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POTENTIAL OF MICROBIAL ANTAGONISTS AS BIOCONTROL AGENTS AGAINST PLANT FUNGAL PATHOGENS

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ABSTRACT

A variety of fungi are known to cause important plant diseases, resulting in a significant lost in agricultural crops. The plant diseases need to be controlled to maintain the level of yield both quantitatively and qualitatively. Farmers often rely heavily on the use of synthetic fungicides to control the plant diseases. However, the environmental problems caused by excessive use and misuse of synthetic fungicide have led to considerable changes in people's attitudes towards the use of synthetic pesticides in agriculture. Today, there is an increase in the awareness of the people about the healthy food and healthy environment. In response to this need, some researchers have focused their effort to develop alternative measures to synthetic chemicals for controlling plant diseases. Among these, is that referred to as biological control using microbial antagonists. Many microbial antagonists have been reported to posses antagonistic activities against plant fungal pathogens, such as *Pseudomonas fluorescens*, *Agrobacterium radiobacter*, *Bacillus subtilis, B. cereus*, *B. amyloliquefaciens*, *Trichoderma virens*, *Burkholderia cepacia*, *Saccharomyces* sp, *Gliocadium* sp. Three species of rhizobacteria isolated from rhizospheres of rice grown in Bali, *i.e. Enterobacter agglomerans*, *Seratia liquefaciens* and *Xanthomonas luminescens* were found to effectively suppressed the growth of *Pyricularia oryzae* Cav. the cause of rice blast disease. Understanding the mechanism by which the biocontrol of plant diseases occurs is critical to the eventual improvement and wider use of biocontrol method. These mechanisms are generally classified as competition, parasitism, antibiosis, and induction of host resistance. Over the past forty years, research has lead to the development of a small commercial sector that produces a number of biocontrol products. The market share of biopesticides of the total pesticide market is less than three percent. However, significant expansion is expected over the next decades due to the expanded demand for organic food, and increased demand for safer pesticides in agriculture and forestry. The challenge is to develop a formulation and application method that can be implemented on a commercial scale, that must be effective, reliable, consistent, economically feasible, and with a wider spectrum. Continual laboratory works followed by field experiments are needed to establish excellent biocontrol agents particularly against plant fungal pathogens.

INTRODUCTION

Agricultural crops are exposed to approximately 70,000 species of pests, but of these only 10% are considered serious pests (Pimentel, 1997). Pest insects, plant pathogens, and weed potentially cause the reduction of world food production more than 40% if pesticides are not applied. Pre-harvest pest losses are approximately 15% for pest insects, 13% for diseases, and about 12% for weeds. After harvest, another 20% of the food is lost to another group of pests (Pimentel, 1997). Plant diseases caused by a variety of fungi may cause significant losses on agricultural crops. All plants are attacked by some kinds of fungi, and each of parasitic fungi can attack one or many kinds of plants. More than 10,000 species of fungi can cause disease in plants (Agrios, 2005).

Fungal diseases may be minimized by the reduction of the inoculums, inhibition of its virulence mechanisms and promotion of genetic diversity in the crop (Strange and Scott, 2005). The use of chemical fungicides in agriculture has been proven to bring about various benefit such as reducing the fungal infection that may rob water and nutrients from crop plants or may cause spoilage while the products are transported to the market. Fungicides may also prevent the growth of fungi that produce toxins, such as aflatoxins. In 1997, worldwide, 5.7 billion pounds of pesticides were used, of which 0.5 billion were fungicides (Goldman, 2008). There are numerous classes of fungicides, with different modes of action as well as different potential for adverse effect on health and environment. Milne (2004) indicated 311 compounds are registered and used as fungicides to control various plant fungal diseases. Of these, seven agents are antagonistic microorganisms and only one agent is derived from plant extract, i.e., extract of *Reynoutria sachalinensis* (Giant Knotweed).

Most fungicides can cause acute toxicity, and some cause chronic toxicity as well (Goldman, 2008). The use of chemical pesticides has been known to cause various environmental and health problems. The International Labor Organization (ILO) estimates that as much as 14 per cent of all occupational injuries are due to exposure to pesticides and other agrochemical constituents (ILO, 1996). The World Health Organization (WHO) and the United Nations Environment Programme estimates that each year, three million workers in agriculture in developing world experience severe poisoning from pesticides, about 18,000 of whom die (Miller, 2004). Appropriate technological improvement, which results in more effective use of natural resources is required in agriculture. One of them is the use of microbial antagonists.

Many microbial antagonists have been reported to posses antagonistic activities against plant fungal pathogens, such as *Pseudomonas fluorescens*, *Agrobacterium radiobacter*, *Bacillus subtilis*, *B. cereus*, *B. amyloliquefaciens*, *Trichoderma virens*, *Burkholderia cepacia*, *Saccharomyces* sp, *Gliocadium* sp. The successful control by these antagonists mainly against the diseases caused by following genera of pathogens : *Alternaria*, *Pythium*, *Aspergillus*, *Fusarium*, *Rhizoctonia*, *Phytophthora*, *Botrytis*, *Pyricularia* and *Gaeumannomyces* (Pal and Garderner, 2006). This paper describes briefly the biocontrol potential of microbial antagonists particularly against plant fungal pathogens.

Fungal Diseases on Agricultural Crops

More than 10,000 species of fungi, can cause disease in plants (Agrios, 2005). Classes of fungi that commonly cause diseases in agricultural crops are Plasmodiophoromycetes (cause clubroot of crucifers, root disease of cereals, and powdery scab of potato), Oomycetes (cause seedling damping-off, late blight, downy mildews, and white rust disease), Zygomycetes (cause soft rot of fruit), Ascomycetes and Deuteromycetes (cause leaf spots, blights, cankers, fruit spots, fruit rots, anthracnoses, stem rots, root rots, vascular wilts, soft rot), and Basidomycetes (cause rust and smut diseases (Agrios, 2005).

Apple scab, caused by the fungus *Venturia inaequalis* is the most important diseases of apples worldwide, and it very likely occurs in every country where apples are grown. In some circumstances, the losses from apple scab can be 70% or more of the total fruit value (Agrios, 2005). *Macrophomina phaseolina*, is important root pathogen and causes dry root rot or stem canker, stalk rot or charcoal rot of over 500 plant species (Sinclair, 1985; Shahzad et al., 1988). The genus *Fusarium* contains a number of species, which have been recognized for a long time as being important plant pathogens (Booth, 1971; Nelson *et al*., 1983). *Rhizoctonia solani* exists in the soil and attacks more than 2000 species of plants (Parmeter, 1970). *Phytophthora capsici* causes foot rot disease in black pepper (*Piper nigrum* L.) and other crops in India and tropical countries (Dinu et al., 2007). This fungus affects all parts of black pepper plants namely roots, stems, shoots, leaves and spikes.

Sudana et al. (1999) reported that 10 millions of banana plants were died because of wilt disease caused by fungus *Fusarium oxysporum* f.sp. *cubense.* Within two years (2007-2009) the banana wilt disease caused the decrease of banana production more than 60% (Sudana et al, 1999). *Phytophthora palmivora* the cause of black pod disease on cocoa has become an important obstacle in cocoa production in Bali. Survey done by Suprapta et al. (2006) indicated that the disease incidence during rainy season in three main cocoa growing areas in Bali was relatively high, varying from 78 to 88%. Stem rot disease caused by *Fusaium oxysporum* f.sp. *vanilae* has been known as one of important constraints for the vanilla cultivation and responsible for the decreasing of vanilla production (Semangun, 2000; Suprapta et al., 2006; Jayasekar et al., 2008, Sulistyani, 2004). Rice blast disease is one of the most important fungal disease on rice that may resulted in apparent yield loss. The disease caused by *Pyricularia grisea* Sacc., (synonym *Pyricularia oryzae* Cav.) (Kato, 2001). The yield losses resulted from the outbreak of blast disease varied according to the geographical condition. In Japan the disease may cause the yield loss up to 100% (Kato, 2001), in China up to 70% (Chin, 1975) and in Bali, Indonesia varied from 21% to 37% (Suprapta and Khalimi, 2012).

Biocontrol of Fungal Pathogens

Biological control of soil borne pathogens by introduced microorganisms has been studied over 80 years, but most of the time it has not been considered commercially feasible. However interest and research in this area increased steadily. There is a shift toward the important role of biological control in agriculture in the future. Several companies now have programs to develop biocontrol agents as commercial products.

Microorganisms that can grow in the rhizosphere are ideal for use as biocontrol agents, since the rhizosphere provides the front-line defense for root against attack by pathogens. Pathogens encounter antagonism from rhizosphere microorganisms before and during primary infection and also during secondary spread in the roots. In the suppressive soil to pathogens, microbial antagonism of the pathogen is especially great, leading to substantial disease control. Although pathogen-suppressive soils are rare, those identified are excellent examples of the full potential of biological control of soil borne pathogens (Weller, 1988).

Isolates of *Pseudomonas* were evaluated for antifungal activity against five fungal plant pathogens, i.e. *Fusarium oxysporum*, *Aspergillus niger*, *Aspergillus flavus*, *Alternaria alternata* and *Erysiphe cruciferarum* (Singh *et al*., 2011). All fungal strains tested showed significant reduction in terms of radial diameter after the treatment with *Pseudomonas* cultures, in comparison with the controls. Out of the five fungal pathogens studied, *Fusarium oxysporum* showed maximum extent of inhibition (% control inhibition = 51.76%) followed by *Aspergillus niger* (50.14%), and least by *Erysiphe cruciferarum* (22.27%). The antagonistic effect of *Pseudomonas* might be explained on the basis of its antifungal secondary metabolites that are capable of lysing chitin which is the most important component of fungal cell wall (Singh et al., 2011). Treatment with the antagonist *Pseudomonas aeruginosa* strain 950923-29 in combination with DL-β-amino-*n*-butyric acid (BABA) effectively suppressed the *Phytophthora* blight disease of pepper caused by *Phytophthora capsici* (Lee et al., 1999).

An isolate of *Trichoderma harzianum* capable of lysing mycelia of *Sclerotium rolfsii* and *Rhizoctonia solani* was isolated from a soil naturally infested with those pathogens (Elad *et al*., 1980). Under green house conditions, incorporation of the wheat-bran inoculums preparation of *T. harzianum* in pathogen-infested soil reduced significantly bean diseases caused by *S. rolfsii*, *R. solani*, or both, but its biocontrol capacity was inversely correlated with temperature. The wheat-bran preparation of *T. harzianum* increased growth of bean plants in a non-infested soil and its controlled *S. rolfsii* more efficiently than a conidial suspension of the same antagonist. In naturally infested soils, wheat-bran preparation of *T. harzianum* inoculums significantly decreased diseases caused by *S. rolfsii* or *R. solani* in three field experiments with bean, cotton, or tomato, and these increased significantly the yield of beans (Elad et al., 1980).

Patale and Mukadam (2011) tested the antagonistic activities of three *Trichoderma* species, i.e. *T. viride*, *T. harzianum*, and *Trichoderma* sp. against seven pathogenic fungi, namely *Aspergillus niger*, *A. flavus*, *Phytophthora* sp., *Fusarium oxysporum*, *Rhizoctonia solani*, *Penicillium notatum*, and *Alternaria solani*. They found that all three species of *Trichoderma* suppressed effectively the growth of seven pathogenic fungi. Atifungal activity of *Pseudomonas fluorescens* was tested against *Pythium ultimim*, *Macrophomina phaseolina* and *Pyricularia oryzae* (Goud and Muralikrishnan, 2009). All three pathogenic fungi were inhibited by *P*. *fluorescens* with inhibitory activities ranging from 50% to 80%.

The asbuscular mycorrhizae fungi (AMF) are the symbiotic fungi that predominate in the roots and soils of agricultural crops. The AMF play an important role in the reduction of plant pathogens, such as *Rhizoctonia solani* (Yao et al., 2002), and *Phytophthora* species (Trotta et al., 1996; Cordier et al., 1996). The antagonistic interaction between AMF with various soilborne plant pathogens is the reason for their use as biocontrol agents.

Among soil microorganisms, yeasts have received little attention as biocontrol agents of soil borne fungal plant pathogens in comparison to bacterial, actinomycetes, and filamentous fungal antagonists. The ability of certain species of yeasts to multiply rapidly, to produce antibiotics and cell wall-degrading enzymes, to induce resistance of host tissues, and to produce plant growth regulators indicates the potential to exploit yeasts as biocontrol agents. *Saccharomyces* sp. was proven to be effectively suppressed the growth of *Sclerotium* sp. (the cause of stem rot disease on vanilla seedlings), *Fusarium oxysporum* f.sp. *vanillae* (the cause of stem rot disease on vanilla in the field), *F. oxysporum* f.sp. *cubense* (the cause of *Fusarium* wilt on banana) and *Phytophthora palmivora* (the cause of black rot disease on cocoa) on PDA medium. The *Saccharomyces* sp. was formulated in compost containing saw dust, maize flour, sucrose and rice bran. This formulation has been patented in Indonesia with patent number IDP 0024496.

Biological control of plant diseases is a result of many different types of interaction among microorganisms and can occur through different mechanisms, which are generally classified as : parasitism/predation, antibiosis, competition, lytic enzymes, and induced resistance (Pal and Gardener, 2006). The most effective biocontrol active microorganisms studied appear to antagonize plant pathogen employing several modes of actions. For example, *Pseudomonas* known to produce the antibiotic 2, 4-diacetylphloroglucinol (DAPG) may also induce host defenses. Additionally, DAPG-producers bacterial antagonists can aggressively colonize root, a trait that might further contribute to their ability to suppress pathogen activity in the rhizosphere of plant through competition for organic nutrients (Heydari and Pessarakli, 2010). A study on the development of bioagents to control rice blast disease on rice caused by *Pyricularia oryzae* Cav. found three potential species of rhizobacteria isolated from the rhizospheres of rice grown in Bali, namely *Enterobacter agglomerans* (isolates Ch2D, Gg14D and Ch4Bdak), *Xanthomonas luminescens* (isolate Ch3D) and *Seratia liquefaciens* (isolate Gh13Da) (Suprapta and Khalimi, 2012).

Challenge for the Success of Field Application

In general, the potential antagonistic microorganisms selected from *in vitro* tests often fail to effectively control plant disease in greenhouse or field trials, particularly to soil borne pathogens. Several factors such as the type and the content of organic matter, pH, nutrient level, and moisture level of the soil influence the efficacy of the biocontrol agents. Due to the variations in environmental factors from one place to other places, sometimes, a good biocontrol agent under *in vitro* conditions fails in *in vivo* conditions. To achieve the success, the environmental factors should be similar to those from which the biocontrol agents were isolated. Likewise, the method of application can influence the success of field trials. In general, there are three means of applying the antagonists for biocontrol, namely seed inoculation, vegetative part inoculation and soil inoculation.

A field trial done by Lee and co-workers (1999) showed that the control efficacy of antagonist *Burkholderia cepacia* strain N9523 against *Phytophthora capsici*, the cause of *Phytophthora* blight of pepper was higher by soil-drenching than by wounded stem inoculation. Dawar et al. (2008) tested the biocontrol potential of different microbial antagonists, i.e. *Bacillus thringiensis*, *Rhizobium melilot*i, *Aspergillus niger* and *Trichoderma harzianum* by coating the seeds with gum Arabic, glucose, sucrose and molasses. This method reduced successfully the infection of root rot fungi on okra and sunflower, i.e *Macrophomina phaseolina*, *Rhizoctonia solani* and *Fusarium* spp. The highest suppression capacity was shown by seed treatment with *T. harzianum* using 2% of glucose.

CONCLUDING REMARKS

Plant diseases caused by pathogenic fungi may result in significant yield losses of agricultural crops. Farmers, in general still rely on the use of synthetic fungicides to control plant diseases. However, the misuse of these chemicals may cause serious environmental and health problems. Microbial antagonists are potential agents that can be explored to provide effective and safe means to manage plant diseases. Several microorganisms have been tested and proven to posses antagonistic properties against plant pathogenic fungi. Our recent study showed that three species of rhizobacteria *i.e*. *Seratia liquefaciens, Enterobacter agglomerans* and *Xanthomonas luminescens* apparently suppressed the growth of *Pyricularia oryzae*, the cause of rice blast disease. The potential of these agents can be improved by continual improvement in isolation, formulation and application methods, particularly in the field.

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REVITALIZATION OF HILL FARMING THROUGH ORGANIC AGRICULTURE IN JAPAN: THE JOETSU TOKYO NODAI AS A BUSINESS MODEL

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ABSTRACT

The hilly and mountainous areas contribute about 40% to the entire agricultural sector in Japan, but agricultural decline has become very apparent in recent decades. There is a great need for revitalization of hill farming by adopting strategic approaches in order to maintain the food production of the country. This paper aims to describe the serious problems facing hill and mountain farming as well as the current status of organic farming in Japan, and to present the case of Joetsu Tokyo Nodai, Inc. established in 2008 in order to deal with these problems.

Key words: Abandoned fields, organic farming, rice, vegetables

INTRODUCTION

Revitalization of hill and mountain farming is urgently needed for the maintenance of food production in Japan. However, there are many serious problems in this low efficiency farming. A strategic approach is significantly important to tackle the existing challenges. For the future of Japanese agriculture, not only the rehabilitation of abandoned fields is vital, but also the establishment of a sustainable farm management system.

This paper aims to take an overview of the current condition of hill and mountain farming as well as organic agriculture in the country, followed by the presentation of the evolution, constraints and prospects of the Joetsu Tokyo Nodai, Inc. This corporation was founded in April 2008 and has since been making continuous efforts to rehabilitate abandoned fields for the cultivation of organic rice and vegetables, which are provided to niche markets as high quality food items with the Tokyo Nodai brand. It is considered to be one business model for the promotion of agricultural development in hilly areas of Japan.

It should be noted that this paper depends heavily on an earlier paper in Japanese (Fujimoto 2012) and my plenary presentation at the ISSAAS International Congress 2012, held in Bicol, Philippines, last 14-16 November 2012.

HILL FARMING IN JAPAN

For statistical purposes, the farming areas in Japan are divided into four categories, namely Urban, Plains, Hill, and Mountain. The Plains has more than 20% of arable land of the total land area and less than 50% of forest coverage, while in the Mountain area the arable land rate is less than 10% and forest more than 80%. The Hill area has 10~20% of arable land and 50~80% of forest coverage. In general, statistics are taken on the basis of municipality or former unit before amalgamation of cities, towns and villages. There are currently a total of 720, 758, 1,022 and 735 municipalities in the Urban, Plains, Hill, and Mountain areas, respectively.

Table 1 shows cultivated area, number of farm households, and the average sale of agricultural products per farm household by area in Japan. It also shows the average age of farmers in these areas. It is clear that a combination of hill and mountain areas contribute roughly 40% to the total farmland area, total sale of agricultural products, and total number of farm households in the country. However, the average farm size remains small at 1.16 ha and 0.96 ha in hill and mountain areas respectively, compared to 1.88 ha in the plains. It follows that the planted area and agricultural sales are also smaller in hill and mountain areas. The average value of agricultural sales per farm household was 1.99 million yen in the mountain area, and 2.53 million year in the hill area, compared to 3.88 million yen in the plains in 2010. Off-farm income opportunities are more severely limited in hill and mountain areas than in the plains where major cities and industries are located. These facts indicate that the average income of farm households in hill and mountain areas is much lower than their counterparts in the plains area.

Table 1. Contribution of hill and mountain areas to the agricultural sector in Japan, 2010.

Areas	**Cultivated land (1,000ha)**	**Number of farm households (1,000 hh)**	**Commercial farm households (1,000 hh)**	**Average sale per household (Million yen)**	**Average age of farmers (years)**	**Rate of abandoned fields (%)**
Urban	550	708	420	2.54	63.0	13
Plains	1,700	911	730	3.88	62.1	6
Hill	996	859	590	2.53	64.1	13
Mountain	354	376	220	1.99	65.3	15
Total	3,608	2,848	1,960	2.98	64.2	11

Sources: MAFF 2010a; MAFF 2010b, pp. 67, 71 and 123.
Note: Rate of abandoned fields (%) = Abandoned area / (Arable land + Abandoned area) x 100

This low level of income and the less favorable living conditions in hill and mountain areas have been the major causes of the lack of farm successors and the aging of the farmers. The average age of hill farmers is 64.1 years old, while that of mountain farmers is 65.3, compared to 62.1 years in the plains area. Another serious issue in hill and mountain areas is the significant increase in abandoned fields. In the Agricultural Census, abandoned fields are defined to be those arable lands not planted to any crops for more than one year and with no intention to cultivate in the foreseeable future. As of 2010, the rate of abandoned fields was as high as 15% and 13% in mountain and hill areas respectively, compared to only 6% in the plains. Actually, abandoned fields have been gradually increasing in recent decades due to general agricultural decline in Japan. As shown in Table 2, more than 217,000 ha of arable land (4.7% of the total arable land) were abandoned in Japan in 1990, increasing to as much as 400,000 ha (10.6%) by 2010.

In other words, even though hill and mountain villages are often regarded as beautiful landscape and a treasure house of cultural heritage, which many city residents actually admire and wish to visit, the life and agricultural activities are not easy at all. Let me neatly summarize the reality of hilly and mountainous farming in Japan by the following 10 keywords: (1) lack of successors, (2) aging of farmers, (3) marginal villages, (4) excessive depopulation of rural villages, (5) social differentiation, (6) small farm size, (7) low efficiency, (8) damage from wild animals, (9) low income, and (10) abandoned fields.

Table 2. Changes in arable land and abandoned fields in Japan, 1990-2010.

Years	Arable land (1,000 ha)	Abandoned area (1,000 ha)	Abandoned rate (%)
1990	5,240	217	4.7
1995	5,040	244	5.6
2000	4,830	343	8.1
2005	4,690	386	9.7
2010	4,590	396	10.6

Sources: MAFF 2010a; MAFF 2010b, pp.74-75.

The term "successor" has two meanings in Japan, namely successor to the household and successor in farming. In suburban villages, the young generation may succeed to the household but not necessarily to farming, as the youth are most likely engaged in off-farm employment and willing to commute to work from the family house. However, in hill and mountain areas, the young generation tends to migrate to the urban area, leaving no child to succeed to either household or farming. Population in a village can be maintained in the former case but decreases in the latter case, leading to an excessive depopulation of rural villages in hill and mountain areas. Those remaining in the village are likely to be elders, causing the so-called phenomenon of aging of farmers. In Japan, if more than half of the village residents are older than 65 years old, it is called a marginal village, and we see now an increasing number of marginal villages in hill and mountainous areas. There were 7,878 marginal villages in 2006 in Japan, of which 423 is expected to disappear within 10 years (Muramoto, et al, 2010)**.**

Why does the young generation tend to migrate? Two fundamental reasons can be pointed out: (1) low agricultural income, caused by low farming efficiency and small farm size, and sometimes damage from wild animals, and (2) inconvenient living conditions caused by social differentiation wherein social infrastructure is far better in cities and towns, while life is very inconvenient in the hill and mountain areas, especially for elderly citizens. It is no wonder that young people do not wish to live in these unfavorable villages.

There is an increasing understanding of and support for hill and mountain farming problems in agricultural policy in Japan. Among various subsidy programs (e.g. Individual Household Income Support Program, Paddy and Upland Fields Income Stabilization Program), the Hill and Mountain Villages Direct-Payment Program, which was introduced in 2000, is the only program exclusively directed to these unfavorable farming areas. Under this program, about 200,000 yen per hectare of cultivated arable land is provided to beneficiaries in hill and mountain areas. It should be noted that half of the subsidy is given to the village community, while the other half is directly paid to the individual farmers. However, this amount is considered far too small to reduce the existing large gap in the average income of farm households between favorable and unfavorable areas, and to provide incentives for the young generation to start and continue farming in these unfavorable areas. For fundamental solutions of the problems of hill and mountain areas, it is therefore necessary to establish the basic social and economic conditions to attract and convince the young generation to settle and continue their engagement in farming, and to maintain village community functions.

ORGANIC FARMING IN JAPAN

Development of organic farming in Japan up to 2004 was reviewed in my previous paper (Fujimoto 2005). Demand for organic products has steadily been increasing in Japan, as general consumers have become more interested in safe foods as a reaction to the emerging pollution of the 1960s and pesticide residue problems in the 1980s (Sugihara 2006). The certification system for organic products was made compulsory from 2001, as a result of the revised JAS Law.

Table 3 presents the trends in domestic production and import of organic products in Japan. Three points deserve mentioning. First, the number of certified organic business entities, including producers, distributors, and importers, has gradually increased from 3,639 (2002) to 5,842 (2010). However, certified organic producers accounted for only 3,815 persons in 2010, and the extent of their certified fields remained small in area at 8,506 ha, accounting for a mere 0.18% of total arable land in the country. These certified fields could be further categorized into paddy fields and non-paddy fields, occupying 2,902 ha and 5,596 ha, respectively. The average area of certified fields per certified producer was only 2.2 ha.

Table 3. Changes in the number of JAS certified organic entities, domestic organic products and imported organic products in Japan, 2001-2010

Years	Certified business entities	Domestic production (tons)	Import (tons)
2001	-	33,734	94,186
2002	3,639	43,789	89,019
2003	4,273	46,192	297,923
2004	4,453	47,428	449,649
2005	4,884	48,172	1,440,178
2006	4,611	48,596	1,296,256
2007	5,104	53,446	1,902,279
2008	5,651	56,164	1,981,262
2009	5,514	57,342	704,204
2010	5,842	56,415	859,943

Sources: Ministry of Agriculture, Forestry and Fisheries, various years.

Second, domestic production of organic products amounted to 33,734 tons in 2001 when certification was made compulsory. This gradually increased to 56,415 tons by 2010. As shown in Table 4, vegetables remained a major organic product from the beginning, followed by rice. However, the total quantity of organic products was very small, in that organic vegetables constituted a mere 0.31% of the total vegetables production in the country, and rice only 0.13%, in 2010. MOA (2011) estimated that the inclusion of non-certified organic products would bring the total availability to more than 100,000 tons in 2010, including 62,644 tons of vegetables (0.39% of total vegetables) and 25,565 tons of rice (0.30% of total rice).

Third, the relatively small number of certified organic producers and quantity of domestic organic production does not necessarily mean a small demand for organic products in Japan. As presented in Table 3, the import of organic products has continued to grow, from 94,186 tons in 2001 to 859,943 tons in 2011. For the period from 2005 to 2008, more than one million tons were imported, due to the heavy purchase of organic sugarcane. In 2010, such commodities as vegetables, soybeans, and fruit were the main items of imported organic food, amounting to more than 188,000 tons, 100,000 tons, and 85,000 tons, respectively. The import of organic rice accounted for more than 14,000 tons.

Table 4. Changes in shares of organic products in Japan, 2001-2010.

Commodity	2001		2005		2010	
	Production (t)	Share (%)	Production (t)	Share (%)	Production (t)	Share (%)
Vegetables	19,675	0.11	29,107	0.18	36,854	0.31
Rice	7,777	0.03	11,369	0.13	10,976	0.13
Fruits	1,391	0.03	2,222	0.06	2,506	0.09
Soy beans	1,162	0.43	877	0.39	1,035	0.46
Green tea	927	1.10	1,610	1.61	2,088	2.46
Wheat/Barley	722	0.06	655	0.06	890	0.12
Others	2,081	1.42	2,332	1.45	2,065	1.65
Total	33,734	0.10	48,172	0.16	56,415	0.23

Sources: Ministry of Agriculture, Forestry and Fisheries, various years.

It is thus clear that although the demand for organic products has been greatly increasing, domestic production has showed a small increase, resulting in the great expansion of imports. The question then arises as to why development of organic agriculture has been so slow in Japan. It is most likely caused by the fact that profitability of organic farming has been kept low, on which the following points can be made. From the production point of view, there are many obstacles in organic cultivation technology. Crop cultivation technology in the 20th century has shown a heavy dependence on synthetic chemical inputs, and the development of alternative inputs is severely limited. In many cases of organic cultivation, therefore, farming has to depend on natural conditions and embedded fertility of soil and crops, with consequent difficulty in improving the unstable and low yield levels. Low level of production is necessarily accompanied by high cost per unit of produce. In other words, because of the lack of stable and high yielding technology, there is a limited number of farmers who are willing to convert from conventional to organic farming.

From the marketing point of view, organic products are limited to those products certified under the JAS Law. Differentiation of organic products from conventional products is a necessary measure, but marketing channels for organic products are rather limited. As Sugihara (2006) pointed out, most of the specialized organic dealers in Japan operate on the basis of a contract with producers and consumers, leaving a narrow and limited space for new producers to find a market for their organic products. The compulsory certification system involves a relatively high cost every year for application, examination, and maintenance, which are to be borne by the producers. There is no subsidy given to the current and potential organic producers for obtaining a certificate in Japan. Yet, the prevailing high price of organic products limits further increase in selling prices. In other words, it is not easy for organic producers to recover their high costs and make a profit from selling their organic products. Low profitability also discourages the emergence of new organic producers.

As shown in Table 5, Organic Agriculture Promotion Law was enacted in December 2006, with which Ministry of Agriculture, Forestry and Fisheries (MAFF) introduced a new Basic Plan for Promoting Organic Agriculture in the following year. This basic plan put forward a clear recognition that organic agriculture would be useful in promoting natural circulation, reducing environmental stress, and in conserving bio-diversity. It may be said that the organic policy in Japan has now shifted from the administration and supervision of organic products to a new phase of the promotion of organic agriculture from the environment conservation point of view. It follows that in 2011 a new direct payment program was introduced for a period of five years for those farmers who adopt environmentally friendly practices, including cultivation of cover crops, living mulch, and organic farming. In 2012, about 12,162 ha of paddy fields were registered for the payment of this subsidy, under the category of organic farming.

Table 5. Chronology of policy and institutional changes in organic agriculture in Japan

Year	Major laws and regulations
1973	First Teikei system for organic products
1989	Organic Agriculture Section in MAFF
1992	Sustainable Agricultural Development, specified as one goal in New Agricultural Policy
1992	National standards for organic products (vegetables and fruits)
1997	National standards for organic products (rice, beans, wheat, barley)
1999	Food, Agriculture and Rural Basic law
1999	Sustainable Agriculture Law
1999	Amendment of JAS Law
2001	Compulsory certification for organic products
2005	National standards for organic products (animal and dairy products, processed foods)
2006	Organic Agriculture Promotion Law
2007	Basic plan for promoting organic agriculture
2011	Subsidy program for environment conservation agriculture (organic agriculture included)

MAFF also set forth a concrete goal for their policy, specifying a target of 50% increase in domestic production of organic products by 2014 over the actual production in 2007 (53,446 tons). However, as shown in Table 3, the actual production in 2010 was 57,342 tons, a mere 7% increase from 2007, pointing to the need for greater encouragement and more effective and support if the goal is to be achieved.

THE JOETSU TOKYO NODAI, INC.

Background

Tokyo University of Agriculture (abbreviated to TUA, and to *Tokyo Nodai* in Japanese) was founded in 1891 and has been conducting research and education activities with a practical science orientation. Contribution to local agricultural development has been one of the main missions of the university. In 2005, TUA signed a cooperation agreement with the City of Joetsu in Niigata Prefecture, and began field experiments in organic cultivation of rice and vegetables in its mountain area under Academic Frontier Research Project (TUA 2005-2009). This area is a typical hill and mountain area where many problems mentioned earlier actually existed, and the extent of abandoned fields accounted for 30% of the total 200 ha of arable land in this Tanihama-Kuwadori area. Some abandoned fields were rented in by TUA from local farmers and cleared for cultivation experiments, which focused on alternative technologies to (1) chemical fertilizer in soil fertility building, (2) synthetic pesticide in pest control, and (3) herbicide in weed control. Therefore, in the case of organic rice farming, compost and green manure, disease-resistant cultivar, and alternative weed control technologies such as paper mulching, deep water control, rice bran, and mechanical weeding were adopted for experiments. For organic vegetables, compost and green manure, locally adoptable types of vegetables, and living mulch were taken up for experiments.

From the second year of the activity, there emerged an increasing number of landowners who offered their abandoned fields for experiments. These offers gradually turned to a request for TUA to establish a university farm in the area. After a series of discussions with local farmers and the City Office, TUA decided to set up a public company, rather than a university farm, to initially clear abandoned fields of about 10 ha and operate an organic farm. With a total of 50 million yen capital paid up from (1) local agriculturists and business community who wished to conserve and promote agriculture in this hill and mountain area, (2) people originating from Joetsu who wished to contribute to local progress, (3) TUA community who wished to apply research findings to the real world and widen means of practical education, and (4) TUA graduates and concerned parties who wished to support this challenge of the university, a corporation named the Joetsu Tokyo Nodai, Inc. (http://www.jnodai.co.jp) was officially founded on the 1st of April, 2008.

As presented in Table 6, its business objectives include not only management of farms and ranches but also training and research businesses in bio-production, processing and marketing. In 2008, agricultural production was conducted under the Academic Frontier Research Project, and the company concentrated on marketing of the products. From 2009, the Joetsu Tokyo Nodai officially entered into farming business by renting in the abandoned fields and employing its salaried staff. The main office is located at TUA Setagaya Campus, Tokyo while the Joetsu Organic Farm is in Tanihama-Kuwadori area, Joetsu City, Niigata Prefecture (Figure 1). The farm is about 340 km away from Tokyo. The JAS organic certificate was first obtained by the corporation in August 2009 and is being renewed every year.

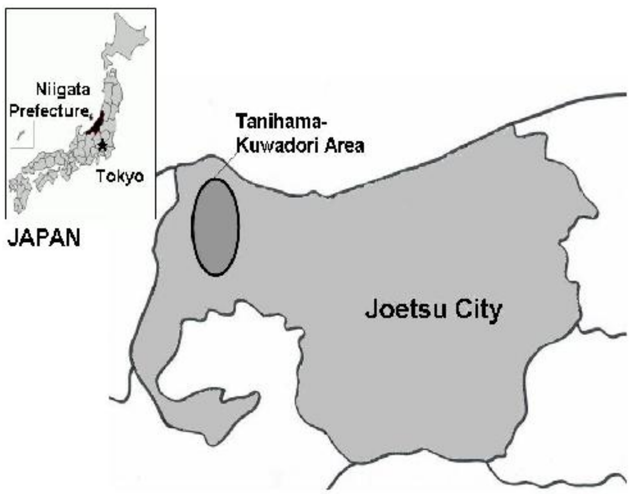

Figure 1. Location of Joetsu Organic Farm

Table 6. Business objectives of the Joetsu Tokyo Nodai, Inc.

Numbers	Objectives
1	Management of farms and ranches
2	Management of orchard and rental farms
3	Management of forests
4	Fishery and aquaculture
5	Purchase, processing (rice cake, pickles, cheese, ham etc), marketing, and retail sale of agricultural, forest, fishery and animal products
6	Manufacturing and sale of alcohol beverages
7	Food and drinking shops
8	Lease, management, transaction and agency services for real estates
9	Contract farming
10	Collection, production, processing (drying, canning, etc) and marketing of medicinal herbs and mountain flora
11	Lease of animals and plants for bio-therapy
12	Training business for bio-production, processing and marketing technologies
13	Research business for bio-production, processing and marketing
14	Ecotourism and food, agriculture and environment education business for urban residents
15	Accommodation business
16	All other business activities related to each of the above objectives

Training Activities

As shown in Table 7, the Joetsu Organic Farm has been a center for practical training and education not only for Japanese but also international students. The following different training programs have been conducted every year on the farm after its establishment:

1 Bio-business practice for second year students of Department of International Bio-Business Studies, Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture. Several groups of students spend two weeks engaging in organic farm practice during the summer as well as spring vacations. A total of 20 to 30 students have thus experienced organic farming and rural community every year.

2 Internship training for third and fourth year students of the above-mentioned department. Usually this is conducted during the summer vacation and sometimes in spring vacation. A total of 5 to 10 students participate every year.

3 TUA's Comprehensive International Education Program (CIEP) has a Joetsu Field Study as a main component. Student participants are able to engage in a whole-day organic agricultural practice at the Joetsu Organic Farm. More than 20 students from various countries participate in this program every year.

4 One of TUA's global partners, Michigan State University (MSU), created an organic farm practice for its students. The Joetsu Organic Farm accepts two to four MSU students for a period of two weeks. These students are often from the MSU's Student Organic Farm. During the practice, MSU students usually live and work together with the second year TUA students, thus giving them the opportunity to have cultural exchange.

Table 7. International training program at the Joetsu Organic Farm, 2008-2012.

Years	Months	Programs	No. of participants	No. of countries of origin
2008	Aug-Sep	Bio-business practice for Tokyo University of Agriculture (TUA)	24	4
		Joetsu Organic Practice for Michigan State University (MSU)	3	1
		Internship, TUA	4	1
	Oct	Comprehensive International Education Program (CIEP), TUA	20	6
2009	Feb	Field training, Advanced School, Institute of Developing Economies (IDEAS)	30	10
	Aug-Sep	Bio-business practice for Tokyo University of Agriculture (TUA)	15	2
		Joetsu Organic Practice for Michigan State University (MSU)	4	1
		Internship, TUA	5	1
	Sep	Comprehensive International Education Program (CIEP), TUA	21	8
2010	Feb	Field training, Advanced School, Institute of Developing Economies (IDEAS)	30	10
		Bio-business practice for Tokyo University of Agriculture (TUA)	5	1
	Aug-Sep	Bio-business practice for Tokyo University of Agriculture (TUA)	15	2
		Joetsu Organic Practice for Michigan State University (MSU)	2	1
		Joetsu Program, China Agricultural University	15	1
		Internship, TUA	4	2
	Oct	Comprehensive International Education Program (CIEP), TUA	25	10
		Joetsu Program, Kasetsart University	15	1
	Dec	Field training, Advanced School, Institute of Developing Economies (IDEAS)	29	14
		Agriculture training for Nikkeijin, Ministry of Agriculture, Forestry and Fisheries	6	3
2011	Feb-Mar	Bio-business practice for Tokyo University of Agriculture (TUA)	12	3
	Jul-Aug	Organic practice, Takada Agricultural High School	160	1
	Aug-Sep	Bio-business practice for Tokyo University of Agriculture (TUA)	9	2
		Internship, TUA	10	3
	Oct.	Comprehensive International Education Program (CIEP), TUA	26	17
2012	Feb-Mar	Bio-business practice for Tokyo University of Agriculture (TUA)	9	1
	May-Oct	Nikkei Training, JICA	1	1
	Jul-Aug	Organic practice, Takada Agricultural High School	160	1
	Aug	Joetsu Program, China Agricultural University	14	1
	Oct	Comprehensive International Education Program (CIEP), TUA	23	3

5 TUA also regularly accepts a group of 15 students each from China Agricultural University (CAU) and Kasetsart University (KU) as part of the exchange program. Domestic program for the visiting students includes a field visit to Joetsu City, and one- or two-day organic farm practice in the Joetsu Organic Farm.

6 Advanced School of the Institute of Developing Economies (IDEAS), Japan, has a field visit in their curriculum, which is often conducted in Joetsu City, including an organic farm experience in the Joetsu Organic Farm.

These are mostly TUA's education and training programs, to which the Joetsu Organic Farm renders its service as the main venue. In addition, the Joetsu Tokyo Nodai, Inc. offers its own training program every year to two to three graduates who wish to study organic farming, by employing them on a contract basis for up to three years. From 2011, the Joetsu Organic Farm has been recognized by Japan International Cooperation Agency (JICA) as one of the training points for invited Nikkei trainees. One JICA Trainee from Cuba was actually accepted for six months organic farm training in 2012.

Production

The Joetsu Organic Farm has been a fully organically JAS-certified producer since 2009. Although the physical farm land area is a little more than 10 ha, the planted area has been increasing by (1) clearing the abandoned fields and (2) introducing a multiple-cropping system of pumpkin-buckwheat. As shown in Table 8, the planted area was 9.20 ha in 2009 but increased to 10.49 ha in 2010 and further increased to 12.77 ha in 2011. By 2012, nearly 15 ha were planted. The multiple-cropping system was newly introduced in the surrounding area where heavy snow remains usually from mid-December to mid-April. The main crops are rice, buckwheat, pumpkin, zucchini, and radish.

Table 8. Planted area (ha) by crop at the Joetsu Organic Farm, 2008-2011.

Produce	2008	2009	2010	2011
Rice	3.17	4.45	4.41	3.69
Potato	0.42	0.28	0.17	0.32
Sweet potato	0.78	0.41	0.17	0.05
Taro	0.00	0.00	0.15	0.10
Pumpkin	1.07	0.85	1.80	3.16
Zucchini	0.28	0.58	0.31	0.31
Radish	0.20	0.51	0.51	0.79
Buckwheat	1.00	1.67	2.76	4.04
Others	0.35	0.45	0.38	0.30
Total	7.27	9.2	10.49	12.77

However, average yields of most of the crops remain very low (Table 9). Our yields may be compared to the national average for some crops under conventional cultivation in 2011, as follows: Rice 2.52 tons against 5.32 tons (Joetsu City), Buckwheat 670kg against 570kg, Radish 38,240 pieces or estimated 30 tons against 42.8 tons, and Pumpkin 2,410 pieces or estimated 3 tons against 11.7 tons. It is clear that only buckwheat in the Joetsu Organic Farm recorded a higher yield than the national average of conventional cultivation, while rice yield was about half of the national average. The low yield was due to low fertility of land and weed problem, for which the Joetsu Organic Farm has continuously been adopting improvement measures. It is clear that further improvements are needed.

Table 9. Average yield per hectare by crop at the Joetsu Organic Farm, 2008-2011.

Produce	Unit	2008	2009	2010	2011
Rice	tons	2.07	3.19	1.73	2.52
Potato	tons	4.70	9.95	3.41	9.42
Sweet potato	tons	5.32	8.59	1.47	2.75
Taro	tons	0.00	0.00	2.39	5.45
Pumpkin	pieces	2,180	1,120	2,130	2,410
Zucchini	pieces	14,830	26,090	30,600	11,980
Radish	pieces	20,000	40,100	39,270	38,240
Buckwheat	kg	500	180	600	670

Table10 shows changes in total sales of the Joetsu Tokyo Nodai, Inc. for the first four years. It is clear that total sales have been steadily increasing each year, due to the expansion of rice, vegetable and buckwheat production, as well as the introduction of processed foods and contract farming. In other words, the Joetsu Tokyo Nodai has been diversifying its business activities from dependence on fresh produce such as rice and vegetables by adding and expanding to the processed food business. In 2011, more than 22 million yen of goods and services was sold with the following shares of different commodities: Rice 24%, Vegetables 26%, Processed foods 16%, Training 10%, and Contract works 11%. Even though government subsidies could be added to this total sale, the company has constantly recorded a net loss and now faces a critical time for financial sustainability.

Table 10. Changes in total sales (1,000 yen) by the Joetsu Tokyo Nodai, 2008-2011.

Particulars	2008	2009	2010	2011
Rice	2,700	4,871	5,972	5,524
Vegetables (buckwheat)	2,800	4,660	3,833	5,874
Processed	-	-	2,028	3,693
Training	-	1,190	1,533	2,375
Contract works	-	373	1,762	2,415
Others	504	1,868	2,548	2,774
Total	6,084	12,962	17,666	22,655

Note: Financial year is from April to the following March.

Issues

Some issues for further development of this company can be summarized as follows. First, the rehabilitation of abandoned fields must be continued, as there is still a large area of unused formerly arable lands. Since Japan is a small country and a major food importer, it is necessary to make fuller use of available resources, and for a land-based business it is desirable to enlarge farm size. However, it is not very economical to work many scattered plots of small size especially in hilly and mountainous areas. The Joetsu Tokyo Nodai therefore has a dilemma, in that it looks for a block of

0.3 ha or so as a minimum size for a new area, but many abandoned fields are actually very small in size and fragmented.

Second, crop yield must be greatly raised in many cases. The building of soil fertility is a vitally important improvement. The quantity of compost can be increased, but additional expenses and income must be carefully calculated. Green manure is another option, but limited land area does not provide much scope for a fallow period and green manure planting. Land conditions, especially drainage condition, have been gradually improved, with the aim of removing poor-conditioned fields, which now account for nearly 20% of the entire fields. Increased production with a higher yield is considered economically more attainable than the expansion of farm size, which requires further payment of rental and water fees.

Third, commercialization of grade B products must be promoted. Due to strict market requirements for good size, color, and shape, farm products are carefully graded in Japan. In the case of pumpkin and zucchini, nearly one third of the total produce is categorized as grade B, which can only be sold at very low price or abandoned. The Joetsu Organic Farm began in 2010 to minimize this vegetable waste by carefully selecting and processing them into dried vegetables. In 2012, a cake manufacturer was newly added to a list of end-users for grade B pumpkins.

Fourth, general consumers seemed to have a limited knowledge of the various kinds of products available in the market. For the time being, there are at least four kinds of safe foods according to their certification: (1) Organic products, certified under the JAS law, (2) Specially grown products, certified by a Prefectural Government, (3) Eco-products, certified by a Prefectural Government, and (4) GAP products, certified by GAP organization. It is thus considered vitally important to inform consumers of the meaning and significance of organic products, since it is sometimes wrongly considered that pesticide-free products under the Specially Grown Products category are the safest food. In this sense, it is timely that the Basic Plan for Promoting Organic Agriculture (2007) clearly realized the need for promoting the understanding and interest of consumers, and mutual understanding among organic producers and consumers.

Fifth, the correct understanding of consumers about the nature of organic products is considered to benefit producers in more advantageous marketing. Producers of organic products expect a fair return to their time and expense in producing their products. Low yield alone indicates the higher costs of organic products, and thus higher prices, which can be considered as too expensive if consumers do not understand the nature of the products. Only those consumers who see the value of organic products in environment conservation and maintenance of health are willing to pay higher prices for these products.

Sixth and finally, the prospect of food processing must be mentioned. The Joetsu Organic Farm has been expanding into the food-processing business. Certainly consumers are willing to buy more foods, which are processed into a more convenient form, and therefore there is a good prospect. In fact, the Government has adopted a new strategy of “the sixth industry” in recent years, in order to promote integrated business activities of agricultural production, processing and marketing. The food processing business of the Joetsu Tokyo Nodai is certainly based on its own agricultural production, with the aim of further production of value added products. For the time being, however, the Joetsu Tokyo Nodai has no license for food processing and contracts with specialized and selected processors to produce their products. It is probably time for the company to have its own food processing plant.

CONCLUSION

The hilly and mountainous areas contribute about 40% to the entire agricultural sector in Japan, but agricultural decline has become very apparent in recent decades. There is a great need for revitalization of hill farming by adopting strategic approaches. This paper aimed to describe the serious problems facing hilly and mountainous farming as well as the current status of organic farming in Japan, and to present the case of Joetsu Tokyo Nodai, Inc. established in 2008 in order to deal with these problems. It is a challenge to establish a business model of sustainable farming in an unfavorable area, and may be termed "local condition specific strategy." With the availability of clean snow melted water and a closed eco-system, the Tanihama-Kuwadori area in Joetsu is ecologically one of the best locations for organic farming. There is an expanding market for organic products in Japan. These two facts combined presented the local conditions for establishing and operating an organic farm. However, ecologically best does not necessarily mean technologically and economically best as well. Thus, the essence of the challenge is to establish ecologically sound and economically viable farming.

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AGRICULTURAL RESEARCH AND DEVELOPMENT IN MALAYSIA

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ABSTRACT

Organized agricultural research in Malaysia only started in 1910 by the Department of Agriculture which was established five years earlier. This was followed by the establishment of private plantation crops research stations such as Dunlop Research Station, the Chemara Research Station and the Prang Besar Research Station. These private research stations focused their research on rubber. Agriculture research began to take an active role in the agriculture development of Malaysia only after Malaysian independence in 1957. The agricultural research and development became an established component of the national development plan during the 5th Malaysia plan (1986-1990) with the creation of the National Council on Scientific Research and Development (NCSRD). In 2002, total R&D expenditures were USD446.7 million (0.69 percent of Malaysia's GDP), of which the private sector involvement in R&D was merely 5 percent, mostly related to the plantation crops. In 2008, the total R&D expenditure increased to RM6.07 billion, which is equivalent to 0.82% of Malaysia's GDP. Research in agricultural sciences in 2008 constitute 5.8% of all researchers carried out in 2008. The main focus of agricultural research now is commodity based where the Malaysian Agricultural Research and Development Institute (MARDI), being the principal government agricultural research agency focused on food crops, while the private sector focused mainly on plantation crops.

INTRODUCTION

Malaysia obtained her independent 55 years ago and agriculture has contributed substantially to its gross domestic product. Currently about 11% of Malaysia's GDP is from agriculture. Agricultural research in Malaysia started in the early 1900's, when Dunlop Research Station was established in 1910. This was followed by the establishment of Chemara Research Station in 1920 and Prang Besar Research Station in 1921. All these were established by the British and research was focused mainly on rubber. The Department of Agriculture was established in 1905 and their research was on other crops. Only in the 5th Malaysia plan (1986-1990) agricultural research and development became an establish component of its national development plan. The focus of agricultural research and development has been crop based, where the government agencies deal with the food crops while the private agencies focus mainly on the plantation crops. The establishment of the Malaysian Agricultural Research and Development Institute (MARDI) in 1969 has intensified agricultural research and development.

Science and Technology Policies

Science and technology have played a significant role in Malaysia's development. The first National Science and Technology Policy (1986-1989) was developed to promote the utilization of science and technology as a tool for economic development and social improvement. The policy encompassed the promotion of scientific and technological self-reliance in support of economic activities through the enhancement of research and development capabilities. This was done through the creation of conducive environment for scientific creativity and the improvement of scientific, educational and other relevant infrastructure.

Formulation of the policies in the area of science, research, technology and innovation was lead by the Ministry of Science, Technology and Innovation (MOSTI). It also implements programs related to S&T and national R&D activities. For instance this year, 2012, has been declared as the Year of Science and National Innovation Movement (SGI 2012). This is an on-going effort by the government to promote and develop the culture of science, technology and innovation to all segments of the society.

A National Action Plan on Industrial Technology Development (1990-2001) was formulated to focus on three thrusts – strengthening institutions and support infrastructure for technological development, ensuring diffusion and application of technology, and elevating science and technology public awareness.

To sustain knowledge-based economy, the government of Malaysia recognized that research and development as well as technological innovations are essential, thus the launching of the Second Science and Technology Policy (NSTP2) which was formulated in 2002 and runs until this year (2012). The NSTP2 provides a framework for improved performance and long-term growth of the Malaysian economy with a special focus on seven strategic thrusts:

- Enhancing national capability and capacity for R&D, technology development and acquisition
- Promoting partnerships between public funded organizations and industries
- Accelerating the transformation of knowledge into value added products, processes, services or solutions
- Positioning Malaysia as a technology provider in key strategic knowledge industries
- Fostering societal values and attitudes that recognize science and technology as critical to future prosperity
- Utilizing science and technology that are in conformity with sustainable development
- Developing new knowledge-based industries.

One of the policy's goals is to enhance national capacity in R&D by creating a competent work force of at least 50 researchers per 10,000 workers. The NSTP2 shows that there has been a steady increase in the gross expenditure on R&D (GERD), leading to a substantial increase in Malaysia's GERD/GDP from 0.22 per cent in 1996 to 0.82 per cent in 2008. GERD increased substantially from RM0.55 billion in 1996 to RM6.07 billion in 2008 (Anon, 2012).

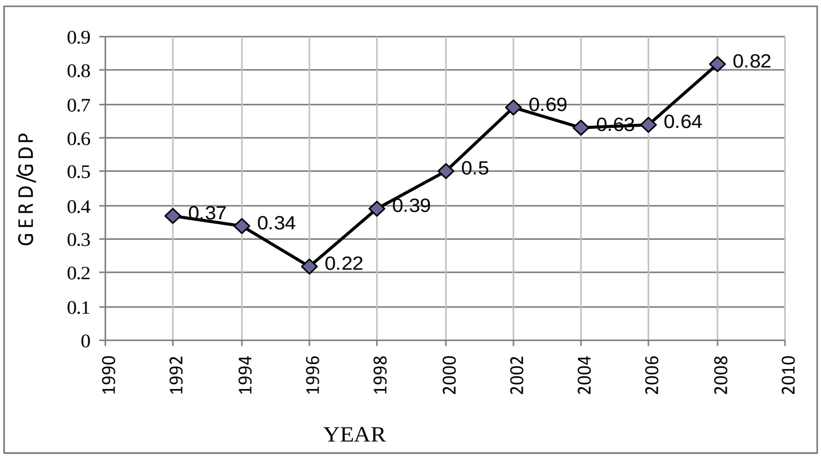

Fig. 1. Gross expenditure for R&D over GDP (%) from 1992 – 2008

In terms of human resource in R&D in Malaysia, in 2008, there were a total of 40,840 research personnel including researchers, technicians, and support staffs (Figure 2). Of this total, 77 per cent were researchers, followed by technicians (6.6 per cent) and support staff (16.4 per cent) (Anon, 2012). The researcher headcount was estimated at 31,442 with a ratio of 28.5 researchers per 10,000 workers. It has increased significantly (76.7 per cent) over a period of seven years (2002 to 2008). However, the target is 50 researchers per 10,000 workers by 2015.

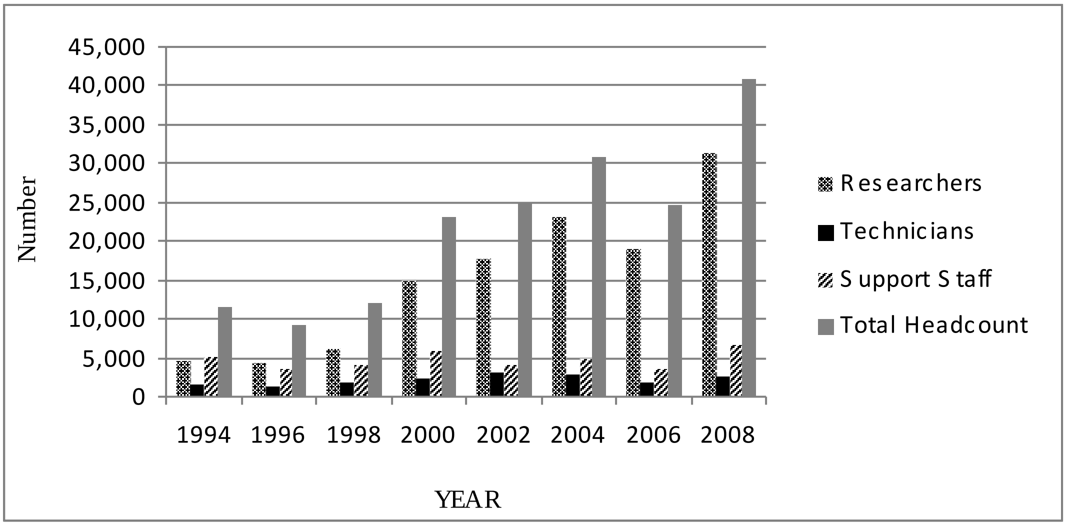

Fig. 2. Number of researchers involved in Malaysian R&D 1994-2008

Institutes of Higher Learning (IHL) in Malaysia had the best qualified researchers, with PhD and Master qualifications (Figure 3), compared to Government Research Institutes (GRI) and the private sectors.

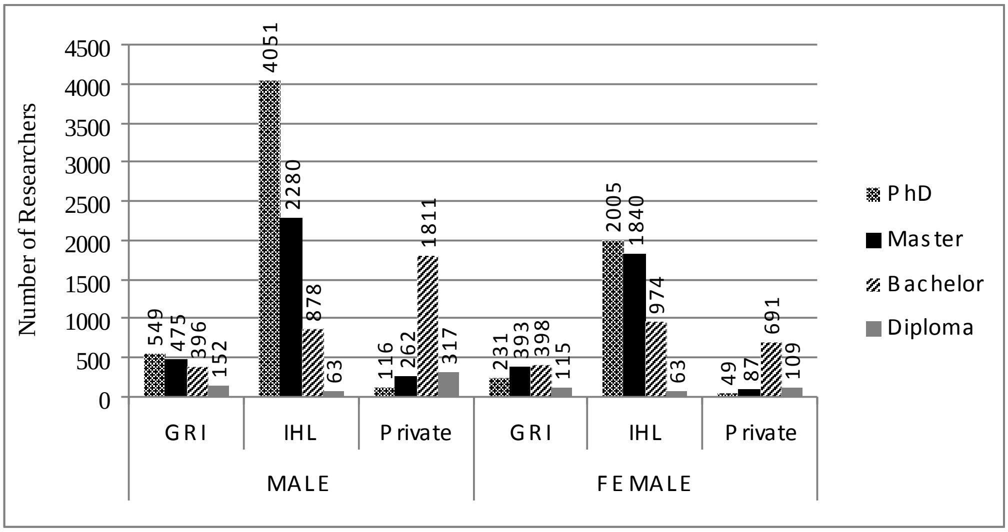

Fig. 3. Qualifications of researchers in GRI, IHL and the private sectors in Malaysia, 2008.

Source: National Survey of Research and Development 2008: Summary (MOSTI)

The implementation of the NSTP2 has aided a range of groups including public research institutes, institutions of higher learning, science and technology-based NGOs, industries especially Small and Medium Entrepreneurs (SMEs) , and science, technology and innovation agencies and communities. These groups benefited through the various initiatives and programs that were implemented by MOSTI including the enhancements of national capability and capacity for R&D, the forging of partnerships between public-funded research organizations and industries, the enhancement of commercialization of R&D outputs.

Presently MOSTI is working on the third National Science, Technology and Innovation Policy (NSTIP), which will come into effect from 2013 to aid the significant economic challenges that the country faces. The NSTIP will be aligned to support the New Economic Model in achieving the goals of a high-income economy, inclusiveness and sustainability by 2020.

R&D in Malaysia

R&D in Malaysia has been implemented using a centralized grant system set up by the government to finance S&T research in public institutions and research agencies since 1988. MOSTI has been given the task of managing this fund through various research funding schemes. The government has accorded high priority to R&D and the gross expenditure on R&D as proportion to GDP increased considerable (Figure 4). This is relatively high compared to countries in the region, except Singapore, but well below those of India, China and the developed countries like United States of America, Japan and Korea (Stads et al., 2005).

Malaysia’s R&D expenditures are generated through government budgetary sources and were generated through internal sources. In 2008, 66% of the total R&D expenditure came from business enterprise’s own funds (RM 4.3 billion - 70.3%). The government research institutes and institute of higher learning spent 29.5% of total research funds (Figure 5).

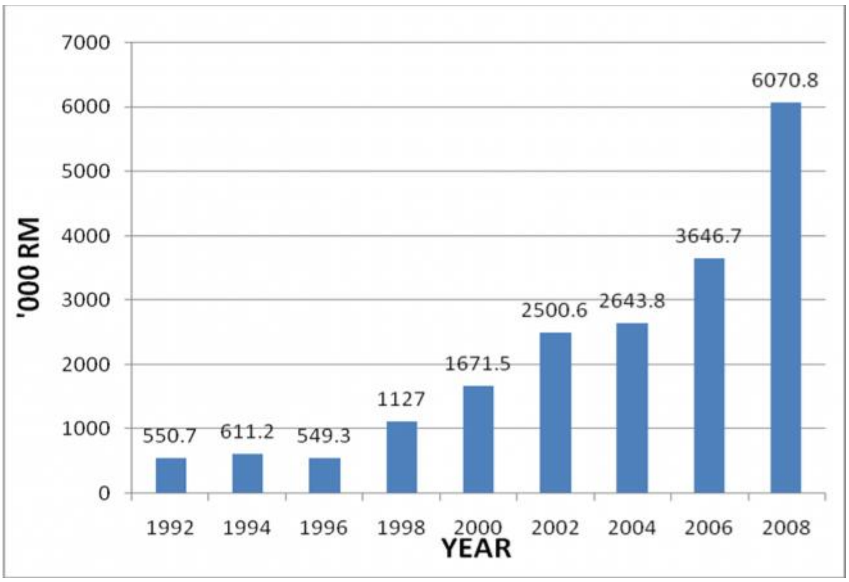

Fig. 4. Total R&D expenditure 1992-2008

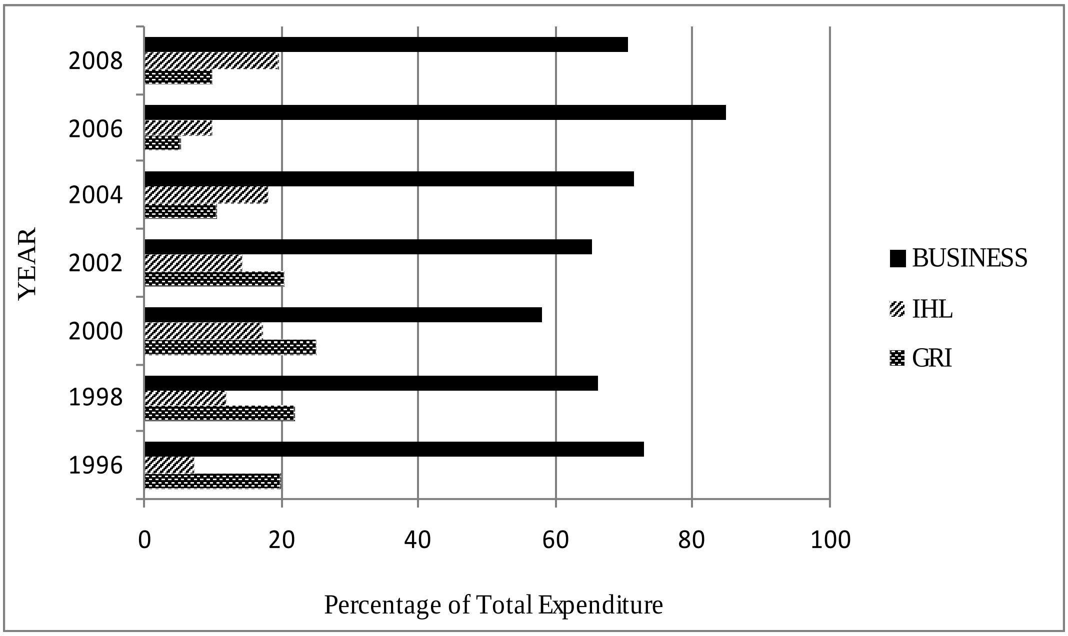

Fig. 5. R&D Expenditure by sector 1996-2008

National Research System

The Malaysian Research and Development Classification System (MRDCS) was first introduced in the 1992 National Survey of Research and Development. It was designed for classifying and describing research activities in Malaysia to the highest detail and accuracy. These classifications provide the basis for the measurement and analysis of R&D activities and statistics that are useful guidelines to the government policy makers, industrialists and researchers. It is also a useful indicator on the direction of R&D and technological change. The sixth edition of MRDCS outline the latest updates and address any technological gaps and barriers. The standard framework set up in these classifications support distinct and highly distinguishable R&D activities for ensuring efficiency and effectiveness in setting priorities, providing funds, maximizing national R&D efforts and also as indicators for international comparisons.

Research, development and technological innovations are essential in the government's strategy of sustainable development and knowledge based economy. The 9th Malaysia Plan which outline Malaysia's mission for the 2006-2010 and the country's vision 2020 defined the generation of new knowledge-intensive activities and employment in ICT and Biotechnology as well as raising the country's knowledge, creative and innovation capacities as the central national aims. One of the means for turning Malaysia into a developed country is through development of human capital of the highest quality.

In 1986, the government introduced a centralized Grant System for R&D. This "Intensification of Research in Priority Areas Programme (IRPA)" was established as a tool to select, prioritize and monitor the national R&D activities. The IRPA was enhanced with the establishment of two new schemes, namely the Science Fund and Techno Fund. The Science Fund support R&D projects within five specific research clusters – ICT, Biotechnology, Industry, Sea to Space and Science and Technology Core. While the Techno Fund funded research projects that are at the pre-commercialization and intellectual property acquisition stage.

Structure of Research System

The National Council on Scientific Research and Development (NCSRD) was established and function as advisory and coordinator of the national R&D. The R&D policy was then formulated by the Ministry of Science and Technology and Innovation (MOSTI), which acts as the secretariat to NSCRD. In December 2010, the Malaysian Cabinet approved the establishment of National Science Research Council (NSRC) to replace NSCRD. The new NSRC was mandated to ensure Malaysia's investment in science and technology make the greatest possible contribution to a high-value economy through an increase in productivity, environmental quality, stimulation in R&D and enhancement of skills of the workforce. Under the NSRC, 10 expert working groups (EWG) have been identified in various science based focus area. These EWG's are:

1. Environmental Sciences
2. Advanced Material Sciences
3. **Agricultural Sciences**
4. Life Sciences
5. Chemical Sciences
6. Mathematics & Physical Sciences
7. Computer Sciences and ICT
8. Health & Medical Sciences
9. Engineering Sciences
10. Humanities & Social Sciences

Research Funding in 10 Malaysia Plan (2011-2015)

As a nation that aspires to become a developed country, Malaysia nourishes its research culture. The public sector still contribute significant funding to agricultural research. The government ministries that are coordinating these research are:

1. Ministry of Science Technology and Innovation (MOSTI)

MOSTI has been provided funds to finance research under the following grants:

a. **Science Fund**: Grant provided by Government to carry out R&D projects that can contribute to the discovery of new ideas and the advancement of knowledge in applied sciences, focusing on high impact and innovative research. The objectives are:

i. to support research that can lead to the innovation of products or processes for further development and commercialization and/or;
ii. to generate new scientific knowledge and strengthen national research capacity and capability.

ScienceFund covers preliminary research leading to laboratory proof of concept or towards the development of new products or processes. The quantum of fund approved will be determined based on the merit of each application. Maximum quantum given is RM500,000 for a duration of 30 months. It's research priority areas are include: Life Sciences, Computer Sciences and Information & Communication Technology (ICT), Agriculture Sciences/Agricultural Engineering, Environmental Sciences, Advanced Materials Science Chemical Sciences , Physical and Mathematical Sciences, Engineering, Medical and Health Sciences , Social Sciences and Humanities

b. **TECHNOFUND** (Pre-commercialization Fund): TechnoFund is a grant scheme which aims to stimulate the growth and successful innovation of Malaysian enterprises by increasing the level of R&D and its commercialization. The scheme provides funding for technology development, up to pre-commercialization stage, with the commercial potential to create new businesses and generate economic wealth for the nation.

The objectives of TechnoFund are:

- to undertake the development of new or cutting edge technologies or further develop/value add existing technologies/products in specific areas (Section 7) for the creation of new businesses and generation of economic wealth for Malaysia;
- to undertake market driven R&D towards commercialisation of R&D outputs;
- to encourage institutions, local companies and inventors to capitalise their intellectual work through intellectual property (IP) registration; and
- to stimulate the growth and increase capability and capacity of Malaysian technology-based enterprises, Malaysian Government Research Institutes (GRI) and Institutions of Higher Learning (IHL) through both local and international collaborations.
-

The quantum of funding is between RM 1.5-3.0 million for up to 30 months. The same priority areas of research is maintained. Eligible applicants can be researchers and other individuals from:

- Small and Medium Enterprises;
- Institutions of Higher Learning;
- Research Institutes; and
- Science, Technology and Innovation (STI) Agencies.

c. **INNOFUND** (Pre-commercialization Fund): Innovation contributes to productivity, economic growth and societal wellness. It can be the recombination, fusion or integration of technologies that lead to new products, processes or services or the refinement of existing technologies with improved value enhanced efficiency or cost reduction. The final result of innovation is new products, processes or systems by which value can be created for customers, businesses and society. Realizing the importance of innovation for wealth creation and social well-being, the Government initiated the Innovation Fund.

The objectives of Innofund are:

a. Enterprise Innovation Fund (EIF)
-The Enterprise Innovation Fund is to increase the participation of micro-businesses, individuals in innovative activities and encourage technological innovation of new or existing products, process or services for commercialisation.

b. Community Innovation Fund (CIF)
-The Community Innovation Fund is to assist community groups in translating knowledge and ideas into products, processes or services that improve the socio-economic standing and quality of life of the community.

2. Ministry of Higher Education (MOHE)

Under the 10th Malaysia Plan and in line with strengthening research and innovation, the Ministry of Higher Education has been allocated research funding of RM741 million for the years 2011 and 2012. This is intended to finance five (5) research programs as shown in Table 2.

a. Fundamental Research Grant Scheme (FRGS):

FRGS promotes research involved in early discovery of knowledge that can contribute to the increased level of intellectuality, the creation of new technologies.

Exploratory research is research which has one of the following characteristics:

- Preliminary work on untested and novel ideas
- Ventures into emerging and potentially transformative research ideas
- Application of new expertise or new approaches to "established" research topic.
- Having severe urgency with regards to availability of, or access to data, facilities or specialized equipment, including quick-response research on natural or anthropogenic disasters and similar unanticipated event.
- Efforts of similar character likely to catalyze rapid and innovative advances.

Research funded by FRGS is for a duration of 3 years with maximum funding of RM 250,000

Table 2. 10MP MOHE Research Grant

No.	Scheme	2011	2012	Allocation (2011-2012)
1	Fundamental Research Grant Scheme (FRGS)	81,000,000	219,000,000	RM 300,000,000
2	a. Exploratory research Grant Scheme (ERGS)	25,000,000	68,000,000	RM 93,000,000
	b. Long Term Research Grant Scheme (LRGS)	45,000,000	121,000,000	RM166,000,000
	c. Prototype Research Grant Scheme (PRGS)	11,000,000	30,000,000	RM41,000,000
3	Research Incentive	11,000,000	30,000,000	RM 41,000,000
4	MOHE Special Project	27,000,000	73,000,000	RM 100,000,000
	TOTAL	200,000,000	541,000,000	RM 741,000,000

b. Exploratory Research Grant Scheme (ERGS):

The ERGS covers basic areas that can support the country's strategic agenda. The areas identified are:

1. Pure and Applied Sciences
2. Technology and Engineering
3. Clinical and Health Sciences
4. Social Sciences
5. Arts and Applied Arts
6. Natural Sciences and National Heritage
7. Defense and Security

c. Long Term Research Grant Scheme (LRGS) include:

- fundamental research that need more than 3 years
- must be Multi-Institutional and Multi-Disciplinary
- problem-based research, inter-discipline, inter-institution
- programme/cluster-based
- Duration 3-5 years (at least 3 years)
- Ceiling fund of RM3million/project

There are two types of LRGS projects:

(i) top-down (programme leaders only from RUs, members from other IPT can be project leaders within the programme)
(ii) bottom-up (leaders can be from other IPTs)

d. Prototype Research Grant Scheme (PRGS)

PRGS finance the pre-commercialization
- Duration ± 1-2 years
- Ceiling fund - RM500k /project

3. Research University Grant Scheme

The five leading Research Universities are also allocated large sums of money by the Ministry of Higher Education since 2007. As an example, UPM has financed a large number of projects under this funding (Fig. 6).

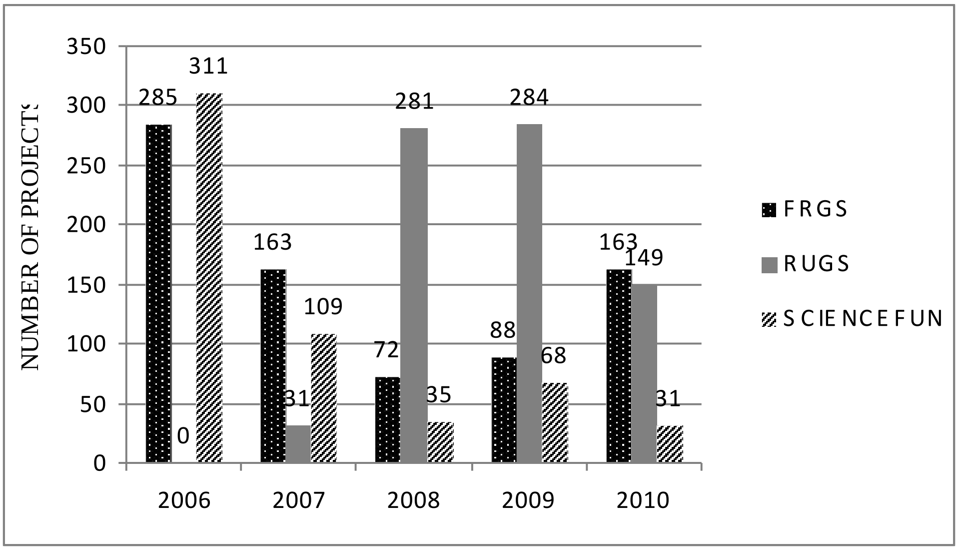

Fig. 6. Number of projects financed by three main government funds at UPM 2006-2010.

Agricultural R&D

Agriculture's contribution to Malaysia's economy has significantly declined over the years, but the government continues to regards the sector as strategically important. Thus Malaysia has been categorized to be at the advanced stage of economic transformation (Raitzer, et al., 2009). The production of sufficient food for the population featured prominently in the First National Agricultural Policy (NAP1) – 1984-1991 and subsequently in the Third National Agricultural Policy (NAP3) – 1998-2010. The NAP1 aimed at achieving at least 80 percent self-sufficiency level (SSL) for major food items. However, the SSL of rice, the staple food for the country, decreased from 91 percent in 1972 to 72 percent in 2005 (Pazim@Fadzim, 2005), mainly due to the increase in population and reduction in agricultural areas due to changes to non-agricultural uses over the same period. In view of these, the NAP3 again aims at increasing domestic food production and sourcing of food strategically to ensure adequate supply of and accessibility to safe, nutritious and high quality food at affordable prices (Govt. of Malaysia, 2000).

Table 3: Economic sectors contribution to Malaysia's GDP

Sectors	2000*	2015**
Services	58.5	61.1
Agriculture	7.6	6.6
Mining	7.9	5.9
Manufacturing	26.2	26.3
Construction	3.2	2.9

*2009/2010 Economic report (MOF); **MP10 Report (EPU)

The Malaysian agricultural sector can be grouped into three sub-sectors, namely:

1. The agro-industrial subsector: comprise of oil palm, rubber, cocoa and timber industries. They mainly serve the export market.
2. The food sub-sector which include rice, fruits and vegetables, livestock and fisheries, which serves the domestic consumption.
3. The miscellaneous group that include pepper, coconuts, sweet potato, cassava and tea, which cater to both domestic and export market.

Agricultural R&D only became an established component of the national development plan from Malaysia's fifth development plan (1986-1990) and agricultural research and technological improvements are and still will continue to be a prerequisite for increasing productivity and income of farmers. Currently there are more than 40 agencies that are involved in agricultural research in Malaysia, including Research Universities and private sectors laboratories. Agriculture research activities has been prioritized along commodity lines, where the five export commodities, vis, oil palm, rubber, cocoa, timber, and kenaf and tobacco have their own board to plan, execute and monitor the research of each of the commodities.

There are about 20 Public Universities and 20 Private Universities that are conducting research in science and technology. The national survey on R&D in 2008 (Anon, 2012) revealed that research in agricultural science as one of the three main field of research (FOR) and constitute 5.8%, with one of the three main socio-economic objectives (SEO) being plant products and plant primary products at 6.1%. R&D in government agencies and research institutions (GRI) which are mainly focused on agricultural research had a total expenditure of RM 603.1 million in 2008, which is a significant increase from 2004 (RM 296.9 million) and 2006 (RM 189.5 million). The main field of research (FOR) conducted were Agricultural Research, ICT and Biotechnology in 2008, while in 2006, the FOR conducted were agricultural science, forestry sciences, sciences, engineering science and biotechnology. The total headcount of R&D personnel was 5,899 constituting of 3,650 researchers and 2,249 technicians and support staffs.

The survey also showed that Institutions of higher learning (IHL) and business enterprise did not spend their research funds on agriculture as one of their three main FOR (Anon, 2012).

In the 10th Malaysia Plan, the National Key Economic Areas (NKEA) identified Malaysian herbs as one of the potential driver of economic activities. Herbal products has been listed as one of the entry point project (EPP) under this NKEA. The Ministry of Agriculture (MOA), established a special division, the Herbal Development Office to lead this group of increasing Malaysia's potential for herbal products. One of the main objectives set out in 2011 was to enhance R&D in herbs and to secure intellectual property right on local herbs. A total of RM2.1 billion has been allocated in the 10MP to do research on local herbs.

The five herbs identified to have potentials were:

1. Tongkat ali (*Eurycoma longifolia* Jack)
2. Kacip Fatimah (*Labisia pumila*)
3. Misai Kuching (*Orthosiphon stamineus* Benth)
4. Dukung Anak (*Phyllanthus amarus, P. niruri, P. urinaria* and *P. debelis*)
5. Hempedu Bumi (*Andrographis paniculata*)

In addition, funds are also provided by the government in the biotechnology sector. The areas of research conducted by the Malaysian Genome Institute (MGI) from 2006 – 2011 includes:

- Comparative Genomics and Genetics
- Genomics and Genetics
- Recombinant Expression Systems
- Metabolic Engineering
- Bioinformatics

A total of 25 projects were carried out by GRIs and IHL in collaboration with internal as well as external agencies (universities and private agencies).

CONCLUSION

Malaysia has been transformed from a country dependent on the production and export of primary commodities to an emerging multi-sector economy and a leading exporter of high technology products. Its growth currently is driven by services and manufacturing sector. The agriculture sub-sector is the 3rd contributor to its economic growth particularly in the palm oil and palm oil based products.

Agricultural research is funded mainly by the government especially to GRI and IHL. Private sector involvement is mainly in the plantation crop sector such as oil palm, and rubber. The food crop research is mainly undertaken by GRI. The agricultural biotechnology is currently in the advancement stage.

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DEVELOPING A BIOECONOMY IN THAILAND

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ABSTRACT

With a growing world population, we face a range of challenges including environmental and socio-economic problems, and energy instability over the next decades. The worldwide demands for increased healthcare and more agricultural products such as food and animal feed, bioindustry and bioenergy are increasing in many countries, including Thailand. The increasing demands are the major economic driving force behind developing a large and rapidly growing segment of the world bioeconomy. The bio-based or bio-economy is based on the economic activities fueled by sustainable production and conversion of renewable biomass for a range of food, health, industrial and energy products. The research and innovation in the biological sciences are powerful tools playing an important role in overcoming those challenges to create public benefits and well-being. Investment and bioeconomic policy emphasize increasing food and energy security, reducing green house gas emission, and growing new jobs and industries.

Currently, the bioeconomy growth faces various challenges. The increasing demands for food, fuels and biomaterials in the context of an expanding human population result in the food versus non-food debates and the biomass feedstock competition between energy and materials that still needs to be fixed. GMOs technologies applied in economic crops worldwide have met strong opposition from national policy and consumers. The development of innovation bio-based products is the research and development intensive, resulting in increasing production cost. If Thailand has still a very low spending on research and development ($\leq$0.24% of GDP), this would be a big challenge for developing novel bio-based products and the initial construction of biorefinery pilot plants. Strategic objectives for a bioeconomy with the potential to facilitate economic growth and meet societal needs includes 1) support R&D investment providing the foundation for the future bioeconomy development, 2) develop and improve regulatory processes and regulations, 3) improve incentive measures for investment, 4) develop infrastructure systems and support instruments, 5) develop a Qualified Human Resource System in fields related to biotechnology.

With its new strategy for 2021, the Royal Thai Government has created a framework through which to accomplish the purposeful series of goals including economic, social and environmental by the end of this decade. Thailand has made positive progress over the past few years in the different domains of the bioeconomy, both in terms of research and supportive policy development. Over the next 10 years, we can expect to see a shift in practice from a sectoral approach towards a more integrated approach to the bioeconomy growth with large public benefits. Therefore, there must be consistency across policies and product sectors, combined with the political momentum to ensure that this goal is placed in the top priority of the national development plan. The potential benefits for the economy, the environment and society as a whole will be achieved through collaboration of all stakeholders to make the Thai bioeconomy a reality.

Keywords: bioeconomy, sustainable development, bioenergy, biobased products

INTRODUCTION OF BIOECONOMY DEVELOPMENT

With an increasing global population moving towards 9 billion by 2050 (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2009), the world is facing a number of social, economy, and environmental crises. More natural resources were consumed and rapidly depleted, especially depleting fossil resources. As a result, this has accelerated the increasing environmental pressures and climate change caused by high greenhouse gas (GHG) emissions. In 1970-2004, greenhouse gas emission increased about 70% (Langeveld et al., 2010). In addition, the needs for increased health services and more resources currently have occurred worldwide including food and animal feed, fibers for clothing, and housing, sources of energy, and chemical for manufacturing. With a dependence on biorenewable resources, the bio-based or bio-economy has been accepted that could offer a unique opportunity to address those complicated crises and to meet the basic needs of life (i.e. food, clothing, shelter, and medical care etc.). So far, mechanisms and processes at the genetic and molecular levels and its application to industrial process have considerably understood and made major socioeconomic contributions in countries. The set of economic activities derived from a number of biological sciences and biotechnological research refer to as bioeconomy. A number of advanced biotechnology (i.e. systems biology, genomics, proteomics, DNA technology, synthetic biology, cell factory, and DNA chip) are playing a key role in developing agriculture, health, chemical, and bioenergy industries. These advanced technologies add value to a host of biobased products and services, boosting the productivity of agricultural products and then agribusiness, and enhancing environmental sustainability (OECD, 2012). Therefore, IEA (2004) reported that the bioeconomy would be able to considerably contribute to reduce greenhouse gas emissions, raise energy supply and reduce dependence on foreign petroleum source, enhance rural development, and protect of ecosystem services and improve environmental concerns. The bioeconomy growth can provide diverse pathways towards the achievement of these goals. The advancement of research and development in biological technologies offers the potential to accelerate its transition to a more sustainable growth model while making Thailand competitive in the future bioeconomy capable of creating new jobs, in rural as well as urban environments.

KEY AGICULTURAL PRODUCTS FOR A BIOECONOMY IN THAILAND

Thailand is one of the world's major agricultural countries with 24.4 million hectares of farm land (Office of Agricultural Economics [OAE], 2012). Agricultural products were accounted for 11.7% of exports and generated nearly US$4.5 billion of Thailand's agricultural trade surplus (OAE, 2011). The major crops (the top export commodity) of Thailand include rice, para rubber, cassava, oil palm, sugarcane and corn. The value of exports are 6.53, 22.631, 2.1, 0.54, 3.6, and 0.1 billion US dollars respectively (OAE, 2010). In addition to conventional agricultural products as food and feed, biobased products derived from biomass have played an important role in the emerging bioeconomy in the near future (Van Haveren et al., 2007). The biobased product is made from biological materials in whole or in some important part derived from living organisms. They include high-value added fine chemicals (e.g. pharmaceuticals, cosmetics, food additives, and vaccines etc.) to high volume materials (e.g. enzymes, biopolymers, biofuels, fibers etc.) (Langeveld et al., 2010).

Of biobased products, biomaterials and biofuels are significant products that are receiving more attention and agree with Thailand's National Biotechnology Policy (National Center for Genetic Engineering and Biotechnology [BIOTEC], 2005).

A. Biomaterials in Thailand

The potential biomaterials receiving more attention include pharmaceuticals, chemicals, biopolymers and fibers (Thoen and Bush, 2006). A bioplastic, a prospective biomaterial made from cassava could be used for a number of industrial processes in Thailand. As industrial raw materials, converting cassava roots into secondary products in particular biobased materials (polylactic acid, PLA) has been estimated that it can add about 150% of the value (USD 2,533 million) (Fig. 1). In addition to PLA, other biomaterials including polyhydroxyalkanoate (PHA) and starch plastic (KU-Green) made from cassava starch (Sudarat et al., 2006) will compete with fossil polymer (PET) in the future.

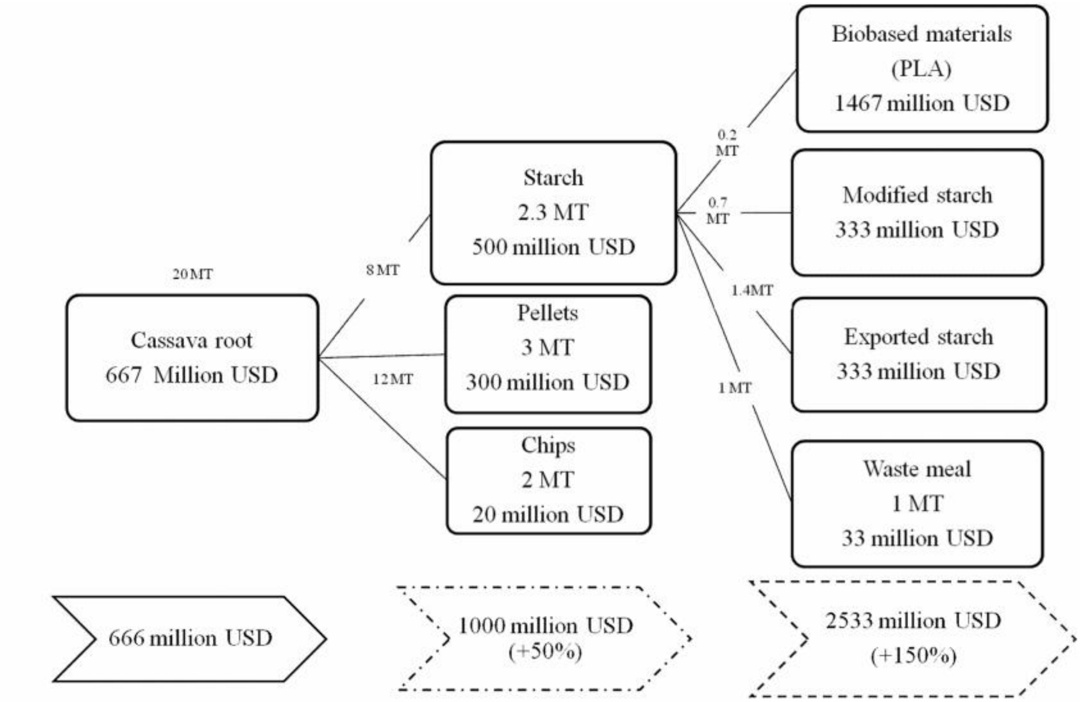

Fig. 1. Cassava value chain in Thailand.

Source: modified from National Innovation Agency [NIA] (2008)

B. Bioenergy in Thailand

In Thailand, the potential of cereal biorefinery for bioenergy production is restricted by the government perceptions of cereals as food and feed. Sugarcane and cassava are major crops used for bioethanol production. As the largest producer in South-East Asia, Thailand allocated around 1.28 million hectares of farm land for sugarcane with about 98 million tons of yield in 2012 (OAE, 2012). The production of sugarcane was 28% higher than that in 2010. This is likely due to a sugarcane development plan for ethanol production devised by government. With the low costs and energy used for producing the crop, cassava is accepted as one of the highest potential raw materials for bioethanol production (Silalertruksa and Shabbir, 2009). Thailand, the world's third largest grower of cassava, allocated around 1.2 million hectares for cassava cultivation with around 22 million tons of yield in 2011 (OAE, 2011). Whereas sugarcane and cassava are grown as main raw materials for bioethanol production in Thailand, many types of lignocellulosic biomass is currently receiving more attention. Lignocellulosic biomass available and used potentially include rice husk, straw, bagasse, cassava pulp, corncob and corn leaf, oil-palm fruit brunch, shell and fiber, as well as wood chip. The surplus biomass can potentially be produced to 11,938.67 ktoe of energy annually (Table 1).

Oil palm is the major crop used for biodiesel production due to low cost and energy requirements. Ministry of Agriculture has formulated a development plan to increase the production of palm oil to meet increasing demands by 2011. The plan called for the adoption of strategies including genetic improvement, better practice management, and also allocating more lands for oil palm plantation (Pleanjai and Gheewala, 2009). As a result, the palm oil production was increased from 8.2 million tons in 2009 to 10.7 million tons in 2011. Moreover, other raw materials (such as used cooking oil; and oils extracted from castor, sunflower, and jatropha) have accepted as potential candidates for biodiesel production in Thailand (Surin et al., 2007).

Table 1 The potential of biomass feedstock in Thailand in 2009.

Species	**Yield** (MT)	**Biomass**	**Biomass availability** (MT)	**Heat value** (MJ/kg)	**Energy potential** (TJ)	(ktoe)
Sugarcane	66,816,446	Bagasse	4,190,794	14.40	60,347.44	1,428.54
		Shoot and leaves	13,439,727	17.39	233,716.86	5,532.52
Rice	31,508,364	Husk	3,510,598	14.27	50,096	1,185
		Straw	25,646,547	10.24	262,620	6,216
Corn	4,616,119	Cob	584,539	18.04	10,545	249
		Stem and leaves	2,758,777	18.04	49,768	1,178
Oil palm	8,162,379	Empty bunch	1,024,868	17.86	18,304	433
		Fiber	162,970	17.62	2,871	67
		Shell	38,959	18.46	719	17
		Leaf stalk	2,203,740	9.83	21,824	516
Cassava	30,088,025	Stem	2,439,236	18.42	44,930	1,063
		Rhizome	1,834,466	18.42	33,790	799
Coconut	1,380,980	Leaf stalk	628990	15.40	9686	229
		Fiber	464250	16.23	7534	178
		Shell	128936	17.93	2311	54
Para rubber	3,090,280	Branch/stem	312,118	14.98	4,675	110
Total	145,853,073		59,539,905		504,339	11,938.67

Source: modified from Department of Alternative Energy Development and Efficiency (2009)

PERSPECTIVES ON BIOECONOMY DEVELOPMENT

For the bioeconomy's success, various challenges must be addressed thought coordinated policy action by governments. Recently, The White House in the U.S. has released a National Bioeconomy Blueprint called as a comprehensive approach to harnessing innovations in biological research. The goals are to address national challenges in health care, food, energy, and the environment (The White House, 2012). In Europe, the EU commission has proposed strategies to shift the EU economy towards a bioeconomy for sustainable growth with a more innovative and low CO_2 emission (Clever Consult BVBA, 2010).

For Thailand, it is the fact that there is a biodiversity, an abundance of biomass feedstocks accounting for 145,853,073 MT/yr, approximately. Most biomass are crop residues derived from starch crops (such as sugarcane, rice, cassava and corn), oil crops (such as mainly oil palm and coconut) and trees (such as para rubber) (Table 1). In addition, Thailand has the capacity to develop significantly a new innovative technology relating to biological science supported by the National

Economic and Social Development Board (NESDB), the National Science and Technology Development Agency (NSTDA) and other relevant agencies. Yearly, the major export commodities of Thailand are produced from farm households. As a result, the Royal Thai government has foreseen the potential of bioeconomy towards the development of country.

GOALS OF BIOECONOMY DEVELOPMENT IN THAILAND

For bioeconomy development, Thailand's National Biotechnology Policy Framework (Phase I: between 2004 and 2011 and Phase II: between 2012 and 2021) has set up by the National Economic and Social Development Board (NESDB), in collaboration with the National Center for Genetic Engineering and Biotechnology (BIOTEC), and the National Science and Technology Development Agency (NSTDA) (National Center for Genetic Engineering and Biotechnology, 2005). The frameworks are to encourage in developing biobusiness and investment in biotechnology research.

There are key six goals of the framework as following:

1. "Emergence and Development of New Bio-Business"
2. "Biotechnology Promotes Thailand as Kitchen of the World"
3. "Thailand Represents Healthy Community and Healthcare Center of Asia"
4. "Utilization of Biotechnology to Conserve the Environment and to Produce Clean Energy"
5. "Biotechnology as the Key Factor for Self-Sufficient Economy"
6. "Development of Qualified Human Resource System"

NATIONAL STRATEGIES FOR BIOECONOMY DEVELOPMENT

To generate economic growth and meet the goals, summarized below are the strategic objectives and the next steps helping realize the full potential of the Thai bioeconomy. In 2007, Thai government granted USD 120 million for investing in biotechnology research and development (Fig. 2). The research funding was allocated to public research centers (46%), academic institution (39%), and private sectors (15%). National Research Centers of Thailand primarily encouraged the research in fields of genetic engineering and biotechnology, medical development, science and technology development, agro-industrial products improvement, rice science, etc.

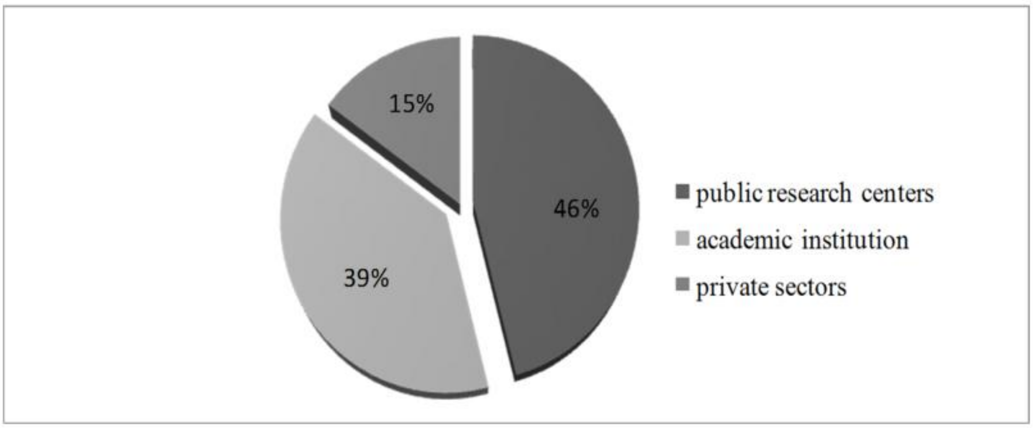

Fig. 2. The distribution of research and development (R&D) funding in biotechnology in Thailand by sectors.

Source: modified from BIOTEC (2005)

A. Develop and improve regulatory processes and regulations

The regulatory processes and regulations were improved to create an environment and incentives for venture capital to be invested in bio-business. For example, agencies prepared and utilized scientific data from research in decision-making, laying down key measures, and negotiating or solving trade barrier problems. Developing a clear policy on genetic engineering, genetically modified organisms and transgenics in Thailand is essential.

B. Improve incentive measures for investment

Measures that have been carried out include taxation privileges, in particular import duties, such as instruments and research investment; supporting the listing of biotechnology companies on the Stock Exchange of Thailand (SET), and making use of Asean Economic Community (AEC) and Asia Cooperation Dialogue (ACD) to attack investment and expand Thailand's markets.

C. Develop infrastructure systems and support instruments

Government developed infrastructures such as a biotechnology and science parks to persuade investment, and using services in research and development. Biotechnology laboratories were set up to certify quality and standard for export products, and inspection of imported products. Establishing Science Park (TSP) in academic institutions across Thailand provided both government and the private sector with facilities such as a laboratory, pilot plant, conference center, and human resources. Agencies established for technology support and management include Industrial technology assistance program (iTAP), Technology Licensing Office (TLO), and National Innovation Agency (NIA). Financial support has been provided by Company Directed Technology Development Program (CD) and National Science and Technology Development Agency (NSTDA) and National Investment Center (NIC).

For example, Chem-Creation Co., Ltd. with laminate-digested enzyme production supported by TSP won the Gold medal award in Environmental session in ITEX 2009, Malaysia (Janwarasuth and Meerod, 2012).

D. Develop a Qualified Human Resource System in fields related to biotechnology

Ministry of Science and NSTDA provided the financial support for students and researchers from both public and private sectors including grants for research project, attending academic conferences, and co-investment etc.

Government formulated the human resource development program to achieve the entire goal mentioned above. Key strategies included the following:

- at least 5,000 personnel to engage as professional biotechnology researchers in the public and private sector,
- at least 500 personnel engaged in biotechnology management
- at least 10,000 students with bachelor's, master's, and doctoral degrees in the fields of modern biological science
- persuade foreign experts in biotech to conduct research and development in Thailand in areas where the country lacks
- create on-the-job training to provide a skilled workforce for the private sectors via cooperation among research institutes, and universities

For example: (Janwarasuth and Meerod, 2012):

- NSTDA provided 8 months of training programs for new biotech companies on entrepreneurship, management, law, technology, and negotiations.
- King Mongkut's university in Thailand offered the workshop on “Problem-Based Learning in Biogas Plant Operation” supported financially by National Center for Genetic Engineering and Biotechnology and NSTDA.
- NSTDA’s Investor Day was a fast track for the private sector to access and adopt the innovation and technology of NSTDA.

ECONOMIC IMPACT OF THE NATIONAL BIOTECHNOLOGY POLICY FRAME WORK (2004-2009)

1. Investment in biological and biotechnology research and development were increased through emergence of new bio-business at different levels, both locally and from abroad. New companies in agribusiness increased from 60 companies in 2002 to 180 companies in 2009 (Fig. 3), approximately. In 2009, agribusiness generated a total revenue of more than USD 1.3 billion including agricultural and food sector (USD 261 million), healthcare and medical sector (USD 834 million), and biotech service (USD 227 million) (Table 2).

2. The value of biomedical products and healthcare in 2009 increased at about USD 520 million higher than that in 2002 (such as diagnostic kits, medical supplies, cosmetics and pharmaceuticals etc.).

3. The economic loss from the major diseases severely affecting Thai people was reduced about 1.1 billion USD.

4. The USD 733 million of energy worth per year was saved using bioenergy from biomass and farm waste.

5. The revenue of local communities at least USD 166 million was increased from selling of their agricultural products.

6. The increased economic competitiveness resulted from developing new advanced biotechnology led to selected products in a sustainable manner.

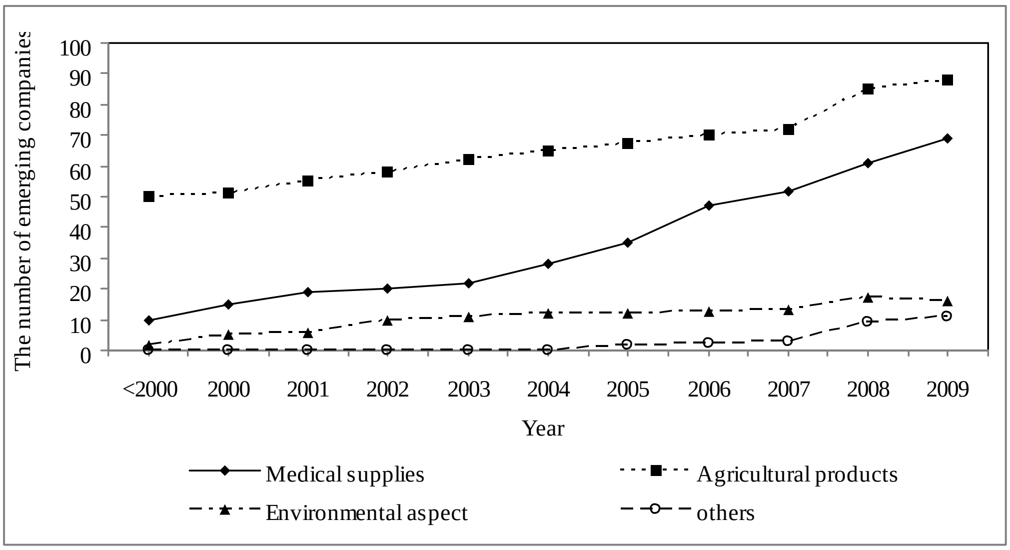

Fig. 3. The emergence of new companies in agribusiness across years in Thailand
Source: modified from Meerod and Janwarasuth (2012)

Table 2. The total revenue of agribusiness in Thailand in 2009.

In 2009	**Million US dollars**
1. Agricultural and food sector	
- Seed production	117
- Vaccines for animals	77
- Animal feed supplements	67
2. Health care and medical sector	
- New medicines	667
- Food supplements	167
3. Biotech service business	
- Medical diagnostic kits	110
- Molecular-level detection/analysis for medical care	117

Source: modified from Meerod and Janwarasuth (2012)

MAIN CHALLENGES AND NEEDS FOR BIOECONOMY DEVELOPMENT IN THAILAND TOWARDS 2021

Over the next 10 years, a decrease in the low-cost supply of petroleum resulting in an increase in the cost of fossil resources, as well as higher demand for energy, and chemicals coupled with restriction on greenhouse gas emission could offer a growing market for biobased products including biofuels, chemicals and plastics. In addition, with higher advanced biotechnology, both food and non-food crops would be significantly used to produce valuable biomaterials such as cosmetics, food additives, and vaccines etc. However, in order to meet these future goals, there would be many key challenges to address as following:

A. Competitive Cost of Materials

The question of food versus non-food crops for industry must be answered. The needs for food and feed will be raised with an increasing world population in the next 10 years. The abandoned or degraded lands on where food crops can not be grown would be more used for biomass crops without any impact on the food supply. Additionally, incentives and high subsidies for energy crops would increase land prices making other biomaterials unattractive. With growing new biobusiness, the feedstock shortages might occur. Therefore, the National's Development Framework is needed to improve the financial support and other incentives for both energy and biomaterial use to balance the feedstock production for the growing bioeconomy.

B. Clear Protocol Required

Advanced biotechnologies are key factors for the optimization of biomass feedstock to supply the future demands in bioeconomy. Some advanced biotechnologies are, however, controversial, especially GM crops, for example. Although many countries have adopted this technology, the public acceptability of this technique in crops and livestocks has not been clarified in Thailand. GM products still await authorization and approval for bio-industry.

C. More Public Funding for R&D

Investments in research and development in area of industrial biotechnology for innovative biobased products is a key challenge. For Thailand, gross domestic expenditure on R&D as a percentage of GDP was low (not exceed 0.24% of GDP). In 2009, Thailand GDP was about USD 253.45 billion devoting to R&D activities only USD 716 million, approximately (UNESCO Institute for Statistics, 2010). Therefore, such a serious mismatch between the investments in industrial biotechnology R&D and the potential biobusiness opportunities for growing bioeconomy in the future is still a key challenge.

D. Preservation and Restoration of Ecosystem

To overcome the challenges in the increased living needs with growing global population, the total amount of agricultural output will have inevitably to double over the next 10 years. This can negatively affect ecosystem stability. Agricultural activities contribute to GHG emissions, including CO_2 and other green house gases (such as methane and nitrous oxide etc.). A wide range of technologies including improved farming practices (agricultural input uses, carbon sequestration, soil and water conservation, farm waste management etc.) should be developed and provided enough financial support for R&D programs. For sustainable development, the advanced technologies need to be integrated with socio-economic aspects on how to introduce new technologies to help local farming communities without negative impact on ecosystem services. Moreover, the revision of the Policies is needed to stimulate innovation in bio-industries, and at the same time, address the environmental concerns.

E. Reform and Update Training Programs to Improve Workforce Skills Needed

Updating training programs and improving academic institution incentives with student training for bioconomy is still required for the next 10 years. The success of bioeconomy development relies on the education and skills of workforces in term of an interdisciplinary program. A gap in education, biological sciences, biotechnology, and chemistry currently exists among bioeconomy workforces. Additionally, there is a lack of awareness of bioeconomy potential both among policy makers, consumers and even the manufacturing industry. Communication and stakeholder involvement remains a big challenge of the long-term development.

Therefore, over the next 10 years we can expect to see a shift in practice from a sectoral approach towards a more integrated approach to the bioeconomy growth with big public benefits. There must be consistency across policies and product sectors, combined with the political momentum to ensure that this goal is placed in the top priority of the national development plan. The potential benefits for the economy, the environment and society as a whole will be achieved through collaboration of all stakeholders to make the Thai bioeconomy a reality.

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THE APPLICATION OF SSR MOLECULAR INDICATOR TO ASSESS THE PURITY AND GENETIC DIVERSITY OF WAXY CORN INBRED LINES

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ABSTRACT

The analysis of 22 waxy corn inbred lines indicated that there were four lines having high homozygous rate: Waxy4, Waxy 9, Waxy16, Waxy 17 (under 7% of heterozygous rate) and 5 lines showed high heterozygous proportion (above 20%): Waxy 12, Waxy 14, Waxy18, Waxy 21, Waxy 22. The SSR primer system used in the experiments is relatively polymorphic with average value of PIC of 0.46. Classifying these lines into groups of heterosis by UPGMA method reveals that at genetic similarity coefficient of 0.38 the experimented lines were divided into six groups, including Group I: Waxy 10, group II: Waxy 16; Group III: Waxy 3, Waxy 5, Waxy 22, Waxy 21, Waxy 8, Waxy 9, Waxy 12, Waxy 18; Group IV: Waxy 2, Waxy 15, Waxy 20 , Waxy 17; Group V: Waxy 4, Waxy 6, Waxy 7, Waxy 11 and Group VI: Waxy 1, Waxy 14, and Waxy 19.

Key words: genetic distance, genetic similarity coefficient, heterosis, polymorphic, pedigree diagram

INTRODUCTION

Hybrid corn with high yield, high quality and interesting characteristics is dominating corn production all over the world. Single hybrid corn is created by the combination between two pure lines which have high combination ability. Therefore, the assessment of the purity and the combination in corn lines plays an important role in breeding hybrid corn. Traditional methods are used to evaluate the combination ability such as: top-cross, reciprocal cross that are based on the observation of morphological characteristics, require so much time and labor.

To quickly shorten the process of evaluation of the purity and the combination ability instead of using traditional methods, DNA molecular indicator is applied in molecular breeding to help breeders achieve many successes. Many techniques have been developed in molecular breeding such as: restriction fragment length polymorphisms (RFLP) (Botstein *et al.*, 1980), random amplified polymorphic DNAs (RAPD) (Williams *et al.*, 1990), amplified fragment length polymorphisms (AFLP) (Vos et al., 1995) and simple sequence repeats (SSR, microsatellites) (Tautz, 1989).

In a comparison of RFLP and SSR techniques, Smith and co-workers. (1997) stated that SSR markers offer advantages of reliability, reproducibility, discrimination, standardization, and cost effectiveness over RFLP and that SSRs represent the optimum approach for the identification and pedigree validation of maize genotypes. Using RFLP, RAPD, SSR and AFLP techniques on maize Pejic et al. (1998) supposed that both the SSR and AFLP technologies can replace RFLP. Garcia et al. (2004) suggested AFLP markers are the best choice evaluation of diversity and assessing the relationships between tropical maize inbred lines.

The study sought to evaluate purity, genetic diversity of 22 waxy corn inbred lines and to classify them into groups by applying SSR molecular indicator.

MATERIALS AND METHODS

Twenty two waxy corn inbred lines that was collected by research group of Hanoi University of Agriculture:

No.	Name of line	Abbreviation	Code	Generations of breeding
1	Waxy 1	W1	CLT-N27	10
2	Waxy 2	W2	CLT-N8	10
3	Waxy 3	W3	CLT-N1	10
4	Waxy 4	W4	CLT-N6	10
5	Waxy 5	W5	CLT-N7	10
6	Waxy 6	W6	CLT-N11	10
7	Waxy 7	W7	CLT-N12	10
8	Waxy 8	W8	CLT-N2	10
9	Waxy 9	W9	CLT-N3	10
10	Waxy 10	W10	CLT-N4	10
11	Waxy 11	W11	CLT-N5	10
12	Waxy 12	W12	CLT-N10	10
13	Waxy 13	W13	CLT-N16	10
14	Waxy 14	W14	CLT-N18	10
15	Waxy 15	W15	CLT-N20	10
16	Waxy 16	W16	CLT-N22	10
17	Waxy 17	W17	CLT-N23	10
18	Waxy 18	W18	CLT-N24	10
19	Waxy 19	W19	CLT-N25	10
20	Waxy 20	W20	CLT-N26	10
21	Waxy 21	W21	CLT-N29	6
22	Waxy 22	W22	CLT-N14	10

DNA extraction method

CTAB (Cetyl Trimethyl Ammonium Bromide) protocol was used for DNA extraction (Saghai Maroof *et al.* 1984). Tissue powder was stirred into emulsion with a glass rod after adding 10 ml extraction buffer prewarmed to 65°C (1% CTAB, 0.7 M NaCl, 50 mM Tris-HCl pH 8.0, 10 mM EDTA pH 8.0) and incubated at 65°C for one hour. Ten ml chloroform with isoamyl alcohol (24/1, *v/v)* was added and the mixture was shaken into the emulsion again. The mixture was centrifuged at the highest speed available (for example, 7000 rpm in *Hettich* Universal 16R) for 10 minutes at 25°C. Supernatant was mixed with 10µl RNase (10 mg/ml) in a fresh tube and laid on the bench for 10 minutes. DNA was precipitated with gentle shaking after adding 0.6 volume isopropanol. DNA was hooked out and transferred into 70% ethanol for washing. After brief drying on Whatman 3mm paper, DNA was dissolved in TE (Tris-EDTA) buffer for use.

The concentration and purity of DNA was measured using a spectrophotometer (Ultrospec/Visible-65). The concentration of DNA was calculated using the following formula:

Concentration of DNA (µg/µl) = OD_{260} x 50 x 50 (µg/ml)/1000

With OD_{260} found at λ=260 nm

The purity of DNA was assessed by OD_{260}/ OD_{280} rate (OD_{280} is found index at λ=280 nm). If OD_{260}/ OD_{280} rate is from 1.8-2.0, we can conclude that DNA is pure.

PCR amplification and electrophoresis on acrylamide was conducted using the AMBIONET'process, 2004: PCR reaction in 25 µl contained 10 mM Tris-HCl (pH 8.2), 50 mM KCl, 1.5 mM $MgCl_2$, 0.01% gelatin, 200 µM dNTPs, 60 ng/µl primer, 1 unit Taq DNA Polymerase (Life Technologies, USA) and 75-100 ng Template DNA. Amplification reaction consisted of preheating for 5 min at 94°C and of 35 cycles of 1 min at 94°C (denaturation) 1 min at 55°/ 61°C (annealing) and 3 min at 72°C (elongation) followed by 7 min at 72°C in Mastercycler Gradient PCR system (Eppendorf) . Amplified products were separated in 4% Typing Grade agarose gel (Life Technologies, USA), containing 0.5 ng/ml EtBr (Ethidium Bromide). Separated PCR products were visualized under UV light and photographed using Kodak Electrophoresis Documentation and Analysis System. Amplified products, which were less than 500 bp and where the polymorphism was difficult to detect in agarose gels were separated on denaturing long 6% polyacrylamide gels with a gel thickness of 0.4 mm. Gels were pre-run, samples denatured in loading buffer and electrophoresed for about 2 h or until the bromophenol blue remained visible. The molecular weight markers used were 25 bp ladder (Life Technologies). Gels were stained with silver nitrate, according to the protocol by Promega. After staining, gels were air dried and photographed.

Molecular data was collected by scoring 1 for present of band, 0 for absence of band and 9 for missing data. The collected data was analyzed using NTSYS-pc 2.1.

Targets: Coefficient of PIC (Polymorphic Information Content)

PIC = 1-ΣPi, where Pi is the frequency of occurrence of i^{th} allele

The heterozygous rate (H%) of per corn line was calculated as:

$$H\% = \frac{\text{Number of SSR primers appeared} \geq \text{2allele/1locus}}{\text{Number of amplified primers}} \times 100$$

The percentage of missing data per line for corn (M% line) and for each primer (M% primer) was calculated as:

$$M\%\ \text{line} = \frac{\text{Number of primers missing data}}{\text{Total of primers}} \times 100$$

$$M\%\ \text{primer} = \frac{\text{Number of lines missing data}}{\text{Total of research lines}} \times 100$$

The genetic distance was calculated using the formula: D = 1 - I
where D is the genetic distance, I is Jaccard index or Jaccard similarity coefficient (Lanza *et al.* 1997)

Corn lines were classified into groups of heterosis using the UPGMA (Unweighted Pair Group Method with Arithmetic Average) method (George *et al.* 2004).

RESULTS AND DISCUSSION

Genetic purity

The 22 lines having average of missing data was 6.95% (Table 1) fluctuating from 0.00 to 11.43%, lower than the threshold (15%).

The average heterozygous rate was 16.07% and ranged from 6.06 to 48.48%. In which there were four lines having high genetic purity as 4 Waxy, Waxy 9, Waxy 16, Waxy 17 (under 7% of heterozygous rate). Results also showed that 5 lines had higher heterozygous rate than 20% (threshold rate) including: Waxy12, Waxy 14, Waxy18, Waxy 21, and Waxy 22. For example, amplification of profiles of 22 waxy corn lines of locus phi053 showed that Waxy 14, Waxy18, Waxy 21 and Waxy 22 have two alleles at this locus (Fig.1). Thus, these lines having low genetic purity should be made more pure and should not be used for crossing.

Table 1. The percentage of missing data (%M) and the heterozygous rate (%H) of 22 waxy maize inbred lines based on 35 SSR loci.

No.	Name of corn line	Percentage of missing data (%)	Heterozygous rate(%)
1	Waxy 1	11.43	16.13
2	Waxy 2	5.71	9.09
3	Waxy 3	5.71	9.09
4	Waxy 4	5.71	6.06
5	Waxy 5	5.71	18.18
6	Waxy 6	8.57	12.50
7	Waxy 7	5.71	9.09
8	Waxy 8	10.14	17.24
9	Waxy 9	8.57	6.25
10	Waxy 10	8.57	18.75
11	Waxy 11	8.57	12.50
12	Waxy 12	11.43	22.58
13	Waxy 13	8.57	15.63
14	Waxy 14	0.00	25.71
15	Waxy 15	5.71	9.09
16	Waxy 16	5.71	6.06
17	Waxy 17	8.57	6.25
18	Waxy 18	5.71	48.48
19	Waxy 19	5.71	12.12
20	Waxy 20	5.71	9.09
21	Waxy 21	5.71	36.36
22	Waxy 22	5.71	27.27
	Average	6.95	16.07

Fig. 1. Amplification profiles in 22 waxy corn inbred lines (from 1 to 22) using phi053 primer (M: ØX174 DNA/HinfI marker)

Polymorphism Information Content (PIC)

Polymorphism Information Content (PIC) is a measure of diversity allele at a locus. Results presented in Table 2 shows the value varied from the lowest 0.13 (phi102228) to the highest 0.72 (umc1136) and average 0.46. The number of allele per locus ranged from 1 to 6 and had an average was 3.26. This result showed that the SSR primers used in the analysis is relatively polymorphic. However, phi102228 and phi089 primers having low PIC value (0.13 and 0.18, respectively) should not be used to genetic diversity analysis of the other waxy corn lines. Beside that, primers umc1277, phi328175 and phi227562 have the rate of missing data higher than 20% (threshold rate). The data of these primers were removed before doing tree analysis.

Table 2. Numbers of allele, PIC value and percentage of missing data of 35 SSR primers

No.	Name of primer	Position on chromosome	Type of repeat	Number of allele	Size (bp)	Percentage of missing data (%)	PIC value
1	phi089	6.08	ATGC	2	87-95	9.09	0.18
2	phi053	3.05	ATAC	6	169-195	4.55	0.62
3	phi029	3.04	AG/AGCG***	6	148-162	4.55	0.65
4	phi087	5.06	ACC	4	150-177	13.64	0.23
5	phi374118	3.02	ACC	2	217-238	13.64	0.43
6	phi127	2.08	AGAC	3	112-126	9.09	0.33
7	nc130	5.00	AGC	3	140-148	9.09	0.46
8	phi109642	2.00	ACGG	2	136-144	4.55	0.34
9	umc1277	9.08	(AATA)5	2	134-138	27.27	0.43
10	umc1279	9.00	(CCT) 6	3	92-101	9.09	0.50
11	phi 072	4.00	AAAC	3	143-167	18.18	0.57

No.	Name of primer	Position on chromosome	Type of repeat	Number of allele	Size (bp)	Percentage of missing data (%)	PIC value
12	phi 083	2.04	AGCT	4	125-137	4.55	0.66
13	umc1304	8.02	(TCGA) 4	2	129-137	0.00	0.24
14	phi452693	6.06	AGCC	6	125-145	4.55	0.70
15	phi448880	9.05	AAG	4	173-188	0.00	0.67
16	umc1066	7.01	(GCCAGA)5	4	139–158	0.00	0.56
17	phi108411	9.06	AGCT	2	125-129	9.09	0.50
18	phi423796	6.01	AGATG	4	121-141	0.00	0.46
19	phi328175	7.04	AGG	3	100-130	22.73	0.66
20	phi102228	3.04-.05	AAGC	2	123-131	0.00	0.13
21	phi109275	1.00	AGCT	4	117-143	0.00	0.64
22	phi065	9.03	CACTT	3	131-151	0.00	0.16
23	phi032	9.04	AAAG	3	233-241	4.55	0.45
24	phi299852	6.08	AGC	4	96-151	18.18	0.48
25	phi109188	5.00	AAAG	4	148-174	13.64	0.52
26	umc1153	5.09	(TCA)4	3	105-114	9.09	0.27
27	umc1136	3.10	GCA	5	132-159	0.00	0.72
28	phi227562	1.12	ACC	3	307-328	22.73	0.64
29	umc1109	4.10	ACG	3	104-116	0.00	0.24
30	umc1196	10.07	CACACG	4	137-161	0.00	0.32
31	phi100175	8.06	AAGC	2	117-141	13.64	0.48
32	phi 076	4.11	AGCGGG	3	161-173	4.55	0.57
33	phi233376	8.03	CCG	4	142-154	0.00	0.47
34	umc1061	10.06	(TCG)6	3	101-110	4.55	0.44
35	phi339017	1.03	AGG	2	148-163	0.00	0.43
	Average			3.26		7.27	0.46

Genetic diversity and pedigree diagram

The experimental results showed that genetic similar coefficient of lines ranged from 0.23 to 0.71. In general, genetic distance of research lines was far. Thus, these lines had different from genetic material. This is one of big opportunities for selecting hybrid waxy corn from inbred lines.

Classifying lines into groups of heterosis by UPGMA method reveals that at genetic similarity coefficient of 0.38 the experimented lines are divided into six groups:

Group I: Waxy 10
Group II: Waxy 16
Group III: Waxy 3, Waxy 5, Waxy 22, Waxy 21, Waxy 8, Waxy 9, Waxy 12, Waxy 18
Group IV: Waxy 2, Waxy 15, Waxy 20, Waxy 17
Group V: Waxy 4, Waxy 6, Waxy 7, Waxy 11, Waxy 13
Group VI: Waxy 1, Waxy 14, Waxy 19

Some researches indicated that the correlation between the genetic distance of parents and the heterosis of their hybrids was positive (Drinic et al 2002; Aguiar et al. 2008). In this research, most of lines had far genetic distance (except waxy 6 and waxy 7). This result leads to a potential in selecting new hybrid corn with high heterosis. Waxy 10 and waxy 16 may be used to test with other lines in this colony.

The grouping of lines, based on genetic distance as determined by the molecular markers, will be an important base in the use, exploitation of materials as well as selection of new varieties. The probability of creating hybrids having high heterosis from crossing among different groups will be higher than those crossed in the same group.

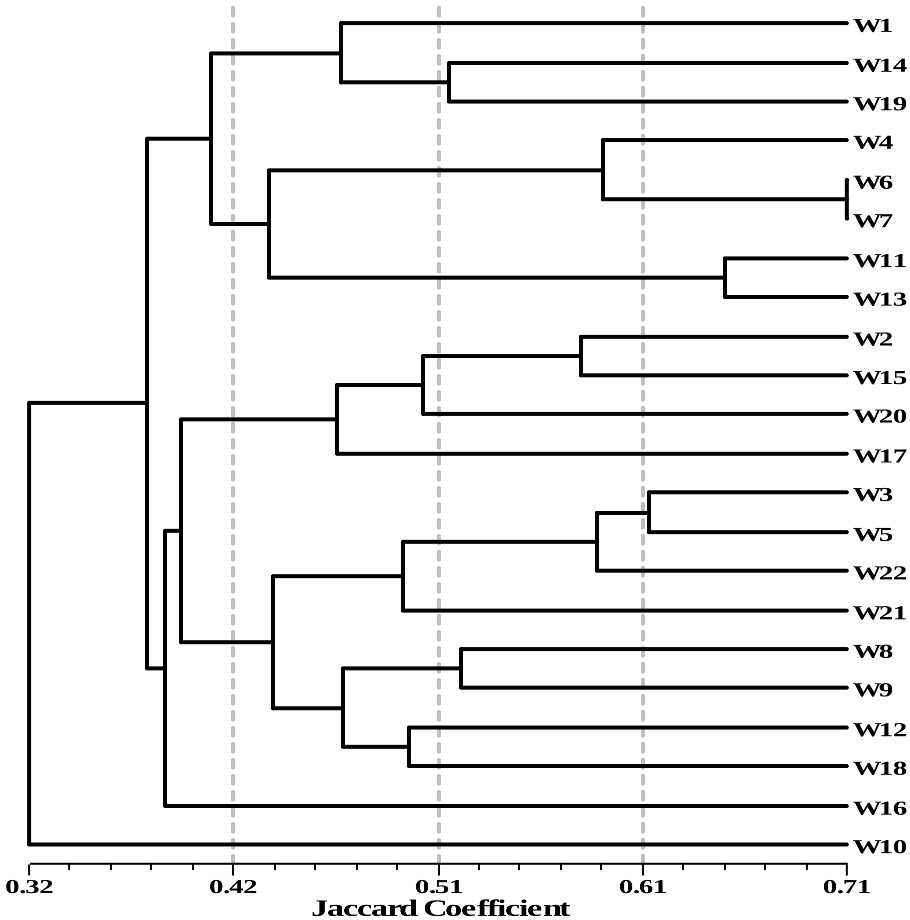

Fig. 2. Pedigree diagram of 22 Waxy (W) corn inbred lines by UPGMA grouping method

Table 3. Genetic similarity coefficient of 22 waxy corn inbred lines

Line	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Waxy 1	1.00																					
Waxy 2	0.52	1.00																				
Waxy 3	0.49	0.53	1.00																			
Waxy 4	0.45	0.40	0.41	1.00																		
Waxy 5	0.47	0.54	0.61	0.49	1.00																	
Waxy 6	0.42	0.44	0.41	0.65	0.53	1.00																
Waxy 7	0.52	0.44	0.39	0.53	0.44	0.71	1.00															
Waxy 8	0.35	0.47	0.49	0.43	0.48	0.49	0.43	1.00														
Waxy 9	0.35	0.39	0.33	0.38	0.43	0.50	0.52	0.52	1.00													
Waxy 10	0.33	0.33	0.28	0.29	0.39	0.29	0.31	0.31	0.29	1.00												
Waxy 11	0.39	0.31	0.29	0.51	0.38	0.42	0.40	0.30	0.32	0.26	1.00											
Waxy 12	0.30	0.29	0.29	0.35	0.56	0.36	0.32	0.52	0.42	0.29	0.29	1.00										
Waxy 13	0.44	0.34	0.38	0.48	0.43	0.38	0.42	0.36	0.31	0.31	0.65	0.33	1.00									
Waxy 14	0.50	0.43	0.40	0.40	0.40	0.36	0.42	0.41	0.40	0.32	0.32	0.33	0.32	1.00								
Waxy 15	0.40	0.58	0.42	0.34	0.46	0.37	0.30	0.42	0.23	0.37	0.37	0.30	0.33	0.30	1.00							
Waxy 16	0.37	0.38	0.40	0.35	0.49	0.43	0.36	0.40	0.26	0.28	0.32	0.37	0.31	0.35	0.38	1.00						
Waxy 17	0.37	0.53	0.37	0.35	0.49	0.43	0.35	0.49	0.33	0.27	0.33	0.33	0.38	0.35	0.45	0.38	1.00					
Waxy 18	0.39	0.36	0.41	0.36	0.46	0.40	0.42	0.48	0.45	0.41	0.32	0.50	0.42	0.40	0.31	0.34	0.46	1.00				
Waxy 19	0.44	0.36	0.36	0.41	0.36	0.34	0.37	0.35	0.25	0.30	0.50	0.33	0.42	0.52	0.43	0.46	0.27	0.27	1.00			
Waxy 20	0.38	0.46	0.37	0.31	0.37	0.37	0.32	0.42	0.27	0.29	0.28	0.29	0.35	0.25	0.56	0.38	0.39	0.33	0.35	1.00		
Waxy 21	0.33	0.43	0.43	0.38	0.53	0.38	0.37	0.47	0.45	0.39	0.29	0.39	0.33	0.39	0.36	0.44	0.38	0.46	0.36	0.39	1.00	
Waxy 22	0.41	0.45	0.58	0.47	0.60	0.48	0.45	0.52	0.41	0.43	0.37	0.44	0.43	0.50	0.35	0.40	0.37	0.40	0.42	0.42	0.54	1.00

CONCLUSION

The analysis of 22 waxy corn inbred lines indicates that there were four lines having high homozygous rate: Waxy 4, Waxy 9, Waxy16, Waxy 17 (lower than 7% of heterozygous rate) and 5 lines showed high heterozygous proportion (higher than 20%): Waxy 12, Waxy 14, Waxy18, Waxy 21, and Waxy 22.

The SSR primer system used in the experiments was relatively polymorphic with a PIC average value of 0.46.

Classifying these waxy corn inbred lines into groups of heterosis by UPGMA method reveals that at genetic similarity coefficient of 0.38 the experimented lines were divided into six groups, including Group I: Waxy 10, Group II: Waxy 16; Group III: Waxy 3, Waxy 5, Waxy 22, Waxy 21, Waxy 8, Waxy 9, Waxy 12, Waxy 18; Group IV: Waxy 2, Waxy 15, Waxy 20, Waxy 17; Group V: Waxy 4, Waxy 6, Waxy 7, Waxy 11 and Group VI: Waxy 1, Waxy 14, Waxy 19.

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OCCURRENCE OF *CHILI VEINAL MOTTLE VIRUS* (CHIVMV) IN INDONESIA AND RESPONSE OF CHILI GERMPLASMS TO CHIVMV INFECTION

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ABSTRACT

Viral diseases are considered to be the major limiting factors in chili production. *Chili veinal mottle virus* (ChiVMV) is one of the important viruses, which decrease yield significantly. Infection of ChiVMV is associated with mosaic and mottle disease of chili in Indonesia. The distribution and incidence of ChiVMV is reported from major chili growing areas in West Sumatra, West Java, Central Java, East Java, and South Kalimantan based on field surveys conducted in 2008 to 2009. Screening of 29 chili accessions against ChiVMV based on symptomatology and disease incidence (%) under screenhouse conditions showed that the genotypes were classified into 5 reaction groups, i.e. Highly Resistant (IPB C1, IPB C10, and PBC 521), Resistant (IPB C8, IPB C14, IPB C17, and Keriting Sumatra), Moderately Susceptible (IPB C48, IPB C60, Tegar, Toro, and Taring), Susceptible (IPB C6, IPB C15, and Tanjung), and Highly Susceptible (IPB C13, IPB C20, IPB C21, IPB C24, IPB C33, IPB C55, IPB C73, IPB C81, IPB C99, Tornado, Andalas, Tegak, Beauty Bell, and Polaris). Further effort should be made to identify the resistance gene that might be incorporated in the breeding program to improve chili yield.

Key words: *Capsicum annuum*, chili pepper, disease resistance, ELISA

INTRODUCTION

Chili is an important and essential component of the daily Indonesian diet. It is also an important commercial crop grown year-round mainly by small-scale farmers both in high and lowlands under rain-fed as well as irrigated conditions. In 2007, it was cultivated on a total area of more than 200 thousand ha producing about 1.13 million of fresh weight with an average yield of 10 ton per ha [Directorate General of Horticulture, Ministry of Agriculture Indonesia, 2008]. The production of chili is limited by a wide range of diseases. *Chilli veinal mottle virus* (ChiVMV) is one of the important pathogens commonly found in chili plants in Indonesia besides *Pepper yellow leaf curl begomovirus* (PepYLCV), *Cucumber mosaic cucumovirus* (CMV), *Ralstonia solanacearum, Phytophthora capsici*, and *Colletotrichum* spp. (Mariyono and Bhattarai, 2009; Taufik *et al*., 2005).

Mottle and mosaic disease caused by ChiVMV infection was first reported from Malaysia by Burnett in 1947 (Brunt *et al.*, 1996), but it is now known widely spread in many countries in Asia including Korea, Taiwan, Thailand, Indonesia, Papua New Guinea, Phillippine, China, Bangladesh, India, Nepal, Sri Lanka and also in Australia, West and East Africa (Davis *et al.*, 2002; Shah *et al.*, 2001 Taufik *et al.*, 2005; Womdin *et al.*, 2001). The incidence of ChiVMV infection may reach 30% and may cause yield loss up to 95% and 30% in sweet chili and small chili, respectively based on field surveys conducted by Green (2004) in 16 Asian countries. ChiVMV is easily transmitted in the field by many aphid species in a non persistent manner (Ong *et al.*, 1979). Infection of ChiVMV causes various symptoms in chili including irregular dark green spot on the leaf (mottle), vein banding, leaf malformation (Latifah *et al.*, 2008 Siriwong *et al.*, 1995; Tsai *et al.*, 2008), and reduction of fruit size (Shah and Khalid, 2001).

During chili disease monitoring in 2005 ChiVMV and PepYLCV was found to be the most prevalent viruses especially in Java (Taufik *et al.*, 2005). In view of this scenario, an effort was made to screen available chili germplasm (Latifah *et al.*, 2008 Millah, 2007; Riyanto, 2007). Further investigation is required especially to study the distribution of ChiVMV in several chili growing areas in Indonesia since previous field survey was only conducted in limited regions. Continuous breeding effort should also be made to screen and evaluate available chili germplasm so that breeders could get resistant material to incorporate resistance gene in highly susceptible cultivars as well for farmers to improve chili yield. This paper reports the current incidence of ChiVMV on field-grown chili in Indonesia and screening results of 29 chili accessions against ChiVMV.

MATERIALS AND METHOD

Field surveys and leaf sampling

Field surveys were conducted from 2008 to 2009 in a total of 23 fields in major chili growing areas in West Sumatra, West Java, Central Java, East Java and South Kalimantan (Table 1). Leaf samples exhibiting symptoms such as mosaic, mottle, or leaf malformation were collected. Each sample from different plants were kept in plastic bags in ice boxes during the survey, and later at 4^0C in a refrigerator before serological test was performed using ChiVMV, CMV, PVY, PMMV and ToMV antisera.

Table 1. Number of tested and virus-infected chilli pepper fields in five regions (provinces) in Indonesia.

Location of collected samples	Number of chillipepper fields infected by a given virus*					No. of tested fields	No. of infected fields
	ChiVMV	CMV	PVY	TMV	PMMV		
West Sumatera	4	1	0	0	0	4	4
West Java	1	1	1	0	0	2	2
East Java	5	3	7	2	1	8	8
Central Java	4	1	0	1	0	4	4
South Kalimantan	2	1	0	1	0	5	2

**Chili veinal mottle virus* (ChiVMV), *Cucumber mosaic virus* (CMV), *Potato Y virus* (PVY), *Tobacco mosaic virus* (TMV), *Pepper mild mottle virus* (PMMV).

Sap transmission for propagation and mechanical inoculation of virus isolates

Leaf samples giving positive reaction to ChiVMV based on ELISA result were selected for propagation of ChiVMV isolates. Selected samples with severely symptomatic leaves were homogenised with a mortar and pestle with 1:10 ratio (w:v) of 0.01 M phosphate buffer (pH 7.0) separately, and the sap was immediately used for mechanical inoculation. Infected sap was applied on carborundum (600 mesh) dusted young leaves (3 weeks after planting) of propagation host (*C. annuum* var. Grosum cultivar Yolo Wonder) or tested chili varieties/lines (Table 4). A second inoculation was performed a week later to confirm ChiVMV infection. Control plants were inoculated with sap from healthy plant or even with buffer. Inoculated plants were kept in insect-free screenhouse for symptom development.

Host response.

Phenotypic data of host reaction was recorded in terms of symptom manifestation following mechanical inoculation of ChiVMV isolate Cikabayan (West Java) on plants of each cultivar/lines, placed under screen house conditions two weeks post inoculation.

Detection of ChiVMV.

Direct ELISA (DAS-ELISA) was performed following the method of Clark and Adam (1977) for screening of 29 chili accessions against ChiVMV. All seedlings of each chili accessions, i.e. 20 to 25 seedlings, were tested for ChiVMV. Detection was performed twice, i.e. a week post first inoculation and a week post second inoculation. A sample was considered positive when the mean absorbance value of the two wells used for each tested sample was greater than twice that of the healthy or buffer control. Disease incidence was measured as the proportion of number of plants giving positive ELISA reaction and total number of tested plants. The cultivar/lines were rated as HR (Highly Resistant, 0-10% infection), R (Resistant, 11-30% infection), MS (Moderately Susceptible, 31-50% infection), S (Susceptible, 51 – 70% infection), HS (Highly Susceptible, >70% infection) based on accumulative data of host response and ELISA values.

RESULTS AND DISCUSSION

Distribution of ChiVMV in chili growing area in Indonesia.

The infection of ChiVMV in Indonesia was reported by Taufik *et al*. (2005) in West Java, Central Java, and South Sulawesi. Further field survey conducted during 2008 to 2009 in West Java, Central Java, East Java, West Sumatera, and South Kalimantan revealed a wider spread and distribution of the disease in Indonesia. Most of the leaf samples collected showed very strong and obvious mosaic, mottle, and malformation symptoms. Virus diagnosis based on ELISA technique was able to detect ChiVMV, CMV, PVY, PMMV and TMV from leaf samples (Table 1). Infection of ChiVMV and CMV was found in almost all fields although with various disease intensity, whereas infection of PVY, PMMV and TMV was only detected in few fields. Symptoms of ChiVMV ranged from mild to severe mottle, with variation of leaf malformation, shoestring and leaf curling. ELISA further confirmed the incidence of the virus from 22 to 77% in areas surveyed during 2008 – 2009 (Table 2).

Although infection of ChiVMV is considered sporadic in almost all chili growing areas in Java, Sumatera, and Kalimantan, the virus has the potential to cause yield loss up to 65% (Subekti *et al*., 2006). Therefore, virus (ChiVMV) resistance is still a major goal of chili pepper breeding programmes.

Table 2. Incidence and symptoms of ChiVMV infection in major chili growing regions in Indonesia*

Location of collected samples	No samples	No samples infected by ChiVMV (% disease incidence)	Symptoms
West Sumatera	13	10 (77)	Mild to severe mottle, leaf malformation
West Java	9	2 (22)	Severe mottle, shoestring
East Java	79	20 (25)	Mild mottle
Central Java	26	14 (54)	Mild to severe mottle, shoestring
South Kalimantan	22	9 (41)	Mild mottle, leaf curling

*Disease incidence was calculated based on ELISA result

Response of chili germplasms to ChiVMV infection.

There were mainly 3 types of symptoms observed on the infected plants. Eight chili genotypes **(**IPB C48, IPB C15, IPB C21, IPB C73, IPB C6, Tegak, IPB C81, Andalas) were observed with mild mottle symptom, 7 genotypes (Tanjung, IPB C20, Tegar, Tornado, IPB C99, IPB C60, Toro) showed mild mottle with leaf malformation symptoms, and 6 genotypes (IPB C13, IPB C24, IPB C55, IPB C33, Polaris, Beauty Bell) showed severe mottle, leaf malformation and dwarfing of plants (Table 3). Similar symptoms, including mild to severe vein mottling, was reported by Shah *et al.* (2011) during screening of indigenous and exotic *Capsicum* genotypes against Pakistani isolate of ChiVMV.

Table 3. Symptom type of ChiVMV infection on 29 genotypes of chili (recorded 2 weeks after inoculation)

Symptom type	Chili genotype
No symptom	IPB C17, IPB C521, IPB C14, IPB C1, IPB C8, IPB C10, Taring, Keriting Sumatera
Mild mottle	IPB C48, IPB C15, IPB C21, IPB C73, IPB C6, Tegak, IPB C81, Andalas
Mild mottle with leaf malformation	Tanjung, IPB C20, Tegar, Tornado, IPB C99, IPB C60, Toro
Severe mottle with leaf malformation and plant dwarfing	IPB C13, IPB C24, IPB C55, IPB C33, Polaris, Beauty Bell

Eight out of 29 genotypes tested (IPB C17, IPB C521, IPB C14, IPB C1, IPB C8, IPB C10, Taring,Keriting Sumatera) showed no symptom until the last observation period (30 days after inoculation) (Table 4). However, when samples of these last 8 genotypes was tested by DAS-ELISA, infection of ChiVMV was detected although only from genotype Taring. Latent infection (infection with no visible symptoms) of viruses has been reported previously (Bashir and Hampton, 1996). *Virus cryptic* infection was discussed by Antoniw *et al*. (1990) to show the phenomenon of symptomless virus infection that may cause significant yield loss. Therefore it is very important to confirm virus infection in germplasms evaluation using reliable detection methods, especially when screening for source of virus resistance.

Chili genotypes varied greatly in their reaction to ChiVMV infection. The genotypes were classified into 5 reaction groups based upon symptom type and % disease incidence. Out of 29 genotypes tested, 3 were highly resistant (IPB C1, IPB C10, and PBC 521), 4 were resistant (IPB C8, IPB C14, IPB C17, and Keriting Sumatra), 5 were moderately susceptible (IPB C48, IPB C60, Tegar, Toro, and Taring), 3 were susceptible (IPB C6, IPB C15, and Tanjung), and 14 were highly susceptible (IPB C13, IPB C20, IPB C21, IPB C24, IPB C33, IPB C55, IPB C73, IPB C81, IPB C99, Tornado, Andalas, Tegak, Beauty Bell, and Polaris) (Table 4).

The reaction of chili accessions was also varied in terms of incubation period. The viral incubation period, indicated by days from inoculation time until first symptoms of the disease appear, in genotypes with HS reaction was shorter (7 to 12 DAI) than genotypes with MS reaction (14 DAI) whereas in genotypes with HR and R reaction symptoms were not visible.

Table 4 Response of 29 chili genotypes to ChiVMV infection.

No.	**Species per genotype**		**Source of germplasm***	**Incubation period (DAI)****	**Disease incidence (%)**	**Response type**
	Red Chili					
1.	*C. annuum*	IPB C1	PSPT C-17	No symptom	5.00	HR
2.	*C. annuum*	IPB C13	AVRDC	7	95.65	HS
3.	*C. annuum*	IPB C14	AVRDC	No symptom	13.04	R
4.	*C. annuum*	IPB C15	AVRDC	10	60.84	S
5.	*C. annuum*	IPB C17	AVRDC	No symptom	21.74	R
6.	*C. annuum*	IPB C24	AVRDC	7	91.30	HS
7.	*C. annuum*	IPB C48	AVRDC	10	47.37	MS
8.	*C. annuum*	PBC 521	AVRDC	No symptom	0.00	HR
9.	*C. annuum*	Tanjung	Local commercial	12	60.87	S
	Red curly chili					
10.	*C. annuum*	IPB C6	PSPT	12	65.22	S
11.	*C. annuum*	IPB C73	PSPT	12	78.26	HS
12.	*C. annuum*	Tegar	Local commercial	10	34.78	MS
13.	*C. annuum*	Keriting Sumatera	Local commercial	No symptom	26.09	R
14.	*C. annuum*	Tornado	Local commercial	10	88.24	HS
15.	*C. annuum*	Andalas	Local commercial	10	100.00	HS
	Small chili					
16.	*C. annuum*	IPB C8	AVRDC	No symptom	17.39	R
17.	*C. annuum*	IPB C10	AVRDC	No symptom	0.00	HR
18.	*C. annuum*	IPB C60	AVRDC	14	30.43	MS
19.	*C. frutescens*	Tegak	Local commercial	12	94.74	HS
20.	*C. frutescens*	Toro	Local commercial	14	35.29	MS
21.	*C. frutescens*	Taring	Local commercial	14	43.48	MS
	Ornamental chili					
22.	*C. pubescens*	IPB C20	AVRDC	7	95.65	HS
23.	*C. annuum*	IPB C21	AVRDC	7	100.00	HS
24.	*C. annuum*	IPB C33	AVRDC	7	100.00	HS
25.	*C. annuum*	IPB C55	AVRDC	10	82.61	HS

No.	Species per genotype		Source of germplasm*	Incubation period (DAI)**	Disease incidence (%)	Response type
26.	*C. annuum*	IPB C81	Local	7	95.65	HS
27.	*C. annuum*	IPB C99	AVRDC	7	92.30	HS
	Sweet chili					
28.	*C. annuum*	Beauty Bell	Local commercial	7	85.00	HS
29.	*C. annuum*	Polaris	Local commercial	7	95.65	HS

[1] Source of germplasm : Centre for Breeding Program, IPB (PSPT); Asian Vegetable Research and Development Centre (AVRDC).
[2]Incubation period is days from inoculation time until first symptoms of the disease appear (DAI: days after inoculation).
[3]Disease incidence : No plants positive ELISA per total no plants tested x 100%.
[4]Response : Highly resistant (HR), resistant (R), moderately susceptible (MS), susceptible (S), highly susceptible (HS).

CONCLUSION

The management of viral diseases has always been focused on the control of insect-vector and the use of resistant varieties. Three chili genotypes, i.e. IPB C1, IPB C10, and PBC 521 were symptomless and negative for ChiVMV after ELISA and might be a useful source of resistance that can be used in the national breeding program.

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POPULATION INTENSITY OF PANICLE RICE MITE *STENEOTARSONEMUS SPINKI* SMILEY (ACARI:TARSONEMIDAE) INFLUENCING RICE YIELD IN VIETNAM

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ABSTRACT

A study was conducted to evaluate the effect of panicle rice mite (PRM) population on the agronomic characters of dominant rice cultivar IR 50404 by artificial inoculation of 1, 2, 4, 8, 16 and 32 adult female mites per panicle at 30 and 45 days after sowing, respectively in Chau Thanh, An Giang,Vietnam for the second crop season (summer-autumn), 2010. Subsequently, the mite population was assessed at 13 and 28 days after introduction where the highest number, 527 mites per tiller and 835 mites per tiller were recorded, respectively from the 32 adult female mites per panicle treatment. In all the treatments, PRM significantly reduced the height of the plant, panicle weight and the curvature of the panicle, and increased the percentage of sterile inflorescences. The highest yield loss was 89.3% when 32 mites per tiller were introduced at 30 days after sowing. The periods of PRM introduction affected the yield loss but these effects were only significantly smaller when the initial number of mites released was small (1-2 mites per tiller). However these were nearly similar at higher numbers of mites released (4-32 mites per tiller).

Key words: Density-yield relationships, Tarsonoemid mite, rice pests

INTRODUCTION

Steneotarsonemus spinki Smiley (panicle rice mite) is one of key rice pests throughout the world (Tseng, 1984). It has been reported that this mite caused 30 to 90% yield loss in rice in the Caribbean (Almaguel et al., 2000). The occurrence of the panicle rice mite in Vietnam had been recorded in Thua Thien Hue, causing damage to 40 has of rice fields and resulting in 15% empty grains (Ngo Dinh Hoa, 1992). In the last five years, the rice panicle mite has become a major pest in the rice producing areas of Vietnam. Do Thi Dao *et al*. (2008) reported 59.9% more yield in the acaricide treated rice field in comparison with untreated control field. A survey in 7 agro-ecological regions of Vietnam in two years, 2010-2011, showed that rice panicle mite was a dominant rice pest in three major rice-growing areas of Vietnam. The damage was heavier in the second crop season of the years (Duong Tien Vien *et al.*, 2012). After rice harvest, the stubble ratoon crop was the main habitat of RPM and from these habitats the RPM spread throughout the field in the next season (Nguyen Thi Nham *et al.* 2010). However, studies have not been conducted on the effects of crop damage on rice yield in Vietnam. This study aimed to determine the influence of different panicle rice mite densities on the yield of rice variety IR 50404, a dominant rice variety which was cultivated in the summer season (April - August 2010) in the Chau Thanh district, An Giang province, in the Mekong river delta.

MATERIALS AND METHODS

Stock Cultures of *S. spinki*

Panicle rice mites (PRMs) were collected from a rice field at Chau Thanh, An Giang (100 -110 ºN and 104.70 – 105.50 ºW). The PRMs were transferred gently to 5 cm. long segments of rice stem (each containing 1 node at the base of the segment and 1 inter-node) using the tip of a needle. These stem segments were then placed on spongy pads which were watered daily. After 2 weeks when the population of PRMs inside the stem sheath was high, the stem segments containing PRMs were cut into 1cm-segments and then transferred onto new 5cm-stem segments to increase the numbers of available PRMs for artificial infestation in the field.

Influence of PRM Densities on Yield

The experiment was conducted at Chau Thanh, An Giang, Vietnam on a dominant rice cultivar IR 50404. Plots were laid out in a completely randomized design with three replicates. Each plot, 0.5 m x 0.5 m in size, was surrounded with 1.2 m high plastic sheet on its perimeter. Plots were spaced 1 m apart to minimize interference between plots and the adjacent field. The rice was sown with 15 tillers per plot, which was the same density at which the farmer had sown the rest of the field (12 kg seed per 1000 m^2). The treatments included introduction of 1, 2, 4, 8, 16 and 32 female PRM per tiller, respectively. In a previous research, we found that the PRM only appeared in the rice fields from 25-50 days after sowing, so the introduction times in this experiment, were 30 and 45 days after sowing (DAS). At these times, the exact numbers of female PRM required for each treatment were transferred from the culture colonies into the leaf sheath of each rice tiller in the experimental plots.

The densities of PRM were monitored twice, at the booting stage (58 days after sowing) and at maturity (88 days after sowing). For the first assessment, 5 tillers were cut randomly in each plot, the PRM in each leaf blade and leaf sheath of each tiller were counted, the length of the lesions was measured and the colour of the largest lesion inside each rice sheath was recorded. For the second assessment, 30 tillers per plot were randomly selected, cut and recorded these parameters: the height of each tiller (from the foot to the tip of the panicle), the total numbers of grains per panicle, the numbers of filled grains, the number of grains damaged by PRM per panicle, panicle weight and panicle curvature (the angle between the vertical axis (stem) and the tip of the panicle). The number of predatory mites was also recorded. However, the density was quite low and there was no significant difference among the treatments. So this was not mentioned in this paper.

Data analysis

One-way analysis of variance (ANOVA) was used to compare the influence of the number of PRM introductions on plant height, panicle weight, the percentage of sterile inflorescences and the curvature of the panicle. Mean values were compared among factors using the LSD test in CropStat Ver. 7.2 (International Rice Research Institute). Linear regression was used to determine the relationship between the number of PRM introductions and the densities of mites per tiller at 13 days and 28 days after introduction, the weight of filled grains/panicle and percentage of empty grains per panicle.

RESULTS

Population Development

At the booting stage, 13 days and 28 days after PRM introduction, the densities of PRM were clearly higher than the control in all the treatments and the numbers of PRM increased as the number of PRM introductions increased at both intervals after introduction (Table 1).

Table 1. Densities of panicle rice mite (± SE) at 13 and 28 days after introduction.

Number of PRM introduced per tiller	Density of PRM (mites per tiller)*	
	28 DAI**	**13 DAI**
0	0 ± 0 a	0 ± 0 a
1	57.33 ± 3.02 a	48.13 ± 5.13 ab
2	110.07 ± 43.25 ab	143.47 ± 26.94 bc
4	214.53 ± 15.11 bc	185.67 ± 27.24 cd
8	341.67 ± 40.54 c	255.60 ± 23.71 d
16	551.20 ± 47.09 d	282.20 ± 46.46 d
32	834.67 ± 103.10 e	526.60 ± 56.50 e

*Means within a column followed by the same letter are not significantly different at 0.05 level in an LSD test; **DAI: Days After Introduction of PRM

The highest numbers of PRM (526.6 mites per tiller after 13 days, 834.7 mites per tiller after 28 days) were observed when 32 PRM had been introduced per tiller, i.e. 16.5 and 26.1 times higher than the initial numbers introduced, respectively. The common slopes estimate for both 13 and 28 days after introduction were positive and significantly different from zero, showing an increase in numbers of PRM as the numbers of PRM introduced increased (Fig. 1).

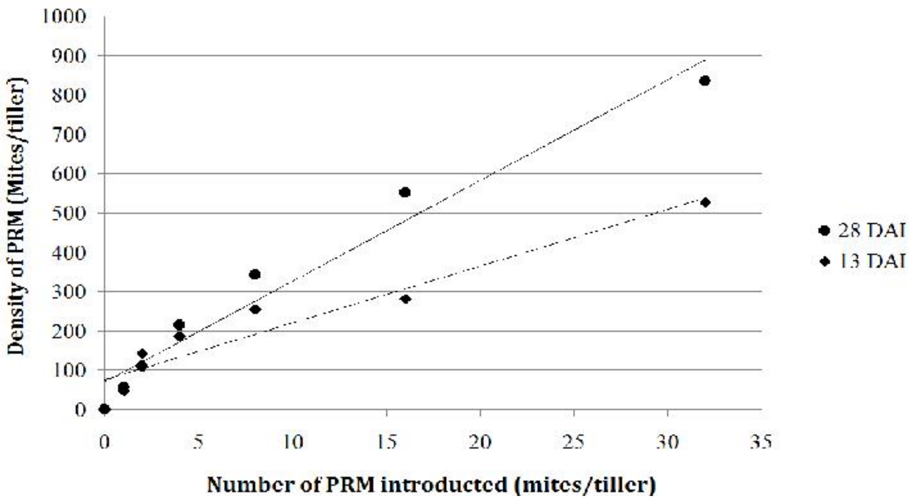


Fig. 1. The relationship between the numbers of mites introduced and the densities of mites per tiller at 13 days and 28 days after introduction. 28DAI: $y = 25.58x + 71.14$, $R = 0.981$ ($F=125.34$, $P < 0.001$, $df=6$); 13DAI: $y = 14.43x + 76.10$, $R=0.953$ ($F= 50.024$, $P = 0.001$, $df=6$); DAI: days after introduction of PRM

Impact on yield

For determining the effect of the different PRM mite densities on the agronomic characters of the rice plant, at maturity (88 days after sowing) 30 random tillers were checked. The results indicated that all rates of PRM introduction significantly affected plant height, panicle weight, sterility percentage and panicle curvature in comparison with the control treatment. The degree of dwarfing of the rice plants was roughly proportional to the numbers of PRM released per tiller. The plants were smallest with the 16 and 32 mites per tiller introduction rates at both introduction times (30 and 45 days after sowing), the plant height being reduced by 14.2 – 17.2 cm compared with the control (Table 2 and 3). In addition, other symptoms observed in infected plants were black lesions in the leaf sheath, off-colour plants, blackened rice husks and deformed grains.

Table 2. Influence of the density of PRM introduced 30 days after sowing on different agronomic characters of rice

Number of mites introduced per tiller	Plant height (cm)* Mean ± SE	Filled grain weight (g per panicle)* Mean ± SE	Reduction in weight (%)	Percent empty grains per panicle (%)* Mean ± SE	Increase in percent empty grain (%)	Panicle angle (^{o})* Mean ± SE
0**	85.41 ± 0.32c	2.25 ± 0.01 f	0	21.48 ± 3.12 a	0	93.72 ± 2.94 e
1	77.00 ± 1.68ab	1.55 ± 0.12 e	31.11	37.66 ± 2.39 b	42.96	72.04 ± 8.11 de
2	77.68 ± 1.74b	1.39±0.04 de	38.22	40.50 ± 1.22 bc	46.96	67.62 ± 4.95 cd
4	74.65 ± 2.90ab	1.07±0.16 cd	52.44	52.53 ± 4.98 c	59.11	52.53 ± 6.42 bcd
8	75.46 ± 1.23ab	0.74±0.22 bc	67.11	68.18 ± 8.77 d	68.50	46.53 ± 11.66 bc
16	71.24 ± 2.85a	0.41±0.13 ab	81.78	72.77 ± 4.49 de	73.47	39.66 ± 9.65 ab
32	71.38 ± 1.31a	0.23 ± 0.04 a	89.33	87.88 ±1.54 e	75.56	22.49 ± 1.94 a

*Means within a column followed by the same letter are not significantly different at 0.05 the level in an LSD test; ** Control

Table 3. Influence of the density of PRM introduced 45 days after sowing on different agronomic characters of rice

Number of mites intro-duced per tiller	Plant height (cm)* Mean ± SE	Filled grains weight (g per panicle)* Mean ± SE	Reduction in weight (%)	Percent empty grains per panicle (%)* Mean ± SE	Increase in percent empty grain (%)	Panicle angle (^{o})* Mean ± SE
0**	89.88 ± 0.82 c	2.51 ± 0.09 d	0.00	15.57 ± 4.73 a	0.00	93.61 ± 3.06 c
1	83.53 ±1.40 b	1.93 ± 0.02 c	23.11	28.06 ± 0.41 b	44.51	85.11 ± 1.50 bc
2	81.44 ±0.43 b	1.80 ± 0.08 c	28.29	31.30±1.40 bc	50.24	80.11 ± 1.50 bc
4	82.57 ±0.71 b	1.47 ± 0.06 b	41.43	38.67±2.06 cd	59.74	76.39 ± 1.51 b
8	80.94 ±0.52 b	1.26 ± 0.04 b	49.80	45.68 ± 2.18 d	65.15	72.89 ± 2.35 b
16	72.44 ± 2.42 a	0.46 ± 0.12 a	81.67	79.02 ± 6.12 e	80.45	45.81 ± 11.14 a
32	72.58 ± 0.83 a	0.35 ± 0.02 a	86.06	83.17 ± 0.48 e	81.28	41.33 ± 1.83 a

*Means within a column followed by the same letter are not significantly different at 0.05 the level in an LSD test; ** Control

The panicle curvature of rice plants infected with PRM was easy to observe in the field in comparison with uninfected ones; therefore this symptom was used as one of the criteria to determine the effect of the PRM on the rice plant. The angle between the stem and the tip of the panicle was measured to determine the panicle curvature. Panicles damaged by PRM will be lighter in weight, so the angle will be smaller than the angle of normal plants. The data from Tables 2 and 3 demonstrated that when the densities of PRM increased, the angle of the panicle was reduced. The smallest panicle angle was observed in the 32 mites per tiller treatment with angles of 22.5^o and 41.3^o at 30 DAS and 45 DAS, respectively.

The effect of PRM introduction density on yield loss was also apparent. Both PRM introduction times (30 DAS and 45 DAS), the mean weight of filled grains per panicle decreased from 2.25 and 2.51 g (control) to 0.23 and 0.35 g (32 mites per tiller treatment), respectively while the percentage of the empty grains increased as the densities of PRM increased. In the 32 mites per tiller treatment, almost all of the grains in the panicle were empty with an average percentage of empty grains of 87.9% and 83.2% for the two introduction times, respectively.

The slopes relating the densities of PRM introduced to the weight of filled grains per panicle and percentage of empty grains per panicle were significantly different from zero. However, the relationship between the number of PRM introduced and the weight of filled grains per panicle was negative, with R values of -0.828 and -0.885 at 30 DAS and 45 DAS, respectively, while the relationships of PRM introduction density with percentage of empty grains were positive with R values of 0.888 and 0.921 at 30 DAS and 45 DAS, respectively (Fig. 2).

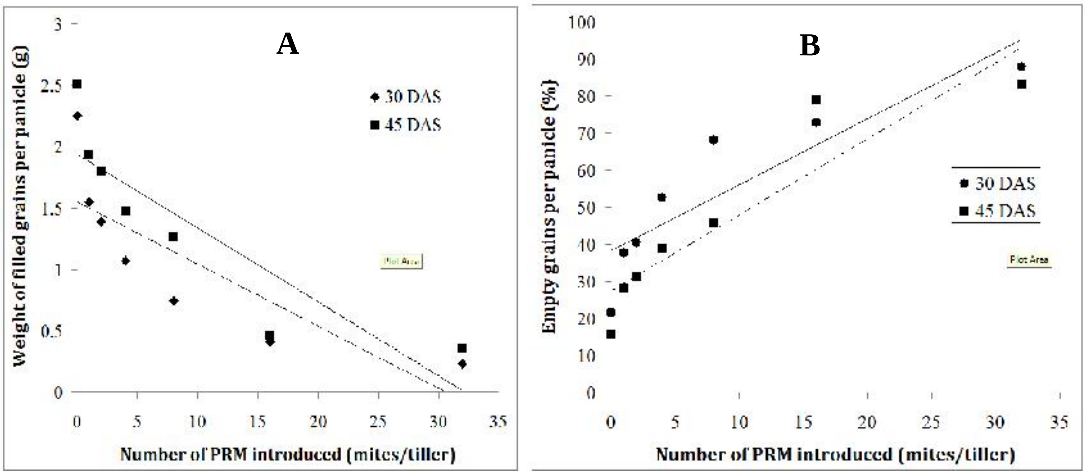
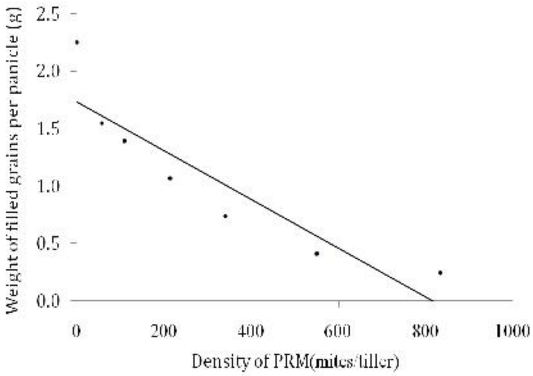


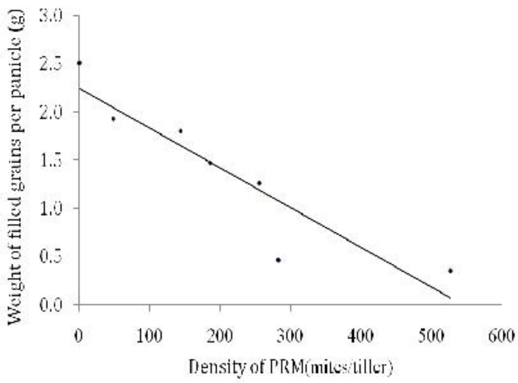
Fig. 2. The relationship between the numbers of mites introduced (mites per tiller) and the weight of filled grains/panicle and percentage of empty grains per panicle at the two introduction times A: 30 DAS $y = -0.051x + 1.546$, $R = -0.828$ ($F = 10.879$, $P = 0.022$, df = 6); 45 DAS $y = -0.060x + 1.938$, $R = 0.885$ ($F = 18.024$, $P = 0.008$, df = 6); B: 30 DAS $y = 1.782x + 38.39$, $R = 0.888$ ($F = 18.733$, $P = 0.008$, df = 6); 45 DAS $y = 2.059x + 27.391$, $R = 0.921$ ($F = 27.940$, $P = 0.003$, df = 6)

Similarly, at the booting stage (58 DAS), the slopes relating the numbers of mites per tiller to full grain weight per panicle were negative and significantly different from zero (Fig. 3).

The PRM introduction times also influenced on the weight of filled grains. PRM released at the low densities of 1 and 2 mites per tiller at 30 DAS significantly reduced the weight of filled grains more than the same numbers of mites released at 45 DAS. However the higher density treatments (4, 8, 16, and 32 mites per tiller) did not result in differences in the weight of the filled grains between the two introduction times (Fig. 4).



30 DAS



45 DAS

Fig. 3. The relationship between numbers of mites at the booting stage and the weight of filled grains per panicle. 30DAS: $y = -0.002x + 1.735$, $R = -0.913$ ($F = 25.125$, $P = 0.004$, df = 6); 45DAS: $y = - 0.004x + 2.247$, $R = -0.919$ ($F = 27.164$, $P = 0.003$, df = 6)

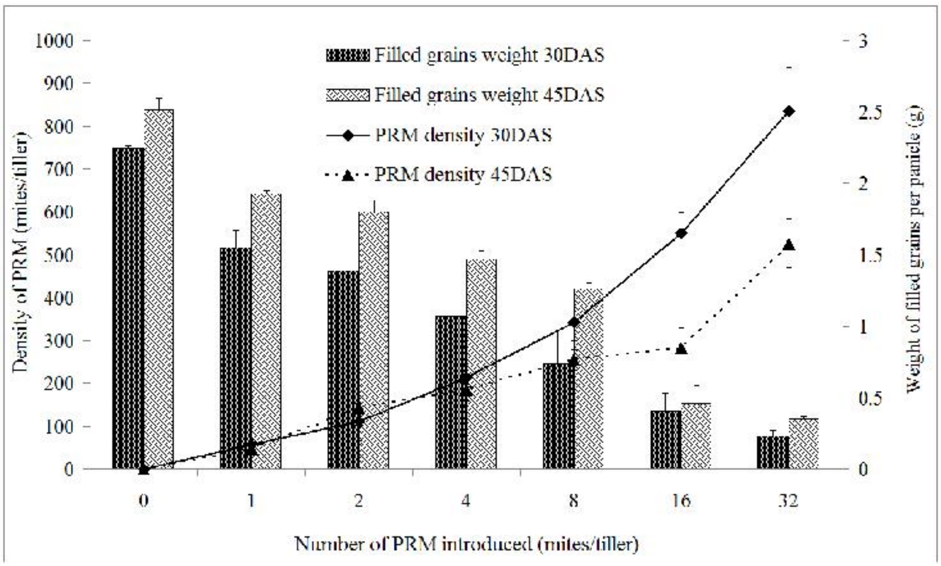


Fig. 4. Influence of two PRM introduction times at 30 and 45 DAS on weight of filled grains per panicle (g)

DISCUSSION

Panicle rice mite is able to create a population boom in a short time (Tseng, 1984) as the results of this experiment again demonstrate. The numbers of PRM in the 32 mites/tiller treatment increased 16.5 and 26.1 fold after 13 and 28 days, respectively, from the initial number introduced. This result was similar to that reported by Ramos and Rodríguez (2001) where the population of PRM multiplied by 24 times at the green ring stage. The ability of the PRM population to increase rapidly may be related to the high temperature and high humidity in An Giang, averaging 28.3^{o}C and 81.4%, respectively, between April and August over the period of 2001 – 2010 (data from website of Vietnam

Institute of Meteorology Hydrology and Environment, 2010). When compared the population growth of different treatments we found that the population growth was fastest in low initial numbers of PRM introduced (1 mite per tiller was 57.33 times at 28 DAI and 71.74 times in 2 mites per tiller treatment at 13 DAI). The population growth decreased as the numbers of PRM introduced per tiller were increased. When the number of PRM in a population was too high, there would be space and food shortage causing the population to grow slowly.

Panicle rice mite caused significant yield loss at all introduction rates. The yield loss increased as the number of PRM introduced increased. When only one mite per tiller was released, the weight of filled grains per panicle was reduced by 31.1% and 23.1% in comparison with the control at 30 DAS and 45 DAS, respectively (Table 2 and 3). The yield loss reached a maximum of 89.3% with 87.9% sterility for the 32 mites per tiller treatment at 30 DAS. These finding were similar to those reported by Rao and Prakash (2003) in Orissa, India, where densities of 7 – 600 mites per tiller caused 4 - 90% sterility.

The time of PRM introduction affected the severity of yield loss. However, this effect was only significant when the initial numbers of mites released was low (1-2 mites per tiller) and nearly similar when the numbers of mites released were higher (4-32 mites per tiller). This may be attributed to a low initial number of PRM at the low introduction rates, the 15 days difference in time between the 30 and 45DAS introductions being too short for the PRM to make a difference in density of PRM on the maturity stage, while with the higher initial numbers of PRM, the main factor which affected the increase in the population was not the time, but the limited food source.

CONCLUSIONS

At the booting stage, an increase in numbers of PRM as the numbers of PRM introduced increased, the highest numbers of PRM were observed when 32 PRM had been introduced per tiller. All rates of PRM introduction significantly affected plant height, panicle weight, sterility percentage and panicle curvature in comparison with the control treatment. The smallest plants were reduced by 14.2 – 17.2 cm with the 16 and 32 mites per tiller introduction rates. For both PRM introduction times (30 DAS and 45 DAS), the mean weight of filled grains per panicle decreased while the percentage of the empty grains increased as the densities of PRM increased. The periods of PRM introduction (30 DAS and 45 DAS) affected the yield loss at low densities.

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THE IMPACT OF THE AUSTRALIA AND NEW ZEALAND FREE TRADE AGREEMENT ON THE BEEF INDUSTRY IN INDONESIA

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ABSTRACT

The participation of Indonesia in the ASEAN, Australia and New Zealand Free Trade Agreement (AANZFTA) may have negative effects on the beef industry in Indonesia. Every year more than 90 percent of beef imports come from Australia and New Zealand. The objectives of this study are to: (1) evaluate the impact of tariff removal on Indonesian production, consumption, domestic price and import of beef, (2) evaluate impact of free trade agreement on beef producer and consumer surpluses and, (3) propose alternative policies that can be implemented to increase domestic beef production and reduce beef imports. The removal of beef import tariffs for imports from Australia and New Zealand under AANZFTA will reduce domestic beef production, increase both beef import and domestic beef supply, leading to a reduction in domestic beef price hence, increased beef demand. AANZFTA will increase consumers' surplus and reduce producers' surplus. Reduction of beef imports in terms of imports from Australia, New Zealand, rest of the world and imported feeder cattle will result in highest producers' surplus, however domestic beef production does not increase significantly. Combination of interest rate reduction, increasing imported breeding cattle, artificial insemination technology and beef import tariffs for imports from Australia and New Zealand, is the best policy alternative to increase domestic beef production and curb beef imports. This policy combination can be implemented ahead of AANZFTA implementation. Nonetheless, Indonesia will achieve only 52 percent of beef self sufficiency with this policy in 2014.

Key words: tariff, consumer and producer surpluses, beef self sufficiency

INTRODUCTION

Over the last two decades, there has been a surge in the number of regional trade agreements (RTAs). Many of them have been bilateral while some of them entailed several countries. Some have been local, within regions, others stretching across regions. Some have involved deep integration, going beyond the WTO, while others have been quite light and superficial (Baldwin and Low, 2009). According to WTO as of 31st July 2010, some 474 RTAs, counting goods and services separately, have been notified to WTO/GATT. Of these RTAs, Free Trade Agreements (FTAs) and partial scope arrangements account for 90 percent while the remaining 10 percent are custom unions. Slow progress in multinational trade negotiations in launching and implementing the Doha Development Round appears to have accelerated further rush to forge these regional integration agreements (Crawford and Fiorentino, 2005 and Cooper, 2011).

The agreement establishing the AANZFTA was signed in Thailand in February 2009 by Australia, New Zealand, and the ten ASEAN countries (Indonesia, Brunei, Malaysia, Philippines, Singapore, Thailand, Vietnam, Laos, Myanmar and Cambodia). AANZFTA entered into force on 1 January 2010 following notification of completion of internal requirement including ratification from eight of the parties which are Brunei, Myanmar, Malaysia, Philippines, Singapore, Vietnam, Australia and New Zealand. Subsequently, on 12 March 2010, AANZFTA entered into force for Thailand following its notification on 12 January 2010. The AANZFTA will enter into force for the three remaining ASEAN member countries (Cambodia, Laos and Indonesia) after they have notified completion of their ratification processes. The AANZFTA is the most comprehensive among the FTA agreements that ASEAN has so far concluded. Unlike others, which have separate components separately negotiated and concluded – goods, services and investments, intellectual property rights, electronic commerce, and economic cooperation are in one document[1].

Generally, tariffs are eliminated on most products (except those considered sensitive) over the phase-out period, with some taking effect immediately while others scheduled to be phased out after several years. Indonesia's interest in this FTA stems from opening opportunities for its textile products exports to Australia and New Zealand markets whereas Australia and New Zealand, due to their competitive advantage, are concerned with their livestock products exports, which include milk and beef, to Indonesia. With respect to agriculture, products that are dominantly exported to Australia and New Zealand by Indonesia are coffee, cacao, rubber and palm oil. However, Indonesia competes with Malaysia and Thailand in both markets for the same products (Hutabarat *et al*., 2009).

Among the FTAs Indonesia is involved in, AANZFTA is the first to have significant impact on the Indonesian beef industry as majority of beef imports come from Australia and New Zealand. In this forum, according to schedule of tariff commitments of Indonesia, the tariff rates for beef will be completely phased out by 2020. Currently, Indonesia imposes import tariff, presently at 5 percent on beef and 0 percent on feeder cattle, as an instrument to protect its domestic beef farmers from competing with exporting countries such as Australia and New Zealand. Approximately 30 percent of national beef demand in Indonesia is met by imported beef (as meat from Australia, New Zealand and rest of the world) and beef from imported feeder cattle (Directorate General of Livestock Services, 2010). In this study, total beef imports refer to the imported beef (meat) and beef produced from imported feeder cattle and tariff removal under AANZFTA applies only to beef (meat), since tariff rate for beef cattle is 0 percent. Although in the long run participation of Indonesia in AANZFTA may have positive impact, for instance, through technology spill-over that can improve Indonesian cattle productivity; however, in the short run, opponents of AANZFTA argue that this FTA is going to exacerbate the current condition in domestic beef industry as it will be exposed to increased competition. The consequences of AANZFTA are that, in the event of tariff free, beef import will increase from Australia and New Zealand, as major beef exporters to Indonesia[2], beef supply on Indonesia market will increase, therefore causing downward pressure on domestic beef price and domestic beef production is expected to decline significantly. Statistical data indicate that export shares of Australia and New Zealand to beef imports (that is, excluding beef from imported feeder cattle) in Indonesia have increased from 27.5 and 34.3 percent in 1990 to 57.2 and 41.4 percent in 2008, respectively. Therefore possible impacts of AANZFTA need to be explored especially when Indonesia aims to achieve 90-95 percent beef self sufficiency by 2014. This research is useful for beef producers and government legislators of Indonesia to evaluate the future of beef industry under AANZFTA, especially on the welfare effects of the proposed policies, and to anticipate the 2014 beef self sufficiency program.

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[1] http://aanzfta.asean.org/index.php?page=about-aanzfta. Accessed on 14/04/2010.

[2] Currently, total beef (meat) import from Australia and New Zealand is already more than 70 percent of the total imported beef (meat), amounting at 45,580 tons in 2008, excluding beef from imported feeder cattle come from these countries

The overall objective of this study is to analyse the impact of AANZFTA on beef industry in Indonesia. Specifically to evaluate the impact of tariff removal on beef industry with respect to production, consumption, import and price of beef, Evaluate impact of free trade agreement on beef consumer and producer surpluses and to propose alternative policies that can be implemented to increase domestic beef production.

INDONESIA'S BEEF SUPPLY AND DEMAND STUDIES

Several studies concerning beef industry in Indonesia have been done. Hutabalian (2009) analysed factors affecting supply of beef. Kariyasa (2004), Priyanto (2003) and Ilham (1998) further incorporated factors affecting demand, imports and domestic price of beef and forecasting of demand and supply of beef using various techniques were done by Kariyasa (2004) and Ilham (2006). Priyanto (2003) and Ilham (1998) differentiated supply into supply from feedlots and smallholders. Simulations to evaluate the impact of beef import tariff, exchange rate and interest rate were carried out by Ilham (1998). In addition to beef import tariff, Priyanto (2003) further evaluated impact of increasing beef cattle population and artificial insemination technology on beef industry in Indonesia. The need for extended research on AANZFTA is evident due to lack of empirical studies on this specific free trade agreement. These studies have ignored the importance of differentiating beef imports according to source of origin such as New Zealand and Australia. Participation of these countries in AANZFTA may impose big challenges to Indonesian beef industry as majority of beef imports come from these countries. Therefore the effects of tariff reduction due to AANZFTA on beef industry have to be known so that Indonesia can take appropriate measures to overcome them.

METHODOLOGY

The model developed for this study is simultaneous equation model which consists of seven structural equations and two identity equations therefore there are nine endogenous variables. Simultaneous equation system approach yields better estimates as it is considered more appropriate in dealing with a system of commodity market in which some variables are simultaneously related (Koutsoyiannis, 1977). The model is the modification of Ilham (1998) and Priyanto (2003) models. The econometric model is as follows:

Domestic Beef Supply

Domestic beef supply (NBS_t) is the summation of domestic beef production (DBS_t) and total beef imports (BI_t). The equation is as follows:

$$NBS_t = DBS_t + BI_t \quad (1)$$

Domestic Beef Production

Domestic beef production (DBS_t) is determined by lagged real domestic beef price ($RDBP_{t-1}$), domestic beef cattle population ($BCPOP_t$), imported breeding cattle (IBC_t), real interest rate (RIR_t) which reflects the cost of borrowing from banks by farmers, lag of artificial insemination technology doses (AIT_{t-1}) and lag of domestic beef production (DBS_{t-1}). Artificial insemination technology improves genetic quality of cattle hence increases calving rate as a result cattle population increases. Lag of AIT is used as results of this technology are observed after a year, implying that the current domestic beef production is determined by the previous year implemented AIT dose. The equation is shown as follows:

$$DBS_t = a_0 + a_1RDBP_{t-1} + a_2BCPOP_t + a_3IBC_t + a_4RIR_t + a_5AIT_{t-1} + a_6DBS_{t-1} + U_1 \quad (2)$$

Hypothesis: $a_1, a_2, a_3, a_5 > 0 \quad a_4 < 0 \quad 0 < a_6 < 1$

Total Beef Imports

Beef imports (BI_t) were differentiated by source of origin, i.e., imports from Australia (BIA_t), New Zealand ($BINZ_t$), feeder beef supply (FBS_t) and the remaining as rest of the world ($BROW_t$), to be able to study the impact of AANZFTA on Indonesia beef industry. Due to lack of data on beef supply from imported feeder cattle, it was assumed that the average slaughter weight of feeder cow is 224 kg (average live weight of 416 kg with 210/390 used as ratio of slaughter to live weight), adopted from Vanzetti *et al*. (2010). This weight was used as conversion factor to get beef production from imported feeder cattle each year by multiplying number of imported feeder cattle every year by this factor. The result was subtracted from domestic beef supply to get supply from domestically reared cattle. This is because beef self sufficiency in Indonesia is calculated based on beef production from domestically reared cattle not from imported cattle to be fattened and slaughtered for beef. Thus the equations were as follows:

$BI_t = BIA_t + BINZ_t + FBS_t + BROW_t$...(3)

$BIA_t = b_0 + b_1RIBP_t + b_2RXR_t + b_3BITA_t + b_4NBD_t + b_5DBS_t + b_6BIA_{t-1} + U_2$................(4)

$BINZ_t = c_0 + c_1RIBPt + c_2RXR_t + c_3BITNZ_t + c_4NBD_t + c_5DBS_t + c_6BINZ_{t-1} + U_3$ ....(5)

$FBS_t = IFC_t *K$...(6)

Hypothesis: $b_1, c_1, b_2, c_2, b_3, c_3, b_5, c_5 <0$ $b_4, c_4 >0$ $0< b_6, c_6 <1$

Equations (4) and (5) indicate that beef import from Australia (BIA_t) and New Zealand ($BINZ_t$), each is determined by real import beef price (RIBPt) (average of import beef price from both countries), real exchange rate (RXR_t)[3], beef import tariff rate for each country ($BITA_t$ and $BITNZ_t$ for Australia and New Zealand, respectively), national beef demand (NBD_t), domestic beef production (DBS_t) and lag of beef import from each country (BIA_{t-1} and $BINZ_{t-1}$ for Australia and New Zealand, respectively). Feeder beef supply (FBS_t) (equation 6) was obtained by multiplying numbers of feeder cattle imported (IFC_t) by conversion factor (K = 0.224 ton/head).

National Beef Demand

Demand function is determined by own-price, cross price and income elasticities of demand. The values show the percentage change in quantity demanded of a particular good to a one percent change in the price of that good, price of substitute, and in consumers' income, respectively. Thus, national beef demand (NBD_t) is the function of ratio of real domestic beef price to real domestic chicken price ($RDBP_t/RDCP_t$), real gross domestic product per capita ($RGDPC_t$) and trend (T_t) which represents consumers' preference. The equation was as follows:

$NBD_t = d_0 + d_1(RDBP_t/RDCP_t) + d_2RGDPC_t + d_3T_t + U_4$ ....(7)

Hypothesis: $d_2, d_3>0$ $d_1< 0$

World Beef Demand

As Indonesia is one of the importers of beef in the world therefore world beef demand (WBD_t) is the summation of Indonesian beef imports (BI_t) and beef imports from the rest of the world ($WBDROW_t$). The equation for world beef demand is as follows:

$WBD_t = BI_t + WBDROW_t$ ....(8)

[3] In Rp/USD, since USD is used in trading among Indonesia, Australia and New Zealand

Real Domestic Beef Price

Real domestic beef price ($RDBP_t$) is depended on difference between real import beef price and its lag ($RIBP_t$ – $RIBP_{t-1}$), real domestic beef cow price ($RDBCP_t$), domestic beef supply (NBS_t) and lag of real domestic beef price ($RDBP_{t-1}$). The equation is as follows:

$RDBP_t = e_0 + e_1(RIBP_t – RIBP_{t-1}) + e_2RDBCP_t + e_3NBS_t + e_4RDBP_{t-1} + U_5$ ....(9)

Hypothesis: $e_1, e_2>0 \quad e_3< 0 \quad 0< e_4 < 1$

Real Import Beef Price

Real import beef price ($RIBP_t$) is assumed to be determined by real world beef price ($RWBP_t$), which is United States beef import price as it is the largest importer of beef, real import beef cow (feeder) price from Australia ($RIBCP_t$) (Indonesia imports feeder cattle predominantly from Australia) and lag of real import beef price ($RIBP_{t-1}$). Real import beef price's equation was formulated as follows:

$RIBP_t = f_0 + f_1RWBP_t + f_2RIBCP_t + f_3RIBP_{t-1} + U_6$..(10)

Hypothesis: $f_1, f_2 >0 \quad 0< f_3 < 1$

Real World Beef Price

Real world beef price ($RWBP_t$) is assumed to be influenced by difference between world beef supply and its lag ($WBS_t – WBS_{t-1}$), world beef demand (WBD_t) and lag of real world beef price ($RWBP_{t-1}$). Thus equation for real world beef price was as thus:

$RWBP_t = g_0 + g_1(WBS_t – WBS_{t-1}) + g_2WBD_t + g_3RWBP_{t-1} + U_7$......................................(11)

Hypothesis: $g_1< 0 \quad g_2 >0 \quad 0< g_3 < 1$

Imported Feeder Cattle

Feedlots prefer imported feeder cattle as compared to domestic feeder cattle because (1) they are cheaper than domestically produced feeder cattle, (2) easiness to obtain large number of feeder cattle through importing as compared to domestic procurement, and (3) time and transportation costs from Australia are cheaper than from other regions in Indonesia such as Nusa Tenggara Timur, Nusa Tenggara Barat and Sulawesi Selatan (Hadi and Ilham, 2002). Imported feeder cattle (IFC_t) equation is assumed to be determined by real import beef cow (feeder) price ($RIBCP_t$), real exchange rate (RXR_t), domestic beef production (DBS_t) and lag of imported feeder cattle (IFC_{t-1}). This is shown as follows:

$IFC_t = h_0 + h_1RIBCP_t + h_2 RXR_t + h_3DBS_t + h_4IFC_{t-1} +U_8$ ....(12)

Hypothesis: $h_1, h_2, h_3 < 0 \quad 0< h_4< 1$

Estimation Method

Twelve endogenous variables were influenced by 8 lagged endogenous variables and 17 exogenous variables. Identification was verified by calculating order and rank conditions and the model was found to be over-identified; therefore Two Stage Least Squares (2SLS) estimation method was applied. 2SLS tends to yield more robust estimates under the circumstance of the existence of model misspecification, missing of relevant variables, multicolinearity and autocorrelation error (Koutsoyiannis, 1977). Data was processed using SAS/ETS Software version 9.1.

Producer and Consumer Surplus Analysis

The consumer and producer surplus concepts were used to measure welfare. The consumer surplus measures the difference between what consumers are willing to pay for a good and what they actually pay. It can also be used to measure the impact on the consumer's surplus of a change in price of a good, *ceteris paribus*. Meanwhile, producer surplus measures the impact on the producer's welfare of a change in price of a good, *ceteris paribus*. The consumer and producer surpluses were represented as follows (Obado *et al*., 2009) (subscript b = base value and s = policy simulation value):

1. **Change in Domestic Producer Surplus**
   $\Delta PS = DBS_b(RDBP_s - RDBP_b) + ½ (DBS_s - DBS_b) (RDBP_s - RDBP_b)$

2. **Change in Domestic Consumer Surplus**
   $\Delta CS = NBD_b (RDBP_b - RDBP_s) + ½ (NBD_s - NBD_b) (RDBP_s - RDBP_b)$

3. **Change in Government Revenue**
   $\Delta GR = (BIT_s * RIBP_s * BI_s) - (BIT_b * RIBP_b * BI_b)$

4. **Net Surplus** $= \Delta PS + \Delta CS + \Delta GR$

It should be noted that the volume of beef imports used to calculate government revenue does not include volume of feeder beef supply because this supply is from imported feeder cattle of which are import duty free.

Data Type and Sources

Data used in this study was secondary time series data from 1990 – 2008, obtained from Central Bureau of Statistics Indonesia, Directorate General of Livestock Services Indonesia, International Monetary Fund, Directorate General of Customs Indonesia and from publications and reports relevant to the study.

RESULTS AND DISCUSSION

Model Statistics and Estimation Results

The estimates of Indonesian beef industry model are presented in Table 1. The results show that the determination coefficients (R^2) of six structural equations ranges between 0.67450 and 0.98722, while the remaining two are below 0.48. This means that, generally, the ability of explanatory variables in explaining variation in values of endogenous variables is quite satisfactory. However, there are parameter estimates whose signs do not conform to the hypotheses and are not significant at α=0.05 – 0.20 level of significance. Two structural equations did not have autocorrelation, whereas the remaining six fell in inconclusive region (0.82<DW<1.87 or 2.13<DW<3.18). Therefore there was no autocorrelation among independent variables, implying that parameter estimates are more efficient and not biased. Concerning F statistic test, the p-values were found to range between <.0001 and 0.0612 for all equations except for domestic beef production (Pr>F = 0.3737). This indicates that in each equation, together, the explanatory variables were able to explain variation in endogenous variables. Parameter estimation results are shown in Table 1.

All of the estimated parameters in the beef production equation have expected signs except beef cattle population. Interest rate is included to account for the cost of borrowing however it is not significant. This indicates the inability of smallholder beef farmers to access capital due to lack of collateral (Sukanata, 2008).

Beef imports were separated into imports from Australia and New Zealand so that it can be easy to observe the impact of AANZFTA on beef industry in Indonesia. On the other hand, these are the major exporters of beef to Indonesia. Most of Indonesia's beef imports come from Australia due to its proximity to Indonesia therefore there are relatively low transportation costs incurred when importing from this country. The estimates obtained for beef imports from Australia are consistent with *a priori* expectations. As expected, beef imports from Australia are negatively related with import beef price, exchange rate, beef import tariff and domestic beef production and positively related with national beef demand.

New Zealand is the second largest exporter of beef to Indonesia. The estimates of beef imports from New Zealand suggest that the primary factors affecting beef imports from this country are real exchange rate, beef import tariff, domestic beef production and national beef demand with expected signs. Real exchange rate and domestic beef production have negative signs as expected.

Table 1. Results of Parameter Estimation and Statistics Tests for Beef Industry Model in Indonesia

Domestic Beef Production

$$DBS_t = 384867.3 + 2.968063RDBP_{t-1} + -0.01969BCPOP_t + 3.0044568IBC_t - 1158.17RIR_t +$$
(0.1136) (0.2650) (0.2044) (0.1636) (0.8065)

$$38.04585AIT_{t-1} + 0.86668DBS_{t-1}$$
(0.1638) (0.7352)

R^2 = 0.39600 Pr > F = 0.3737 F value = 1.20 DW = 2.17

Beef Imports from Australia

$$BIA_t = 26930.80 - 469.901RIBP_t - 0.01050RXR_t - 96.1892BITA_t + 0.072436NBDt - 0.12571DBS_t$$
(0.0728)** (0.5341) (0.2764) (0.5542) (0.1491) (0.0087)*

$$+ 0.399544BIA_t$$
(0.1276)

R^2 = 0.93187 Pr > F = <.0001 F value = 25.07 DW = 2.12

Beef Imports from New Zealand

$$BINZ_t = -2791.44 + 338.6734RIBP_t - 0.00527RXR_t - 91.4101BITNZ_t + 0.055306NBDt -$$
(0.7041) (0.4908) (0.2009) (0.3746) (0.0397)*

$$0.03693DBS_t + 0.707301BINZ_t$$
(0.1162) (0.0006)*

R^2 = 0.95219 Pr > F = <.0001 F value = 36.52 DW = 1.42

National Beef Demand

$$NBD_t = 198837.1 - 12169.1(RDBP_t / RDCP_t) + 5.047602RGDPC_t + 12649.96T_t$$
(0.0177)* (0.6962) (0.1434) (0.0058)*

R^2 = 0.67450 Pr > F = 0.0010 F value = 9.67 DW = 2.29

Real Domestic Beef Price

$$RDBP_t = 10890.23 + 1015.296(RIBP_t - RIBP_{t-1}) + 1.488288RDBCP_t - 0.01084NBS_t + 0.0496RDBP_{t-1}$$
(0.1940) (0.1779) (0.0644)** (0.6382) (0.8755)

R^2 = 0.47623 Pr > F = 0.0612 F value = 2.96 DW = 2.27

Real Import Beef Price

$$RIBP_t = -1.93065 + 1.046104RWBP_t + 0.001755RIBCP_t + 0.413441RIBP_{t-1}$$
(0.0396)* (0.0264)* (<.0001)* (<.0001)*

R^2 = 0.98722 Pr > F = <.0001 F value = 360.46 DW = 2.29

Real World Beef Price

$$RWBP_t = 0.029060 - 1.8E\text{-}8(WBS_t - WBS_{t-1}) + 5.20E\text{-}8WBD_t + 0.801940RWBP_{t-1}$$
(0.9444) (0.8231) (0.1755) (<.0001)*

R^2 = 0.79938 Pr > F = <.0001 F value = 18.59 DW = 2.09

Imported Feeder Cattle

$$IFC_t = 765688.7 - 171.341RIBCP_t - 0.48451RXR_t - 0.91509DBS_t + 0.810754IFC_{t-1}$$
(0.0001)* (0.0021)* (0.0001)* (0.0280)* (0.0001)*

R^2 = 0.89631 Pr > F = <.00001 F value = 28.09 DW = 1.69

Notes: * indicates 5 percent level of significance, ** indicates 10 percent level of significance,
Numbers in brackets indicate t-statistics

All variables influencing national beef demand were found to conform to the theory with expected signs. Trend represents consumers' preference while real GDP per capita represents consumers' income. Chicken is a substitute of beef. The ratio of domestic beef price to domestic chicken price has negative sign as expected.

The analysis results of domestic beef price in Table 1 show that the difference between import beef price and its lag, and domestic beef cow price have positive signs as expected. The coefficient of domestic beef supply is negative as expected but it is not significantly different from zero. The coefficient of lagged real domestic beef price is positive as expected but statistically insignificant.

The estimates of all variables included in real import beef price equation conform to the theory and are statistically significant at five percent level. As expected real world beef price, real import beef cow price and lagged real import beef price are positively related with real import beef price.

In the meantime, real world beef price is affected by difference between world beef supply and its lag, world beef demand and lagged real world beef price and have expected signs. The coefficient of world beef demand is positive while difference between world beef supply and its lag is negative as expected. The coefficient of lagged real world beef price is significant at five percent indicating that lagged adjustment model is appropriate.

Feeder cattle import is mainly determined by real import beef cow price, real exchange rate, domestic beef production and lag of imported feeder cattle. Their estimates are consistent with *a priori* expectations and are statistically significant at five percent level. Real import beef cow price, real exchange rate and domestic beef production are negatively related with feeder cattle imports.

Evaluation of Impacts of Alternative Policies on Beef Industry

Eleven *ex ante* policy simulations carried out in this study include:

1. Removal of import tariffs for beef imports from Australia and New Zealand
2. Interest rate reduction to five percent
3. Increasing imported breeding cattle by 30 Percent
4. Increasing artificial insemination technology in previous year by 40 percent
5. Combination of policies in policy simulations 2, 3 and 4
6. Increasing import tariffs for beef imports from Australia and New Zealand by 20 percent each
7. Combination of policies in policy simulations 5 and 6
8. Combination of policies in policy simulations 1 and 5
9. Reducing beef imports from Australia, New Zealand, rest of the world and imported feeder cattle by 90 percent each
10. Combination of policies in policy simulations 5 and 9
11. Combination of reducing real interest rate to four percent, increasing beef import tariff by 40 percent, increasing imported breeding cattle by 60 percent and increasing AI technology by 64 percent.

The impacts of these policies are summarized in Table 2. Policy simulation 1 assumes Australia and New Zealand as largest exporters of beef to Indonesia in AANZFTA. From Table 2 it can be observed that removal of beef import tariffs for beef from Australia and New Zealand will mostly increase import from New Zealand by 69.76 percent from the current import level of 5,757 tons, which translates to 4,015.9 tons per year; while imports from Australia will increase by 25.58 percent from the current import level of 8,511 tons, which translates to 2,177.4 tons annually. The eventual effect will be increase in total beef import by 10.65 percent or 6,396.7 tons. Meanwhile, increase in beef imports is coupled by corresponding increase in domestic beef supply by 6,174 tons from the current supply of 362,144 tons or 1.7 percent. Real domestic beef price will decline by 0.3 percent, as the result of increase in domestic beef supply. Hence, national beef demand will increase by 79 tons or 0.022 percent. Domestic beef production will decline by 0.073 percent, which translates to 222 tons, in response to reduction in real domestic beef price. On the other hand, imports of feeder cattle will increase by 0.46 percent or 908 heads in response to contracted beef production in domestic market. Consequently, increase in number of imported feeder cattle will increase feeder beef supply by 203.3 tons. Although not significantly increased, increase in total beef imports by Indonesia will increase world beef demand by 6,396 tons or 0.089 percent.

As a result, due to positive influence of world beef demand towards real world beef price, real import beef price will increase by 0.07 percent. This in turn will increase real import beef price by 0.084 percent. As expected, with this policy beef consumers will experience gain in consumer surplus of about Rp 25.4 billion while beef producers will lose in producer surplus about Rp 21.2 billion (Table 3).

Through regulation of Ministry of Agriculture No. 40/Permentan/PD.400/9/2009 and Regulation of Ministry of Finance No. 131/PMK.05/2009, the government is providing livestock breeders in cattle breeding farming cattle breeding credit scheme at subsidized interest rate of five percent for maximum of six years. With this credit, the expectation is that the breeding industry and breeders will increase and develop as a result cattle population will increase and employment will be created. It is expected that it will accelerates efforts to reach beef self sufficiency in 2014. In this study interest rate was reduced to five percent (policy simulation 2). Artificial insemination (AI) is one of the efforts utilized by government to improve genetic quality of livestock and breeding cattle are imported to complement AI. During the period 1990 – 1999 semen production grew by 37 percent annually. This level was increased to 40 percent (policy simulation 4) to study impact of AI on beef production if similar conditions prevail. Number of breeding cattle imported was increased to 30 percent (policy simulation 3).

Table 2 reveals that among the three policy alternatives, AI has significant impact on increasing domestic beef production and reducing beef imports, followed by increasing imported breeding cattle. Increasing AI technology doses in previous year by 40 percent increases domestic beef production by 15,984 tons, increasing imported breeding cattle by 30 percent leads to rise in domestic beef production by 4,212 tons while reducing interest rate increases domestic beef production by only 1,803 tons. So it can be concluded that the five percent interest rate is not enough to increase domestic production significantly. The most important policies are increasing artificial insemination technology and breeding cattle. However, if government combines these three policies (policy simulation 5) domestic beef production will increase by 21,999 tons. On the other hand, domestic beef breeders believe that the current import tariff is too low to sufficient protect domestic beef industry.

Due to letter of intent that was signed between Government of Indonesia and International Monetary Fund, Indonesia can not increase its beef import tariff above five percent. However if government could increase import tariff by 20 percent (policy simulation 6) domestic beef production would increase by just 45 tons although total beef imports are reduced by 1,279.3 tons. However, if policy simulation 7 is carried out larger domestic beef production can be attained, that is, 22,043 tons. To minimise the effect of AANZFTA on domestic beef industry, policy alternatives in policy simulation 8 can be implemented since they still yield higher domestic beef production, that is, 21,776 tons.

Table 2. Impact of policy alternatives on beef industry in Indonesia.

Label	Unit	Mean	Policy Simulations (Units)										
			1	2	3	4	5	6	7	8	9	10	11
NBS	Ton	362144	6174	101	-852	-2813	-3563	-1235	-4798	2611	-52530	-31380	-8748
DBS	Ton	302059	-222	1803	4212	15984	21999	45	22043	21776	1604	22754	37156
BI	Ton	60084.7	6396.7	-1702.3	-5063.3	-18796	-25561.7	-1279.3	-26841	-19165	-54133.6	-54133.6	-45904.1
BIA	Ton	8511.1	2177.4	-340.2	-866.9	-3240.9	-4448.1	-435.4	-4883.6	-2270.7	-7660.0	-7660.0	-8385.6
BINZ	Ton	5756.6	4015.9	-164.8	-483.6	-1798.9	-2447.2	-803.2	-3250.4	1568.7	-5180.9	-5180.9	-5755.1
RDBP	Rp/kg	23173.3	-70.2	-1.2	9.5	31.4	39.6	14.1	53.7	-30.6	592.3	351.6	97.9
NBD	Ton	361227	79.0	1.0	-8.0	-24.0	-30.0	-16.0	-46.0	49.0	-615.0	-354.0	-85.0
IFC	Head	197675	908	-5345	-16575	-61412	-83332	-181	-83513	-82424	-177908	-177908	-141800.4
FBS	Ton	44279.3	203.3	-1197.3	-3712.8	-13756.3	-18666.4	-40.7	-18707.1	-18463.0	-39910.4	-39910.4	-31763.4
RIBP	US$/kg	2.9776	0.0025	-0.0005	-0.0017	-0.0063	-0.0085	-0.0005	-0.0090	-0.0060	-0.0146	-0.0146	-0.0155
RWBP	US$/kg	2.1300	0.0015	-0.0003	-0.0010	-0.0037	-0.0050	-0.0003	-0.0053	-0.0036	-0.009	-0.009	-0.0092
WBD	Ton	7184388	6396	-1703	-5064	-18796	-25562	-1280	-26841	-19165	-54134	-54134	-45904

Table 3. Impact of policy alternatives on beef producer surplus and consumer surplus in Indonesia **(Rp 000)**

Welfare Change	1	2	3	4	5	6	7	8	9	10	11
Producer Surplus	-21 196 750	-363 553	2 889 568	9 735 601	12 397 117	4 259 349	16 812 423	-9 576 178	179 384 570	110 204 098	31 390 362
Consumer Surplus	25 355 363	433 472	-3 431 695	-11 342 905	-14 305 183	-5 093 414	-19 399 125	11 052 796	-214 136 884	-127 069 646	-35 368 284
Government Revenue	-22 778 085	-731 488	-1 958 178	-7 295 833	-9 973 876	2 409 364	-9 551 169	-22 778 085	-20 509 065	-20 509 065	-3 685 223
Net Surplus	-18 619 472	-661 568	-2 500 305	-8 903 136	-11 881 942	1 575 300	-12 137 872	-21 301 467	-55 261 379	-37 374 613	-7 663 144

In efforts to stimulate domestic beef production to achieve beef self sufficiency by 2014, the Government of Indonesia aims at reducing total beef imports to 10 percent. In Indonesia, beef self sufficiency means that 90 percent of beef demand is met by domestic beef production while the remaining 10 percent still needs to be imported to meet the demand of restaurants, hotels and high income families as domestic production cannot meet their demand in terms of quality. Total beef imports in terms of beef imports from Australia, New Zealand, rest of the world and imported feeder cattle were reduced by 90 percent each (policy simulation 9) to evaluate the impact of this policy on domestic beef production. The results show that this policy is not favorable to domestic beef industry. Although total beef imports are significantly reduced by 54,133.6 tons, domestic beef production increases by just 1,604 tons. Consequently, domestic beef supply declines by 52,530 tons leading to increase in domestic beef price by Rp 592/kg hence beef demand decline by 615 tons. To lessen the effect of this policy alternative, it can be carried out concurrently with policy alternatives in policy simulation 5 (policy simulation 10). Domestic beef production would rise by 22,754 tons while domestic beef supply declines by 31,380 tons and demand declines by 354 tons.

Policy simulation 11 was carried out as a drastic policy combination that can be implemented to drastically reduce beef imports and stimulate domestic production. Beef imports from Australia and New Zealand are almost reduced by 100 percent each, with 8,385.6 and 5,755.1 tons reductions, respectively. Imported feeder cattle are decreased by 141,800 heads which translate to 31,763.4 tons reduction in feeder beef supply. These reductions leads to 45,904.1 tons decline in total beef imports whereas domestic beef production rises by 37,156 tons. On the whole, domestic beef production is significantly increased with implementation of policy alternative in simulations 5, 7, 8, 10 and 11.

Beef producers will experience decline in producers' surplus with policy simulations 1, 2 and 8 while consumers benefit with the same policies (Table 3). Highest producers' surplus is achieved with policy simulation 9 whereas highest consumers' surplus is achieved with simulation 1. Government will gain in import tariff revenues from increasing import tariffs for beef imports from Australia and New Zealand, but will lose from other policy simulation alternatives. Indonesian society as a whole will lose in welfare from all policy alternatives except for policy alterative of increasing import tariffs for beef imports from Australia and New Zealand.

To determine level of beef self sufficiency by 2014, projections of domestic production, imports and consumption of beef from 2009 to 2014 were done using the formula to calculate average geometric rate of annual growth in Excel (Table 4). Based on statistical data, Table 4 illustrates that domestic beef production in 2008 was 264,998 tons while consumption was 438,280 tons. Under status quo conditions, domestic beef production is projected to be 374,866 tons by 2014 while consumption will be 794,969 tons.

Table 4. Projections of production and consumption of beef from 2009 to 2014 in Indonesia.

Year	Domestic beef production, tons (a)	Beef Imports, tons (b)	National Beef Demand, tons (a+b=c)	Percent Beef Self Sufficiency [(a/c)*100]
2008	264998	173282	438280	60.46
2009	283309	214419	497728	56.92
2010	301621	255555	557176	54.13
2011	319932	296692	616624	51.88
2012	338243	337829	676073	50.03
2013	356555	378966	735521	48.48
2014	374866	420103	794969	47.15
2014[a]	412022	382862	794884	51.83

Table 4 further reveals that Indonesia's beef self sufficiency will tend to decrease from 60 percent in 2008 to 47 percent in 2014. This implies that 53 percent of beef demand in Indonesia will still need to be met by beef imports by 2014. Policy simulation 11 was found to yield highest domestic beef production and reduces beef imports by almost 100 percent from Australia and New Zealand. If this policy is implemented, domestic beef production would increase by 37,156 tons while beef demand would decline by 85 tons. Thus, by 2014, this policy can increase domestic beef production to 412,022 tons while beef demand could decline to 794,884 tons. Nonetheless, this policy can help Indonesia achieve only 52 percent of beef self-sufficiency (2014[a] figures, Table 4).

CONCLUSION

Removal of beef (meat) import tariffs for imports from Australia and New Zealand under AANZFTA will increase beef imports from New Zealand and Australia. As a result, domestic beef supply will increase. Consumers will be better off as domestic beef price will be reduced due to increased domestic beef supply. Despite decline in domestic beef price, this policy will not reduce domestic beef production drastically.

ASEAN, Australia and New Zealand free trade agreement will reduce producers' surplus and increase consumers' surplus as expected. This policy will result in highest consumers' surplus. Among the policy alternatives proposed, huge producers' surplus can be attained if total beef (meat) imports in terms of imports from Australia, New Zealand, rest of the world and imported feeder cattle are banned by 90 percent each. However, producers benefit at the expense of consumers as this policy reduces domestic beef supply and increasing domestic beef price hence reducing beef demand.

In case Indonesia can be allowed to increase beef import tariff, combination of interest rate reduction to four percent, increasing number of imported breeding cattle by 60 percent, artificial insemination technology by 64 percent and beef import tariffs for imports from Australia and New Zealand by 40 percent each can be the best policy alternative that can be utilized to increase domestic beef production and discourage beef imports drastically. This policy combination can be implemented ahead of implementation of AANZFTA in Indonesia. However, this policy cannot assist Indonesia to achieve 90-95 percent beef self sufficiency but only 52 percent.

Subsequent to AANZFTA implementation, whereby beef import tariff in Indonesia will be completely phased out in 2020, government can minimize the impact of this free trade agreement by reducing interest rate, increasing number of imported breeding cattle and artificial insemination technology. All policy alternatives will result in loss in government revenue and society as a whole.

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POPULATION CORRELATES AND CRITICAL PEST LEVEL (CPL) OF THE LEAFHOPPER, *AMRASCA BIGUTTULA* AND ASSOCIATED INSECT PESTS ATTACKING OKRA, *HIBISCUS ESCULENTUS* (L.)

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ABSTRACT

This study was conducted in two locations; San Manuel and Capas, Tarlac from 2008-2010. It aimed to determine the population density of major insect pests attacking okra as affected by time of planting, establishment of critical pest level (CPL) of *Amrasca biguttula* and other associated insect pests, and to assess phenologically the rate of first instar larval/nymph emergence from an eggmass. Feeding tests of insect pests with host were conducted in an experiment nethouse with sufficient batches of trials which had established the critical pest level. *Amrasca sp*. and *Dysdercus cingulatus* were found with high population density during the dry seasons planting of 2009-2010, while *Spodoptera litura* registered a population mean ranging from 11.75 to 23.66 regardless of observation sites. High population of *Amrasca sp.* was evident during January and onwards as affected by temperature and as shown from the gathered population data which confirmed that planting of okra during dry seasons would entail significant damage of the crop. With a series of feeding interaction tests conducted for *Amrasca biguttula,* its critical threshold level was established with a population ratio of 45.53 per 50 plants with an allowable yield reduction threshold of 10 percent (%). The generated data is recommended for adoption which contributes to reduced frequency of chemical application and production of quality exportable green okra. Moreover, phenological forecast on the hatchability of the eggs of two major insect pests; *Amrasca bigutula* and *Dysdercus cingulatus* were found correlated with temperature while *A. biguttula* was found correlated with crop age and temperature.

Key words: *Dysdercus cingulatus, Heliothis armigera, Spodoptera litura,* phenological forecast, feeding test

INTRODUCTION

Okra is a vegetable crop under the Malvaceae family, scientifically known as *Hibiscus esculentus* L. Some agricultural studies and literatures underscored the nutritional importance of okra due to its valuable nutrients. It has been recognized as an important food crop due to its high seed protein content of 21% and abundant essential nutrients. It has been noted as a good source of vitamin, phosphorus, and iron. Mature okra seed contains 20% edible oil.

For the last thirteen years, this crop has been intensively cultivated by farmers, particularly in the Province of Tarlac, due to its export potential as well as the contribution to the economy of the province. Although farmer-cultivators have enjoyed and are continuously enjoying the gains from okra production, they have been facing with problems like pest resurgence and development of insecticide resistance in okra leafhopper (*Amrasca biguttula*) which becomes a major problem in okra production due to the calendar spraying practice by the growers. In 2005, information gathered from the okra growers revealed that pesticide detectable residues from okra fruits sampled from foreign market access were beyond acceptable limit due to the effect of calendar spraying (OPPA, 2005).

Amrasca biguttula is also considered as one of the major pests of legumes in Southeast Asia. This pest was originally under the genus *Empoasca*, but Gapud (1995) and Caasit-lit (1989) confirmed that this genus was renamed to *Amrasca*. Both nymphs and adults feed on the lower surface of the leaves. They suck the sap and cause hopper burn. Heavy damage is shown by yellowing of the leaf margin and curling of the leaves. High infestation during the vegetative stage ultimately causes stunting followed by the death of the plant (Scheirner, 2000).

Okra leafhopper is also known as eggplant leafhopper, cotton leafhopper, green jassid and Indian cotton leafhopper. This pest is difficult to control and it was found very destructive. Various strategies like alternate use of pesticides had been done by farmers themselves to control this pest but did not emerged as sustainable control strategy. Moreover, it is not economical but causes environmental pollution instead. This could be the reason why farmers should be guided with workable and viable control measures, through reduced frequency of pesticide application.

Relatively, the result of this study is an imminent component of the export scheme such as production of quality green okra with tolerable/acceptable pesticide residue, as a market assurance for foreign consumers.

MATERIALS AND METHODS

Determination of correlates on major insect pest populations of okra as affected by time of planting

The establishment of trial plots were done to generate information on monthly population trend of major insect pests attacking okra. It aimed to serve as basis for planting guide and enable farmers to avoid the damage particularly caused by *Amrasca sp.* and ultimately reduce the effect of pesticide residue. Clusters of farms in four sites in San Manuel and Capas, Tarlac planted with okra in January planting 2009 and January planting 2010 were identified as observation sites. An area of 2,500 m^2 per trial was used for data collection. In each observation unit, data were gathered at 30, 45, 60 and 75 days after planting on 100 tagged plants randomly selected across the test plots in an X pattern. Correlation of determinants; crop age and temperature in relation to major insect pests abundance were determined. The results were tabulated and analyzed statistically.

Feeding Test and Determination of Critical Pest Level (CPL)

Collection and mass rearing of *A. biguttula*

Egg colonies of *Amrasca biguttula* were collected from the field and mass reared in a room temperature using ball jars. Disinfected fresh okra leaves, honey and wetted cotton balls were provided in the rearing jars from egg up to adult stage. The rearing media were replaced daily until enough supply of leafhopper adults was attained. The rearing set-ups were the source of insects for test replicates. Initial observations and recording were made to determine the susceptible stage of *Amrasca* and to assess the duration of each stadium from egg to adult and validated in nethouse experiment.

The Critical Pest Level (CPL) of *Amrasca* sp. was determined through feeding tests. Three hundred polyethylene bags size #9 were planted with susceptible okra plants arranged in Completely Randomized Design (CRD) replicated three times. The treatments were as follows:

T1 - 2 egg cluster with 100 eggs
T2 - 2 egg cluster with 150 eggs
T3 - 2 egg cluster with 200 eggs
T4 - 2 egg cluster with 250 eggs
T5 - Control Check

Egg clusters deposited on leaves of okra taken from reared *A. biguttula* sp. were pinned on the leaves of an identified center plants in the assigned experiment treatments, done for five set up; dry seasons from January 2009 to June 2010. Data collections were made at 30, 45, 60 and 75 days after crop emergence. Cost of control and the value of the product were determined based on the tolerable yield reduction (TYR) caused by crop response with *Amrasca* sp.

Theoretical critical pest level was equated with equivalent crop damage from the total incidence of hopper burn. Reduction of pest by parasites, entomopathogen, competitors, antagonists and environmental conditions were estimated. The computation of the action critical pest level (ACPL) was made based on the ratio of insect population and equivalent crop damage using the method of Cadapan *et al.* (1996).

Fabrication and installation of net house

A net house was fabricated and constructed using steel materials. The structure has a measurement of 10 m x 10 m equivalent to an area of 100 m^2; with 4.5 m in height .Flat thin narrow steel reinforcement was used across the perimeter of the fabrication, structurally enclosed with a white fine mesh cloth. Trenches were established around edge-ends, with 6.5 inches depth purposely to prevent the entrance of pest other than the test insect. Ten steel net cages were framed separately as an enclosure material on control check treatments made up of steel post measuring 1.5 meters in height with four sides containing a diameter of 0.5 meter installed through acetylene machine with its corner ends enclosed with fine mesh cloth.

Preparation of host plant and layout of the experiment

Three hundred #9 thick black polyethylene bags were planted with highly susceptible okra variety secured from Biotech UPLB using a sterilized soil media following the peri-urban cultural requirements according to the method of Ulrichs (2001). Individual bags were planted with the rate of 5 seeds per bag and thinned to 3 plants at 10 days after crop emergence. Five treatments in a set were laid in a Completely Randomized Design, arranged in 3 replicates. One week after seed emergence, control check(s) were provided with steel cages which enclosed the test plants free from other insect pests.

Phenological forecast of *Amrasca biguttula* and *D. cingulatus*

Phenological forecast from egg to nymph emergence of the leafhopper, *Amrasca biguttula* and *Dysdercus cingulatus* was predicted. Basically, this is an important approach in the timing of chemical control. Temperature was used to correlate the determinants as it exerted dominance on developmental rate of the insect pests. The computation was done by using the electronic model established by Mols (1989) that evaluates the monitored daily temperature, oviposition and the rate of development of insect (in days) specifically on emergence of the first nymphal stadium from an egg. The forecast equation used, viz:

$$Y=a+b.X. \qquad \text{(Equation a)}$$

The value of X is the prevailing temperature T and Y is the rate of development r, then: r=a+b.T; TS=D.(T-Td) (Equation b)
where:

Ts = the temperature sum appropriate to the particular event
D = the duration in time units
T = the prevailing temperature
Td = the threshold temperature for development of insect
T-Td = the effective temperature
Tmin = the temperature in a given period of the effective temperature of each day
Tmax = is the temperature that exceeds the threshold temperature that would initiate emergence of a insect stadium from egg.

The constant a and b is transformed 1/D=(T-Td) / Ts, 1/D=(1.Ts).T-Td/Ts. (Equation c)

Thus r=1/D, b=1/Ts, a=Td/Ts. (Equation d)

Using temperature sum of several days on this study with the equation:

Ts=Σï (Tmin +Tmax) /2-Td. (Equation e)

The generated output of this study establishes a sustainable control based on judicious decision making in as much that *Amrasca* and other major insect pests attacking okra are unpredictable as to their population and feeding habits.

RESULTS AND DISCUSSION

Determination of major insect pest populations in okra as affected by time of planting

The leafhopper attacking okra, *Amrasca biguttula*, and other associated insect pests of the crop were studied, particularly on their periodic occurrence across okra farms located in San Manuel, Tarlac City, Tarlac Province. The occurrence of the identified insect pests shows that there was a consistent population occurrence of *Amrasca biguttula* during the assessment period, dry season of 2009 – 2010 (Tables 1 to 5). The mean population of the two major insect pests, *Helicoverpa armigera* and *Dysdercus cingulatus* has comparably with slight differences with mean population ranging from 4.97 to 16.04 except for *Spodoptera* with mean population which ranges from 11.75 to 23.66 regardless of observation sites.

On the other hand, there was sudden increase in the population of existing insect pests noted 30 up to 75 days after crop emergence. Consistency in the population density of *Amrasca species* was noted as this pest behaves persistently on its feeding habit from vegetative to maturity of the host. Its high population density is attributed to its biological growth potential and its multiple generation capacity (Esguerra, 1989).

Slow population build-up of *Helicoverpa sp.* was observed (Tables 1 – 5), registered which ranges from of 0.44 to 4.66 at 30 days after planting (DAP) increasing slightly at 45 days after planting (DAP) ranging from 0.86 to 17.50. This explains that intensive feeding of the pest starts as the crop reaches fruit bearing stage (Martin *et al*, 1978; Markose *et al*, 1990).

As to periodic occurrence of *Amrasca*, the month of January planting has registered high population density which has exceeded the critical threshold and damage threshold level. This indicates that planting of the crop within January of the planting period of the years with low precipitation would entail significant damage and increases cost of control.

Table 1. Insect Pests Attacking Okra and their Population Means as Affected by Time of Planting and Plant Age (Observation Site 1) Dry Season November plantings 2008 and 2009

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	50.00	47.00	58.00	95.50	250.50	62.63
Spodoptera litura	15.00	12.00	11.00	9.00	47.00	11.75
Helicoverpa armigera	2.56	2.00	8.00	11.00	23.56	5.89
Dysdercus cingulatus	0.23	2.23	7.50	10.00	19.96	5.00

[1/] DAP = days after planting

Table 2. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting and Plant Age (Observation Site 2) Dry Season January planting 2009 and January planting 2010

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	59.50	57.00	83.00	114.50	314.00	78.50
Spodoptera litura	19.00	12.00	11.50	7.00	49.50	12.38
Helicoverpa armigera	1.86	1.33	1.06	13.40	17.65	4.41
Dysdercus cingulatus	1.66	1.06	1.53	15.67	19.89	4.97

[1/] DAP = days after planting

Table 3. Insect Pests Attacking Okra and their Population Means as Affected by Time of Planting (Observation Site 3) Dry Season February planting 2009 and February planting 2010

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	18.00	87.00	86.50	100.00	291.50	72.88
Spodoptera litura	22.33	21.06	28.00	23.26	94.65	23.66
Helicoverpa armigera	1.66	1.78	20.00	21.50	44.94	11.24
Dysdercus cingulatus	1.82	2.08	9.00	20.00	32.90	8.23

[1/] DAP = days after planting

Table 4. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting (Observation Site 4) Dry Season March planting 2009 and March planting 2010.

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	50.00	28.50	64.00	79.00	221.50	55.38
Spodoptera litura	20.00	19.00	25.00	24.00	88.00	22.00
Helicoverpa armigera	4.66	17.50	20.00	22.00	64.16	16.04
Dysdercus cingulatus	9.00	2.23	3.36	11.50	26.09	6.52

[1/] DAP = days after planting

Table 5. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting (Observation Site 5) Dry Season April planting 2009 and April planting 2010.

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	56.00	29.00	78.00	89.00	252.00	63.00
Spodoptera litura	18.00	14.00	17.00	18.50	67.50	16.88
Helicoverpa armigera	0.44	0.86	7.00	14.00	22.30	5.58
Dysdercus cingulatus	0.66	1.08	4.00	8.47	14.20	13.55

[1/] DAP = days after planting

Table 6 and Figure 1 show the summarized population means of major insect pests as affected by time of planting. *Amrasca biguttula* exhibited high population among insect pests, followed by *Spodoptera litura* with a mean population range of 11.75 to 23.66. Planting season in February 2009 has the highest population mean followed by crop sown in March 2009, with the least population density of 11.75. Insignificant differences were noted among planting time comparing November and January planting time from February and March planting season. *Helicoverpa armigera* and *Dysdercus cingulatus* registered the low population means of all planting months.

Table 6. Summary of population means of major insect pests of okra, *Hibiscus esculentus* L., as affected by time of planting taken November 2008 to March 2009 planting months of the cumulative years.

Time of Planting	*Amrasca biguttula*	*Spodoptera litura*	*Helicoverpa armigera*	*Dysdercus cingulatus*
November 2008	52.63 b	11.75 b	5.89 c	6.00 b
January 2009	78.50 a	12.38 b	4.41 c	4.97 c
February 2009	72.88 a	23.66 a	11.24 b	8.23 a
March 2009	55.38 b	22.00 a	16.04 a	6.25 b
April 2009	63.00 b	16.88 b	5.58 c	3.55 c
Mean	66.48	17.33	8.63	5.60

* Means followed by the same letter(s) within the same column of individual species are not significantly different at 5% level of DMRT.

Correlation of determinants

Figure 1 shows the relationship between the crop age of *H. esculentus* and population of *Amrasca biguttula* 10 days after emergence up to 60 days of growth of the crop. There was a consistent and persistent feeding by *Amrasca* sp. on the crop regardless of the age. There was a linear correlation observed with r = 0.81 which indicates that the feeding interaction as affected by the crop age is not a determinant on feeding preference of the insect pest, as the same, consistently caused damage during the growth cycle of the crop, which is indicative that the insect is a serious pest of okra, as confirmed by Agsaoay and Briones (2010).

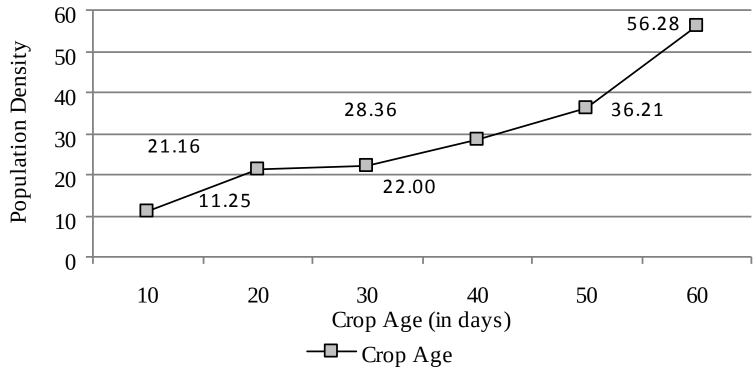

Fig. 1. Correlation between *Amrasca biguttula* population and age of the crop 10 days after emergence up to 60 days after planting.

On the other hand, Figure 2 reveals the relationship of four insect pests of the crop, namely: *A. biguttula*, *S. litura*, *H. armigera* and *D. cingulatus*. Feeding performance of the *A. biguttula* exceeded other associated pests. There was an inverse relationship on abundance as affected by temperature for *S. litura*. This insect pest exhibited slight damage during the early stage of the crop and leveled off as the age of the crop increased. Correspondingly, *D. cingulatus* population increased, and feeding performance started at 45 DAP up to the maturity of the crop.

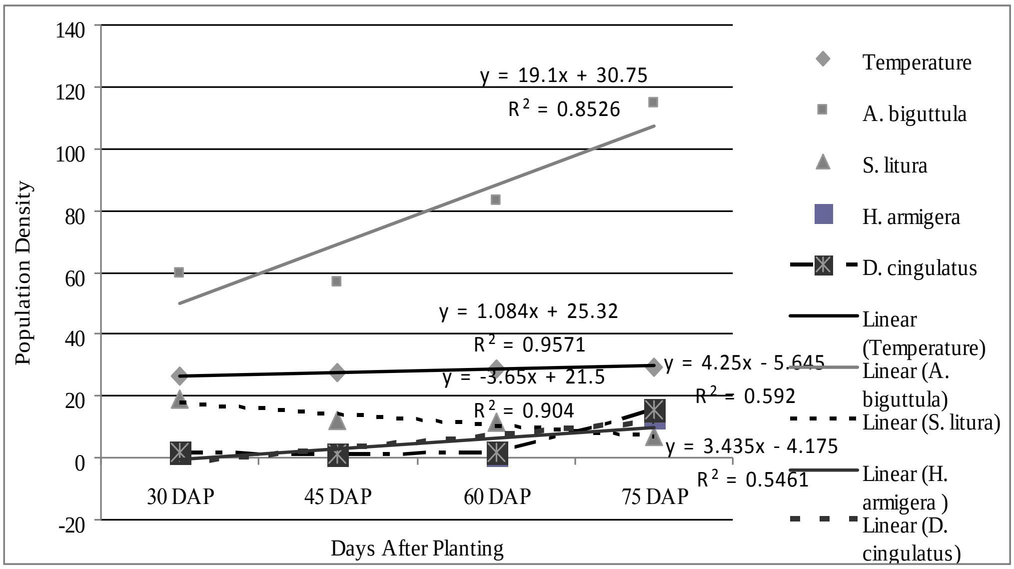

Fig. 2. Relationship between temperature and population of insect pests attacking okra as affected by time of planting (November 2009 – January 2010).

Critical Pest Level (CPL) of *Amrasca biguttula*

The critical pest count, yield (tons ha^{-1}) differences and damage threshold (%) were determined during the dry season, January to June 2009 and October 2009 to May 2010 in an experiment nethouse. Assessment was done at 30, 45, 60, and 75 days after planting. Significant differences were observed among treatments (Table 7). Treatments 1 and 2 released with 100 and 150 eggs, respectively did not differ significantly on the assessed critical pest level. A comparison among treatments showed Treatments 1 and 2 differ significantly from the rest of the Treatments; 3, 4 and 5. Yield differences and damage threshold did not vary significantly as shown by the damage threshold except when compared to the control.

Table 7. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1–2 egg clusters with 100 eggs	57.00	31.00	57.00	79.00	224.00	56.00a	10	6.90	3.10	31.0 a
T2 – 2 egg clusters with 150 eggs	68.50	57.50	70.00	36.00	232.00	58.00a	10	6.56	3.44	34.0 a
T3 – 2 egg clusters with 200 eggs	36.00	50.00	31.00	78.50	195.50	48.88c	10	6.75	3.25	32.5 a
T4 – 2 egg clusters with 250 eggs	41.00	56.50	60.50	86.50	244.50	61.13b	10	7.00	3.00	30.0 a
T5 - Control Check	8.00	9.00	7.50	10.00	34.50	8.63d	10	9.83	0.17	0.02 b

[1] First Trial
[2] Critical Pest level = 45.53
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 8 showed the critical pest count on Trial 2. The mean count shows insignificant differences among treatments 1, 2, and 3, while significant differences were noted when compared to treatments 4 and 5. Damage threshold on the other hand registered almost insignificant differences except when compared to the control check (T5). The highest damage threshold was noted in treatment 4, with the highest mean pest population of 73.37. Critical pest level registered 45.30.

Insignificant differences were noted in Tables 9 and 10. Damage threshold did not differ among treatments which ranges from 25 to 30% although mean pest count varies significantly among treatments. Control check (T5) has the lowest population with 7.75, but the damage threshold registered the highest value compared from among treatments.

Table 8. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	12.50	22.00	93.33	95.00	222.83	55.71 b	10	7.00	3.00	30 .0 a
T2 – 2 egg clusters with 150 eggs	16.67	13.75	75.00	87.50	192.92	48.23 b	10	7.00	2.50	25.0 b
T3 – 2 egg clusters with 200 eggs	20.50	75.00	11.67	75.00	182.17	45.54 b	10	7.19	2.81	28.1 a
T4 – 2 egg clusters with 250 eggs	18.00	87.50	86.67	101.33	293.50	73.37 a	10	6.40	3.60	36.0 a
T5 – Control Check	8.00	7.50	9.00	10.00	34.50	8.63 c	10	8.83	1.17	0.96 c

[1] Second Trial
[2] Critical Pest level = 45.30
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 9. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	25.67	28.00	100.00	54.25	207.92	51.98 a	10	7.00	3.00	30.0 a
T2 – 2 egg clusters with 150 eggs	32.33	37.33	63.67	10.50	143.83	35.96 c	10	7.19	2.81	28.1 a
T3 – 2 egg clusters with 200 eggs	27.00	62.33	32.00	66.50	187.83	55.21 a	10	6.90	3.10	31.0 a
T4 – 2 egg clusters with 250 eggs	33.00	33.00	2.75	56.33	125.08	36.27 b	10	7.19	2.81	28.10 a
T5 – Control Check	6.50	7.00	8.50	9.00	31.00	7.75 d	10	7.50	2.5	25.0 a

[1] Third Trial
[2] Critical Pest level = 36.38
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 10. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	29.00	32.33	123.50	70.00	254.83	63.71 a	10	6.38	3.62	36.2 a
T2 – 2 egg clusters with 150 eggs	36.33	49.00	73.67	14.00	173.00	43.25 c	10	7.19	2.81	28.1 a
T3 – 2 egg clusters with 200 eggs	32.33	70.33	36.00	104.50	243.16	60.75 a	10	7.00	3.00	30.0 a
T4 – 2 egg clusters with 250 eggs	47.00	37.00	58.50	87.50	230.00	57.50 b	10	7.00	3.00	30.0 a
T5 – Control Check	8.00	7.50	9.50	4.50	29.50	7.38 d	10	7.50	2.50	25.0 a

[1] Fourth Trial
[2] Critical Pest level = 45.52
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Similarly, Table 11 particularly Treatments 1–4, obtained a consistent insignificant differences, for both mean population and damage threshold except when compared to the control check. Critical pest levels registered with a value of 36.38 and 49.72, respectively.

Table 11. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	26.00	15.67	73.33	110.67	225.67	56.42 b	10	7.06	2.94	29.40 a
T2 – 2 egg clusters with 150 eggs	35.67	39.25	112.33	80.67	267.92	66.98 a	10	6.50	3.50	35.00 a
T3 – 2 egg clusters with 200 eggs	22.33	105.67	23.00	153.50	304.50	76.13 a	10	6.31	3.69	36.90 a
T4 – 2 egg clusters with 250 eggs	51.00	19.00	36.00	52.33	185.33	46.33 b	10	7.44	2.56	25.60 ab
T5 – Control Check	6.50	7.00	8.00	9.50	31.00	7.75 c	10	9.68	3.62	0.63 c

[1] Fifth Trial
[2] Critical Pest level = 49.72
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

The result of this study has established critical pest level for Amrasca, a potent guide on pest management. The research output serves as an action order for an alternative to calendar spraying and minimizing risk on pesticide residue on exportable and for local consumption green okra.

Phenological forecast for the two major insect pests of okra

Figures 3 and 4 show the result of correlation of determinants on nymphal and larval emergence from egg mass of the two major pests, *Amrasca biguttula* and *Dysdercus cingulatus*. With the mean daily temperature of 36^{O}C had caused simultaneous biological emergence of the two major pests from egg within 3 days. As the temperature increases, corresponding increase (in days) decreases. The increase of temperature (^{O}C) hastens the hatchability of the eggs of the two insect pests species.

The result indicated that temperature is related to the growth and development of the insect. The inverse relationship is important in insect pest management particularly phenological forecasting as basis of timed- application of pesticide.

The value indicates that there was reliability of the equation for determinants as indicated by its r equivalent to 0.968 which is significant at 5% level. This means that 96.8% development time of the insect was attributed to temperature.

The generated research output resulting from forecasting of *Amrasca species* of this study coupled with appropriate sampling method reduces frequency of pesticide application resulting to a reduced pesticide residue on green okra fruits. On the other hand, the established critical pest level (CPL) on this study serves as guide for the okra growers in controlling the pest (*A. biguttula*).

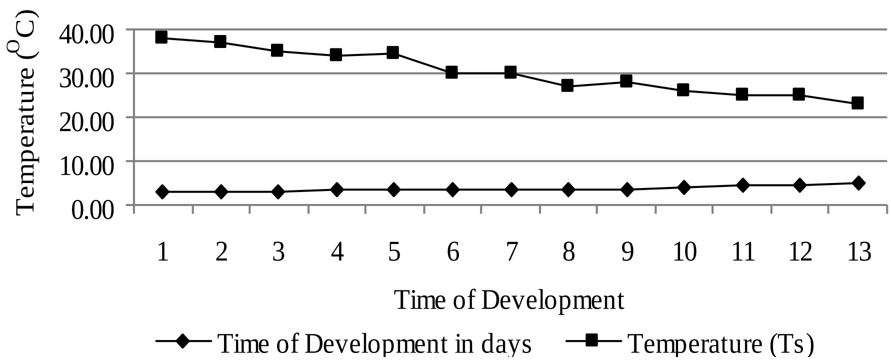

Fig. 3. The relationship between the time of nymph emergence from egg of *A. biguttula* and daily mean temperature (^{O}C).

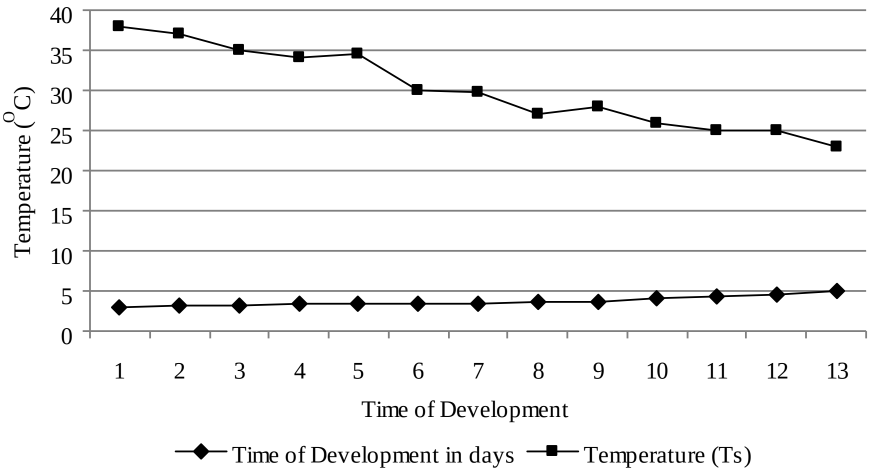

Fig. 4. The relationship between the time of development of *Dysdercus cingulatus* and the sum of temperatures (Ts ^{O}C) in days.

CONCLUSION

Result of this research work unraveled the concern for assessing damage caused by leafhopper, *Amrasca biguttula*, as one of the most diversed insect pest of okra.

Amrasca sp. and *Dysdercus cingulatus* were found with high population density during the dry seasons planting of 2009-2010, while *Spodoptera litura* registered a population mean ranging from 11.75 to 23.66 regardless of observation sites.

High population of *Amrasca sp.* was evident during January and onwards as affected by temperature and as shown from the gathered population data which confirmed that planting of okra during dry seasons would entail significant damage of the crop. With a series of feeding interaction tests conducted for *Amrasca biguttula*, its critical threshold level was established with a population ratio of 45.53 per 50 plants with an allowable yield reduction threshold of 10 percent (%). The generated data is recommended for adoption which contributes to reduced frequency of chemical application and production of quality exportable green okra.

Moreover, phenological forecast on the egg clusters hatchability of two major insect pests; *Amrasca bigutula* and *Dysdercus cingulatus* were found correlated with temperature while *A. biguttula* was found correlated with crop age and temperature.

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INTEGRATION AMONG REGIONAL VEGETABLE MARKETS IN INDONESIA

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ABSTRACT

Horticulture played an important role in the Indonesian economy. Its share of GDP, which was dominated by vegetables and fruits, tended to increase since 2003 up to 2008. However Indonesian per capita consumption of vegetables was still under FAO recommendation. The study of price integration among regions is important in order to increase the marketing efficiency of vegetables in Indonesia. Government intervention is needed both at the producer and consumer level, especially in determining the efficient prices. The success of this intervention depends heavily on government's understanding of price transmission in the fruits market. This research measured the integration level of regional vegetables markets in Indonesia. Engle-Granger test showed that all vegetable prices at PIKJ integrated with producer's prices, except red chili price. Ravallion model showed that integration did not exist for all commodities. However, there was no significant difference of the market integration performance between the highest and the lowest production area.

Key words: spatial integration, Ravallion model, cointegration

INTRODUCTION

Horticultural commodities have quite a large agricultural potential because they have high economic value and have many added values compared to other commodities. Vegetables are one of the commodities from the horticultural sub sector. Indonesia is known as one of the tropical vegetables producing countries and has vegetables producing center areas in almost all its regions.

The contribution of the horticulture sector in Indonesia's Gross Domestic Product tended to increase during the last decade. Two major contributors were fruits and vegetables, followed by floriculture and herbs. In 2003 the GDP from the horticulture sector was Rp 53.89 trillion, and then increased to Rp 80.29 trillion in 2008. However, the per capita consumption of vegetables in Indonesia was still low, about 40 kg in 2008. This was below the FAO recommendation for developing countries which is 73 kg per year. One of the conditions that must be satisfied when increasing the households' consumption is the price must be affordable for the people in the country (Purwoto, 2001).

Vegetables are a very important and strategic commodity because this type of commodity is a primary need for humans; it must be available at all times in an adequate amount and quality, it must be safe for human consumption, and the price must be within the range of the people's budget. The prices that tend to fluctuate not only have negative impacts for the people, but also increase the possibility of the farmers experiencing loss if the price information in the marketing chain does not reach the farmers. Thus the linkage between producer and market is very important in order to increase farmer's welfare (Tru, 2012).

The government's intervention, especially in the form of pricing policies, especially in the producer level, is much needed in ensuring the stability of vegetables prices. In Indonesia, some vegetables such as large red chili and shallots are classified by Bank of Indonesia (2010) as major contributors on inflation. The government's ability to determine the most suitable pricing policy is strongly influenced by how profound the decision makers' understanding of the market structure, behavior and effectiveness is. One of the methods to understand the structure, behavior, and effectiveness of the market is by understanding the relative strength of a market and the price diffusion from one market to another through a market integration study among regions in a country.

According to Tomek and Robinson (1972), the relationship between prices in different markets which are separated geographically could be analyzed using the spatial market integration concept. This can be done by utilizing the spatial equilibrium model. This model is developed by using the excess demand and excess supply curves from two regions involved in trade so that it is possible to make forcasts of the prices formed in each market and the amount of the commodities to be traded.

Spatial price integration may be defined as price transmissions between markets which are reflected in the shifts in prices in market geographically different for the same commodities. According to Ravallion (1986), if there is trade between two regions and the price at the importing region equals the price at the exporting region plus transportation costs due to shipment between the two, it can be said that there is spatial integration between the two regions.

Some of the previous studies concerning the market integration of agricultural commodities referred to the Ravallion model. Due to the developments in econometrics, many studies have been using the time-series approach in order to see whether two or more markets are integrated (Nyange, 1999; Sarker and Sasaki, 2000; Myae, et al, 2005; Kilima, 2006; Rufino, 2008). The Ravallion model is used to observe the price transmission from the reference market to the regional markets. The Engle-Grangel analysis is used to observe whether a co-integration is happening between the (wholesale) price at the reference market and the (producer) price at the regional level market (Jaleta, 2012). This study employs both approaches.

In general, this study aims to identify whether market integration exists among regional vegetables markets in Indonesia and to describe the movement of prices at the vegetables producer level (provinces level) and the prices of the vegetables at wholesale market *Pasar Induk Kramat Jati* (PIKJ) in Jakarta, Indonesia. Some of the main vegetables were seleceted in this study. They are: (1) shallots; (2) large red chili (3) potatoes; (4) cabbage and (5) tomatoes.

METHODOLOGY

Data and the Data Processing

The data used in this study is obtained from PIKJ; Ministry of Agriculture Indonesia and Indonesian Central Statistic Agency. In this tudy, PIKJ is assumed as the central market, because mostly vegetable traders bring their products from production area in Sumatera and Java islands into this market.

The data mainly used is the secondary time-series data, which comprises of the monthly data from 2001 to 2008. It includes the wholesale price data and the supply volume at PIKJ and also the price at the producer level in each production center province data. Eventhough vegetables are highly seasonal, because PIKJ is a wholesale market located in Jakarta, everyday traders from production centers supply the products into this market. In this study, four provinces which produced the largest and the lowest production were selected. In Table 1 and 2, two provinces which produced the largest are coded with number 1 and 2, while the other provinces with number 3 and 4. This study employs the cointegration and the Ravallion model. Data processing is done using the EViews 6 software.

The Co-integration Approach

The first approach is done using the Engle-Granger co-integration procedure. This procedure uses the following regression equation:

$$P_t = \alpha + \beta_1 R_t + \beta_2 t + e_t \tag{1}$$

where P_t = the producers' price in the production center province during the time *t*
R_t = the wholesale price at PIKJ during the time *t*
t = the time trend
e_t = random error

This is followed by a testing for the random error using the Augmented Dickey-Fuller (ADF)-test :

$$\Delta e_t = \lambda e_{t-1} + \sum_{k=2}^{n} \Theta_k \Delta e_{t-k} + \mu_t \tag{2}$$

where
Δe_t = $e_t - e_{t-1}$
μ_t = the random error of Δe_t

The hypotheses in this procedure are:
$H_0 : \lambda = 0$
$H_1 : \lambda \neq 0$
If the zero hypothesis is rejected, this means that both markets are integrated.

The Ravallion Model

The Ravallion model which is empirically applied by Heytens (1986) has been used widely, developed, and discussed within the market integration analysis. According to Tahir and Riaz (1997), studying market integration using the Ravallion model could also be used to determine the leading market among the local markets. It is begun from the following equation:

$$R = f(P_1, P_2, P_3, ..., P_n, X) \tag{3}$$
$$P_i = f_i(R, X_i),\ i = 2,.....,n \tag{4}$$

In this case, *n* is the regional markets with the price *P*; *R* is the price at the reference market. In thi case, n are markets in provinces and PIKJ is assumed as reference market. X_i is the vector showing the other factors which might affect the price at market *i* (including the reference market and the markets at the other production center regions). Because equation (3) and (4) only measure the price at the present time, the time lag influence inserted to the price will form a more dynamic structure. But if the lag period is too long, the model will become more complicated so that the the prices at each market is assumed to have only one lag phase, which is:

$$P_t = a_i P_{t-1} + b_{i0} R_t + b_{i1} R_{t-1} + c_i X_t + \varepsilon_t \tag{5}$$
for $i = 1, 2, ..., n$

Equation (5) is sensitive towards the occurrence of multi co-linearity when the prices at the production center and the reference market strongly correlate. Making assumptions in the form of a first difference will decrease the effect of the multi co-linearity as (R_t–R_{t-1}) and (P_t–P_{t-1}) usually have weak correlation compared to R_t and P_t. this transformation will result in:

$$P_t\text{-}P_{t-1} = a_iP_{t-1}\text{-}P_{t-1}+b_{i0}R_t+b_{i1}R_{t-1}+c_iX_t+ \varepsilon_t \quad (6)$$

The $b_{i0}R_{t-1}$ is added to the right side of the equation

$$(Pt\text{-}Pt_{-1}) = (a_i\text{-}1)(Pt_{-1}\text{-}R_{t-1})+b_{i0}(R_t\text{-}R_{t-1}) +(a_i+b_{i0}+b_{i1}\text{-}1)R_{t-1}+c_iX_t+ \varepsilon_t \quad (7)$$

Equation (7) may be simplified to:

$$(P_t\text{-}P_{t-1}) = ß_1(P_{t-1}\text{-}R_{t-1})+ ß_2(R_t\text{-}R_{t-1}) +ß_3R_{t-1}+ß_4 X_t+ \varepsilon_t \quad (8)$$

where:

a_{i-1} = $ß_1$
b_{i0} = $ß_2$
$a_i+b_{i0}+b_{i1}$-1 = $ß_3$ and c_i = $ß_4$

In this study, the X_t variable is the supply volume at PIKJ. More specifically, the Ravallion model in this study may be formulated as:

$$(P_t\text{-}P_{t-1}) = ß_1(P_{t-1}\text{-}R_{t-1})+ ß_2(R_t\text{-}R_{t-1})+ß_3R_{t-1} + \beta_4 X_t+ \beta_5 X_{t-1}+ \varepsilon_t \quad (9)$$

In order to obtain a clearer interpretation, equation (9) is re-written to

$$P_t= (1+ß_1)P_{t-1}+ ß_2(R_t\text{-}R_{t-1})+ (ß_3\text{-} ß_1)R_{t-1} +\beta_4 X_t+ \beta_5 X_{t-1}+ \varepsilon_t \quad (10)$$

where:

b_1 = $1 + \beta_1$
b_2 = β_2
b_3 = $\beta_3 – \beta_1$

Equation (10) may be written as:

$$P_t= b_1P_{t-1}+ b_2(R_t\text{-}R_{t-1})+ b_3R_{t-1} +b_4 X_t + b_5X_{t-1}+ \varepsilon_t \quad (11)$$

In order to show the effect of previous prices in the regional market towards the formation of the producers' price in the regional market at a certain time, the Index of Market Connection (IMC) is utilized. The IMC was developed by Timmer (1987) which is defined as the ratio of the regional market coefficient to the reference market coefficient, i.e.;

$$IMC = \frac{b_1}{b_3} \quad (12)$$

If IMC value of less than one indicates short term integration. In this case, b_2 is the measurement of the rate of price change at the reference market which is transmitted to the regional market. This parameter measures the long term integration and the value expected is one or nearing one. If the value of the b_2 coefficient is one (b_2 = 1), both markets are completely integrated in the long term. The difference between the two indicators is that b_2 shows the percentage of the price change happening in the reference market which is transmitted to the regional market. The IMC shows the current relative percentage of the producers' price at the regional market which is obtained through the previous producers' price at the regional market and the wholesale price at the reference market, PIKJ.

In this approach, the short term integration is formulated as follows:

$H_0 : b_1/b_3 = 0$
$H_1 : b_1/b_3 \neq 0$

The value of $b_1/b_3 = 0$ if the value of $b_1 = 0$, so the hypothesis above can be written as:

$H_0 : b_1 = 0$
$H_1 : b_1 \neq 0$

Statistical test used is:

$$t_{statistic} = \frac{b_1 - 0}{S(b_1)}$$

If the zero hypothesis is rejected, it means that the market is not integrated in the short term. For long term integration, the hypothesis is formulated as:

$H_0 : b_2 = 1$
$H_1 : b_2 \neq 1$

The value of $t_{statistic}$ is obtained from:

$$t_{statistic} = \frac{b_2 - 1}{S(b_2)}$$

If the zero hypothesis is rejected, it means that the market is not integrated in the long term.

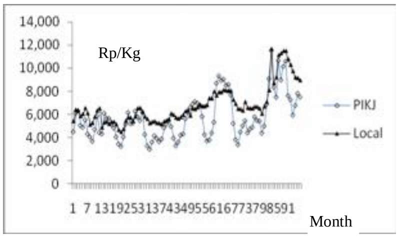
RESULTS AND DISCUSSION

The Correlation Analysis

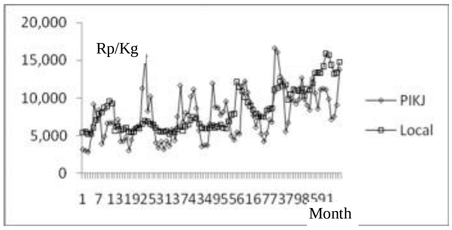
In Indonesia, there are five kinds of vegetables which can potentially yield large crops annually, shallots, large red chili, potatoes, cabbage, and tomatoes. These five commodities are produced in almost all of the provinces in Indonesia. Based on the data from the Ministry of Agriculture, the production of these five vegetables is inclined to be fluctuative. In the period of 2002 to 2008, based on the average production, the largest to the smallest production is: cabbage, potatoes, shallots, large red chili, and, lastly, tomatoes.

From the data in PIKJ, the prices of those vegetables during the 2001 to 2008 period experienced a relative increase. Every year, large red chili reaches the highest price followed by shallots. The movement of five vegetable prices at PIKJ and producer level along that period (96 months) can bee seen in Figure 1.a - 1.e. In this case, the producer level prices are average price from four production centers. All figures generally show that the commodity prices at PIKJ and producer level fluctuated in similar direction. However, the prices at producer level are average price, where the statistic analysis below may give different conclusion.

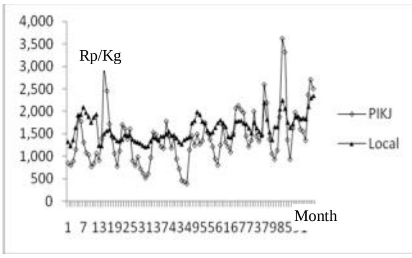
Furthermore in order to see the close relationship between variables analyzed in this study, the correlation analysis is conducted. Some results from the correlation coefficients are as follows. In the case of shallots, the strongest correlation is between the previous month's wholesale price with the current wholesale price at PIKJ. Besides that, a strong correlation also occurs between the previous month's wholesale price at PIKJ and the current price in Central Java and East Java. When compared to the shallots, the large red chili's correlation between the previous month's price and the current price in the regional markets is weak. Besides that, the supply volume at PIKJ has a weak relationship with the producers' price in production center provinces.



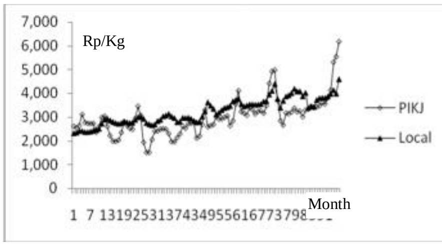
a. Plot of Shallots Price



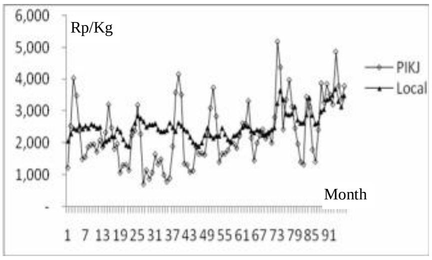
b. Plot of Red Chili Price



c. Plot of Potatoes Price



d. Plot of Cabbage Price



e. Plot of Tomatoes Price

Fig. 1. The Plots of Vegetable Prices in PIKJ and Producer's Price, 2001-2008

As for potatoes, the price from the producers in West Java and Central Java has a fairly strong correlation to the price at the reference market, seen from their high correlation values. However the supply volume of potatoes has a weak correlation to the producers' price and the PIKJ price between the current month's price and the previous month's price. As for the case with cabbage, besides the correlation between the current month and the previous month at PIKJ, the correlation of all of the variables is weak. The correlation between the supply of cabbage at PIKJ and the all the variables is weak, even though some of the correlation coefficients are negative.

The correlation between variables for potatoes is not too different from that of cabbage. Compared to other other commodities, the price of tomatoes at PIKJ the current month compared to the price at PIKJ the previous month has the lowest degree of correlation. This means that the sellers at PIKJ almost never use the information of the previous price in determining the current price. The correlation between the supply and the price at PIKJ is negative and is higher than other commodities.

The Cointegration Analysis

Testing using the Engle-Granger cointegration analysis is done to observe any indications of long term integration between the wholesale prices at PIKJ with the producers' prices at the production center provinces. In this case, the number of lag is chosen based on the minimum Akaike Information Criteria statistic. Table 1 shows the results of the ADF test for market integration for all the commodities studied. From the ADF test results, the commodity of shallots' zero hypothesis is rejected, meaning that the producers' price at the production centers cointegrate with the price at PIKJ.

Table 1. The Co-integration Test Results between PIKJ and Producer's Prices

Commodity	The Production Center Province	$T_{statitsic}$	T_{table} (critical value)	
Shallots	1. Central Java	-3.518[a]	1% level	-4.058
	2. East Java	-4.238[a]	5% level	-3.458
	3. Lampung	-3.986[a]	10% level	-3.155
	4. South East Sulawesi	-3.494[a]		
Large red chili	1. West Java	-2.807		
	2. North Sumatra	-3.813[a]		
	3. Central Sulawesi	-1.217		
	4. South East Sulawesi	-2.425		
Potatoes	1. West Java	-3.949[a]		
	2. Central Java	-3.771[a]		
	3. Lampung	-3.859[a]		
	4. Bengkulu	-2.616		
Cabbage	1. West Java	-4.444[a]		
	2. Central Java	-3.244[a]		
	3. D.I Yogyakarta	-4.218[a]		
	4. East Nusa Tenggara	-2.693		
Tomatoes	1. West Java	-4.430[a]		
	2. North Sumatra	-4.055[a]		
	3. D.I Yogyakarta	-3.842[a]		
	4. Central Sulawesi	-3.894[a]		

Note: [a] is significant at the real level of 10%

For the large red chili commodity, the only zero hypothesis rejected is the the producers' in North Sumatra. This means only the producers' price in North Sumatra is cointegrated with the price of large red chili at PIKJ. In contrast, for potatoes, only Bengkulu's zero hypothesis is not able to be rejected. This means that the prices at the potato production centers except in Bengkulu are cointegrated with the price at PIKJ.

For cabbage, the producers' prices in all provinces are integrated with the price at PIKJ, except for East Nusa Tenggara's. For tomatoes, all zero hypotheses are rejected, meaning that the price of tomatoes in all provinces is integrated with the price of tomatoes at PIKJ.

The Ravallion Model Analysis

From the regression estimate result with the Ravallion Model, the IMC value for the foru production center provinces is much larger than 1. The testing of the $b_1 = 0$ hypothesis supports this (see the IMC testing in Table 2). In this case, the zero hypothesis is rejected which means there is no short term integration between the price of vegetables at the production center and the price at PIKJ. The rejected zero hypothesis and the IMC value which is much larger than 1 shows that the producers' price during the previous month at the production center has more influence on the current month's vegetables price compared to the price at PIKJ.

Table 2. Index of Market Connection of PIKJ and Producer's Price.

The Production Center Province	IMC	(b_2)-1[a]	T_{stat} [b]	t T_{stat} [c]	T_{table}	R^2-*adj*	DW-$_{stat}$[d]
Shallots							
1. Central Java	3.514	-0.570	10.399	12.419	2.576	0.868	1.941
2. East Java	2.745	-0.460	8.945	6.747	2.576	0.803	2.114
3. Lampung	10.915	-0.826	14.838	14.86	2.576	0.833	2.096
4. South East Sulawesi	16.079	-0.965	25.556	22.838	2.576	0.946	2.209
Large red chili							
1. West Java	5.656	-0.757	16.713	16.735	2.576	0.842	1.861
2. North Sumatra	7.449	-0.879	15.278	16.102	2.576	0.814	1.468
3. Central Sulawesi	25.646	-0.942	33.630	30.264	2.576	0.960	1.812
4. South East Sulawesi	15.011	-0.982	27.187	23.126	2.576	0.932	2.100
Potatoes							
1. West Java	4.664	-0.802	13.480	16.453	2.576	0.863	1.851
2. Central Java	3.463	-0.685	10.819	10.603	2.576	0.823	1.872
3. Lampung	-341.88	-0.926	27.211	9.929	2.576	0.907	1.962
4. Bengkulu	9.331	-0.969	19.224	14.685	2.576	0.878	1.606
Cabbage							
1. West Java	4.911	-0.745	8.826	17.393	2.576	0.677	2.023
2. Central Java	11.08	-0.664	15.193	10.039	2.576	0.737	1.834
3. D.I Yogyakarta	20.539	-0.827	16.761	12.789	2.576	0.807	1.815
4. East Nusa Tenggara	86.826	-0.972	23.117	47.477	2.576	0.873	2.414
Tomatoes							
1. West Java	3.791	-0.818	9.554	30.224	2.576	0.800	2.112
2. North Sumatra	-402.286	-1.001	13.031	36.958	2.576	0.638	1.495
3. D.I Yogyakarta	2.700	-0.710	11.379	26.237	2.576	0.823	1.817
4. Central Sulawesi	26.026	-0.963	12.164	35.563	2.576	0.672	2.029

Note: [a] the coefficient value
[b] the $t_{statistics}$ value for coefficient b_1
[c] the $t_{statistics}$ value for coefficient (b_2)-1
[d] the value of dl = 1,425 ; du = 1,641

The result of the long term integration test with the zero hypothesis $b_2 = 1$ is also rejected at all vegetables production centers (see coefficient P_{t-1} in Table 3). This also means that the vegetables producers' price in the four production center provinces observed do not integrate in the long term with the price of vegetables at PIKJ. This means that the price changes in PIKJ are not well transmitted to the producer level at the production centers. It can be said that the marketing efficiency has not been fully obtained for the vegetables commodity in Indonesia. This may be caused by the vegetables producers' lack of access to information of the price movements at PIKJ. Besides that, the pressure from higher level marketing institutions also makes the prices received by the producers not parallel to the prices at PIKJ.

Table 3. The Ravallion Model Regression Equation Estimation Results

The Production Center Province	Coefficient					
	Intercept	P_{t-1}	$(R_t - R_{t-1})$	R_{t-1}	X_t	X_{t-1}
Shallots						
1. Central Java	0.251	0.711[a]	0.430[a]	0.202[a]	0.029	0.004
2. East Java	0.510	0.678[a]	0.540[a]	0.247[a]	0.016	-0.006
3. Lampung	-0.261	0.815[a]	0.174[a]	0.075[a]	0.050	0.031
4. South East Sulawesi	-0.160	0.957[a]	0.035	0.060[a]	0.037	-0.033
Large red chili						
1. West Java	-0.883	0.840[a]	0.243[a]	0.148[a]	-0.102	0.166[a]
2. North Sumatra	-2.893	0.833[a]	0.121[a]	0.112[a]	0.010	0.213[a]
3. Central Sulawesi	-3.238	0.967[a]	0.058[a]	0.038	0.134[a]	0.072
4. South East Sulawesi	-2.009	0.931[a]	0.018	0.062	-0.084	0.217[a]
Potatoes						
1. West Java	0.958	0.736[a]	0.198[a]	0.158[a]	-0.011	0.005
2. Central Java	0.554	0.716[a]	0.315[a]	0.207[a]	-0.010	0.013
3. Lampung	0.707	0.931[a]	0.074	-0.003	-0.013	0.005
4. Bengkulu	-0.231	0.888[a]	0.031	0.095[a]	-0.008	0.034
Cabbage						
1. West Java	1.398	0.673[a]	0.255[a]	0.137[a]	-0.050	0.051
2. Central Java	-0.283	0.843[a]	0.336[a]	0.076	-0.304[a]	0.362[a]
3. D.I Yogyakarta	1.767	0.865[a]	0.173[a]	0.042	0.050	-0.124
4. East Nusa Tenggara	0.091	0.934[a]	0.028	0.011	-0.012	0.035
Tomatoes						
1. West Java	1.868	0.628[a]	0.182[a]	0.166[a]	-0.058	0.035
2. North Sumatra	2.868	0.820[a]	-0.001	-0.002	-0.090	-0.004
3. D.I Yogyakarta	-3.096	0.722[a]	0.290[a]	0.267[a]	0.182	0.025
4. Central Sulawesi	4.333	0.777[a]	0.037	0.030	-0.134	-0.050

Note: [a] is significant at the 10% level

The difference in the analyses results using the two approaches is due to the difference in the point of view in understanding market integration. The co-integration model only sees whether the price movements in the two markets are parallel or not. The Ravallion model sees the two integrated markets, observing whether the price change in provincial market is more affected by the previous price changes in the same location or by the price changes at the reference market (PIKJ).

CONCLUSIONS AND RECOMMENDATIONS

Some conclusions can be derived from this study. In exception of the large red chili, this study shows a difference in the results of the market integration analyses using two different approaches, the co-integration model and the Ravallion model. The cointegration models show that the producer prices integrate with the reference market (PIKJ). However the results from the Ravalllion model show that there is no integration behavior between the market at the producer level and the PIKJ. Furthermore the supply volume at PIKJ does not have much influence in affecting the producers' price formation in production center provinces.

The different results may be due to different objectives of analysis. The cointegration model can be used to investigate the long-run relationship between commodity prices among regions. The Ravallion model is further aimed to determine whether a central market can be reference or barometer for some local markets. Also in the Ravallion model some variables can be included such as volume of production to observe the impact of supply on price movement.

Two analyses from this study show that the large red chili commodity should receive more attention as both approaches show that market efficiency has not yet been reached. In other words, PIKJ has not yet become the price barometer for this commodity. The analysis matches with the latest report from the Bank of Indonesia, where large red chili price was categorized as one of the major contributor to Indonesian general price volatility.

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