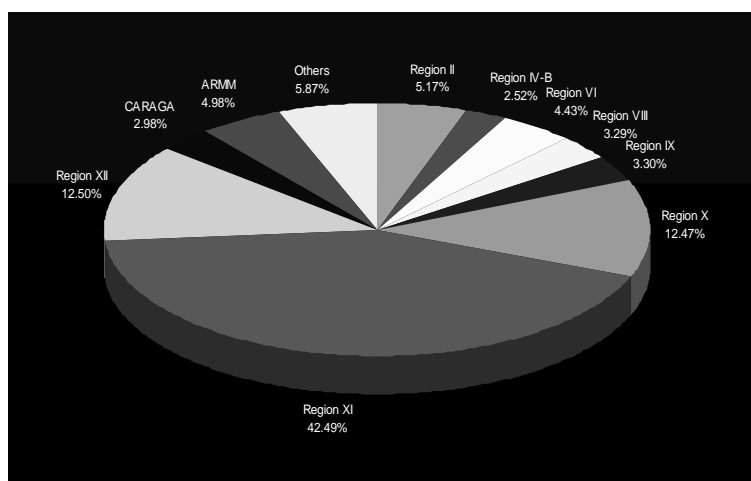
Key words: Cobb-Douglas production function, Ordinary Least Squares (OLS) method, and returns to scale,

INTRODUCTION

Banana is the most important fruit crop grown in the Philippines in terms of production and hectareage. The high demand for banana by Filipinos in their food diet owing to its nutritive value and affordable price compared to mango and pineapple has encouraged farmers to continue growing banana in many production areas. There are 80 banana cultivars in the Philippines which are grown for domestic and international markets. Cavendish is mainly produced for the export market but Señorita and Lakatan also increase their popularity among importers. Saba or Cardaba is commonly used in processing of banana chips and catsup. For the local market, Lakatan, Latundan, Bungulan and Saba emerge as the highly demanded cultivars (Rivera 2004).

According to Rivera (2004), the ideal conditions for banana growing are the following: (1) soil is deep, friable, and rich in organic matter with complete nutrient and mineral elements, and has adequate moisture throughout the year; soil texture of 40% clay, 75% silt or 85% loam; soil pH of 6.5, soil topography of flat to rolling lands up to 45 degrees gradient; (2) tropical climate with temperature range of 22 to 32 degrees Celsius; (3) land elevation from sea level to 1,000 meters above; and (4) minimal air movement. Inputs in banana farming include suckers, corms and eye buds obtained from corms that can be used as planting materials; and fertilizer and labor that are utilized for land preparation and planting, fertilization, pruning, thinning, weeding and cultivation, flower and fruit management and harvesting. The country posted an average annual banana production of 5.04 million mt from 1990 to 2008. During the same period, area planted to banana and number of hills averaged at 372,735 ha and 182.70 million hills, which resulted to an average annual yields of 13.31 mt/ha and 0.03 mt/hill. A hill is where the mat is placed which grows banana suckers. The positive annual growth in banana production at 5.24 percent was attributed to yearly increases in area planted (1.92%), number of hills (3.75%), yield/ha (3.27%) and yield/hill (1.41%) in the period 1990-2008. In 2007, national production was registered at 7.48 million mt covering 436,762 ha and 250.54 million hills. (BAS 2009).

Region XI (Davao Region) topped the banana producing regions with 42.49 percent share in national banana production in 2007 (Fig. 1). Next in rank included the following regions: XII (12.50%), X (12.47%), II (5.17%), Autonomous Region of Muslim Mindanao (ARMM) (4.98%), VI (4.43%), IX (3.30%), VIII (3.29%), CARAGA Administrative Region (2.98%) and IV-B (2.52%). As Mindanao area is less visited by typhoons, Regions XI, XII (SOCCSKSARGEN) and X (Northern Mindanao) provide favorable weather condition for banana cultivation.



Source of basic data: Bureau of Agricultural Statistics (BAS)

Fig. 1. Share in terms of banana production, by region, Philippines, 2007

On the average, banana production in the province of Oriental Mindoro in Region IV-B reached 125,378 mt from an area planted of 14,041 ha with 5.48 million hills for the period 1990-2008. Yields averaged at 13.31 mt/ha and 0.02 mt/hill. Annual increase in banana production of 3.50 percent per annum could be due to expansion in area planted which grew at 4.10 percent per year during the same period. Yields per hectare and per hill showed negative growth rates of 0.01 and 0.44 percent annually for the past 19 years. In 2007, banana production in the province reached 163,729 mt covering 18,371 ha and 7.43 million hills. Yields were registered at 8.91 mt/ha and 0.022 mt/hill (BAS 2009). Oriental Mindoro accounted for the bulk (87%) of the total banana production in Region IV-B. The remaining 13 percent was contributed by the provinces of Palawan, Romblon,

Occidental Mindoro and Marinduque (Fig. 2).

As land resources become scarce due to rapid land conversion and urbanization, higher production levels of agricultural crops including banana in the future are to be achieved through improvement in yield. As of now, no study has been done in the Philippines that identifies the explanatory variables which influence the yield of banana.

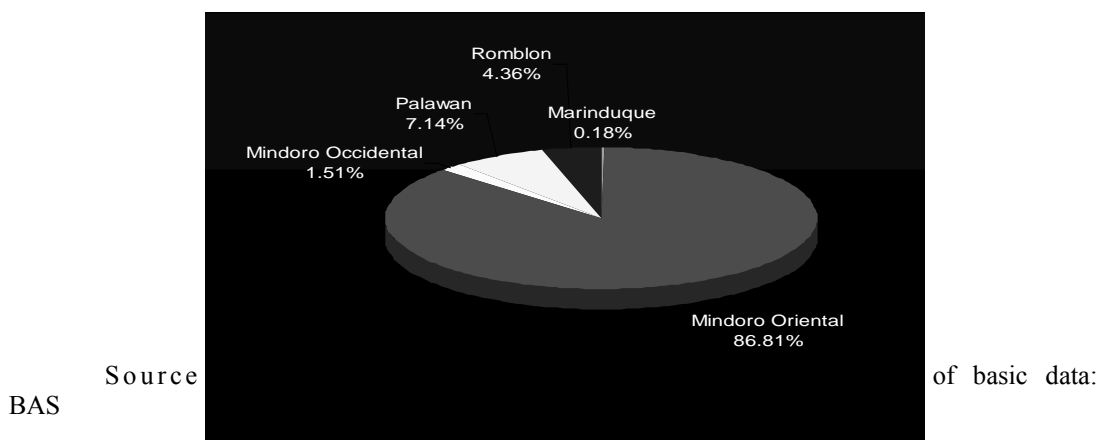


Fig. 2. Share in terms of production, by province, Region IV-B, 2007

This study aims to: (1) determine the factors affecting yield performance of banana farms located in Oriental Mindoro; (2) identify the problems/constraints encountered by banana growers; and (3) provide policy directions that would enhance the productivity of banana in the province. This would enable banana growers to focus on the important yield response determinants and to address the problems/constraints identified in the study.

Several studies have identified the determinants of yield for different agricultural crops. Apart from inputs of production, other factors have influenced yield levels. Using Cobb-Douglas functional form, Ahmad et al. (2005) found that higher amounts of seed and fertilizer and sowing in the months of September and October significantly improved carrot yield. On the contrary, high input prices, limited capital and inadequate labor during peak load period contributed to the decline in yield. Javed et al. (2001) determined the factors affecting yield of sunflower. Based on the study, the seed rate and the numbers of irrigation systems and bags of urea and diammonium phosphate positively influenced sunflower yield. In addition, land preparation, sowing method (i.e., drill or broadcast) and incidence of pest attacks substantially affected yield. Grower- and farm-specific characteristics could also determine crop yield. Bakhsh et al. (2004) revealed that years of farming experience and education, household size, use of farmyard manure and inorganic fertilizer, and number of irrigation systems would increase yield of cauliflower. In the case of cotton, the years of education, land preparation, plant protection measures and quantity of nitrogen and phosphorus applied in the farms had positive relationship with yield (Bakhsh et al. 2005). Yamano (2008) examined the integration of dairy and banana farms in Uganda and the effects of selected determinants on banana yield. Results of the study revealed that the amount of organic matter, plot size, tenancy, number of male household members, farm assets, land altitude, population density, and rainfall. In estimating the yield response model for banana, this study also used the Cobb Douglas functional form (Javed et al. 2001, Bakhsh et al. 2004, Ahmad et al. 2005, and Bakhsh et al. 2005) and considered both the inputs of production and grower- and farm-specific characteristics as explanatory variables.

METHODOLOGY

The study area covered Oriental Mindoro, the leading banana growing province in Luzon in terms of area and volume of production for the past 10 years based on the statistics generated from the BAS. From this province, four major banana producing municipalities were chosen as research sites after reviewing the available information from the Office of the Local Government Units (LGUs) of Oriental Mindoro and interview of key informants. Two main banana producing barangays in each selected municipality were considered and the list of banana growers was derived from these barangays with the assistance of barangay officials and agricultural technicians. Out of 250 banana growers, 80 of them were randomly selected from eight barangays representing the municipalities of Bansud, Socorro, Pinamalayan and Bacu in Oriental Mindoro.

Primary data were collected through personal interview using pre-tested interview schedule in 2007. These include production, area planted to banana, fertilizer, labor, planting material cost, number of hills/ha, number of stalks/hill, tenurial status, types of banana cultivar grown, intercrops, topography, distance between hills, years of education and farming experience, age and gender of the banana grower, household size and distance of farm to residence of the banana grower.

Multiple regression analysis was conducted to determine the factors affecting yield performance of banana farms in Oriental Mindoro. The Cobb-Douglas production function, which provides measures of output elasticity, was estimated using the Ordinary Least Squares (OLS) method. This functional form assumes a unitary elasticity of substitution and a constant elasticity of production for all inputs (Coelli et al. 2005). As shown in Equation 1, the yield response model of the sample Oriental Mindoro banana growers considered 16 explanatory variables including inputs of production and grower- and farm-specific characteristics.

$$\ln Y = \beta_0 + \beta_1 \ln F + \beta_2 \ln L + \beta_3 \ln P + \beta_4 \ln S + \beta_5 TS + \beta_6 BC + \beta_7 I + \beta_8 T + \beta_9 ST + \beta_{10} DH + \beta_{11} E + \beta_{12} FE + \beta_{13} AF + \beta_{14} G + \beta_{15} HS + \beta_{16} DF + e \quad [1]$$

where: \ln = natural logarithm;

Y = yield of banana (kg/ha);

F = amount of fertilizer applied (kg N /ha);

L = amount of labor utilized (manday/ha);

P = planting material cost (Php/ha);

S = number of stalks/ha;

TS = tenurial status (0 if owner-operator; 1 if share-tenant/leaseholder);

BC = types of banana cultivar grown (0 if monoculture; 1 if diversified);

I = intercrops (0 if absent; 1 if present);

T = topography (0 if combination of flat and rolling; 1 if hilly to rolly);

ST = soil type (0 if clay loam or sandy clay loam; 1 otherwise);

DH = distance between hills (0 if less than 20 m²; 1 if equal or greater than 20 m²);

E = years of education (formal schooling);

FE = years of farming experience;

AF = age of the banana grower;

G = gender of the banana grower (0 if male, 1 if female);

HS = household size;

DF = distance between farm and residence of the banana grower (km);

β_0 = intercept;

β_i s = regression coefficients; and

e = error term.

The null hypothesis¹ that the sum of coefficients of fertilizer/ha (β_1), labor/ha (β_2), planting material cost/ha (β_3), number of stalks/ha (β_4) and area planted to banana (β_5) is equal to one, which suggests constant returns to scale, was tested following the test procedure done by Mari et al. (2007). A decision rule was made where a parameter estimate of area when statistically insignificant at 10 percent probability level based on t-test result implies the acceptance of the null hypothesis. Hence,

the sample Oriental Mindoro banana growers are in the constant returns to scale (CRS) stage of production. Otherwise, the alternative hypothesis of variable returns to scale is accepted where a sum of coefficients of fertilizer/ha, labor/ha, planting material cost/ha and number of stalks/ha derived from Equation 1 when less than one denotes decreasing returns to scale and when greater than one means increasing returns to scale.

¹ In a Cobb-Douglas functional form of $y = \beta_0 F^{\beta_1} L^{\beta_2} P^{\beta_3} S^{\beta_4} A^{\beta_5} e^{\varepsilon}$, where y is total banana production (kg); F is the amount of fertilizer applied (kg N); L is the amount of labor utilized (manday); P is the planting materials cost (PhP/ha); S is the number of stalks per farm; A is the area planted to banana (ha); the sum of β_1 to β_5 is the degree of homogeneity. This measures the returns to scale where a sum less than, equal, or greater than one suggests decreasing, constant or increasing returns to scale, respectively. To test for the significance of the sum of the coefficients, multiply and divide the right-hand side by $A^{\beta_1} A^{\beta_2} A^{\beta_3} A^{\beta_4}$. After rearranging terms and transforming into linear equation by taking the natural logarithm, the final form of the production function becomes: $\ln y = \beta_0 + \beta_1 (F/A) + \beta_2 (L/A) + \beta_3 (P/A) + \beta_4 (S/A) + h (\ln A) + \varepsilon$, where h is the sum of β_1 to β_5 .

RESULTS AND DISCUSSION

Characteristics of Banana Grower-Respondents

The sample banana growers in Oriental Mindoro reported an average production of 15.55 mt which ranged from 0.24 mt to 107 mt in 2007. This covered an area of 2.66 ha ranging from 0.25 ha to 12 ha. The minimum and maximum yields attained by the banana growers were 0.30 mt/ha and 28.80 mt/ha, respectively, with an average yield of 6.63 mt/ha (Table 1). This disparity in yield is due to differences in input utilization. There were banana growers who did not fertilize (64) and incurred planting material cost (53). This is attributed to the high cost of fertilizer and unavailability of affordable and quality planting materials. Specifically, the prices of ammophos, ammosul, complete and urea per 50-kg sack in the province were registered at PhP 764/sack, PhP 505/sack, PhP 771/sack and PhP 933/sack in 2007, which were 3.06 percent to 5.50 percent higher than in 2006. On the average, the amount of fertilizer used was 7 kg N/ha and the planting materials cost incurred was PhP 228/ha (Table 1). Other inputs such as labor, planting material cost and number of stalk/ha were also lower under the minimum yield of 0.30 mt/ha as against the input utilization in the maximum yield of 28.80 mt/ha (Table 1).

Table 1. Production and inputs utilization of 80 sample banana growers, Oriental Mindoro, Philippines, 2007.

Item	Minimum	Maximum	Average
Production (kg)	240	107,007	15,546
Area (ha)	0.25	12.00	2.66
Yield (kg/ha)	300	28,800	6,628
Fertilizer (kg N/ha)	0.00	35.00	7.00
Labor (manday/ha)	8.60	97.50	38.03
Planting material cost (PhP/ha)	0	1,600	228
No. of stalks/ha	300	5,000	1,240

Source of data: PGPA survey, 2007

Majority of the banana grower-respondents, accounting for 83 percent were males. In terms of tenurial status, only 19 percent of them were classified as owner-operators while the rest were leaseholders or share-tenants. Leaseholders are those who rent the banana farm and normally pay a

fixed rental in kind. In this study however, the three leaseholders from the sample banana growers were all related to the land owners, thus the sharing arrangement was similar to that of the share-tenants wherein 33 percent of the harvest was given to the land owner and the remaining 67 percent to the leaseholder or share-tenant. This arrangement is commonly followed in Oriental Mindoro. Four banana farmers forged into an equal sharing arrangement after deducting production expenses (Table 2).

Forty-two banana growers operated monoculture farms while 38 growers cultivated diversified farms. The former included Saba banana only while the latter had three different cultivars, namely: Saba, Latundan and Lakatan. For the presence of intercroops, about 88 percent of the respondents planted coconut, lanzones, rambutan and calamansi. In terms of soil type, 57 out of 80 banana growers had clay loam or sandy clay loam type which corresponded to the ideal soil texture comprising of 40 percent clay, 75 percent silt and 85 percent loam. On the other hand, nearly 73 percent of the respondents had hilly to rolly type of topography, which is not ideal for banana farming. Fifty-nine growers had adopted a distance between hills of equal or greater than 20 m² vis-à-vis less than 20 m² by 21 growers (Table 2).

Table 2. Selected grower- and farm-specific characteristics obtained from 80 sample banana growers, by type, Oriental Mindoro, 2007.

Grower/Farm Characteristics	Number	Percent
Gender		
Male	66	83
Female	14	17
Tenurial status		
Owner-operator	15	19
Leaseholder/Share-tenant	65	81
Types of banana cultivar grown		
Monoculture	42	53
Diversified	38	47
Intercrops		
Absent	27	34
Present	53	66
Soil type		
Clay loam or sandy clay loam	57	71
Others	23	29
Topography		
Combination of flat and rolling	22	27
Hilly to rolly	58	73
Distance between hills		
Less than 20 m ²	21	26
Equal or greater than 20 m ²	59	74

Source of data: PGPA survey, 2007

As shown in Table 3, the average years of education and farming experience were 7 and 23, respectively. Education ranged from 2 years to 15 years while farming experience was from 3 years to 55 years. The average age of the banana grower was 52, which ranged from 26 years old to 93 years old. Older and more educated and experienced banana growers could have yield advantages over their counterparts, provided they applied the knowledge and skills on farming acquired through time. In terms of distance of farm to the residence of the banana grower, it ranged from 0.005 km to 10.00 km with an average of 1.42 km. Those growers who lived far may not be able to visit their banana farms more often than those who lived near their farms.

Table 3. Grower- and farm-specific characteristics of 80 sample banana growers by type, Oriental Mindoro, 2007.

Item	Minimum	Maximum	Average
Years of education	2	15	7
Years of farming experience	3	55	23
Age of the banana grower	26	93	52
Household size	1	12	4
Distance of farm to residence of the banana grower (km)	0.005	10.00	1.42

Source of data: PGPA survey, 2007

Factors Affecting the Yield Response of Banana Farms

Based on the results of the multiple regression analysis as shown in Table 4, the significant determinants of banana yield of 80 sample grower-respondents in Oriental Mindoro in 2007 were the following: fertilizer/ha, labor/ha, tenurial status, types of banana cultivar grown, soil type, distance between hills and distance of farm to residence of the banana grower. About 65 percent of the total variation in banana yield could be explained by the changes in the 16 explanatory variables contained in the yield response model. This model was significant at 1 percent probability level.

The Cobb-Douglas functional form provides measures of output elasticities. Hence, the coefficients of fertilizer/ha (β_1), labor/ha (β_2), planting material cost/ha (β_3) and number of stalks/ha (β_4) are interpreted as elasticities of output. Of these production inputs, only fertilizer and labor significantly influenced banana yield. In particular, a 10 percent increase in the amount of fertilizer per hectare applied in banana farm would bring about 0.01 percent improvement in yield, holding other factors constant. On the other hand, if the labor utilized in a one-hectare banana farm would rise by 10 percent, yield would also increase by 5.99 percent, *ceteris paribus* (Table 4).

The output elasticities from β_1 to β_4 summed up to 0.76, which was significant at 1 percent probability level (Table 4). This function coefficient of the OLS model denotes that banana production in Oriental Mindoro is characterized by decreasing returns to scale. Hence, a 1 percent increase in the current utilization of all inputs would bring about 0.76 percent improvement in yield. The positive sign of the coefficient of tenurial status, which was significant at 10 percent probability level, implies that owner-operators have higher banana yield as compared to leaseholders or share-tenants (Table 4). The practice of fertilizer application of all owner-operators had contributed to their better yield as against the other types of banana growers. The former were less capital-constrained vis-à-vis the latter.

For the types of banana cultivar grown, the positive and significant coefficient at 1 percent probability level suggests that the banana yield of diversified farms is greater than that of monoculture farms. This is attributed to the differences in yield among three banana cultivars (i.e., Saba, Latundan and Lakatan) and area devoted to these specific cultivars. Soil type and distance between hills also significantly influenced banana yield at 1 and 5 percent probability level, respectively. The positive sign of the coefficients means that banana growers with farms having clay loam or sandy clay loam soil or adopting a distance between hills of equal or greater than 20 m² have greater yield than their counterparts. These ideal farm-specific characteristics will enable the soil to maintain the right amount of moisture and provide proper drainage and the banana plant to have abundant exposure to sunlight, which are required to improve the yield of banana.

In terms of distance of farm to residence of the banana grower, the negative and significant coefficient at 5 percent probability level indicates that banana growers who live far from their farms experience lower yield. The great distance to reach the farm prevents banana growers in visiting their farms more often; hence, they could not perform the proper cultural management which includes pruning, thinning, integrated pest management, weeding and cultivation, and flower and fruit management.

Table 4. Regression results showing the effects of selected explanatory variables on banana yield using Cobb-Douglas functional form, Oriental Mindoro, 2007.

Item	Coefficient	t-value
Intercept	4.3094**	2.5901
Regression Coefficients		
Fertilizer/ha	0.0007***	3.4946
Labor/ha	0.5990***	4.0053
Planting material cost/ha	(0.00005)	(0.2916)
Number of stalks/ha	0.1607	1.3003
Tenurial status	0.3570*	1.8152
Types of banana cultivar grown	0.5163***	2.9813
Intercrops	(0.2287)	(1.4466)
Topography	(0.0073)	(0.0527)
Soil type	0.5672***	3.1002
Distance between hills	0.3948**	2.3743
Education	(0.1038)	(0.5471)
Farming experience	0.1029	0.8921
Age of the banana grower	0.0583	0.1749
Gender of the banana grower	(0.2365)	(1.2770)
Household size	0.0099	0.0522
Distance of farm to residence of the banana grower	(0.0821)**	(2.1167)
Adjusted R ²	0.6530	
F-value	10.31***	
Returns to Scale	0.76***	

***, ** and * Significant at 1, 5 and 10 percent probability level.

Source of basic data: PGPA survey, 2007

Problems and Constraints in Banana Production

Limited supply of high-yielding and disease-free banana planting materials was the foremost problem encountered by more than half (53%) of the banana respondents in Oriental Mindoro. Tissue-cultured planting materials were inadequate and costly, thus, banana growers in the province opted to use planting materials derived from their own farms or those from their neighbors or relatives. Some of these were carriers of pests and infected by diseases which result to low banana yield.

Another major problem reported by 37 percent of the banana respondents was high incidence of pests and diseases. Rats had eaten banana fruits while aphids had served as vectors of a disease called bunchy top. The common diseases occurring in banana farms located in Oriental Mindoro were bugtok for Saba and bunchy top for Lakatan and Latundan. Bugtok is caused by a virulent strain of *Pseudomonas solanacearum*. It enters the plant through tiny openings at the top of

the ovary and through the ovules where intense discoloration develops. It spreads to the vascular tissues of the pedicel up to the peduncle. On the other hand, bunchy top is caused by a virus and its symptoms include stunting, yellowing of the leaf margin, bunching of the leaves and formation of dark streaks at the midrib or petiole. Other identified problems included the absence of strong banana grower-respondents (32%) and limited access to information on appropriate production technologies (27%).

CONCLUSIONS AND POLICY DIRECTIONS

This study determined the factors affecting yield performance of banana farms located in Oriental Mindoro, identified the problems/constraints encountered by banana growers, and provided policy directions that would enhance the productivity of banana in the province. Based on the trend analysis, production and area planted to banana increased both at the national and provincial levels covering the period 1990-2008. However, the yield per hectare and per hill showed an upward trend for the Philippines and downward trend for Oriental Mindoro. In 2007, this province occupied 87 percent of the total banana production in Region IV-B.

The determinants of yield performance of 80 banana farms in Oriental Mindoro in 2007 were identified as fertilizer/ha, labor/ha, tenurial status, types of banana cultivar grown, soil type, distance between hills and distance of farm to residence of the grower. Results of the multiple regression analysis of the Cobb-Douglas production function using OLS technique showed that higher utilization of fertilizer and labor; tenurial status in favor of owner operators; operation of diversified farms; and establishment of ideal farm-specific characteristics such as clay loam or sandy clay loam for soil type, distance between hills of $\geq 20 \text{ m}^2$ and shorter distance from farm to residence would significantly and positively affect banana yield. On the other hand, the function coefficient of the OLS model (0.76) denotes the decreasing returns to scale stage of banana production in the study areas.

Limited supply of high-yielding and disease-free banana planting materials of three banana cultivars hinders growers to use tissue-cultured materials and to operate diversified farms. There were banana growers who chose to utilize planting materials from their farms or those from their neighbors or relatives, some of which are infected by pests and diseases, instead of shouldering the higher cost of tissue-culture planting materials. Also, despite better yields realized in diversified banana cultivar farming, some growers still produce Saba only because of the same reason. By linking banana growers with reliable sources of quality planting materials, yield could be improved. The International Network for the Improvement of Banana and Plantain (INIBAP), Department of Science and Technology – Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (DOST-PCARRD) and state universities and colleges (SUCs) could provide technical and budgetary support to the propagation and distribution of banana cultivars which were better yielding and highly resistant to virus and other systemic diseases.

Formation of banana cluster to effectively forge strong linkages between banana growers and suppliers of quality planting materials could also be facilitated. Five to ten banana growers, who undertake common production and marketing plan for identified and committed markets, will comprise a cluster. In Oriental Mindoro, two clusters can be formed: one for monoculture and another for diversified farms. Through these clusters, assistance on how to access inputs, information-sharing on sources of quality planting materials and proper cultural management, and provision of technical assistance from the government and other resource organizations will be extended to the member-growers.

High incidence of pests and diseases reduces banana yield in Oriental Mindoro. Through the adoption of site-specific Integrated Pest Management (IPM) and dissemination of information on banana pests and diseases and their control, the effects of these infestations would be minimized. chances of pathogen entering the rhizomes, roots and stem of banana plant. Rivera (2004)

enumerated the pests and diseases and their control and the IPM technologies applicable for banana. To prevent the attack of aphids, chemical spraying can be employed. Control measures for banana diseases include field and mat sanitation, leaf pruning, application of fungicide, insecticide and nematicide, and removal of infected plants. On the other hand, four steps in IPM are the following: (1) reducing pests in the soil before planting; (2) minimizing the number of pests present in planting materials; (3) ensuring healthy roots and vigor in plantation; and (4) lessening the chances of pathogen entering the rhizomes, roots and stem of banana plant.

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REFERENCES

- Ahmad, B., S. Hassan and K. Bakhsh. 2005. Factors Affecting Yield and Profitability of Carrot in Two Districts of Punjab. *International Journal of Agriculture & Biology*. Vol.7. No.6. 20 April 2005.
- Bakhsh, K., W. Akram, M.A. Raza and I. Hassan. 2004. Determination of Factors Affecting Cauliflower Yield in Punjab, Pakistan. *International Journal of Agriculture & Biology*. Vol. 6. No.6. 23 September 2004.
- Bakhsh, K., I. Hassan and A. Maqbool. 2005. Factors Affecting Cotton Yield: A Case Study of Sargodha (Pakistan). *Journal of Agriculture & Social Sciences*. Vol.1, No.4. 20 July 2005.
- Bureau of Agricultural Statistics. 2009. <http://countrystat.bas.gov.ph/>.
- Coelli, T.J., D.S.P Rao, C.J. O'Donnell, and G.E. Battese. 2005. An Introduction to Efficiency and Productivity Analysis, Second Edition. United States of America: *Springer Science+Business Media, Inc.*, 2005. 41-83 pp.
- Javed, M.S., A. Ali and H. Badar. 2001. Factors Affecting the Yield of Sunflower in the Province of Punjab (Pakistan). *Pakistan Journal of Applied Sciences* 1(3): 345-346.
- Lantican, F.A., B.M. Bathan, M. A. Lantican, D. L. L. Monis and K. J. G. Lantican. 2009. Nature, Causes and Sources of Productivity Growth in the Philippine High Value Fruits Subsector (Mango and Banana). *Final report submitted to SEARCA, PhilRice and DA-BAR*.

- Mari, F.M., R.A. Memon and H.D. Lohano. 2007. Measuring Returns to Scale for Onion, Tomato and Chiles Production in Sindh Province of Pakistan. *International Journal of Agriculture and Biology*. 30 June 2007.
- Rivera, R.A. 2004. Philippine Banana Production and Marketing. Available online at http://hvcc.da.gov.ph/pdf/banana_phil_prodn_market.pdf. Accessed on 9 February 2010.
- Yamano, T. 2008. Dairy-Banana Integration and Organic Fertilizer Use in Uganda. Discussion Paper: 08-03. *GRIPS Policy Information Center*. Available online at <http://www3.grips.ac.jp/~pinc/data/08-03.pdf>. Accessed on 9 February 2010

**ISSAAS INTERNATIONAL CONGRESS 2009
NOONG NOCH BOTANICAL GARDEN AND RESORT, PATTAYA,
CHONBURI, THAILAND, JANUARY 11-15, 2010**

AGRICULTURE FOR BETTER LIVING AND GLOBAL ECONOMY

ABSTRACTS OF PAPERS - KEYNOTE ADDRESS

**Agriculture for Better Living and Improved Global Economy
Paiboon Ponsuwanna**

For many years, Thailand has been recognized as the leading exporter of various agricultural products, ranging from fresh ingredients to processed canned foods, in the world market. Exportation statistics from the World Trade Organization indicate that Thailand is ranked at 13th in the world, with 2.4 percent of the market share. There are over 9,000 food-processing plants and manufacturers in the country which export agricultural products worldwide including the European Union, Japan, and Australia. These products can range from rice, shrimp, chicken to tuna and many more. As one of the most important nations that export agricultural products, Thailand needs to consider well the issues of Food Safety and Food Security. At present, food safety has become the center of attention among developed nations. As such, the demand for higher levels of food safety has led to the implementation of regulatory programs that address more types of safety-related attributes. These regulatory programs are intended to improve public health by controlling the quality of the domestic food supply and the increasing flow of imported food products from countries around the world. For that reason food processing schemes namely the Traceability and Cold Chain Management should be developed and improved. While traceability refers to the capability to trace goods along distribution chain on a batch number or series number basis and improvement of supply-side management, cold chain management is a temperature-controlled supply chain with uninterrupted series of storage and distribution activities that can maintain a given temperature range. Cold Chain Management is used to help extend and ensure the shelf life of products such as fresh agricultural produce and processed foods. We all know that the demand for food is ever increasing nowadays. Therefore, it is necessary to develop production capacity to meet with the needs of the world population. Also, it is most likely that there will be over 9,000 million people in the next 20-30 years. Consequently, sufficient raw materials for food production should be readily prepared in order to avoid food shortage

**Agriculture for Better Living and Global Economy: Thailand
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Thailand possesses a very fertile environment with population of 63 million and growth rate is low due to a very effective birth control measure. Average life span of the Thai is around 72 years which leads towards the ageing society. Special foods for the aged are highly needed. Thailand policy is emphasized on food which may bring the country toward a world major production site and is trying to become a kitchen of the world. Nevertheless the reduction of fertile land which is suitable for agriculture and the increasing aged farmers are major concerns which may determine the success of such policy. Functional foods and herbs may play a significant impact especially for the niche market. The need for food in the near future is increasing in both quantity and quality. Food safety is a concern of many countries, thus research and development should be seriously considered. Value-added products from agricultural produce are significantly increasing through extensive research. Such examples are the extraction of beta carotene and vitamin E from palm oil, capsaicin from chili pepper, and sericin from silk which are used in the cosmetic and food industry. The value of these extracts is substantially high as compare to the primary products themselves. These products lead to a drastic increase in the utilization of the primary produce which in turn influence the price.

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AGRICULTURE FOR BETTER LIVING AND GLOBAL ECONOMY

ABSTRACTS OF PAPERS—SCIENTIFIC SESSIONS

Novel Bioproduct of Bacterial Antagonist Amended in Growing Soil Promotes Plant Growth and Induces Plant Resistance Against Diseases of Rice

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Two-bacterial antagonist strains, *Bacillus* sp. D10 from rice rhizosphere obtained in this study and the commercial strain *Pseudomonas fluorescens* SP007s that have proven ability to suppress rice diseases in the paddy, were subjected to cross linked matrix with several inexpensive organic carriers for development of a novel bioproduct for soil improvement. These 2 strains survived in the selected best product (dry cow dung:rice bran chaff:rice husk ash dust:coir dust:decomposed plant matter with 1:1:4:4:10 by volume) at 2×10^{13} cfu/ml for 120-day at room temperature. Greenhouse experiments with either SP007s or D10 products amended in grown soil at ratio 1:10 by volume significantly enhanced plant growth with increased seed germination and seedling vigor including stem high, root length, fresh weight, and long leaf of rice ($P=0.05$). When rice plant assays were employed with these strain products applied as single soil amendment (1:10 by volume) and combined with cell suspension by seed treatment (1×10^4 cfu/ml) and foliar spray (1×10^8 cfu/ml), the significant reduction of 2 diseases, sheath blight and leaf blight caused by *Rhizoctonia solani* and *Xanthomonas oryzae* pv. *oryzae* respectively were found in correlation with increase of defense-related enzymes including phenolic compound, β -1,3-glucanase, and peroxidase in rice leaves. This demonstrates that strains SP007s and D10 are in the efficient delivery system of either organic carrier or application fitness for enhance plant growth and biocontrol activity.

Effect of Bio-factors against Potato Common Scab Disease in Vietnam

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Potato common scab is a serious disease that attack potato tuber during forming tuber stage to harvest. This disease affects not only potato production (if it occurs in early stage), but also on tuber quality. The study on potato common scab (*Streptomyces scabies*) and disease management has been reported by many researchers. However, the study on using *Trichoderma viride* and acid humic against potato common scab is still limited. This research aims to study the effect of *T. viride* and acid humic against potato scab in a field trial in Vietnam. The result shown that, *T. viride* and acid humic have good effect in controlling potato common scab on scab tuber and scab index. The experiment data in Dalat city shown that, scab tuber in control experiment was 89.2% in compare with 52.7% which tested with *T. viride* and 64.7% which tested with acid humic. And on scab index were 47.3% (in control experiment) comparing with 21.9% (tested with *T. viride*) and 24.9% (tested with acid humic) respectively) with similar results in Bacninh province. The percentage of tuber infested by common scab was 22.1% in control treatment in compare with 0% which tested with *T. viride* and 4.0% tested with acid humic. Scab severity also shown a positive result. It was 8.4% scab index in control treatment comparing with 0% and 1.1% on those tested with *T. viride* and acid humic respectively. For potato production, *T. viride* and acid humic have also good effect on treatments both in Dalat city and in Bacninh province. Potato plants tested with *T. viride* and with acid humic, gave higher production than control treatment. Thus, *T. viride* and acid humic can control potato common scab on tuber and have a direct impact on potato productivity.

Safed Musli (*Chlorophytum borivillianum*) Tuber Emergence as Affected by

Exogenous Application of Humic and Gibberellic Acid

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Safed musli, belonging to the liliaceae family, is an herbaceous plant which originates from India (Parmar *et al.*, 2007). Tuber germination of safed musli has been reported to be variable, requiring two to eight weeks to germinate, and this contributes to the heterogeneous growth of the crop. It is necessary to increase its germination uniformity as well as the time of germination in order to obtain an efficient production and management system. Various aspects of the crop propagation and management are currently being established under the Malaysian condition. Exogenous application of growth regulator is known to stimulate germination in order to achieve uniformity (Brocklehurst *et al.*, 1982). This study was therefore designed to assess the effects of exogenous application of gibberellic acid (GA3) and humic acid (HA) on the emergence of safed musli. The experiment was conducted at Universiti Putra Malaysia, Malaysia on 2009. Tubers were soaked for one hour in different concentrations of GA3 (10, 15 and 20 mg/L), HA (5, 10, and 15%), and distilled water (control). After one hour, tubers were sown in poly bags and replicated four times using randomized complete block design. Results showed that pretreatment is needed in order to obtain uniformity in growth, high germination percentage (GP) and better root and shoot development. Treatment with 20 mg/L GA and 15% HA were more superior to other treatments. However, in term of vigor index (VI), 20mg/L GA3 recorded the highest VI having the best shoot and root development in relation to GP. Prior to planting, safed musli tubers should be treated with exogenous GA3 at 20mg/L.

Assessment of the Needs and Problems of Vegetable Farmers in Rizal: Basis for Policy Formulation and Design of a Functional Extension Program

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This study was conducted to generate information on the farmers' problems associated with marketing, support services, and other issues and concerns as well as on farmer training needs in vegetable production and postharvest technology hopefully to serve as basis for the formulation and design of a functional extension program. Survey questionnaire was obtained to collect data from vegetable farmers. The municipal/city agriculturists were interviewed as in depth case to full fill more information. Problems encountered by most of the farmers associated to marketing of products including low farm gate price, no established market channels, limited access to information on supply and demand and distribution of vegetables, high competition of vegetables produced within the province and those from other provinces/regions while those attributed to support services were focused on credit, trainings, farms tools and equipment, irrigation system, poor farm to market roads, storage facilities, source of good seeds, and high cost of inputs. Polluted irrigation water, high cost of labor, and inadequate reading materials were limiting factors for successful vegetable production and non-membership to farmers' organization constraints farmers' access to government support. Significant number of the respondents expressed their need to be trained on the different aspects of vegetable production such as planting and cultivation, fertilizer usage, pest control and management and also harvest and postharvest technology. Addressing these problems and training needs through the formulation of a sensible policy and design of a functional extension program are deemed necessary to improve vegetable farmers' productivity in the province.

The Biology and Development of the Tachinid fly *Zenillia Dolosa* (Meigen) (Diptera: Tachinidae) in Host *Mythimna Separata* (Walker)

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All tachinids are endo-parasitoids and important natural enemies of many lepidopteran spp. They have been used in many applied biological control programs worldwide. *Zenillia dolosa* Meigen (Diptera: Tachinidae) is an ovoviviparous parasitoid, which lays incubated microtype eggs on the food plants of many lepidopteran pest species. This fly is a widespread gregarious parasitoid occurring throughout other Asian and European countries. Life history of this parasitoid was investigated in the laboratory on the host *Mythimna separata* (Lepidoptera: Noctuidae). Total developmental time from oviposition to adult emergence decreased as temperature increased from 15 to 30°C. Fecundity was highest at 20°C (1580.6 ± 93.40 eggs per female) but was reduced at 30°C (892.7 ± 146.2 eggs per female). Parasitoids successfully developed in 4th to 6th instar host larvae; host instar at time of parasitization significantly influenced the development of the immature parasitoid which was shorter as host instar increased. Both host mortality and parasitoid puparial weight were affected by the number of parasitoid eggs ingested per host: host mortality increased and puparial weight decreased when clutch size increased from 1 to 10 eggs per host.

Performance of Okra (*Abelmoschus esculentus* (L) Moench) in Response to Different Kinds of Organic Fertilizers

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This study sought to determine the effects of the different kinds of organic fertilizers on the growth and yield performance of okra (*Abelmoschus esculentus* (L) Moench) variety smooth green using the recommended rate of application of 9 tons/hectare. The experiment was laid out in RCBD using six treatments: T1 = Control (no fertilizer); T2 = Inorganic Fertilizer (IF); T3 = Cow manure based organic fertilizer (CMBOF); T4 = Chicken Manure Based Organic Fertilizer (ChMBOF); T5 = Bioplus Organic Fertilizer (BPOF); T6 = Vermi Compost Organic Fertilizer (VCOF). Each plot was replicated three times. Experimentation was limited to one trial. The okra plants fertilized with organic fertilizers were smaller than those plants applied with inorganic fertilizers 47 days after planting, however, those plants applied with VCOF have comparable height with those plants fertilized with IF at the end of the experimentation. Plants with CMBOF, ChMBOF, and BPOF have the same height and comparable with the control plants. The application of organic and inorganic fertilizers has no influence on the performance of okra in terms of leaf length, stem diameter, days to first harvest, fruit length, basal fruit diameter, and number of fruits per plant. Those plants applied with different organic fertilizers produced the same weight of fruits, significantly heavier than the fruits harvested from the control and comparable with those plants applied with IF. Hence, the application of organic fertilizer could be a good alternative to inorganic fertilizer in okra production.

Influence of Planting Hole Size on the Yield of Yam Varieties

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This presentation seeks to determine the effects of different planting hole sizes on the yield performance of the different yam varieties. Data were generated through field experimentation utilizing RCBD, 3 x 3 factorial arrangements with 3 replications. Three yam varieties and three sizes of planting holes comprised the treatment combinations during the growing season in May 2005 - January 2006. The results showed that the yielding capability of the three varieties differs significantly. Ubeng-ube (Balolong) variety yielded 28.99 t/ha while Ubeng-ube (Mindoro) variety produced only 13.72 t/ha. Kinampay variety has the lowest yield with 8.06 t/ha. The high yielding ability of Ubeng-ube (Balolong) variety could be attributed to its characteristic of developing bigger and more than one tuber per plant. The size of planting hole significantly influenced the performance of the yam plants. The yield is significantly increased by 34.98% when planted in a 3.375 cu.ft. hole. A nonsignificant interaction between variety and planting hole size was observed, indicating that the varietal difference was not significantly affected by the planting hole size and that the planting hole

size effect did not differ significantly with the yam varieties tested considering yield (t/ha) and number of tuber/hill as predictors. Ubeng-ube (Balolong) variety is more profitable to produce than the other varieties tested especially when it is planted in a 3.375 cu. ft. hole.

**Germplasm Collection, Characterization and Evaluation of Chickpea (*Cicer arietinum*)
Varieties under Highland and Lowland conditions under Benguet Conditions**

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Chickpea (*Cicer arietinum* L.) is a newly introduced crop in the Philippines particularly in the highland condition. Its' aim is to introduce, evaluate and promote varieties intended for processing. Thirty chickpea varieties from ICRISAT was collected and evaluated under highland with an elevation of 1,245 masl and lowland with an elevation of 640 masl. The different varieties were characterized and evaluated based on the IBPGR descriptors' list for chickpea. Characters evaluated were on vegetative growth such as growth habit, leaf size, leaf area, number of branches, plant canopy height and width, flower duration, biological yield, grain yield and incidence of pest and diseases. Six varieties of desi-type and kabuli type were selected based on vegetative growth, yield, seed yield and resistance to pest and diseases. Varieties selected for the highland conditions were ICCV 93952, ICCV 93954, ICCV 06102, ICCV 92311, ICCV 95334 and ICCV 07307. Varieties selected for the lowland conditions were ICCV 10, ICCV 93952, ICCV 07114, ICCV 92311, ICCV 95332 and ICCV 07307. Pest and diseases seen were; pod borer (*Helicoverpa armigera*), ascochyta blight, dry root rot, alternaria leaf blight, fusarium wilt, stunt and alfalfa mosaic virus. ICCV 93954, a desi-type variety was found promising for flour processing due to its high milling recovery of 80%. Chickpea flour was analyzed and showed higher protein, dietary fiber, iron and fat as compared to wheat flour. Chickpea cookies and puto was developed by substituting chickpea flour with wheat flour using three formulations; 1:1 ratio, 1:2 ratio and 1:3 ratio. Results showed no significant differences among the rations, however 1:2 (1 cup chickpea and 2 cups wheat flour) ration gave the highest acceptability rating of 6.84.

Inheritance of Important Traits in Sweet Corn Single-cross Hybrid

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Sweet corn (*Zea mays* L. *saccharata*) is an important crop in Malaysia, and its production has continuously increased, mainly due to its high return. Single-cross Hybrid 969, an imported hybrid variety, has performed well and is widely planted throughout the country, proving it desirable as a source of inbred lines. Previous studies have generally indicated that complete dominance is important in the genetic control of yield traits in corn hybrids. Hence, many commercial single-cross hybrids which showed high inbreeding depression at early generations of inbreeding were found not suitable to be used as germplasm sources (Basra, 2002). Objectives of this study were to evaluate performance of the F1 and F2 populations of Hybrid 969, to determine inbreeding depression in the F2 population, to estimate broadsense heritability of the traits measured in the populations, and to predict gain from selection of the traits measured on the populations. Results show that the F2 population had all measurements significantly lower than the F1 population, except for days to tasseling and silking where the reverse was true. Estimates of inbreeding depression were highest for dehusked and husked fresh yield (-61.1% and - 54.7%, respectively). This has resulted from increased homozygosity of the recessive alleles responsible for the control of these characters (as a result of selfing), the effects of which were masked or partly masked by dominant alleles in the heterozygous form in the F1 population. Days to tasseling was found to be the most heritable trait, followed by dehusked and husked ear diameter (91.0%, 81.5% and 74.4%, respectively). This indicates that these traits can be improved more rapidly through selection at early generations of segregation than those with lower heritability estimates (Bonos *et al.*, 2003). Results also indicate that a substantial gain from selection of the top 20% of the population can be expected when phenotypic selection is used.

In conclusion, significant differences in performance between the F1 and F2 populations indicate high inbreeding depression after one generation of selfing in the sweet corn Hybrid 969, although there were individuals in the F2 population that showed highly desirable performance. Hence selection of these desirable segregants with the character of interest could be exploited for development of inbred lines derived from Hybrid 969.

Multiplication Rate of Selected Potato Entries to Rapid Multiplication Technique

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Selected eight potato entries were evaluated to their performance in rapid multiplication technique. The entries 2.21.6.2, 380241.17 and the check variety Igorota had the most vigorous growth among the eight entries. Furthermore, the Igorota significantly gave the highest number of stem cuttings produced in three months period with 152 stem cuttings/25 mother plants. This was followed by the entries 676070 and 380241.17 with 100 and 97 stem cuttings respectively. Other entries (2.21.6.2, 5.19.2.2, 573275, Granola and Ganza) produced stem cuttings from 45 to 86 stem cuttings in three months period. Significant differences was obtained on the tuber yield of the different entries under greenhouse. The entries 5.19.2.2 and 676070 had the highest number of tubers with 30 and 27 per m² respectively. The lowest were from entries Igorota, 573275 and 2.21.6.2 with tubers ranging from 18 to 23 pieces per m².

Cassava Disease Detection by Fractal Analysis of Digital Images

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A crop monitoring system that provides early detection of plant disease is indispensable for future crop protection. Diseased plants are usually observable from visual symptoms and hence suggest the possibility of damaged plants identification using machine vision [1]. This requires a quantity which is capable of characterizing atypical appearances of the diseased plant organs. This study evaluated the validity of some fractal parameters in plant disease identification. Colored images of normal and diseased cassava leaves were captured with a digital camera at a horizontal by vertical resolution of 1600 by 1200 pixels. The original color images were grayscaled and thresholded to detect their edge outlines. These were converted to binary images prior to analysis. Fractal analyses based on box-counting algorithm were performed for individual image to estimate fractal dimensions and lacunarities using FracLac v.2.4e for ImageJ. The software functioned in placing non-overlapping grids over the image by varying the grid size from 2 to 540 pixels. The number of boxes required to cover foreground pixels as well as the number of pixels in each box were counted. Two types of fractal dimensions i.e., standard box-count dimension (*D_{std}*), and minimum cover box-count dimension (*D_{mc}*) were calculated. The slope corrected *D_{std}* and *D_{mc}* which eliminate the effect of plateaus slope were also observed. The lacunarities considered includes prefactor lacunarity (Λ_{pf}) derived both from box counts and pixel masses, average lacunarity (Λ_{avg}) and binned probability density lacunarity (Λ_{bpd}) obtained both from foreground masses only, and foreground plus empty boxes. The results showed that *D_{std}* and *D_{mc}* of diseased leaves images were significantly greater than those of normal leaves which were similar to slope corrected *D_{std}* and *D_{mc}*. This indicates that the diseased regions appeared on the cassava leaves had introduced a marked complexity to the leaves profiles. The lacunarities of diseased leaves were found smaller than those of typical leaves for all cases. Nevertheless, these differences were not statistically significant except for the Λ_{avg} obtained from foreground plus empty boxes. This implies that alteration in spatial heterogeneity due to the diseased regions, under the present condition, was not obvious. The fractal dimensions are therefore of promising parameters to make the diseased plants identifiable.

Effect of Salted Hide Moisture on Contamination of Halophilic and Halotolerant Bacteria

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Without any preservation, fresh hide is rapidly destroyed by microorganism. Hide salting prolongs hide quality from microorganism contamination. However, halophilic and halotolerant bacteria growing, in salty condition, can spoil the cured hide. In this condition, hide moisture content is an important factor for bacterial growth. The easiest and cheapest method to reduce hide moisture is air drying. In this experiment, the effect of salted hide moisture on halophilic and halotolerant bacteria number was studied. Salt at the amount of 25% green hide weight was used for drum salting, while that of 40% for hide salting in cement pond or traditional one. Cured hide pieces were taken for moisture determination and halophilic and halotolerant bacteria count every week for six weeks. The bacteria peaked at the first week after salting and then decreased in relation to the moisture content. The bacteria were limited at low level as moisture was about or <30 %. The results suggest that the hide moisture content can be an indicator for low halophilic and halotolerant bacteria contamination.

Influence of Fluidization Drying and Tempering Time on Quality of High-amylose Brown Rice

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The main objective of this work was to study the influence of fluidization drying using air at temperature of 130 and 150 °C on various parameters of Suphanburi 1 local *Indica* rice. The moisture diffusivity of paddy was determined. Fresh paddy was dried from initial moisture contents of 22 and 25% w.b. to 18-19% w.b. It was then tempered for different periods before ventilated by the ambient temperature at the last stage. The experimental results indicated that the initial moisture content and drying temperature influenced on drying time. The longer tempering time and higher drying temperature could improve the percentage of head rice yield whilst the whiteness decreased. Starch characteristics were studied by Rapid Visco Analyser (RVA), x-ray diffraction, and differential scanning calorimetry (DSC). Pasting properties were effected by the initial moisture content and drying temperature. The pasting temperature and setback were increased when high initial moisture content paddy was dried by high temperature, but peak viscosity and final viscosity decreased. All starch thermal treated samples displayed the typical A, B, and V type x-ray diffraction pattern whereas the shade dried samples showed only A type x-ray diffraction pattern. The apparent crystallinity determined by x-ray diffraction was reduced with increasing initial moisture content and drying temperature. The degree of gelatinization was increased with the higher initial moisture content, drying temperature and tempering time.

Postharvest Loss Assessment of Potato Entries Grown Across Locations in the Philippine Highlands

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The study assessed the postharvest losses of potato entries, determine the effect of locations on postharvest losses of potato entries, and to determine the interaction between of potato entries and location of production on postharvest loss. Based on the results, CIP 380241.17, Phil 2.21.6.2 and Phil 5.19.2.2 had the lowest yield loss from harvest to 18 weeks of storage with temperature ranging from 21-22.5 °C and relative humidity ranging from 68.75 to 91.80%. Moreover, potatoes harvested from Loo had the lowest yield loss immediately after harvesting and during storage. Both location and entry are important factors in selecting potatoes for low incidence of decay and weight loss. CIP

380241.17 and 5.19.2.2 could be stored when price is low and can be sold after hence it had less weight loss after 18 weeks of storage. Careful harvesting and appropriate method for harvesting are important considerations in decreasing postharvest loss.

**Evaluation of Selected Potato Entries Grown Across Location
for its Chipping Quality**

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Five potato selections from the multilocal trials of the NPRCRTC and three check varieties were harvested across locations, Bonglo, Loo and Madaymen, Benguet and evaluated for chipping quality at the NPRCRTC processing laboratory in March 2007. Potato selections evaluated across locations did not show any difference in terms of dry matter content, chip recovery as well as in the sensory characteristics. However, it varies among the potato entries evaluated. Dry matter content was observed to be high in check variety Igorota, 676070, 5.19.2.2, 573275 and 2.21.6.2 with 20 – 23%. Lowest DMC was observed for Granola and Ganza with 16 – 19%. Highest chip recovery of 32 – 35% was observed for entries 5.19.2.2, 380241.17, 2.21.6.2 and Igorota. For the sensory characteristics, potato entries 380241.17, 5.19.2.2, 2.21.6.2, Ganza and Igorota has the best quality with a chip color of slight browning (1 – 2%) to no browning, slightly oily as well as acceptable to highly acceptable chips. 676070, 573275 and Granola gave an unacceptable chips because of excessive browning and oily chips.

Meta - Analysis on Environmental Impact of Eucalyptus Plantation in Thailand

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The Meta-analysis on environmental impact of eucalyptus plantation in Thailand has its purpose on the study of general features of researches studies on it and the synthesis of these researches by using meta-analysis method. Forty researches that led to the synthesis were printed and published during the year of 2532 to the year of 2551. Data collection on each research characteristic summarized on research data base and using the method of Glass, McGaw&Smith (1981) have the effect sizes value of 213. The synthetic results conclude: 1. The majority of meta-analysis in this study is in the category of organization. The most of research from the Royal Forest Department (53.7%). The largest part of the researches is in appearance of final report (46.3%) which most published in the 1987-1991 (34.1%). This research focus on the sample which were collected from the Northeast Region. The most frequently studied environmental impact is soil environmental impacts from eucalyptus plantation for plant biomass. The minor impacts are on water resources, toxicity of Eucalyptus and others plants species that plant together with eucalyptus.

**Pod Setting and Yield Response to High Temperature Stress on Soybean
[*Glycine max* (L) Merrill]**

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This research determined the effect of high temperature stress during reproductive development on pod setting, seed set, and yield of soybean. To create variations in temperatures Degree Days, plants were covered with transparent plastic sheets. Normal conditions without cover plastic cages (25°C) and single layer plastic cages (30°C) or double layer plastic cages (35°C) with transparent plastic walls were placed above the plant canopy. The results show that high temperature stress imposed during Early Flowering (EF) and EF to Pod Development (PD) decreased seed yields of all three genotypes by affecting pod formation, seed set, and dry matter accumulation. High temperature during EF and PD did not affect pod production in AGS, whereas the high temperature during EF decreased pod production by 25.58% for the Dieng genotype and 34.92% for the Willis genotype also during PD decreased pod production by 37.5% for the Dieng genotype and 63.33% for the Willis genotype but it had no effect on the AGS. The high temperature stress also affected both weight per

seed and seeds per pod. The effects of the PD high temperature stress was more pronounced compared to the EF stress. On average, the PD high temperature stress decreased weight per seed and reduced seeds per pod compared to control, whereas the EF high temperature stress had marginal effects on these three variables. The EF high temperature stress decreased seed yield per plant. Both the EF and PD high temperature (30 to 35°C) decreased the seed yield of all three genotypes. Between the three soybean genotype, the Willis genotype produced as many pods per plant and more seeds per plant than the AGS, more seeds per plant than the Dieng genotype under stressful conditions. Although the AGS genotype had a smaller individual seeds, its yield was greater than the Dieng and Willis genotype. These results suggest that the AGS genotype may have a better ability to tolerate high temperature stress than the Dieng and Willis genotype.

**The Makapuno Production Through Embryo Culture Technology:
Ladder to Achieve Better Living of the Community**

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An enterprise that improves the quality of people's lives, addresses poverty, and empowers the marginalized sectors of the society is the makapuno nut growing and its byproduct processing through embryo culture technology. It is an innovative and fast technology with 100% nut production. which produces clean and disease-free pure Makapuno seedlings. Makapuno meat which could be used for pies, cakes, shakes, drinks, ice cream flavor and candies have soft endosperm that almost fills the nut cavity; Makapuno nut does not germinate because the meat rots easily once the nut is harvested. Embryo culture technology solves this problem. Rearing the seedlings should be in a well maintained nursery, open, level, well drained with good source of water irrigation and far from any existing sources of coconut insect pests and diseases. After 3-5 months, the plants with 4-6 splitting leaves, can be transferred to the field during the cooler months. Under optimum cultural management practices, flowering starts after 4 years. Before the dispersal of the ready to transplant Makapuno seedlings, recipients are trained on the proper care and management of growing the plants and accomplish a memorandum of agreement in this line. When the farmer- recipients started harvesting they are to payback the seedlings from the produce. The potential revenue generated from growing Makapuno the conventional way can yield only 2 to 17 % Makapuno nuts per bunch, while the technology can produce 99 to 100 %. At harvest time, people could be employed to work in the farm, process its by-products and earn income every 45 days.

**Shoot Proliferation of Banana cv. Grande Naine Through Horizontal Sectioning
of the Shoot Tip**

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Cavendish (AAA genome type) is one of the most important banana cultivar with about 47% global production (Arias et al., 2003). The edible bananas and plantains are conventionally propagated through vegetative means using sword suckers which is very slow. The *in vitro* method is used for mass production. Here, we report an improved technique for rapid multiplication for large scale micropropagation. The aim of this study was to establish an applicable protocol for shoot proliferation through horizontal sectioning of the individual shoot tip using suckers of banana cv. Grande Naine (*Musa* spp. AAA group). The excised shoot tips were cultured on MS medium supplemented for one month. After 2 months, the multiple shoots which emerged from each segment were isolated and cultured on MS medium supplemented with three different concentrations of BAP (10, 20, 30 µM) for further multiplication and determination of the best BAP concentration for shoot proliferation with monthly subculture interval. As a control the excised shoot tips were cultured on MS medium supplemented with 10, 20 and 30 µM BAP, with one month subculture interval for six month without sectioning. All experiments were arranged in CRD with three replications with 10

explants per replication per treatment. Parameters observed were the number of shoots produced per explants per subculture. The horizontal sections of cv. Grande Naine placed onto MS medium containing 10 μ M BAP resulted in high multiple shoot production. The multiple shoots obtained in this step were isolated and cultured on MS medium supplemented with 10, 20 and 30 μ M of BAP for further shoot proliferation. The mean number of proliferated shoots obtained at 10 and 30 μ M of BAP was 3.53 and 4.12 after four subcultures respectively. The number of proliferated shoots can be maximized by using horizontal sections of the individual shoot tip resulting in 49 % increase.

**The Expression of Antisense *EcLIM* Gene in *Eucalyptus camaldulensis* Dehnh.
by *Agrobacterium tumefaciens*-Mediated-Transformation**

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The LIM proteins which got their names from three first discovered homeodomain proteins: LIN11, ISL1 and MEC3, are transcription factors that involved in lignin biosynthesis and specifically bind to the important cis-acting element, PAL-box sequence. The NtLIM gene from tobacco has been reported to control the expression of several lignin biosynthesis genes in eucalyptus including phenylalanine ammonia-lyase (PAL), cinnamate-4-hydroxylase (C4H) and 4-hydroxycinnamate CoA ligase (4CL). In this research, we investigated the function of LIM gene in lignin biosynthesis in eucalyptus by antisense transformation of EcLIM gene from eucalyptus into elite eucalyptus clone. The partial EcLIM gene was cloned from *Eucalyptus camaldulensis* cDNA and the antisense orientation was constructed into a binary vector, pCambia1304, under the control of CaMV35S promoter together with hygromycin-resistant gene as a plant selectable marker gene. The recombinant plasmid was then transformed into *Agrobacterium tumefaciens* strain EHA105 for the genetic transformation of in vitro eucalyptus. The putative transgenic lines were selected based on their hygromycin resistance character and the existence of antisense EcLIM gene was confirmed by PCR analysis. Nine transgenic lines were transplanted in a bio-safety greenhouse. It was found that survival rate of the transgenic lines were higher than the wild type and none of visible abnormal phenotype was observed. The three-month-old transgenic lines were taller than wild type. The expression of LIM gene in transgenic eucalyptus lines were reduced more than 90 % compare to the wild type as measured by real-time PCR of xylem RNA. For further work, lignin contents and pulping characteristics will be investigated in one-year-old trees.

**Hybrid Testing of Sweet Corn and Waxy Corn using Seed Storage Proteins
by Ultrathin-Layer Isoelectric Focusing Technique**

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The hybrid test of F-1 hybrid is very important in seed production industry especially for the cross pollination crop such as corn. To ensure farmer's satisfactory, seed companies have to intensively test their hybrid seeds. Ultrathin-layer isoelectric focusing (UTLIEF) technique is the one that was considered as reliable, convenient and low cost. Three different protein extraction solvents including water, phosphate buffer and 4M urea were tested with mature seeds of six sweet corn cultivars. The results revealed that these six sweet corn varieties could be distinguished by UTLIEF technique using any of these three solvents. However, protein bands obtained from water extraction

had clearer and sharper resolution than extract with phosphate buffer or 4M urea. Thus, water was selected as solvent for the hybrid tested in sweet corn and waxy corn. The inbred lines and their F-1 hybrids were subjected to hybridity tested using UTLIEF. Seed storage proteins were extracted with water and were separated on the pH 2-9 acrylamide gel according to their isoelectric when the electrical voltage of 2500V was applied. The results demonstrated that this technique could be successfully used for hybrid test in both sweet and waxy corns. For sweet corn, ten distinct protein bands could be used to indicate parental lines and their F-1 hybrid. For waxy corn, even only four protein bands could be observed but they were clear cut for hybridity test. In the waxy corn seed, there was a distinct band which indicated that the seed was not the F-1 hybrid seed. Thus, the UTLIEF technique not only offers the means for hybrid test but the genetic purity test also.

Varietal Identification of Cucumber using Seed Protein Analysis by Ultrathin Layer Isoelectric Focusing Technique

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Genetic purity test is crucial for quality control in seed production, especially for F-1 hybrid variety. The test should be reliable, rapid, simple and affordable. Unfortunately, the most reliable DNA fingerprint test is costly while the simple grow-out test is a very time-consuming method. The ultrathin-layer isoelectric focusing (UTLIEF) test was reported as a new, rapid and relatively cheap technique to differentiate plant varieties based on the polymorphism of seed protein in rice, corn and tomato (Yan et al., 2006; Leist and Knoblauch, 2003; Wang et al., 2000). Cucumber (*Cucumis sativus* L.) is the major crop for F-1 hybrid seed production of Thailand. The applicable UTLIEF technique as the genetic purity test for cucumber seed will greatly enhance its seed quality control efficiency. The objective of this experiment was to find a suitable extraction buffer and pH gradient to be used for running the UTLIEF on the protein stored within the cucumber seed in the IEF-SYS horizontal electrophoresis system. Four buffer solutions including water, 0.005 M NaCl, phosphate buffer and 0.005 M Na₂ EDTA were tested in combination with two pH gradients of 2-11 and 4-5 plus 3-10 range. It was found that pH range of 2-11 on polyacrylamide gel and extracted protein by water yielded the most polymorphic and clearest bands. Positive result was found when the technique was used to identify 5 open pollinate commercial cucumber varieties. The efficiency of UTLIEF technique in hybridity test for F-1 hybrid cucumber seed needs to be tested to confirm the feasibility of using this UTLIEF technique in routine genetic purity test for cucumber seed production.

Polymorphic Microsatellite Markers from Expressed Sequence Tags of Rubber Tree (*Hevea brasiliensis* Muell. Arg.)

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Para rubber tree (*Hevea brasiliensis* Muell. Arg.) is an economically important plant in tropical areas that produces 98% of the world's natural rubber. Microsatellite marker from expressed sequence tag (EST-SSRs) become the ideal markers for constructing high-resolution genetic maps and identifying traits of interest as well as genetic analysis. In this study, polymorphic EST-SSR markers were developed from ESTs of rubber tree deposited in public databases. A total of 226 primer pairs were designed and 48 primer pairs were screened on 31 cultivated clones of *H. brasiliensis*. Of the 48 EST-

SSR loci, 18 yielded polymorphisms with two to six alleles per locus. The average unbiased and direct count heterozygosities were 0.456 and 0.516, respectively. Cross-amplification of the 48 EST-SSR loci was tested with cassava (*Manihot esculenta* Crantz) and physic nut (*Jatropha curcas*) which belong to the same Euphorbiaceae family. Five and six EST-SSRs showed polymorphic patterns in cassava and physic nut, respectively. In addition, all 226 EST-SSRs were tested with our selected parental varieties of a mapping population, RRII105 and RRIM600, resulting 24 polymorphic markers which will be applied to construct genetic linkage map of this species in the future.

Aglibut Sweet Tamarind (The Commercialization of the Philippines 1st Sweet Tamarind Variety Registered under NSIC-BPI)

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The Pampanga Agricultural College-Philippines developed the 'Aglibut sweet' and is now promoting it for widespread planting not only in Central Luzon but also in other parts of the country. 'Aglibut sweet' is the first sweet tamarind registered in the Philippines. To commercialize such important commodity, it involved training of interested farmer-entrepreneurs, conduct of field days, establishment of demonstration farms, commercialization project proposal development and submission to external funding agencies, free technical consultation for walk-in buyers and previously-trained growers, credit assistance in the form of seedlings loan, technical backstopping necessary for the establishment and development of off-campus scion groves/nurseries at selected local government units and state colleges and universities. Other promotional activities for the commercial production of 'Aglibut sweet' include: production of information, education and communication materials; participation in technology commercialization forum; trade fair and exhibits; and media advertisement. As an offshoot of the above-mentioned activities, the following were realized: increased income of PAC and other partner-institutions from the sale of planting materials, fresh fruits and other food and non-food products, increased financial and logistical supports from the various government agencies to further advance sweet tamarind as a commodity-based industry, the creation of sweet tamarind research and development center which pursues continuous development and upgrading of technologies relative to sweet tamarind.

Enhancing the Utilization of the Light Trapping Technology for Insect Pest Management of Major Crops in Selected Provinces of Region 1, Philippines

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The light trapping technology was showcased for four major crops, namely, rice, corn, mango and vegetables at different municipalities of the four provinces of Region 1. The technology uses the ultraviolet lamp that at specific wavelength greatly attracts various insect species. With lamps installed at farmers' fields, the number of insect pests, influence on the increase in yield and the degree of chemical reduction were noted to assess its effectiveness. Generally for rice, corn and vegetables, weekly insect pest collection by the light trap was highly extensive while population of the trapped natural enemy was very minimal. Crop yield increased from 5% to 50% and a reduction in chemical spraying from 25% - 100% were noted for rice, corn and vegetable farms exposed to the light trap in comparison to farms without light traps. Mango exposed to light trap had considerable number of fruits per panicle causing a 50% increase in fruit yield. In addition, about 20-30% reduction in chemical spraying against insect pests was also observed. Excellent crop protection was augmented by weekly spraying of 0.1% calcium hypochlorite + a commercial hair shampoo which further reduced disease incidence resulting in clean and unblemished fruits. Net monetary benefit derived by partial budget analysis showed high economic returns in using the light trap. Cost effectiveness of the technology as an insect pest management tactic was highly demonstrated which warrants commercial availability of crops which are GAP (Good Agricultural Practices) -certifiable, i.e. with general safety to consumers.

**Management Practices in Potato Production of Three Potato Varieties
by Farmers in Benguet, Philippines**

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Farmers' management practices of growing three potato varieties; Igorota, Solibao, and Raniag were documented. Information gathered came mainly from seven case-farmer respondents selected based on their length of experience in growing the varieties and their willingness to share their knowledge and experience. Among the three varieties, Igorota (seed tuber) was kept and maintained by farmers until the sixth cropping. Solibao and Raniag were planted only once or until three cropping seasons. Solibao was less preferred in the market while Raniag was a low yielder in elevation. The yielding ability of Igorota could be maintained until the sixth cropping if seed tubers were sourced out from different farm locations and elevations every cropping season. The three varieties had higher yields during October to February planting. Igorota and Solibao had robust vegetative growth but lower tuber yield during the wet season but showed resistance to late blight; hence farmers practiced longer fungicide spraying intervals. Raniag was harvested as early as 75 to 90 days after planting, Igorota at 80-110 days, and Solibao at 90-120 days. Dehaulming one to two weeks before harvesting, curing by covering piled tubers in cement floor one month prior to transport, or spraying with a fungicide two weeks before harvesting were done to reduce bruises and feathering. Igorota was suitable for in-ground storage despite its 3-month dormancy period. The tubers of Igorota and Solibao turned green faster than Granola (farmers' variety). Cropping pattern practices dictated the need for 6-month seed tuber storage. Hence, one-level piling of the seeds in seedbed racks can be done under diffused light storage in cooler temperature to prolong the dormancy of Igorota to more than three months. The growing period was shortened when Igorota seed tubers were already shriveled.

Effect of Potassium Humate on Electrical Conductivity and pH of Acidic Soil

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Potassium humate (K-humate) derived from brown lignite coal organic material by alkaline extract ion; aromatic in nature, abundant in carboxylic and phenolic groups can provide favourable reactive sites for cation exchange, bind and adsorb phototoxic elements, increase pH buffering capacity, improve penetration and retention of Ca in the soil, helps root enlargement and play an important role for nutrient transport to plants. The aim of this work is to determine the effect of K-humate on electrical conductivity (EC) and pH of acidic soil. An incubation experiment was carried out for 60 days in the month of March and April 2009 on a Kangkong soil series. The soil was prepared, sieved through 2 mm sieve and 25g of soil were used in vial. The layout of experiment was completely randomized design with three replicates and six treatments. K-humate (0, 25, 50, 75 and 100 kg ha⁻¹) and phosphorus (0 and 70 kg P₂O₅ ha⁻¹) in the form of triple super phosphate were applied on the surface of the soil before watering; water was applied at field capacity level. After each 15 days of incubation, soil samples were collected and analyzed for EC and pH up to 60 days. It was observed that when only P (T₂) was applied maximum values were found for EC in contrast at same treatment minimum pH values were observed. Whereas the values of EC and pH both are significantly increased as dose of K-humate increases over control, among the K-humate treatments highest values were noted at T₆ (70 kg P₂O₅ and 100 kg K-humate ha⁻¹), respectively. However, no significant difference was found between T₅ and T₆. Results indicates statistically significant increases (849-946 μ S cm⁻¹ and 5.48-6.03), at T₆ (70 kg P₂O₅ and 100 kg K-humate ha⁻¹) in soil EC and pH respectively, relative to the control.

**The River Analysis Simulation Model for Paddy field in Saline soil: A case study in
the Lower Nam Kam River Basin, Thailand**

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A study on flood management in lower Nam Kam River Basin, a tributary of Mekong River Basin in Nakhon Phanom Province, was carried out. Although there have been some regulated structures in the upstream of the Nam Kam and the Nam Bang rivers (branch stream of Nam Kam) which managed by the Royal Irrigation Department (RID) in recent years, however, the fluctuated water level in floodplain nearby the river mouth is easily influenced by backwater from the Mekong River and cause flood in floodplain area. Unfortunately, some sources that might cause surface and ground water contamination by some saline soil spots beneath the ground level were investigated by RID. The gate regulations for the proposed reservoir in the lower Nam Kam river should be well operated with awareness of the dispersion of saline water from those sources. The present research was conducted by analyzing flood delineations using the river analysis system model (HEC-RAS) for the estimation of main hydraulic parameters of the Nam Kam River and would be applied to cases of without and with the regulated structures by proposed dam and reservoir. The results from the model fitted with the observation and recorded data of both river stages and electric conductivities (EC) of shallow wells nearby saline soil spots since 2005. This study is a part of research in sustainable conjunctive use of groundwater and surface water in saline soil with the aims for further management of operation of gates, reservoirs, and groundwater utilization to avoid salinity dispersion.

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Results of Studies the Possible Correlations between SPAD Value and Total Nitrogen Contents in the Leaves of Sugarcane (*Saccharum officinarum* L.)

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Plant analysis is an important tool for monitoring and evaluating the nutrient status of crops. Conventional tissue analysis is time-consuming for evaluate the nitrogen status. The objective of this study was to investigating the possible correlations between SPAD value and the total nitrogen concentration in leaves of sugarcane using the SPAD- 502 chlorophyll meter. The experiment was conducted in Kamphaeng Phet soil series (Kp: Oxyaquic (Ultic) Haplustalfs) of Sandy clay loam texture under rain-fed area at Koaleaw district in Nakorn Sawan province during May,2008 to April,2009. Treatments included five N rates of 0, 12 (chemical fertilizers application based on soil analysis as recommended by Department of Agriculture), 9*, 18* and 36* kg N rai-1 (*chemical fertilizers based on quantities of applied nitrogen and estimated uptake of 100, 50, 25%)(as urea). The experiment was a completely randomized block design with five replications. SPAD-values were taken from the middle section of the top visible dewlap blade between 2 to 8 months. Results showed nitrogen concentration in the leaves of sugarcane was correlated with SPAD values. Chlorophyll meter readings above 34 SPAD unit for sugarcane leaves were considered sufficient nitrogen concentration. SPAD readings less than 34 were considered that nitrogen was in the deficiency range. The chlorophyll meter (SPAD-502) can be used as an effective tool to predict nitrogen status of sugarcane under field condition.

Production of Egg Yolk Antibody Specific to *Vibrio harveyi* and Evaluation of Its Stability for Feed Additive

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Vibrio harveyi is a natural microflora in the marine environment which causes luminous disease in black tiger shrimp (*Penaeus monodon*). The disease leads to high mortality and large economic losses in cultured shrimp. Due to the widespread use of antibiotics to control the disease, many luminescent *Vibrios* have become resistant, thereby making antibiotic treatments ineffective. The antibiotics eventually remain in the shrimp body. Passive immunization using pathogen-specific antibodies raised in chickens has been reported to be a promising approach to control the infection. In our previous research, we preliminarily proved that chicken anti-*V. harveyi* antibody has a potential to effectively control this disease; however, the stability of the egg yolk immunoglobulin (IgY) as feed additive needed to be evaluated further, which is the objective of this study. Twelve Roman-Brown laying hens were vaccinated with glutaraldehyde killed *V. harveyi* and C-phosphate guanosine oligodeoxynucleotide (CpG-ODN). The latter was added to enhance the specific antibody production. IgY was extracted from egg yolk by water dilution method then freeze-dried. The specific antibody was determined by ELISA. The concentration of IgY was approximately 9.8 mg/ml of egg yolk with 34.2% purity and 12.2% specific IgY. The stability of IgY in various conditions involving pH, temperature, effect of proteolytic enzyme to IgY activity and storage temperature was investigated. The results indicated that IgY was quite stable at pH 6 to 8. Temperature higher than 70°C significantly affected IgY activity; however, the presence of 30% sorbitol effectively enhanced IgY stability. The behavior of IgY with pepsin and trypsin was also examined and the result showed that after 4h incubation, the activity of IgY remained at 9 and 94% for the mixtures with pepsin and trypsin, respectively. The result also showed that the best storage temperature is -20°C.

Role of Host Fruit Cues to the Response of *Bactrocera dorsalis* (Hendel)

(Diptera: Tephritidae)

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Bactrocera dorsalis (Hendel) (Diptera: Tephritidae), a polyphagous fruit fly, has complex host response patterns. Results of previous study indicated that if female flies could touch the fruit surface, the preference also correlated with changes in fruit firmness. To further understand the role played by different host cues in female orientation, two experiments were run. These isolated host visual and olfactory cues for three ripening stages of mango *Mangifera indica* L. (Anacardiaceae) variety Namdorkmai. Results of these studies indicated that host fruit color least influenced the assessment of host quality by female flies, whereas host fruit volatiles played an important role in the determination of host quality. The influences of physical changes and chemical changes of mango ripening to female fly responses were discussed.

Use of Essential Oils and Organic Acids as Piglet Feed Additives

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Improvement of post-weaning growth rate and efficiency of feed utilization have been achieved by supplementing starter diets with feed additives. Presently, natural ingredients such as essential oils, which are found in many plants like spices and herbs, and organic acids have been used in piglet feed to improve their performance and prevent certain digestive problems, especially in the post-weaning period. The study sought to find a suitable mixture and an appropriate inclusion level in the diet of a feed additive prepared from essential oil mixes (EOM) and organic acids mixes (OAM) in post-weaning pig diet supplementation using growth performance and feed utilization as decision parameters. EOM included clove oil, mint oil, orange peel oil at the ratio of 1:1:1 by weight and OAM included fumaric acid, lactic acid and citric acid (1:1:1 by weight). The first experiment studied for 49 days on the performance and fecal characteristics of 28 days old weaned pigs consisting of 40 males and 40 females crossbred Duroc×(Large White×Landrace). The second experiment studied on the digestibility of nutrients in 40 weaned pigs grouped 4 pigs/group/diet by CRD. Diet 1 was control diet containing corn and soybean meal as the main ingredients. Diet 2 to 10 were control supplemented with 5, 10 and 20 g/kg of diet of the ratio of EOM:OAM 1:1, 1:2 and 2:1, respectively. There were significant differences in average daily gain (ADG) and feed conversion ratio of weaned pigs amongst diets. The weaned pigs fed diet 5 which contained 5 g/kg diet of each of clove oil, mint oil and orange peel oil 0.06%, respectively and each of fumaric acid, lactic acid and citric acid 0.11%, respectively, tended to be the greatest of ADG. Fecal shape and color did not differ amongst diets. The highest of digestibility coefficient of nutrients was found in diet 5. In conclusion, the mixture containing 0.06% each of clove oil, mint oil and orange peel oil, and 0.11% each of fumaric acid, lactic acid and citric acid was the suitable mixture for piglet feed additive at inclusion level 5 g/kg diet.

Satisfaction of Rice Farmers with Living Conditions in Penang and Kelantan, Malaysia

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A concept of "Quality of Life" has been a controversial issue for living standard and satisfaction level of people's life. Malaysia achieved an economic growth with the development of manufacturing

sector, and living standard was greatly improved by material affluence. While Malaysian government referred to quality of life (QOL) in relation to monetary approach, there is no mention of non-monetary perspectives of people's life. It is necessary to measure how much people are satisfied with their living standard and condition at more micro level for further policy development. Interview surveys were conducted in the two villages from 2008 to 2009 in Sebrang Prai, Penang state and Pasir Mas, Kelantan state. A total of 42 and 39 farm households were studied respectively. This paper aims (1) to define the term "quality of life" in the Malaysian context, (2) to measure quality of life in two villages, and (3) to find out determinants of well-being of paddy farmers in two villages. There are two different reactions to living condition between the more industrialized and less developed villages. In terms of objective perspective, "age" was a commonly important determinant in the both villages. However, it indicates opposite tendencies which younger people tended to have higher satisfaction in the less developed area, and elder people tended to have lower satisfaction in the industrialized area. In terms of subjective perspective, there were apparent attributes relating to employed family members and local activities in the more industrialized area, while key determinant did not come up in the less developed area. The regional characteristics had influenced main determinants of QOL especially in the more industrialized area.

Land Tenure Systems and Rental Determination in a Suburban Village in Hanoi, Vietnam

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Agricultural production in tropical countries such as Vietnam depends basically on the use of endowed fertile land resources. In Vietnam, farmlands operated formerly by communes were redistributed among their members in the 1980s under Doimoi Policy. Currently, land and related policies have direct effects on the livelihood of rural populations through influences on land tenure, farm size and fragmentation of land holdings, land use, land and credit markets. The average farm size in Red River Delta ranges from 0.2 ha to 0.3 ha per household and plots of the cultivated land are scattered over many places. This results in difficulties in farm management (e.g. mechanization, irrigation and specialization) and in the pursuit of productivity improvement, requiring intensive labor input in cultivation. This paper aims to determine and to clarify the current land tenure systems, including the pattern of land holding and the existing tenancy contracts of the farm respondents, to investigate the recent changes in land use system for agriculture production. Data were collected by a questionnaire survey, which was conducted in February 2008 in Da Ton Commune, Gia Lam District, Hanoi. It was found that operating lands in Da Ton commune were not only small in size but also fragmented. Da Ton commune had experienced drastic changes in land use patterns and recently there emerged tenancy contracts, especially in the case of fruit land. It was considered that tenancy contracts were established as a part of the broader socio-economic system in the village.

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Effects of Antioxidants Supplementation Dietary on Poly Unsaturated Fatty Acids of Longissimus Dorsi Muscle of Goat

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Consumers demand high quality and convenient meat products with natural flavor and taste, and they appreciate the fresh appearance of meat. Goat meat (chevon) is leaner than mutton and beef, because it incorporates less subcutaneous and intramuscular fat. A study was conducted to investigate the effects of dietary supplementation of antioxidants on fatty acids profile of male kids meat. 32 male goat kids were used in a completely randomized design to determine the effects different dietary supplementation of antioxidants consist control (CN), 400 mg/kg Vit E (VE), 0.5 percent/kg DMI turmeric (TU) and 0.5 percent /kg DMI *Andrographis paniculata* (AP) of kids. The animals were slaughtered at end of experiment and *longissimus dorsi* (LD) was taken. The LD muscle was vacuum packed and frozen (-80oC) for fatty acids measurement. Total fatty acid from meat samples was extracted using a chloroform-methanol solvent extraction system as described by Folch et al. (1957). Result showed that the application of herbs such as TU and AP significantly increased

linoleic fatty acids and also other omega 6 fatty acids in LD muscle. However, incorporation of VA, TU and AP into the animal diet had significant effects on the muscle fatty acid composition of the important commercial muscle cut, such as LD. There was also increased n6:n3 ratio for the TU treatment compared to other treatments (CN, VE and AP). TU and AP increased PUFA: SFA in LD muscle against CN, there was a general improvement in the fatty acids profile of chevon in goats supplemented with the herbal plants antioxidant.

**Participatory Communication Approach to Preserve Existing Indigenous
Agricultural and Natural Resource Strategies in Barangay Amganad, Banaue, Ifugao**

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The indigenous knowledge on resource use is a key concept in the sustainability of agriculture and the environment. It is embedded in community practices, institutions, cultural values and belief systems. To preserve indigenous strategies, the community plays an important role in sharing experiences, information and in the process of creating an effective media of communication materials. The study aims to present participatory communication approach as a tool in the development of communication materials to preserve existing Indigenous Agricultural and Natural Resource Strategies (Ians) in Barangay Amganad, Banaue, Ifugao. Key Informant interview was conducted to solicit information on Ians in the study area along with actual field reconnaissance. Selected participants were invited to join the Focus Group Discussion and workshops in the development of communication materials. The output of the FGD and workshop were used in the development of prototype communication materials on two IANRS, *Muyong* and *Payew*, respectively. The community members identified the most effective forms of communication materials to preserve and popularize their community poster, story book or comics and radio plug. The community poster message was generally well understood and perceived to be intended for the Ifugao farmers and their families. For the comic story booklet, participants showed high comprehension and enjoyed the story they conceptualized during the workshops. The communication materials produced through participatory communication approach are highly understandable, acceptable and attractive to the participating community. It also fosters synergy among experts, semi-technical staffs, government workers and the community. These types of communication materials if properly disseminated could help in the preservation of IANRS.

Socio-Economic and Environmental Contributions of Agroforestry Based Farm

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The agroforestry based technology demonstration farm was established to adopt soil and water management technologies contributing to the stable and sustainable agricultural production in the pilot marginal lands and to establish farmers' participatory techno-demonstration farms (TDF) to disseminate the developed technologies. The farm is located in hillyland agro-ecological zone in Sampaloc, Tanay, Rizal, Philippines which represents the country's extensive marginal soils known as acid upland soils. Previously, the area is dominantly grassland. The farm tested mature technologies for dissemination and adoption within the immediate environs with similar soil-related problems. After four years, this study was conducted to evaluate the agroforestry based technology demonstration farm specifically the site, farmer-cooperators and the agro-technologies adopted in terms of their impact, efficiency, relevance and sustainability. Results revealed that the adopted agrotechnologies include soil conservation (vegetation control, contour orchard, strip/alley cropping), soil fertility management (combined organic and inorganic fertilization, crop rotation/diversification, soil amendment and fertility restoration), water conservation, pest management showed positive results. The technologies' impact on the environment were: marked reduction of the volume of eroded soil, improved soil fertility, improved chemical soil property, increased organic matter and

percent base saturation, and improved pH. There was also a steady increase in vegetative cover and biodiversity. An analysis of the diversified cropland uses showed that there was an increase in land utilization. The project helped increase the net farm income from raising the different alley crops. The farm offered employment opportunities to the community. The demonstration farm was found relevant as it conforms to the thrusts and program of the national government. In general, the farmers in the community are willing to adopt the agro-technologies that were demonstrated.

**Technology Adoption of Alternative Planting Materials and Processing
Varieties in the Philippine Highlands**

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This study determined the level of technology adoption of rooted cuttings, generation zero seeds and true potato seeds as an alternative to clean seed tubers of the locally developed varieties Igorota, Solibao, and Raniag. The survey was conducted in the seven potato producing municipalities of Benguet and Mountain Province: namely, Atok, Bakun, Bauko, Buguias, Mankayan, Kabayan, and Kibungan. Results showed that rooted cuttings had the highest adoption level with 38% of the farmers having tried planting at least once, followed by generation zero seeds (19%) and true potato seeds (2%). The other 44% and 19% of the farmers are aware of rooted cuttings and generation zero seeds, respectively but did not try planting principally because of lack of resources to grow seeds (clean area, cash and manpower). With respect to varieties, Igorota had a high adoption level (82%) while Solibao and Raniag had low adoption levels, 25 and 18%, respectively. High adoption level for Igorota was attributed to its high yield and tuber characteristics, which is accepted in the market. Solibao has elongated tuber shape and Raniag has low yield. Attendance to training and seminars as well as membership in organizations had higher influence in technology adoption levels than farm area and land ownership. Trainings had contributed a lot to the increased awareness and adoption of rooted cuttings and Igorota variety.

**Nature of Risks and Efficacy of Risk Adaptation Measures of Farming Communities
in Selected Community-Based Watershed Management Projects in the Philippines**

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The growing threats facing farming communities and their vulnerability to climate-related hazards under 3 different watershed conditions in the Philippines, namely, lowland-hilly, downstream and hilly-mountainous areas are examined in this paper. Because farming communities are heavily dependent on agriculture for livelihood which is very vulnerable to extreme climatic conditions, then they are most exposed and vulnerable to risks and hazards associated with extreme weather and climate occurrences, the kind and nature which vary across different sites. The paper thus discusses the farmers' risks management strategies across varying bio-physical locations within the context of a risk, hazard and capacity framework. This is based on the analysis of data gathered through a rapid appraisal using FGDs of different watershed areas and riskmapping to determine the current issues and concerns related to farmers' risk situations. Simple statistical and regression analysis was also used to assess the current vulnerability of farming communities for each site and the factors that determine their ability to adopt specific risk mitigating measures. The efficacy of specific adaptation measures was examined in terms of its impact on the farm income per hectare, the selected impact variable. The results show that farmers are exposed to multiple hazards which include typhoons, drought and plant pests. Water shortage and lack of capital also affect farmers most severely. The effects of extreme rainfall, soil erosion, strong winds and dry spells vary by location. The farmers' responses to these hazards vary and range from development of small water systems to modifying land use. These decisions on the kinds of risk-mitigating measures to adopt are influenced by their socio-economic conditions and physical attributes of their farms. The implication of these findings is that there is a need to get a very good understanding of the conditions of these communities within the watersheds if effective strategies are to be developed to reduce their

vulnerability to extreme climatic conditions.

**Vulnerability and Resilience of Watershed Communities
Under Conditions of Risks Associated with their Farming Systems**

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This paper examines the factors that help shape the vulnerability and resilience of farming communities when faced with risks associated with their farming systems in 3 different watershed conditions in the Philippines, namely, downstream, lowland-hilly and hilly-mountainous areas. Data for the study were gathered through focused group documentation and household survey. Simple statistical measures such as frequency counts, percent ratings, range and means were used in the analysis of the household survey data. The results of the analysis show that farmers are exposed to a combination of 25 different kinds of risks in a year. Majority of the risks faced by farmers are naturally occurring which are due to climate/weather variability. Majority of the farmers rated the effects or impacts of the climate/weather variability as “very high” or “high” with 72% of all respondents across sites estimating their losses from crops alone from “moderate” to “very high”. Farmers however have been able to adapt and institute measures to mitigate the impacts of these climatic events and other forms of risks, which for the most part however are ad hoc in nature and limited. The limitations of farm household assets such as human capital, physical and productive assets, social capital, financial capital and other support systems and entitlements influence the nature and degree of vulnerability. These findings highlight the need for the promotion of sustainable and resilient communities. The specific issues and recommendations are discussed in the paper.

**Alternative Agriculture for Better Living of Poor Farmers in High Land at Tambon
Lakdan, Amphor Namnao, Phetchaboon Province.**

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This research aimed to use alternative economy to solve poverty problem of farmers for better living. Alternative production practice was tested by comparing the economic output with that from monoculture. A learning process for farmers was also an aim of this research. The concept of alternative agriculture focused on crop variety in harmony with geography and ecosystem. Strawberry and indigenous vegetables, shortlived plants were chosen by farmers as alternative crops so that they could earn enough income. The planting area was 1 ngan. From 12 volunteer farmers, 3 farmers (25%) got good yield, 9 farmers were not successful because they could not leave or reduce conventional production practices. They also had to pay debts to Bank for Agriculture and Agricultural Cooperatives and from the village fund. They therefore could not take proper care of the new crop. Successful farmers earned 55,000 baht/1 ngan from strawberry. The investment cost for strawberry stocks was 6,000 baht, with fertilizer cost of 2,000 baht. They could sell the produce at local/community markets to both tourists and local people. Moreover, output from indigenous vegetables could reduced their food expense. Comparing with monoculture, the researchers found that most farmers grew maize in an average area of 31.29 rai/family. The investment cost was 5,278 baht/rai while the income was 4,800 baht/rai. After humidity reduction of the products, they earned only 3,360 baht/rai. Each family had an average production cost of 165,148.62 baht while average earning was only 108,494.40 baht. The conventional production practice utilized extensive land area while production cost was higher than income. Besides, farmers could not control marketing mechanism. Comparing with alternative agricultural practice relying on temperate plant - a more proper choice with its location, less land area was utilized, while giving higher yield, and having more marketing channels. Therefore, the government sector should strongly promote alternative agricultural practice. Although, this experiment was found successful for only 3 farmers, all 12 farmers could learn from both successful and unsuccessful experiences for correcting production

problems in their next crops.

The Analysis of Investment Climate in Agriculture in Hanoi province, Vietnam.

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Hanoi province, Vietnam has much potential for agricultural development such as a large consumer market for agricultural products, soil and water resources, natural climate, physical and social infrastructure, and so on. Hanoi is also one of provinces of the whole country where has attracted a larger number of investors. However, there is a few of investment projects in agriculture in Hanoi in recent years. This paper presents a result of the structure interview for managers of 200 samples including agricultural firms, co-operatives and farms in Hanoi province in 2008-2009. The finding shows that even these enterprises are happy with their business performances and profitability, the investment climate could be negative effects obstructing investment incentives in agriculture. The study finds out 8 key factors determining the investment climate in agriculture in Hanoi province. The constraints are ranked by the interviewees from the highest to the lowest to be land issue, provincial policies for agriculture, capital, physical infrastructure, administrative procedures, market, technology and labor issue. In which land issues and provincial agricultural policies are the most important constraints; the second group are capital, physical infrastructure, governmental administration; the third are market, technology, and labor issues.

The Agricultural Women Groups in Thailand: The Organization for a Better Living to Support Local and Global Economy of Thai Farmers' Families

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Thailand is an agricultural country where many women participate in agricultural practice. This research focused on the agricultural women groups (AWGs) that have reflected a better living and local and global economy of Thai farmers' families. The paper examined the factors associated with the successes of the popular agricultural women groups, so called the National Agricultural Women Groups (NAWGs) over the past 30 years and considered how those factors have assisted the NAWGs in accommodating to the changes that have occurred in rural Thailand during that time. This study investigated the NAWGs in Thailand which had a total of 24 NAWGs throughout the country from 1982 to 2006. The study applied observation, participatory action research (PAR), archival recorded, faced to faced in-depth interview and telephoned-long interview. The respondents were the leader, committee, members, people working for the NAWGs, the DOAE's officers working with each group, a total of 176 respondents. The paper explained the importance of AWGs towards farmers' families. Obviously, the AWG was a tool for agricultural women. It helped women develop their occupations, increased family income and enhanced the quality of life of families and communities. This study showed that almost all NAWGs achieved remarkable successes but not all of them could maintain their successes. The study revealed that the internal and external participants of the NAWGs were the important elements affecting the organization empowerment, in particular role of leader.

Thai Swine Production under Contract Farming: A Case Study of Autonomous Raisers

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The study sought to determine the pig production structure and marketing channel of autonomous swine raisers under contract farming, the constraints and recommendations in order to formulate development model towards farmer participation. Studied samples were the nationwide selected 9

autonomous swine raisers under contract farming. Interview schedule was obtained to collect data. The study revealed that autonomous swine raisers under contract farming were practiced in fattening pigs only. There were 3 raising patterns including price guarantee, marketing guarantee, and hired contract. In case of price guarantee and marketing guarantee, the farmers invested by themselves as hired contract raising except input used including breeding, feed, and medicine. It also found that the hired contract raisings were provided by their parties. Price guarantee products sold at fixed guarantee price in advance yearly. Marketing guarantee products sold in the flexible agreement depending on their own satisfaction to the free market or sold back to the parties at market price. For hired contract, labor force rate was between 1.20 - 1.80 baht per kg of body weight increased. Major production constraints were lack of academic supporting from concerned government agencies, lower standard requirement products, and high cost respectively. In addition, most of the major marketing constraints were uncertainty price, less supporting from concerned government agencies, and also price interfered by the candidate parties respectively. Recommendations were the collaboration between concerned agencies and autonomous swine raisers in order to let sub-contract swine raising farmers' concern as they were stakeholders of the firms; governmental concerned agencies should enact farm size law in order to solve surplus products, price concerns, and illegal animal movement; and also export promotion to neighboring countries must be concerned.

Commercial Sericulture Production in Northeastern: A Case Study of Sericulture Farmers in Huafai Village, Khon Kaen Province, Thailand

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The objectives of the study were to determine the existing supply chain condition of sericulture production in Huafai village, Khon Kaen province, Northeastern, their constraints and recommendations in order to improve sericulture production towards farmer participation. In-depth interview and SWOT analysis were obtained to collect data. Studied samples were the selected stakeholders in commercial sericulture firms including sericulture farmers, middlemen, extension officers, and sericulture specialists. The finding revealed that in term of mulberry cultivation, the most popular mulberry variety was "BURIRUM60". Most of mulberry cultivated areas were irrigated towards commercial production system by furrow method. Cultivation techniques were also operated using extension officers recommendations. Major of disease and pest were root rot disease and mealy bug, respectively. There were two patterns in silkworm rearing including rearing for cocoon sale and silk yarn production. Most popular silkworm varieties were "DOKBUA" and "NANGNOI" that reared 8-12 cycles a year. Rearing period was obtained around 23-25 days. Rearing room was constructed permanently. Mulberry leaves were fed at the appropriate silkworm age. Major disease was gasserry disease. Farmer controlled disease by applied lime on silkworm regularly. Most of silk yarn product was first grade and was reeled using apparatus from The Queen Sirikit Institute of Sericulture. Fabric weaving was done towards standardization. Almost all silk yarn and fabric products were sold at the community and by middlemen, respectively. Variable cost of sericulture production was around 34,656.18 baht (US \$ 990, 1US \$ = 35 baht) yearly while income from cocoon 95 baht (US \$ 2.7) per kg., silk yarn 1,100 baht (US \$ 31.4) per kg, and silk fabric 220 baht (US \$ 6.2) per meter. SWOT analysis indicated that the strong point was farmer's experience in sericulture production and sericulture production was done through the integration between local wisdom and modernization technology. The weak point was instability of quality products and less concern for product quality. In terms of opportunity, the farmers were provided inputs, capital and knowledge from the government agencies. The threat point was the competition from low price of imitation products. The constraints were the instability of marketing channel and less bargaining power. Integrated firms should be promoted and more marketing channel should be supported.

Financial Capability and Buying Practices of Barangay-Based Abaca Entrepreneurs

in the Province of Catanduanes

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This study focused on the financial capability, operational profile, and abaca buying practices of 80 abaca entrepreneurs (AEs) in Catanduanes, Philippines and their relationships using descriptive statistics and regression analysis. The average capital investment of barangay-based abaca entrepreneurs was P10,167 and mostly drawn from personal funds. Private loans dominated the source of capital of the entrepreneurs. The average current operating budget of AE is P7,700 and few have a current operating budget of more than P20,000. Majority of respondents purchased more than 1,000 kilos of abaca fiber per month or a monthly average of 880 kilos. "All-in-one" and "Resiko" were most prevalent buying practice among entrepreneurs. Cash and commodity credits dominated the incentives extended by the traders to the abaca farmers as a buying practice. Cash loan extended by entrepreneurs to abaca farmers (AFs) was influenced by the *cash loan* obtained by the AEs. On the other hand, cash loan extended to AFs was also influenced by three factors, namely, current operating budget, loans acquired by entrepreneurs, and average monthly delivery of abaca fibers. Accordingly, if an entrepreneur's operating capital, loans acquired and delivered were high, chances were, AEs could most likely extend loans to abaca farmers. Moreover, abaca fiber production was typically financed by the entrepreneurs. Consequently, abaca farmers sold their products to whom they received financial support. Unfortunately, price of abaca fiber was dictated by the buyer including the mode at which the fiber will be bought and the farmer was left with no choice.

Farmers' Perception on Durian Innovative: A Case Study of Certified Orchards Growers in Chanthaburi Province, Eastern Thailand.

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The objectives of the study were to determine 1) some personal background of durian growers, 2) their perception including knowledge, attitude, and practices regarding durian innovative, 3) relationship between some personal background of durian growers with their perception, and 4) constraints and recommendations in durian innovative. The research methodology was done through in-depth interviews scheduled with stakeholders and 71 durian growers whose orchards have been certified through GAP by the Department of Agriculture, the Ministry of Agriculture and Cooperatives, Thailand. Descriptive statistics were presented in percentage and arithmetic means. Inferential statistics to test the hypothesis was Pearson product moment correlation coefficient. Testing the reliability of knowledge and practices were obtained through the KR-20 and the KR-21 with the reliability at 0.78 and 0.72, respectively. The semantic differential scaling methods of two attitude innovatives were obtained by internal consistency through Cronbach's alpha with the reliability at 0.71 and 0.83. The findings revealed that average cultivated area was 36.42 rai (5.83 hectares) per household. Average of durian cultivation experience was 25 years. Average income from durian cultivation was 409,505 baht (US \$ 11,700.14, 1 US \$=35 baht) per year. Most durian fruits were sold to the dealers at the orchard. Most corrected knowledge and appropriate practices were added water application to 85% of evaporation rate from the class A evaporation pan at 10-11 weeks over fruit duration. Most agreed opinions were harvesting day estimations after full bloom including "MONTHONG" at 110 days, "CHANEE" at 100 days, and "KRADUM THONG" at 80 days. Positive factors affecting knowledge and practices on durian innovative were cultivated areas, durian cultivation experiences, number of group belonging, number of marketing channel, and durian production planning. Positive factors affecting attitude on durian innovative were durian cultivation

experiences and number of marketing channel. Most constraints were less niche market in domestic demand. Most recommendations were urgent measures in order to get rid of immature durian fruits in the market.

A Comparative Study on Direct Marketing of Farm Products:

Cases in Japan, Korea, Italy and the United States

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Today, the sales at farmers markets (FMs) are increasing again in some developed nations. Those “new” farmers markets are providing win-win relationship to both farmers and consumers. In addition, many farmers markets are functioning as centers of community development. However, the operation and management are quite unique from a market to another. This study aimed to comparative study on direct marketing of farm product among Japan, Korea, Italy and the US, especially focusing on objectives, operations and managements. Then, potential and problems of the farmers markets as a center of community empowerment are also discussed. In order to reveal situations of the farmers markets, interview items were obtained to market managers in Japan, Korea, Italy, and the US from 2004 to 2009. The interview items were also obtained to farmers, relevant organizations and local government. The result indicated that there were two types of farmers markets. One was farmer-driven or rural-driven farmers markets, and those were seen in Japan and Korea. The other was consumer driven or urban-driven farmers markets, and those were seen in Italy and the US. Both had the similar characteristics, and both were highly supported by consumers at this moment.

Sustainability Assessment of Organic Vegetable Cultivation in Chiang Mai, Thailand

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Thai farmers are interested in alternative vegetable farming such as safe use farming, natural farming, chemical pesticide free farming and organic farming. They strongly believe that alternative farming can provide economic feasibility due to the high prices of their products, while reducing the burden on the environment. Based on a questionnaire survey of 142 vegetable growers under different production systems in Chiang Mai Province in 2008, this paper aims to clarify whether or not organic farming is a feasible form of sustainable agriculture under small farm size conditions. Sustainability of organic farming is analyzed in terms of farm income, and environmental and social impact in comparison with other production systems. There was diversified farming of rice, vegetables, fruits and livestock in Mae Rim District, Chiang Mai Province. In the villages studied, average overall cost of environmental and social impacts of kale production was estimated to be 350 USD per year (one rai is equivalent to 0.16 ha; one USD is equal to 34.35 Baht at the time of study in 2008). The environmental and social impacts were the most important factor in improvement of production efficiency among four vegetable farming systems. The conventional kale production appeared to have the highest negative environmental and social impact, while the lowest was attained by organic farming. Only in the case of organic production, the average cost decreased due to the reduced negative impact, and organic growers could raise farm income per ha per year to 7,150 USD. This situation demonstrates that organic farming had the sustainable manner due to the highest profit with higher prices contributing to the highest income, and the lowest negative impacts for environmental and social sectors in comparison with other production system in Chiang Mai.

**Effect of Pineapple Juice and Papaya liquid on Physical Properties in Sweet Pork
from Culling Sow Meat.**

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Sweet pork, in Thai, is called "Moo Sa-Wan" and is usually made from normal pork meat. Sows are culled for many reasons, e.g. old age, reproductive failure, poor performance etc. Meat from culling sow gives tough texture and low quality. Bromelain from pineapple juice and papain from papaya liquid are proteolytic enzyme and help protein breakdown. Both of enzymes are safe and proved by FAO. So, the aim of this study was to use pineapple juice and papaya liquid to improve quality of sweet pork which is processed from culling sow. Sirloin and rump meat were treated with pineapple juice (5, 7.5, and 10 ml.) and papaya liquid (0.8, 1.2, and 1.6 g.) and compared with control (Sirloin / rump; no pineapple juice and no papaya liquid), kept in plastic bag packaging with oxygen absorber inside for 30 days. The result found that pineapple juice and papaya liquid had pH values at 3.69 and 5.61, respectively. The rump of 1.2 g. papaya liquid's formula has lost the most weight after roast at 46.46%. The average percentage weight loss after frying sweet pork; rump of 1.2 g. and sirloin of 0.8 g. papaya liquid's formula up to 50%. The water activity value was 0.64 to 0.77. There were not significantly differences in shear value among treatments but rump fermented with papaya liquid's formula had higher shear value than sirloin. The microbiology after packaging storage from day 1 through day 30 found total plate count <10 cfu / g, yeast and mold <10cfu/g, *Escherichia coli* <3 MPN/g. There were no detected *Staphylococcus aureus*, *Clostridium perfringens* and *Salmonella* in products. It can be concluded that sweet pork fermented with pineapple juice and papaya liquid were safe and followed Community Standard Products, 296/2547.

Food Security towards Self Sufficiency of Rice Production in Malaysia

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The objectives of the study were to determine the status of rice production in Malaysia, constraints and recommendations in terms of policy, and implementation towards food security intervention program. The research methodology consisted of gathering and upgrading information concerning rice production from relevant agencies and in-depth case studies. The results revealed that food security and self sufficiency were ultimate goals of government policy in promoting agriculture as a third engine of economic growth. The national average yield of rice in Malaysia is 3.55 t/ha while that of other Asian countries is 4.30 t/ha. From the previous decades until the current time, Malaysia has been importing rice because not only is the supply insufficient, but also the rice industry in Malaysia does not have a comparative advantage due to several factors, in particular uneconomic land size, water shortage, limited labor force and high production cost. Nevertheless, the government has fully supported the rice industry with massive fiscal outlays to offset these constraints. However, rice production continues to be chronically inefficient. A limited labor force has been a serious problem in rice production in the last two decades. Only 3.3%, accounting for 12,495 of young farmers aged between 15 and 29 were still in the farms. Between 2003 and 2007, the total number of paddy cultivators was dropped 23% from 268,600 to 206,400. The increasing cost of agricultural inputs, particularly fertilizers and pesticides as a result of increased fuel prices had an impact on production and income of farmers. In order to promote self sufficiency intervention program on rice productivity, modernization of farming technology has been disseminated since early 1970's, with the double cropping rice technology fully implemented in 1988 especially in eight granaries areas. In terms of the current food security policy, the Malaysian government has identified three main strategies with a budget of more than USD 800 million for the period of 2008-2010, with the goal to increase SSL to 86% in 2010. Increased rice production through improvement and optimization of farm management including effective fertilization and input application, land leveling, pest control, and farm mechanization, have been promoted nationally. There is also a policy to encourage private sector investment in rice cultivation through commercialization and entrepreneurial approaches.

**Study on Location Movement of Rice Production and Export Possibility of
High Quality Rice in Thailand**

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Rice is one of the most significant cereal crops in the world. At this present time, rice is main staple food for thousand millions of people in Asian countries. Thailand is one of the world's biggest rice producer and the biggest exporter in term of quantity in the world. Increase of world population and per capita income has significant influence on the total amount of rice consumption, causing the sizable structural change in the demand and supply of rice. Thailand is still sustaining the world's biggest exporter of rice. However, as the international competitiveness of rice is getting higher, in order to maintain comparative advantage for rice production and export internationally, rice exporter should take good quality and taste into consideration, coping with change of demand structure. At this moment, Thailand is usually suffering from over production of rice because the growth rate of production is quite higher than the rate of consumption per capita in the recent years. Even though rice is substantially important staple crop, the increased income per capita in the recent years compelled rice consumption to decrease even in Thailand. Rice consumption per person yearly decreased from 144 kilogram in 1980 to below 104 kilogram in 2003. Rice is widely cultivated in everywhere nationwide in Thailand. Global warming has been preventing stable and efficient rice production. On the other hand, in order to meet rice quality to consumer preference and taste, farmers grow rice with good quality. However, a rice production with high quality depends on the location specific conditions by region. In particular, the northeast region is comparatively suitable for growing the high quality rice. Farmers in this region will be expected to get benefit from producing it. This study aims to clarify the location movement of rice production taking the quality into account in Thailand for last two decades, making use of government statistics and identify some main reasons not only from the various aspects of national and socioeconomic conditions and technology, but also why high quality rice (ex: Jasmine rice) should be used in relatively poorer region like Northeast. Understanding the location movement and export possibility of high quality rice will surely be helpful on considering the better way to improve the rice production management as well as the increased income and productivity for rice farmer in such unfavourable areas as the Northeast region in Thailand through deeper surveying.

Study on Appropriate Area Ratio between Food and Energy Crops in Thailand

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A study on the appropriate area ratio between food crops and energy crops in Thailand was conducted through the analysis of primary and secondary data. Farmers planting food and energy crops in Thailand were interviewed. Rice was considered a representative of food crops while tapioca and sugar cane were considered representatives of energy crops. Moreover, eucalyptus, a fast growing tree, was studied as a raw material for alternative energy. This study had two 2 parts: (1) deriving equation on trend of plantation of food and energy crops in Thailand during the period B.E. 2010 – 2024 using mathematical simulation model; and, (2) determining the relationship between influence factors on food and energy crops plantation in Thailand as well as farmers' responses to government policies on agriculture. These factors include product price, product volume, cost, and government policies on agriculture, among others. Information obtained were analyzed by applying a weighting score and rating score of importance obtained from interviewing with famers were done on influencing factors of decision making for 4 kinds of crop plantation. Results from the study are of two parts: (1) mathematical simulation model showed that the area for three kinds of plantation (rice, tapioca, and sugar cane) during the stated period had expanded; and, (2) the most influencing factor for decision making in tapioca, sugar cane and eucalyptus production was production price; whereas for rice, the most influencing factor was the conventional occupation which had been practiced from generation to generation. and cause of rice is a strong food for Thai population consumer.

The Development of Private Standard: ThaiGAP vs GLOBALGAP

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This study demonstrated the development of private standard and trend of moving forward in next ten years. Currently ASEAN become gather for sharing common market and trade among region. The technical of production is increasing more and more in quality assurance and reliability key concerns. ThaiGAP; the private standard in Thailand, was developed from Western GAP in 2006 under the responsibility of Cluster of Western GAP members which involved from 4 key players i.e.; Kasetsart University at Kamphaengsaen Campus, Fruit and Vegetable Producers Association, Board of Trade of Thailand and Farmers. The constraint from food safety regulation in trade country resulted more awareness and should be implemented along the chain of custody. Upstream of production chains, GLOBALGAP was known as the pre-farm gate standard with pillars of food safety, environment, quality, worker and animal welfare. This standard is managed by Food Plus, the secretariat, and be used by retailers and approved certification body. Although the standard is voluntary, it is known that GLOBALGAP certification is accepted for putting on shelf. If not, supplier can select another channel of putting produce in another market. Private standard of GLOBALGAP provides equivalency scheme of practice. The scheme is divided into 2 categories, 1). General Regulation and CPCC (Full scheme) 2). Benchmarking Modified Check List (BMCL) of owner standard or CPCC. According to ThaiGAP standard, the choice of BMCL was selected. At the current status, ThaiGAP is at the process of witness in parallel to Independent Technical Review. The review and correction of practicing to make clear sentence were suggested. It is concluded that the technical process can be progressed and will be benchmarked within the process of 12 months. However, the body of management or secretariat has not yet stable and sustained. This issue must be solved under the collaboration among public, private and relevant sectors.

**Measuring the Impact of the Investment Climate on Total Factor Productivity
(TFP) in Agricultural Sector: The Case of Hanoi, Vietnam**

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This study measures the impact of investment climate factors on the total factor productivity (TFP) of manufacturing firms on agricultural area in Hanoi, Vietnam. Endogeneity of the production function and of the investment climate variables is addressed by using a variant of the control function approach, based on individual firm information, and by aggregating investment climate factors by various business lines. Specifically, the analysis is conducted in two steps: first, an econometric production function is estimated to produce a measure of TFP at the firm level; in the second step, variation in TFP across firms is statistically related to indicators of the investment climate as well as firm characteristics. The result yields a number of insights on the factors that underlie productivity. In a variety of business lines, indicators of poor investment climate, especially labor number and administrative clearance time, have significant negative effects on total factor productivity. Decreasing by one day in administrative clearance time could increase TFP by 1.2 - 3.3%. Indicators such as time of land rent, investment capital, land area, and stability of policies have positive effects on TFP. However, levels of effects from investment climate factors on TFP are different among business lines.

**Problems and Obstacles in Production and Marketing of Organic Fruits
from Eastern Thailand**

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The objectives of this research were to study the cost, return/profits, problems and constraints to production and marketing of organic fruits as compared to fruit grown with chemicals, including marketing costs and margins of organic fruit sellers, and the factors affecting decision making to meet

consumer orders. Results revealed that the average production cost of organic fruit was 20,927.20 Baht/rai or 12.66 Baht/kg. The return was 44,998.29 Baht/rai or 14.99 Baht/kg, giving a total profit of 24,071.08 Baht/rai. For chemically grown fruit, the average production cost was 18,267.92 Baht/rai or 12.39 Baht/kg, giving a return of 25,471.19 Baht/rai or 5.03 Baht/kg. Thus the total profit was 6,969.94 Baht/rai. From the production cost survey of both types of farming, it was found that organic fruit farming entailed higher cost of production than fruit grown with chemicals. However, organic farming also had a higher return from production/rai/year, total profits/rai/year and selling price (baht)/kg of product. Middlemen selling organic fruits spend an average cost of 9.46 Bht/kg with a total marketing cost of 55.15% of the retail price. The farmers got a dividend of 44.85% with the marketing cost at 14.50%, whereas the wholesalers and retail sellers had marketing margins of 15.49 and 25.16%, respectively. Organic fruit farmers faced the problem of not being able to supply market demands due to insufficient production. Problems with distribution of organic fruit products faced by middlemen include high transportation costs especially when production was not in accordance with market needs. Farmers growing fruit using chemicals faced the problem of high cost of production factors. Chemical farmers faced distribution problems due to lack of market knowledge and marketing skills, resulting in an inability to negotiate with the middlemen who fruit buyers. On the part of the consumers, their decision-making to purchase was highly affected by the type and quality of products, price, and distribution channel factors. Cultural and social factors affected their decision making moderately while promotion had the lowest effect.

Global Over-Fishing: A Perspective of Sustainable Development

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Global fisheries resource is the one of the important bio-resources that belongs to people all over the world. Since the last 30 years, the global natural resources of fishery has been utilized especially the areas called Exclusive Economic Zone (EEZ), 200 nautical miles away from coast. With the reason of common properties of global fisheries resources, every one can take advantage of these fisheries resources that led to global over fishing. In this day and age, the world has faced with global over-fishing accounted for 28 % of the total fish stock. More crucially, the global fishing went beyond the maximum sustainable yield (MSY), estimated by Food and Agriculture Organization (FAO), continuously spread out all over the world. This study aims to measure the Global status of bio-resources to find out how to protect them by applying the bio-resources econometric model. The methods of econometrics were the tools that gave the meaningful results for the sources of Global over-fishing. According to the bio-natural resource econometric model, we found the increasing in the over-all price of fisheries products as well as the growth rate of global population which were the key factors that forced the world fisheries industry got involved. For reaching the sustainable utilization of the global fisheries that would lead to the sustainable development. Food and Agriculture Organization (FAO) has endeavored to encourage all nation members to reduce the global over-fishing through the policies such as the old vessel buy back program and subsidization of fisheries in order to reduce the number of fishing vessels. The countries such as Australia and New Zealand successfully implemented policies in individual transferable quotas and taxes of southern blue fin tuna and yellow blue fin tuna resulted in recovery and stability of parent stocks.

The Selection of Microorganism for Degradation of Oil Spoilage

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Oil contaminated soil and water cause pollution to the environment. Bioremediation / biodegradation

by natural microorganisms represent of mechanisms by which oil pollutants eliminated from the environment This research investigated the efficiency of natural microorganisms for the bioremediation / biodegradation of lubricated oil. Natural microorganisms were collected from oil contaminated seawater and beach sand. Five hundred and nineteen samples were collected from sea coast gulf of Thailand including Chonburi, Rayong, Chanthaburi, Prachuapkhirikhan, Phetchaburi, Samutsakhon, and Samut songkhram. Two hundred and fifty two samples were collected from Andaman sea coast area from 2 provinces including Phangnga and Chumphon. Twenty eight samples were collected from Nakhonpathom, Suphanburi and closed areas, then bacterial isolates were isolated on Nutrient Agar by spread plate technique founding of pure strains 2,407 bacterial isolates. The efficiency of the biodegradation was investigated by natural microorganisms in qualitative and quantitative approaches. The qualitative test was operated for screening microorganisms by point inoculation on Mineral Salt Medium Agar plates, which composed of 2% (v/v) new lubricated oil and used lubricated oil. The result was found that 60 isolates degraded new lubricated oil and 811 isolates degraded used lubricated oil. These microorganisms were used to quantity test for oil degrading capability on Mineral Salt Medium. The results showed that the 1% (v/v) oil concentration for 96 hours was appropriated for microorganisms. Some species of *Bacillus* showed the highest degrading 10% (v/v) oil concentration for 96 hours. Future study, the natural microorganisms that had high ability will be used to eliminate oil contaminated soil and water in true conditions.

**Characterization of the Antimicrobial Substances Produced
by *Bacillus* sp. B-1 Isolated from Culture Pond**

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Genus *Bacillus* produces many antimicrobial peptides of varying structures such as bacteriocins, sublancin and subtilisin. Although bacteriocins active against a varied bacteria including important pathogens such as *Listeria monocytogenes*, *Staphylococcus aureus* and *Streptococcus* sp. The aim of this study was preliminary characterization of antimicrobial substances especially biological and physical properties such as high temperature, pH, sensitivity of proteolysis enzymes and sodium chloride (NaCl). The antimicrobial activity was determined by bacteriocin activity assay by the application of the critical dilution method (agar well diffusion) described by Schillinger *et al.* (1989). *Bacillus* sp. B-1 produce antimicrobial peptides with properties of inhibition effects on *Streptococcus agalactiae* AQSA 001, *Aeromonas hydrophila* AQAS 001, *Staphylococcus aureus* ATCC 12600, *Escherichia coli* JM 109, *Listeria innocua* ATCC 33090, *Micrococcus luteus* IFO 12708, *Bacillus circulans* JCM 2504 and *B. coagulans* JCM 2257 and especially *L. innocua* ATCC 33090 which yielded the highest sensitivities of indicator strain (320 AU/ml). The cell-free neutralized supernatant of *Bacillus* sp. B-1 were stable at 100 °C during a period of 20 minutes (20 AU/ml) and maximum activity of pH 4.0, 6.0, 8.0 and 9.0 at 4 °C (320 AU/ml) and maximum activities of pH 2.0, 4.0 and 6.0 at 100 °C for 60 minutes were 80 AU/ml. The antimicrobial substances were sensitive to the proteolytic properties of α -chymotrypsin, trypsin, proteinase K and protease and exhibited stable qualities at 6, 12 and 15 % sodium chloride.

**Janitor Fish Skin Leather: A Potential Solution to Local water's Degradation and
Fish Species Deterioration?**

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As early as 1998, the unabated proliferation of Janitor Fishes (*Pterygoplichtys pardalis* and *Pterygoplichtys disjunctivus*) in the Philippines was considered a pest outbreak already but is still unresolved until now. In the meantime, the technical possibility and financial viability of turning the Janitor Fish skin into more economically useful leather have already been proven. This study is in support of earlier studies on Janitor Fish as possible source of leather since it assessed the market potential of leather and leather products from Janitor Fish skin and therefore a possible solution to local water's degradation and fish species deterioration not only in the National Capital Region

(NCR) and Bulacan but the whole country as well. Primary data were obtained through a survey of 275 potential end-users employed in various occupations in NCR, 10 tanneries from Bulacan and 20 leather goods manufacturers. Descriptive, logit regression and SWOT analyses were employed. Results revealed the good market potential of the Janitor Fish skin leather since 60% of the 275 end-user-respondents were willing to purchase leather products from Janitor Fish skin and 70% of the tanneries utilizing cow hides and 67% of those using carabao skin were willing to shift to Janitor Fish skin leather. Similarly, 85% of the leather goods manufacturers signified their willingness to shift a proportion of their leather goods production from cow hides to Janitor Fish skin. Janitor Fish leather was also found price competitive considering the fact that its physical attributes are at par with that of the currently utilized leather materials. Foremost among the recommendations is the development of safe and proper breeding technology that will ensure not only the supply of Janitor Fish but also the safety of the local waters.

Fry Quality of Promising Potato Selections Grown From Three Locations of Benguet

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The study aimed to identify the location that produces potato selections with the best fry quality, determine the potato entry with the best potato fry quality and determine the interaction between locations and potato entries on fry quality. The potato tubers harvested in Loo had the highest dry matter content and fry yield. In addition, the fries produced from entries harvested at Loo were liked much by the panelists. The fries produced from the tubers harvested at Bonglo and Sagpat were moderately crispy, moderately perceptible, moderately oily, slightly firm, slightly brown and were liked moderately by the panelists. PHIL 2.21.6.2 and Igorota have good fry quality based on high dry matter content and high fry yield. Both entries produced fries which were liked much by the panelists. Growing PHIL 2.21.6.2 and Igorota in Loo might result in the production of tubers with good fry quality.

Multi-location Yield Trial of Potato Entries Grown Across Locations and Seasons in the Philippine Highlands

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The study was conducted to evaluate agronomic yield, late blight and Leafminer incidence of selected potato entries across locations/zones and seasons; recommend to the National Seed Industry Council (NSIC) selected entry for official variety release. Five potato entries grown and selected from preliminary yield trial were evaluated from 2006 to 2009 under different ecological zones/elevations from low mountain zone (1350 meters above sea level); mid-mountain zone (below 2000 meters above sea level) and high mountain zone (2000 and above meters above sea level) for wet and dry season. Treatments were laid out following the Randomize Complete Block design (RCBD) with 40 tubers per replications in all locations and seasons. Entries 380241.17, 2.21.6.2, 676070 and 5.19.2.2 were best performers in terms of survival, vigor, canopy cover, and leafminer and late blight incidence. These four entries significantly out yielded the check varieties Igorota (processing type), Ganza (newly approved variety), and Granola (table type/ farmers variety). Based on the results entries 380241.17, 2.21.6.2, 676070 and 5.19.2.2 are highly recommended for potato production under low, mid and high mountain zones during wet and dry. These potato entries are recommended for the National Seed Industry for variety released.

A Study of Screw Press Rice Bran Oil Extraction Related to Press Cake Characteristics

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The relationships among speeds of screw press, compression distances and types of rice bran were studied for optimal condition of cold press oil extraction of rice bran. Results of the study showed that the compression distance of 1.7 and 1.3 cm at the screw speed of 8.4 rpm were the optimal condition for providing the highest yielding of 4.17 and 8.2% oil extraction for raw rice bran and parboiled rice bran, respectively. The texture and discharge pattern of the pressed cake is a reliable guide to predict the oil content in the pressed cake.

**Effect of Various Habitats in Thailand on the Abundance of *Azotobacter*
In Rhizospheric Soils**

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The soil samples were collected from several locations with difference in agricultural practices, crop groups, soil moisture contents (SMC), pH and soil organic matter (SOM) contents. The number of total bacteria and *Azotobacter* in all samples were enumerated in nutrient agar and Ashby's medium, respectively. The results showed that plant groups had significant effect on the population and density of *Azotobacter* in soils. The maximum number and density of *Azotobacter* among plants was found in vegetable rhizospheric soils as much as 4.24×10^6 cfu.g⁻¹ and 28.78 %. The SOM contents showed significant impacts on *Azotobacter* growing. The maximum amount of *Azotobacter* (4.06×10^6 cfu.g⁻¹) was found in soil with 2.6 to 3.5 % SOM. The density of *Azotobacter* among various SOM was significant effect. The maximum density of *Azotobacter* (27.29 %) was found in soil with 3.6 to 4.5 % SOM. The soil pH had significant effect on the population and density of *Azotobacter*. The maximum population (4.48×10^6 cfu.g⁻¹) and density of *Azotobacter* (25.58 %) was found at pH 5.1 to 5.5. The SMC contents showed significant influence on the abundance of *Azotobacter*. The highest population of *Azotobacter* (5.33×10^6 cfu.g⁻¹) was found at 21 to 25 % SMC, but not effected to the density of *Azotobacter*. However, the locations and types of agricultural practices had no significant effect on the abundance and density of *Azotobacter*.

Activity of Antagonistic Microbes against *Phytophthora palmivora*, the Causal Agent of Pod Rot Disease on Cacao

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Phytophthora palmivora, the causal agent of pod rot disease is the most important factor limiting production of cacao (*Theobroma cacao*) in Bali area Indonesia, causing the decreases of cacao yield to 40%. Because of high disease pressure and environmental concerns, alternative measures to chemicals fungicides are needed to control *P. Palmivora*. Biological control (biocontrol) using antagonistic microbes, as agent is one of alternatives approaches for managing pod rot disease. In this work, we evaluated the ability of four antagonistic microbes namely; *Bacillus* sp., *Trichoderma* sp., *Saccharomyces* sp., *Pseudomonas fluorescens* sp., for their ability to suppress the growth of *P. palmivora* in PDA medium and soils. Infestations of antagonistic microbes *P. fluorescens* sp., *Trichoderma* sp., *Saccharomyces* sp. and *Bacillus* sp. into soils could suppress the population density of *P. palmivora* to 90.44%, 89.40%, 70.00%, 65.40% respectively and protected the cacao pod from the rottenness to 71.36% 70.85%, 63.42%, 56.40% respectively. These results indicate that there were antagonistic activities of four microbial antagonists to suppress the growth of *P. palmivora* in soil that can be used as agents to control pod rot on cacao.

Synergistic Activity of Extracts of *Samanea saman* and *Allamanda cathartica* in Suppressing the Growth of *Fusarium oxysporum* f.sp. *capsici*

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Fusarium oxysporum f.sp. *capsici* is a pathogenic fungus that causes wilt disease on paprika pepper (*Capsicum annuum*). The disease can cause a significant yield losses on paprika particularly when it is grown in the green house. In order to control the disease, farmers are generally rely on the use of synthetic fungicide that containing Cu (cuprum). However, the residue of this heavy metal on the paprika fruit may influence the quality of the fruit, hence, it is necessary to find other safer agents from plants which effectively can be used to control the disease. Methanolic extracts of one hundreds plant species of various families collected from Bali Island, Indonesia were evaluated for their antifungal activity against *F. oxysporum* f.sp. *capsici* on potato dextrose agar (PDA) medium. Among these plant species, 11 plant species showed antifungal activity against *F. oxysporum* f.sp. *capsici*. The methanolic crude extracts of the leaves of two plants, i.e. *Samanea saman* and *Allamanda cathartica* showed synergistic activity in suppressing the fungal growth of *F.oxysporum* f.sp. *capsici* on PDA medium. Minimum inhibitory activity (MIC) of the extracts of *S. saman* and *A. cathartica* were 0.4% and 0.8%, respectively, while the MIC of their mixture was only 0.3% (w/v). This result indicated synergistic activity of the extracts of *S. saman* and *A. cathartica* in suppressing the growth of *F. oxysporum* f.sp. *Capsici*.

A Botanical Insecticide Formulation for Controlling Four Species of Stored Product Insect Pests

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A botanical insecticide formulation containing seed extracts of *Annona squamosa* and *Annona glabra* belonging to Annonaceae has been developed to control four species of stored product insect pests, *Callosobruchus chinensis* (Coleoptera: Bruchidae), *Oryzaephilus surinamensis* (Coleoptera: Silvanidae), *Sitophilus oryzae* (Coleoptera: Curculionidae), and *Tribolium castaneum* (Coleoptera: Tenebrionidae). Botanical insecticide formulation was applied by topical application method at the dosage of 1, 5, 10, 20, 50, and 100 µg/insect and residual effect method at the concentration of 0.01, 0.05, 0.08, 0.1, 0.2, and 0.4%. By topical application method, the botanical insecticide formulation yielded more than 80% mortality of *C. chinensis* and *O. surinamensis* at 20µg/insect, while by residual effect meth-

od, the formulation yielded 80% mortality of *C. chinensis* and *S. oryzae* at 0.1%.

Biological Control of Coconut Hispine Beetle, *Brontispa longissima* Gestro by Using the Parasitoids, *Asecodes hispinarum* Bouček (Hymenoptera: Eulophidae)

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The coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae) is one of the potentially most serious pests of coconut palms (Liebregts, 2006). Chemical pesticides to control this pest are economically impractical and environmentally unsafe. Therefore, biological control is considered to be the best approach to solving this pest problem. Scientists searched for effective biological control agents, and found the larval parasitoid *Asecodes hispinarum* Bouček was effective in the Pacific region (Sathiamma *et al.*, 2001; Food and Agriculture Organization, 2004). This experiment was studied in Panya Indra golf course, Bangkok, 2007 based on control coconut hispine beetle by using *A. hispinarum*. The parasitoids were observed in five months after released. The mummified larvae were collected in June, August and November. The percent of parasitization were found to be 3.48%, 8.59% and 14.05%, respectively. The severe leaf damage levels decreased in December. The results showed that the new leaves of coconut palm were fresh with less damage. The trees showed clear signs of recovery with green shoots, returning to pre-infestation levels. The biological control program of the coconut hispine beetle is excellent examples of achieving sustainable, long-term control of a very damaging invasive pest that minimizes impacts on the environment.

The Potential of Carbon Dioxide Content on Aboveground Biomass in *Eucalyptus camaldulensis*

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This study assessed the potential of carbon dioxide content on aboveground biomass in *Eucalyptus camaldulensis* at the age of 1, 2, 3, 4 and 5 years old. The result indicated that *E. camaldulensis* at the age of 1, 2, 3, 4 and 5 years old could store carbon dioxide 2.962, 7.154 15.049, 22.156 and 23.667 ton/rai, respectively. Comparing to teak plantation at the age of 6 years old and para-rubber plantation at the age of 5 years old, it was found that *E. camaldulensis* at the age of more than 3 years old could better store carbon dioxide. Moreover, the study on Carbon Credit value in *E. camaldulensis* at the age of 1, 2, 3, 4 and 5 years old found that the value of it was 495.72 - 849.83, 1,197.29 - 2,052.55, 2,518.60 - 4,317.71, 3,708.03 - 6,356.78, and 3,960.91 - 6,790.30 Bath/rai, respectively.

Land Use Change and Factors Affecting Changes in Huaynamphung Sub-watershed, Thailand

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Land use change is the complete replacement, including modifications of one cover type by another land cover type. It depends on the factors that affect the decision making of land owners both bio-physical and socio-economic, respectively. The study was conducted in Huaynamphung sub-watershed in Thailand. The study aims to assess the land use change from 1988 to 2008 and determines the factors affecting the decision of the farmers in the study area. Satellite imageries of the area were interpreted to create land use maps for 1988 and 2008, respectively. Land uses were classified into 7 classes as follows: (1) natural forest; (2) paddy field; (3) field crop; (4) orchards and tree plantation; (5) grassland; (6) settlement and (7) water. Factors affecting land use change were determined through random household survey. Results showed that the area of natural forest and field crop have

changed significantly compared to other land uses. However, the land area of natural forest decreased while the land area of field crop increased. Similarly, the land areas of orchards and tree plantation, settlements and water have increased. Moreover, in terms of factors affecting land use changes, 101 respondents out of 204 respondents have changed their crop due to both biophysical and socio-economic factors. Price of productivity; management; government advocacy; and diseases, insects and pests were the most important factors affecting the decision of farmers in the study area. The land use in the study area has changed over the period of 20 years. These changes were associated with farmers' decision making and other socio-economic factors. Biophysical factors also play an important role in land use changes but were not the same degree as that of the socio-economic factors.

Continuous Fixed Bed Biosorption of Pb (II) by Chitosan-Immobilized Biomass of Fungus *Rhizopus arrhizus*

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Environmental pollution especially that contaminated with toxic heavy metals, is spreading through the world with industrial progress. This study focused on biosorption of Pb (II) by dead chitosan-immobilized *Rhizopus arrhizus* beads with continuous fixed bed condition. Zeta potentials at different pH were measured to demonstrate the surface charge of the powdered fungal biomass and plain chitosan beads. The optimum pH value for Pb (II) biosorption was found to be 5.0 at 30°C corresponding to the zeta potential of - 21.1 and +18.5 mV for the biomass and the chitosan beads, respectively. Different chemicals were used to study the effect of pretreatment of *R. arrhizus* biomass on biosorption of Pb (II). Pretreatment with detergent and alkali chemicals such as NaOH were exploited for increasing the biosorption capacity in comparison with autoclaved biomass elucidated by FT-IR spectroscopy. For continuous fixed bed biosorption experiment, asexual spores of the filamentous fungus *R. arrhizus* were used as the resting biomass as they tolerate the chitosan gelling for mycelia growth in chitosan beads. Breakthrough curves were analyzed at the flow rate of 1 mL/min and Thomas model was used to describe the experimental data. The beads with Pb (II) loaded were desorbed with 1M HNO₃ solution. After acid desorption and regeneration with deionized water, the beads could be reused to adsorb Pb (II) ions at a comparable capacity.

Enhanced Insecticidal Activity of Integrated Bacterial Antagonist *Paenibacillus pabuli* SW01/4 with Basil (*Ocimum sanctum*) Extract for Chinese Kale Protection

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Most farmers use synthetic insecticides to control Chinese kale insect pests. Excessive application of insecticides leads to the human health and environmental effect. In order to resolve this problem, bacterial antagonist and botanical extract can be used as alternative strategy of conventional insecticides. We evaluated the insecticidal activity of combined *Paenibacillus pabuli* SW01/4, a bacterial antagonist and basil leaf extract (*Ocimum sanctum*), under laboratory and greenhouse experiments. Commercial cypermethrin insecticide was used as positive control. The 30-day old kale plants were sprayed with SW01/4 suspension mixed with basil extract, compared to plants treated with either SW01/4 or plant extract alone for offered common cutworm feeding trials. Ten worms per plant arranged in CRD design were investigated under control conditions. The treatment with SW01/4 mixed with basil extract significantly provided the highest mortality of common cutworm per plant with 50% reduction that was significantly different (P=0.05) from other treatments. After feeding for 1 day, insect damage remained lower on plant treated with SW01/4 combined with basil extract than other treatments. The hypothesis of plant metabolites induced by bacterial antagonists or elicitation of

physiological changes in plants and active ingredient in plant extract that were toxic and repellent to most insect pests for support our study was discussed.

The Bioconversion of Water Hyacinth (*Eichhornia crassipes*) to Bioethanol

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The effect of chemical pretreatment methods such as acid and alkali treatment on conversion of lignocellulose (cellulose, hemicellulose) in water hyacinth was investigated. The highest sugar content in acid pretreated could be observed in water hyacinth treated with 3% H₂SO₄ solution (up to 18.16% w/w). Subsequent treatment of acid or alkali pretreated sample with 0.8 w/w enzyme (mixture of cellulase and hemicellulase) resulted dynamic increase of sugar in sample (up to 32%w/w). In addition, increasing the applied enzyme concentration from 0.8 % w/w to 4% further increased the sugar content in sample (up to 55.5% w/w). Combination of acid treatment and ultrasonic vibration improved the digestion of lignocellulose substances in water hyacinth up to 61.99 %w/w. Sub-critical water (200 °C for 10 min) as a physical method and subsequent enzyme treatment (0.8% w/w) resulted up to 17 % w/w sugar in sample. Bioethanol concentration during fermentation (at 30 °C) of pretreated sample using *Saccharomyces Cerevisiae* increased with increasing the fermentation time. After 3 days fermentation up to 60 % of sugar in sample was converted in ethanol.

Efficiency of Microorganisms Isolated from Soil for Plant Diseases Control and Plant Growth Promotion

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This research studied natural microorganism which eliminate the plant pathogens and are plant growth promoting, from soil in Nakhonpathom province, by cross streak plate method on two types of medium, PEMBA1 and GSP Agar2. There were 342 isolates of *Bacillus* sp. and 281 isolates of *Pseudomonas* sp. The antibiotic property was tested by streak plate method and 130 isolates could produce antibiotics. The antibiotic production results were classified in 5 levels. There were 41 isolates could produce in level 3-5, and they show possibilities to resist fungi that cause plant disease such as *A. flavus*, *A. niger*, *A. alternata*, *C. capsici*, *F. solani*, *L. theobromae* and the bacterial *X. campestris* pv. *glycine*. Stem end rot of mango and chili anthracnose disease were tested by detached fruit technique. Founding of 20 isolates could eliminated the diseases more than 50 %, and 108 isolates could control more than 50 % of chili anthracnose disease. Then, these microorganisms were used for controlling of the sudden death syndrome disease of soy bean and bacterial pustules of soy bean. Test results showed that 66 isolates and 22.66 % of 29 isolates could control the sudden death syndrome and bacterial pustule of soy bean more than 50 %, respectively. Moreover, these microorganisms were used to growth promoting of soy bean in green house, the abilities of growth promoting was compared by dry matter. In addition, Indole-3-acetic acid (IAA) was tested. Founding of 38 isolates which had abilities of antibiotic could abilities to support the growth promoting of soy bean in green house and IAA production, 29 isolates and 9 isolates were *Pseudomonas* sp. and *Bacillus* sp., respectively. These microorganisms high efficiency will be used to study and apply in agricultural in the future.

Productivity Enhancement of Upland Farming System in Tanay, Rizal

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The Productivity Enhancement of Upland Community Project was implemented within the context of improving the management and productivity of marginal hillylands of Tanay, Rizal. To improve the economic and social condition of these beneficiaries, the University introduced EPMMA technologies on soil and water conservation, soil fertility management and the URS low cost soilless vegetable farming. The project had two components: the on-farm yam and taro production and the in-campus rootcrop based cropping system. The on-farm yam and taro production adopted soil conservation measures such as contour farming and use of organic fertilizer. Two cropping of yam were done wherein 800 and 1,000 ubi sets were distributed to and planted by seven farmer cooperators during the first cropping (June 2006) and second cropping (May 2007), respectively. An approximately 2000 square meter lot was developed for taroproduction. Water conservation management technique was accomplished through improvement of one unit shallow well spring and the construction of a 10 m wide x 15 m long and 1 m deep small farm reservoir. For the in-campus component, a self-designed 144 square meter hydroponics greenhouse was constructed. Trial planting of lettuce, pak choy, tomato, cucumber, herb and honey dew melon were undertaken. Contour farming, use of organic fertilizer and minimum tillage were practiced in the culture and management of yam. Approximately 5,000 square meter lot was developed and planted with minimum tillage. Manpower capability was strengthened through training for AFP enlisted personnel, LGUs, and students. Moreover, the project served as destination site of educational tours and an information stop shop for farmers' inquiries on soil conservation farming and hydroponics. With the project, the effective cultivated area both on-farm and in-campus were increased by about 40%, a benefit-cost ratio of 2.34 was attained, soil and fertility structure were improved, academe/LGU/farmer-cooperators linkage was further strengthened, additional employment was generated and the adopted technologies were disseminated and gained acceptance within and outside the province of Rizal. Moreover, sustainability of the project was guaranteed with the institutionalization of the same in the operation of URS Tanay.

Organic Liquid Fertilizer as Base Nutrient Solution for Growing Lettuce in Hydroponics

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Chicken manure tea was used as an alternative liquid nutrient solution to grow leaf-type lettuce (*Lactuca sativa L.*) var. Waldmann's Green in two hydroponics systems: the aggregate culture and the nutrient film technique. Lettuce was fed with pure chicken manure tea (PCMT), fortified chicken manure tea (FCMT) and the produces was compared with lettuce grown by using inorganic nutrient solution (INS). The PCMT consists of 0.02% total nitrogen (N), 0.02% total phosphorous pentaoxide (P₂O₅), 0.14% total dipotassium oxide (K₂O), 0.02 % total calcium oxide (CaO), 0.05% total magnesium oxide (MgO), 0.03% Sodium (Na), 1.26 ppm Zinc (Zn), Trace Copper (Cu), 3.78 ppm Manganese (Mn) and 64.28 ppm Iron (Fe). The FCMT was formulated using the PCMT by adding in a 50-liter PCMT, 34.4 grams of calcium nitrate and 18.41 grams of magnesium sulfate. Adding of these salts increased the Total Dissolved Solutes (TDS) of the FCMT to 4,238 ppm and had a pH of 7.3. All nutrient solutions were maintained at a pH of 5.8 to 6.4 and TDS of 500-600 ppm during the first week, 700-750 ppm during the second week and 800-850 ppm on final week of growing lettuce. Results showed that there was no significant difference on growth performance of lettuce grown in two hydroponics systems and fed with PCMT, FCMT and INS. Lettuce grown in aggregates obtained an average economic yield of 53.1 grams, mean root weight of 20 grams and with a mean total biological yield of 66.5 grams. The organic nutrient solutions was negative of *Escherichia coli* (*e.coli*). Lettuce leaf was also negative of *e. coli*. The use of PCMT reduced the cost of production and increased the net income. The return on investment using PCMT was 39%.

Effect of the Extracts of *Embelia ribes* Burm. f. (Myrsinaceae) Leaf on Broad Mite,

***Polyphagotarsonemus latus* (Acari: Tarsonemidae)**

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Contact details: *faaspnv@ku.ac.th: Sustainable Utilization of Bio-resources

To decrease the use of chemical acaricides, this study aimed to select natural plant extracts in controlling broad mite (*Polyphagotarsonemus latus* (Banks)) by investigating the repellent effects and toxicities of twelve *Embelia ribes* Burm. F. leaf crude extracts on *P. latus*. Both dry (d) and fresh (f) *E. ribes* leaves were extracted by two methods: moving-bed contacting method (MB) and fixed-bed contacting method (FB). In each method, leaves were sequentially extracted with 3 different solvents: methanol (M), dichloromethane (D) and hexane (H). Firstly, twenty adult gravid females of *P. latus* were fed on a mulberry leaf disc applied with each type of plant extracts (0.5% w/v in ethanol) by 2 ways: no choice and choice bioassays. The 10% ethyl alcohol was used as control treatment. The best four potential extracts that repelled *P. latus* from leaves and reduced their reproduction were: dry leaves by fixed-bed contacting method with dichloromethane (dFB/D), dry leaves by moving-bed contacting method with hexane (dMB/H), and both fresh and dry leaves by fixed-bed contacting method with hexane (fFB/H and dFB/H). *P. latus* stayed on the dFB/D, dMB/H, fFB/H and dFB/H leaf discs less than control leaf discs by 67.87, 48.58, 49.10 and 54.63%. The oviposition rates were reduced by 98.78, 88.73, 88.73 and 87.96% relative to control, respectively. Results from choice bioassay showed all twelve extracts repelled *P. latus* to the ethanol side of leaf discs within 32 hours, with one exception. The extracts from fresh leaves by moving-bed contacting method with dichloromethane (fMB/D) did not repel *P. latus* to the ethanol side in the first 8 hours. Secondly, the three best extracts from dry leaves were tested in no choice bioassay. The repellent effect on *P. latus* of dFB/H extract was higher than the dMB/H and dFB/D extracts. Therefore, the dFB/D, dFB/H and dMB/H extracts of *E. ribes* leaves could possibly be used to repel *P. latus*. However, the impact of these extracts on broad mite's natural enemies should also be of concern.

Effect of the Extracts of *Embelia ribes* Burm. f. (Myrsinaceae) leaf on Predacious Mite *Amblyseius cinctus* Corpuz and Rimando (Acari: Phytoseiidae)

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Toxicity effects of the extracts of *Embelia ribes* leaf on gravid female and eggs of the predacious mite *Amblyseius cinctus* were studied for selecting botanical acaricides from wild plants to control *Polyphagotarsonemus latus* without adverse effects on their predator, *A. cinctus*. The selected *E. ribes* leaf crude extracts were extracted from dry *E. ribes* leaves by 3 methods: moving-bed contacting method with hexane (dMB/H), fixedbed contacting method with dichloromethane (dFB/D) and with hexane (dFB/H). Then each extraction was dissolved into three concentration levels (dMB/H and dFB/D: 0.3, 0.5 and 0.7% w/v; dFB/H: 0.2, 0.4 and 0.6% w/v) and their solvent, ethyl alcohol 10%, was 0% w/v. Each solution was sprayed on a gravid predacious female or dropped on predacious female's habitat to evaluate direct-contact toxicity effect and habitat-contact toxicity effect of each solution on female mortality, longevity and oviposition rate in the first experiment. Female predacious mites that contacted with any selected *E. ribes* leaf extracts could lived long as and produced eggs at the same rate as female that contacted with only their solvents. The higher concentration did not significantly cause the higher toxicity to female. Although different contacting methods did not cause the difference in oviposition rate of female, the higher toxicity to female longevity of the extracts occurred to sprayed female than female that lived on dropped habitats. In addition, the probit analysis of dead females during experiments suggested that dFB/D, dMB/H and dFB/H had the lowest toxicity to sprayed female, according to their LC50: 0.149, 0.467 and 0.827% w/v, respectively. In the later experiments, only dFB/H solution were sprayed on 2 stages of predacious mites; female and

egg. The female predacious mites, sprayed with dFB/H (0.6%w/v), had lower oviposition rate and shorter longevity than ethyl alcohol-treated females. While the hatching rates of the 0.4% w/v dFB/H-sprayed eggs was higher than the ethanol sprayed eggs, the eggs directly in contact with several con-

centrations of dFB/H and ethanol were not different. This inconsistent results might be due to the side-effects of ethyl alcohol 10%. Thus, we should investigate for better solvents of the dFB/H extracts. Next, the study effect of dMB/H to control *P. latus* without adverse effects on *A. cinctus* should also be concerned due to the low LC50 when predators got in contact with the extract in their habitat.

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