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ECONOMIC ANALYSIS ON BULK HANDLING OF MINDANAO CORN GRAIN TO MANILA AND CEBU, PHILIPPINES

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ABSTRACT

The study aimed to assess the economic feasibility of an integrated bulk handling system for yellow corn grains produced from Mindanao and marketed in Manila and Cebu. It is meant to address the problems on production and marketing inefficiencies of the Philippine corn industry. The present practice is characterized by low adoption of modern technologies, high postharvest losses, and high transport and marketing costs as a result of inadequate market infrastructures. The government is promoting the adoption of bulk grain handling technology to reduce postproduction costs and losses. The general objective of the study is to establish the social benefits that society could receive from the adoption of the bulk handling technology by comparing it to the traditional method. Using triangulation method of collecting data and employing value chain, financial and economic analyses, the study compared the traditional and the bulk handling systems. Results revealed that the bulk handling chain is better-off however; multiple comparison tests of income indicated that farmer-clients/adopters of bulk handling were worse-off because of the non-inclusion of the social benefits. The willingness of farmers to pay for bulk processing is higher if they are adopting the technology while lower for non-adopters. Price gap of the willingness-to-pay for adopting the technology could be covered by the social benefits from the project. A positive net present value and net social benefit (NSB) signified that this government intervention is worthwhile.

Key words: net social benefit, postharvest losses, willingness-to-pay

INTRODUCTION

Corn *(Zea mays L.)* is the second most important crop, after rice, in the Philippines. Two types of corn are grown in the country, white and yellow corn. Corn is consumed as a staple in the form of milled white corn grits by about 20 percent of Filipinos mostly from the Visayas islands. Major corn producing areas are mostly from Cagayan Valley in Luzon island and Mindanao island (Fig. 1). On the other hand, yellow corn is predominantly used as feed ingredients. It accounts for about 70 percent of livestock mixed feeds and 25 percent are processed as corn starch, corn oil, gluten and snack foods (Lantican, 2009). Based on the National Statistical and Coordinating Board (NSCB), livestock and poultry integrated sector accounts for 26.95 percent of the gross value added in agriculture, fishery and forestry in 2011 at constant prices contributing around USD14,525.31 billion (USD1 = PhP43.31 in 2011).

Some 1.5 million farmers depend on corn as major source of livelihood. This is in addition to transport services, traders, processors and agricultural input suppliers who directly benefit from corn production, processing, marketing and distribution (de Luna, 2012).

Fig. 1. Map of the Philippines

The Philippine corn industry has great opportunities because local demand is steadily increasing because of the annual growth rates of the local livestock by 1% and poultry by 5% (BAS and LDC, 2012). Further, importation of corn will be scarce because of the shift in the thrust of foreign-producing countries to use corn bio-fuels. However, the Philippine corn industry has been plagued by production and marketing inefficiencies which can be attributed to low adoption of modern corn production technologies, high postharvest losses, and high transport and marketing costs because of inadequate market infrastructure (Lantican, 2009).

In the Philippines, the government provides strong support in the form of technical assistance, partial input subsidy, postharvest and infrastructure upgrading, research and development budget, all aimed at improving the corn subsector.

In 2007, under the Corn Program of the Department of Agriculture (DA), a PhP40 million project Corn Processing and Trading Center (CPTC) of the National Agribusiness Corporation (NABCOR) partly adopted the bulk grain handling technology on the processing level. At present 13 CPTC projects are being operated nationwide. Seven of these are located in Mindanao. Now, the project is being operated and financed by the government showcasing bulk handling system from farm in corn in cobs to dry shelled corn grains ready for market.

The objectives of this paper are to describe the traditional and the bulk handling systems, determine if the bulk handling system of corn grain from Mindanao to Manila and Cebu has reduced costs and postharvest losses incurred as well increased the income, and establish the net social benefit of the project.

Theoretical Framework

A government policy that made at least some people better-off, while making nobody worse-off, would unambiguously improve social welfare; in economic theory such a policy is termed Pareto efficient. However, in reality such policies rarely exist, and a requirement for Pareto efficiency would result in policy inertia. A more practical requirement is that a policy should only be implemented when those who gain from the policy could compensate those who lose, and still be better off. Such a policy is said to offer a potential Pareto improvement (Barr, 2012).

The aim of cost-benefit analysis (CBA) is to provide a framework for assessing the ability of a project to offer a potential Pareto improvement. In undertaking a CBA, the analyst estimates all of the costs and benefits of a policy proposal in monetary terms for ease of comparison. If the benefits are greater than the costs, that is if there is a net social benefit, then in theory the gainers from the proposal would be able to compensate the losers and still be better-off, and the policy represents a potential Pareto improvement (Boardman et al, 2006).

Social benefits/costs analysis is a tool used by policy makers to systematically evaluate the impacts to all of society resulting from individual decisions. This is more quantitative analysis of social benefits and costs, where a monetary value is placed on the benefits and costs to society of individual decisions (Australian Government, 2007).

Previous studies on bulk handling in the Philippines were on the development of an appropriate bulk handling system for corn at the farmer-cooperative level of operation conducted by Bermundo et al. (2001) which recommended the potential areas where this system could be introduced in the collection and handling grain during harvesting, shelling, drying, storage and marketing. Further, Joaquin et al (2005) revealed that the introduction of bulk handling facilities and systems in Bukidnon resulted in a decrease in total postharvest losses, better quality in terms of aflatoxin contamination especially during wet season and increased financial performance of the cooperative because of the premium price of produce obtained.

In Canada and China, Fan and Jayas (2008) compared the grain distribution and handling of the two countries and showed how the inefficiencies were addressed. In Canada, bulk grain handling and transportation is practiced and has well developed mechanization and computerization while in China it has been developed through the implementation of the Grain Distribution and Marketing Project (GDMP), initiated in 1992 and completed in 1999 which improved the efficiency of moving grain from surplus to deficit areas and to shift from bag to bulk handling and eventually achieved a significant reduction in grain distribution costs and losses.

Unlike the previous studies in the Philippines, where the research focused on the bulk handling system on the farmer-level operation, this study assessed the economic feasibility of an integrated bulk handling system for yellow corn grains produced from Mindanao to Manila and Cebu to achieve the reduction in grain distribution costs and losses as of that in Canada and China.

METHODOLOGY

The research used data and information from survey, key informant interviews, focus group discussions and available secondary data. The research method consists of qualitative and quantitative methods for interviewing farmers, traders, processors, shippers, consignees/distributors, feedmillers, farmer's cooperative officials, and government officials. Combination of individual interviews and group discussions were likewise employed. Moreover, this study compared and analysed the value chain activities, financial and economic aspect s of the traditional and the bulk handling system.

The information from the survey was analysed and presented using descriptive, means and percentages. Value chain mapping was done to show the commodity flow and activities done by the farmer, the different market intermediaries up to the consumer using the traditional system and the bulk handling system. Financial and partial budget analyses were done on prices, incomes and marketing margins of the different market intermediaries along the chain and were compared on per kilogram basis. Multiple comparative tests were employed to know who among the actors were spending or earning more. Moreover, social benefits such as reduction postharvest losses, saved time and other cost were computed on per hectare basis.

The study was conducted in Mindanao particularly in Talakag, Bukidnon and Banga, South Cotabato where CPTC projects of the government were located. These represented the six operational CPTC projects in Mindanao with same component facilities, operational scheme of implementation, and bulk handling processing for corn. Through stratified random sampling, 344 farmer-clients or adopters of bulk handling system in the NABCOR project and 175 farmer-non-clients or non-adopters, 30 traders, 13 processors/integrators, 13 shippers, 2 consignees/distributors, and 23 feed millers/end-users were interviewed through the aid of structured questionnaire.

For this study, social benefits are the reduction in postharvest losses, saved time and other costs and good price for good quality product.

Postharvest loss reduction (from harvesting to marketing of the traditional against bulk handling system) is determined by the perception of the key actors involved in a particular activity (Equation 1).

Postharvest lossreduction = $(L_{har}+L_{p}+L_{h}+L_{sh}+L_{d}+L_{m})_{non\text{-}adopter} - L_{har}+L_{hp}+L_{sh}+L_{d}+L_{m})_{adopter}$ Eq. (1)

Where:

L_{har} = losses in harvesting
L_{hp} = losses in hauling and piling
L_{sh} = losses in shelling
L_{d} = losses in drying
L_{m} = losses in marketing

Further, time saved in adopting bulk handling system is computed based on the reduced man-days between the two systems (Equation 2) as well as the other costs. Finally, net social benefit is assessed based on the decision rule, if NSB>0 bulk handling system for corn from Mindanao to Manila and Cebu project of the government is worthwhile while NSB<0 meant otherwise (Equation 3).

Time saved from harvesting to marketing = (Man-days/$ha_{traditional}$ x labor cost/day) – (man-days/$ha_{bulk\ handling}$ x labor cost/day) Eq. (2)

Net Social Benefit =$[(Q_{grains/ha} \times P_{grains/kg}) + (L_{bulk\ handling/ha} \times P_{grains/kg}) + (M_{bulk\ handling} \times P_{labor/day}) + (Sk_{shipment/ha} + H_{shipment/ha})] - [(Q_{cobs/ha} \times P_{grains/kg}) + (Dep_{bulk\ handling/ha}) + (Proc_{processing\ cost/kg} \times Q_{grains/ha})]$ Eq. (3)

Where:

$Q_{grains/ha}$ = quantity of corn grains per hectare
$P_{grains/kg}$ = price of corn grains per kilogram
$Q_{cobs/ha}$ = quantity of corn cobs per hectare
$P_{cobs/kg}$ = price of corn cobs per kilogram
$L_{bulk\ hanlding/ha}$ = postharvest loss reduction per hectare using bulk handling system

$P_{grains/kg}$ = price of corn grains per kilogram
$M_{bulk\ handling}$ =man-days saved per hectare using bulk handling system
$P_{labor/day}$ = price of labor per day
$Sk_{shipment}$= reduction in cost of sacks during shipment per hectare
$H_{shipment}$= reduction in handling cost during shipment per hectare
$Dep_{bulk\ handling}$ = depreciation of investments for bulk handling/kg
$Proc_{processing\ cost/kg}$ = processing cost per kilogram for bulk handling

RESULTS AND DISCUSSION

The Chain Map

Traditional system key actors and activities done. The actors involved in the Mindanao corn grain value chain are the farmers, traders, processors/integrators, shippers, consignee/distributor, and feedmiller/end user.

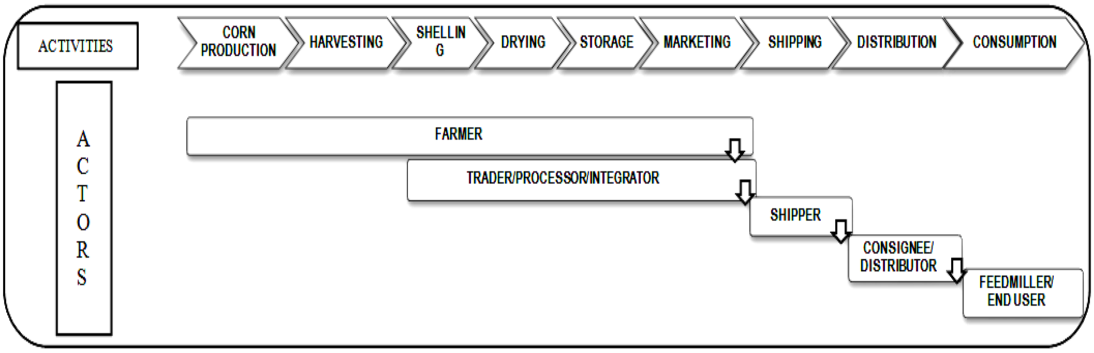

Fig. 2. Yellow corn grain value chain key actors and activities done from Mindanao to Manila and Cebu, traditional system, 2012

The actor involved in the production of corn is the ***farmer***. He is likewise in-charge of the harvesting, shelling, drying and marketing of his produce.

The ***trader*** buys dried corn grains from the farmer and delivers this to the processor/integrators. The ***processor/integrator*** processes corn grains into animal feeds for own livestock requirements or for commercial purposes, sometimes re-drying corn grains that are not properly dried (with MC higher than 14%). He is one of the sources of the ***shipper*** who supplies corn grains in Manila and Cebu. The shipper has contacts in these demand areas. The ***consignee/distributor,*** who upon receiving the corn grains at the port of destination, distributes the product to the ***feedmiller/end user*** who uses grains as one of the ingredients for the animal feed formulation.

Bulk handling key actors and activities done. The actors involved in the Mindanao corn grain bulk handling value chain are the farmers, processors, shippers, and the feed miller/end user (Fig. 3).

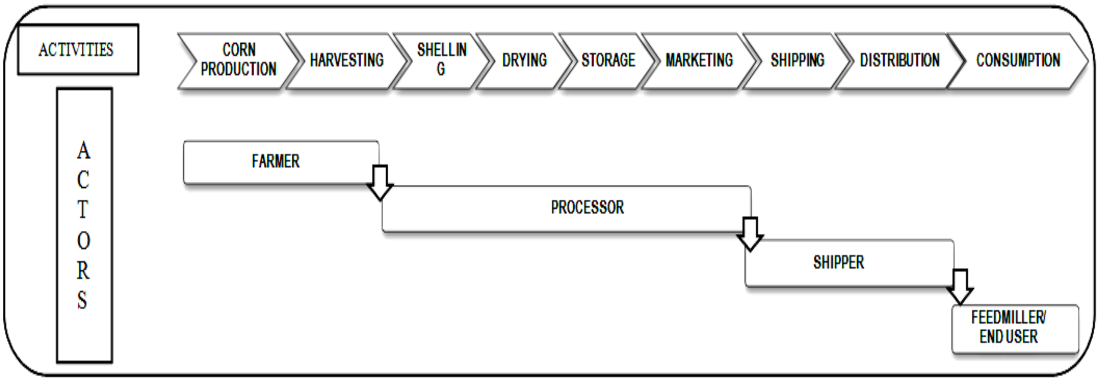

Fig. 3. Yellow corn grain value chain key actors and activities done from Mindanao to Manila and Cebu, bulk handling system, 2012

The actor involved in the production of corn is the ***farmer***. He is likewise in-charge of planting and harvesting his produce. The ***processor*** buys corn on cobs from the farmer and mechanically processes them. He practices bulk handling system. He dries the corn on cobs (COC) from its initial moisture content down to 18 percent MC for around 36 hours, shells it and fully dries the corn grains into 14 percent MC for around four to six hours. After grain drying tempering of the corn grains follows for about 1 hour before loading them into the container vans for shipment to Cebu or Manila to the ***feedmiller/end user***. Note that traders and consignee/distributors are eliminated in the bulk handling system.

Costs and Income

Table 1 presents the costs incurred and the net income received by the different actors involved in the chain.

Table 1. Yellow corn grain value chain, Mindanao to Manila and Cebu, traditional system, 2012 USD/ kg

Actors	Farmer	Trader	Processor/ Integrator	Shipper	Consignee/ Distributor	Feedmiller / End user	Total
Costs, USD	339.11	14.36	30.83	32.09	8.45	2.11	426.95
Net Income, USD	155.41	12.67	33.36	16.89	12.67	*	231.00
Costs Share,%	51.54	2.18	4.69	4.88	1.28	0.32	64.89
Net Income Share, %	23.62	1.92	5.07	2.57	1.93	-	35.11
TOTAL	**75.16**	**4.10**	**9.76**	**7.45**	**3.21**	**0.32**	**100.00**

Exchange rate: USD1 = PhP42.23 *Final product is in animal feeds not in corn grains

In Mindanao, the farmer incurred the highest cost at around 51.54 percent cost share as well as the highest net income received23.62 percent share in the entire chain. On the other hand, the feedmiller had the least cost incurred at 0.32 percent cost share in the chain. The consignee/distributor received the least net income share in the chain. Cost share in the entire chain was at 64.89 percent while net income share was at 35.11percent.

Although the income per kilogram is high at the farmer level, they are not really earning that much because the volume they handled is only based on their area planted for the season. Hence, if we would look at the income received by each actor based on the volume handled, farmer would have the least income because of the smallest volume handled among the chain actors.

With bulk handling, the bulk of the costs and income have been absorbed by the processor because the farmer has been unloaded by several activities such as drying, shelling and storage as well as the traders who was eliminated in the chain**.** Thus, Mindanao's farmer cost incurred has been lowered to 49.57 percent whereas an increased in the trader's cost to around 190.40 percent compared to the traditional system. However, income for the farmer has been reduced to around 37.98 percent because this time his product is corn on cobs (COC) which commands lower price than corn grains resulting to additional income of around 567.60 percent for the processors. For the entire value chain, cost share incurred has been lowered to 31.45 percent because the number of actors has been reduced while income share has been increased by 45.70 percent because good quality product commands high price in the market (Table 2).

Though the farmer in terms of kilograms has the highest earnings but in terms of volume handled they would be earning the least among the chain actors.

Table 2. Yellow corn grain value chain, Mindanao to Manila and Cebu, bulk handling system, 2012 in USD/kg.

Actors	Farmer	Processor/ Integrator	Shipper	Feedmiller / End User	Total
Costs, USD	171.03	89.5	32.1	0.01	292.7
Net Income, USD	96.28	222.7	18.6	-	336.6
Costs Share,%	27.2	14.2	5.1	-	46.5
Net Income Share, %	15.3	35.2	3.0		53.5
Total	**42.48**	**49.5**	**8.1**		**100**

Exchange rate: USD1 = PhP42.23
*Final product is in animal feeds not in corn grains

Using the Statistical Package for Social Sciences (SPSS), a multiple comparison test was done to determine who among the actors involved in the chain spent and earned more. Table 3 indicates that actors such as the consignee/distributor, trader, shipper and trader/processor spent the same while the farmer-client (using bulk handling system) and farmer-non-client (using traditional system) spent more than the rest of the actors. However, between the farmer-client and the non-client, the former spent less than the latter which implies that farmers could reduce their costs with the bulk handling project.

Table 3. Multiple comparison test result of cost incurred by the different actors in the corn grain chain, 2012

	Type of Respondent	N	Subset		
			1	2	3
Student-Newman-Keuls[a]	Consignee/distributor	2	8.4500		
	Trader	30	16.8900		
	Shipper	16	32.9400		
	Processor/integrator	13	55.7400		
	Client	344		171.71	
	Non-client	175			333.23

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = .920.
[a] Uses Harmonic Mean Sample Size = 8.806.

Further, a multiple test result of net income received by the different actors involved shows that the shipper, consignee/distributor and trader earned the same while the farmer- client and non-client and trader/processor received more than the others. Among the actors, trader/processor received the highest net income followed by the farmer non-client and the farmer-client. Since we only consider the monetary income, it indicates that farmer non-client/non-adopter is better off than the farmer client/adopter (Table 4). However, the bulk handling system has social benefits (i.e.,reduction in postharvest losses, activities unloaded from the farmers, time saved, and others)which could not be reflected on the tests, hence, economic analysis on the valuation of these has been done (See economic analyses).

Table 4. Multiple comparison test result of income received by the different actors in the corn grain chain, 2012.

	Type of Respondent	N	Subset			
			1	2	3	4
Student-Newman-Keuls[a]	Consignee/distributor	2	8.4660			
	Shipper	16	9.2906			
	Trader	30	16.2036			
	Farmer Client	344		104.0801		
	Farmer Non-client	175			182.02	
	Processor/integrator	13				252.274

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 1.632
[a] Uses Harmonic Mean Sample Size = 8.806.

Gross Margins

Table 5 shows that among the actors involved in the corn grain traditional system value chain, the farmer received the highest gross margin while the consignee/distributor received the least. The second highest gross margin received was the processor/integrator followed by the shipper and the trader. Gross margin distribution among the different actors closely matches with the total share distribution in the entire value chain. On the average, value added from the farm to the end user was around USD147/kg for the entire chain.

Table 5. Gross margin shares of the different stakeholders of the yellow corn grain value chain, Mindanao to Manila and Cebu, traditional system and bulk handling system, 2012, USD/kg

Chain Actors	Traditional System				Bulk Handling System			
	Selling Price (USD)	Buying Price (USD)	Gross Margin		Selling Price (USD)	Buying Price (USD)	Gross Margin	
			Amount (USD)	Share (%)			Amount (USD)	Share (%)
Farmer	498.74	-	-	77.2	267.74	-	-	42.6
Trader	526.19	498.74	27.45	4.2	-	-	-	-
Processor/ Integrator	578.55	526.19	52.36	8.1	578.55	267.74	310.81	49.4
Shipper	629.23	578.55	50.68	7.8	629.23	578.55	50.68	8.1
Consignee/ Distributor	646.12	629.23	16.89	2.6	-	-	-	-
Feedmiller/ End User		646.12	-	100		629.23	-	100

Exchange rate: USD1 = PhP42.23

However, in bulk handling system, the farmer sells COC which commanded lower price than corn grains, he received lower margins compared with that of the traditional system. Since the processor absorbed the activities unloaded from the farmers, margins were shared between them. Note that not only the farmer and processor benefited from the system but also the feed miller/end user who received lower price of corn grain which could be attributed to the less number of actors involved in the chain resulting to less marketing costs and more competitiveness in the market.

Further, total share distribution for the entire value chain and gross margin of the different actors in the chain implies that they concur with each other. On the average, value added from the farm to the end user was around USD361.49/kg for the entire chain which is almost triple than the traditional method.

Moreover, using partial budget analysis the bulk handling marginal costs and benefits have been assessed. Above we mentioned that with this technology farmers would have enough time to farm which could resulted to additional one cropping for them. Considering this as a potential additional return and the reduced costs, results show that the farmer adopter in Mindanao would be better off than the farmer non-adopter, with a positive effect of USD73.91/kg (Table 6).

Table 6. Partial budget analysis of adopting bulk handling system (selling corn on cobs) versus traditional method (selling dried corn grains), Mindanao, 2012 in USD/kg

Positve Effects (A)		Amount (USD)	Negative Effects (B)	Amount (USD)
ADDED RETURNS			**REDUCED RETURNS**	
Potential additional 1 cropping season		**96.28**	Non-adopter	155.41
REDUCED COSTS			Less: Adopter	96.71
Shelling	15.62			
Drying	9.71			
Transport	9.71			
Storage	1.27			
TOTAL REDUCED COSTS		***36.32***	***TOTAL REDUCED RETURNS***	***58.70***
TOTAL POSITIVE EFFECTS		***132.60***	***TOTAL NEGATIVE EFFECTS***	***58.70***
NET EFFECT (A-B)			**73.91**	

Exchange rate: USD1 = PhP42.23

Economic Analysis

The Project. The NABCOR projects in Mindanao would be used as the take-off point of the entire bulk handling system from production to the demand areas like Cebu and Manila. This would be in addition to its own requirement in Mindanao. Customized 20 footer container vans would be used in the bulk shipment of corn grains from Mindanao to Manila and Cebu.

The project would operate in 10 months per year and has a capacity of 26,000 MT of corn on cobs in a year (26 days/month operation). The government would provide the facilities and the working capital of USD 1,912 Billion. It would be operated for five to six years and turned over to an eligible cooperative which has the capacity to run the project.

Based on the feasibility study, at 70 percent utilization and marketing 60 percent of its product to the local market, 30 percent to Cebu and 10 percent to Manila, the project can recoup its investment within 2.49 years and with benefit-cost ratio (BCR) of 2.24. Further, an Internal Rate of Return (IRR) of 34.85 percent and a net present value (NPV) at 16 percent per annum of USD51.134 million indicates that this project is acceptable based on National Economic Development Authority's (NEDA) 15 percent hurdle rate (Table 7).

Break-even point price for local market is USD533.36/kg; for Cebu is USD572.64/kg; and for Manila USD592.91/kg while break-even point volume is 2.6 million kg/year for the local market, 914,799kg/year for Cebu market and 272,796 kg/year for Manila market. In terms of service area the project needs around 987 hectares to supply the corn on cobs requirement of the project.

Sensitivity analysis indicates that the project is more sensitive on the change in selling price of corn grains than in volume.

Table 7. Financial analysis and assumptions used for bulk handling scheme of the CPTC, Mindanao to Manila and Cebu, 2012

ITEM		AMOUNT, USD
INVESTMENT COST	**USD1,908 B**	
Facility cost		USD1,655 M
Working capital		USD 253 M
Fixed cost, P year^{-1}	**USD 330.4 M**	
Depreciation		108.2 M
Repair and Maintenance		15.1 M
Registration and licences		16.3 M
Interest on investment		165.5 M
Interest on capital investment		25.3 M
Variable cost, P year^{-1}	**USD 540.9 M**	
Fuel, oil and grease		27.8 M
Salary and wages		64.2 M
Power cost		68.7 M
Water cost		0.8 M
Labor, transport and handling cost		374.7 M
Packaging material		4.8 M
Miscellaneous expenses	USD 5.4 M	
TOTAL OPERATING COST	**USD 876.7M**	
Volume processed, dry grains, kg year^{-1}	10,010,000	
Buying price of COCs, USD kg^{-1}	244.93	
Selling price, USD kg^{-1}		
Local market	565.88	
Cebu	617.40	
Manila	637.67	
Gross income, USD year^{-1}	**USD 1,433.2 B**	
Net income for the first year, USD year^{-1}	**USD 375.4 M**	
Payback period, years	2.49	
Internal rate of return (IRR) @ 16% p.a.	34.85	
Benefit cost ratio	2.24	
Net present value, USD	**USD 51,134 M**	
Breakeven		
Selling price, USD kg^{-1}		
Local market	533.36	
Cebu	572.64	
Manila	592.91	
Volume, dry grains, kg year^{-1}		
Local market	1,644,453	
Cebu	576,036	
Manila	171,776	
Service area, ha year^{-1}		
Local market	427	
Cebu	150	
Manila	45	

Willingness-to-pay for bulk processing. The willingness of farmers to pay for bulk processing is higher if they are already adopting the technology while non-adopters is lower because they based their answers on the direct costs incurred in the shelling and labor cost for sundrying of corn (Table 8). Thus, results indicated that willingness for adopting the bulk handling by the non-clients was USD17.71 kg^{-1}, than the actual fee of USD73.90 kg^{-1}, thus a negative price gap of USD54.90 kg^{-1} or negative price gap of USD 22.17 kg^{-1}.

Table 8. Willingness-to-pay of farmer for bulk processing of corn, 2012 USD/kg

Item	Actual Bulk Handling Fee	Willingness-to-pay for bulk handling	Price Gap
Farmer Client	73.90	84.46	10.56
Farmer Non-client	73.90	17.74	(54.90)
Average			**(22.17)**

Exchange rate: USD1 = PhP42.23

Postharvest Losses. The study determined postharvest losses through qualitative and quantitative bases. Qualitative is based its physical appearance (i.e., 14% moisture content, golden yellow in color and free from foreign matters) while quantitative losses is based on the weight loss.

Traders imposed price deduction of around one to three percent if the quality of corn grains did not meet requirements while price deduction of one to three percent based on the total weight for quantitative losses. If the product does not meet both the qualitative and quantitative requirements, price deductions would be based on whichever was higher.

Based on the farmers' perception, postharvest losses (from harvesting to marketing) of about 12.35 percent were incurred using traditional system while about 3.31 percent were incurred using bulk handling system. Hence, a reduction in postharvest losses of around 9.04 percent would be achieved by adopting bulk handling system (See NSB). Moreover, this implies additional corn supply for the industry.

Saved time and other costs. With the project, farmers would be able to save time hence, reducing man-days by 13.42 per hectare or savings of around USD85,008.99/ha or USD22.59/kg (See NSB). It is expected for the farmers to plant 3 times a year because they have more time in the farm considering that several farm activities have been unloaded. This redounds to additional corn supply for the industry and additional income for the farmers and other actors in the chain. With the project, costs on sacks and handling during distribution would be reduced as well.

Net Social Benefit (NSB).This was computed to reflect the social benefits from adopting bulk handling system. Results indicated that NSB was USD110,918.94 per hectare or USD29.48/kg. This shows that social benefits received by the society if they would adopt bulk handling could cover the average price gap of USD22.17/kg between the actual bulk handling fee and willingness for bulk processing (Table 9). Moreover, a positive NSB meant that this government project is worthwhile.

Table 9. Net social benefit from adopting bulk handling system for corn, Mindanao to Manila and Cebu, 2012

ITEM	Non-Adopter	Adopter	Per Hectare	Rate	Benefit, USD ha^{-1}	Costs, USD ha^{-1}
Volume/ha	3,763.11		3763.11	565.88/kg	2,129,468.69	
		7,526.21	7526.21	267.74/kg		2,015,067.46
Reduced postharvest losses	12.35	3.31	34,018.51	565.88/kg	192,506.72	
Saved man-days	31.75	18.33	13.42	6,334.50/ md	85,008.99	
Reduced sack costs	63	-	63	358.96/sack	22,614.48	
Saved Handling costs	15962.94	802.37			15,160.57	
Depreciation	-	23820.49				23,820.49
Processing costs	-	73.90	3763.11			278,093.83
TOTAL					**2,444,759.45**	**2,316,981.78**
NET SOCIAL BENEFITS					**USD 127,777.76 ha^{-1} or USD 33.96 kg^{-1}**	

Note: Volume ha^{-1} of COC = 7,526.21 kg; Volume ha^{-1}; corn grains = 3,763.11 kg
* Conveyor consumption of 10 kwh^{-1} at USD422.3 kwh^{-1} used for 45 min
Cost of sack = USD 358.96 pc^{-1}; One sack = 60 kg Handling cost $sack^{-1}$ = USD 63.34 kg^{-1}

Problems and Constraints

Problems encountered by the farmers in their present corn production were the following: unfavourable weather condition, lack of finances and labor supply, high transport cost due to unpaved farm to market roads, the distance of their farm from the market, the low and fluctuating price of corn and lack of information. Other key actors aside from the shippers disclosed that they were receiving low quality of corn, supply shortage and high price. Shippers said that lack of infrastructure at the port was their primary problem.

CONCLUSIONS AND POLICY IMPLICATIONS

Bulk handling system reduced the costs incurred by the Mindanao corn farmers because of the activities unloaded from them and absorbed by the processors. However, this resulted to a decrease in the income of the farmers because of selling COC instead of selling in corn grains which commanded higher price. Moreover, processors earned more though they incurred higher costs in the bulk handling system. Consequently, the project has improved the entire value chain by reducing its costs and increasing its income. The positive net social benefit denotes that this government project is worthwhile.

Thus, to encourage the farmer non-adopters to bring their produce to the processing center and to serve as incentive for the adopters, a rebate or patronage refund should be implemented by the processors. Furthermore, bigger processing center's capacities could lower processing costs which could encourage farmer non-adopters to sell their produce. Good quality product would mean a bigger chance to compete with Luzon products during their lean months and export to the neighboring Asian countries in the future.

Since the farmers are now concentrating on producing more corn supply, the government should continue to explore potentials in the industry and link this program both to the local and international market. In addition, the DA should continue to promote the use of moisture meter to accurately measure the MC of corn and meet the requirements of the market. The Department of Public Works and Highways meanwhile, should prioritize the farm to market road projects to address the problem on high transport costs. Government should also look into the capability of the domestic ports on handling bulk agricultural goods such as corn grains. Lastly, aggressive promotion through trainings, publications and other media forms on the adoption of bulk handling system for the corn industry must be implemented.

Results of the study can be valuable information to policy makers for making policy decisions that would support government plans in enhancing the competitiveness of the corn industry to confront globalization.

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SIMULATING CLIMATE-INDUCED IMPACTS ON PHILIPPINE AGRICULTURE USING COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

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ABSTRACT

This research employed a computable general equilibrium model to analyze the likely extent of climate-induced impacts on the Philippine economy and its agricultural subsectors. Using two simulation scenarios (*i.e.* decline in agricultural productivity, and combination of a decline in agricultural productivity and fishery policy response), the results reveal that the real gross domestic product (GDP) at factor cost, export quantity, import quantity and employment will decrease. However, if the government will employ fishery policy response that would target an increasing production in the fishery subsectors (i.e. ocean fishing, freshwater/coastal fishing, and aquaculture), then the reduction in percent deviation from the base for real GDP, export and import quantity, and employment will be lower. Overall, climate-induced impacts will result in a net loss to the Philippine economy and its key agricultural sectors in the short run. Therefore, it is imperative for Philippine farmers to adopt adaptation measures that will lessen the impacts of climate change such as use of organic, indigenous and/or diversified farming practices coupled with safety nets provided by the national and local government units for the affected farmers in the agricultural subsectors – banana, corn, sugarcane, rice and fiber products.

Key words: climate change, closure, modeling, shock, short-run

INTRODUCTION

The Philippines is a minor emitter of global greenhouse gases, but its location and geography make it highly vulnerable to the impacts of climate change specially by natural disasters and periodic El Niño and La Niña (Rincon and Virtucio, 2008). In 2007, the Philippines was ranked as the 43rd largest emitter of carbon dioxide in the world, accounting for 0.27% of the total global carbon dioxide emissions ($MtCO_2e$), excluding land use change (WRI, 2011). Indeed, climate change is a serious threat to the country's economy especially to agricultural sector. Since agricultural production relies heavily on the environment, increased uncertainties and risks from natural calamities and disasters greatly affect the production of agricultural goods.

Rainfall and temperature variability are the two main contributing factors affecting agricultural production in the country. Intergovernmental Panel on Climate Change (IPCC, 2007, p. 475) reported that since 1971, average temperatures in the Philippines have increased by 0.14 ºC per decade. This has led to increased annual mean rainfall (since the 1980s), increased number of rainy days (since the 1990s), and increased inter-annual variability of onset of rainfall. This situation is most likely to continue, since the Philippine Initial National Communication on Climate Change (PINCCC) (Republic of the Philippines, 1999) have projected a temperature increase of 2-3^{0}C in annual temperatures.

There are varying estimates of climate change impacts resulting in yield reduction of selected Philippine agricultural crops and production losses due to damages from onslaught of climate-induced events, such as typhoons, floods, drought/El Niño, La Niña, and pests and diseases. Increasing temperature due to climate change results in: (1) decreased crop yield due to heat stress; (2) increased livestock deaths due to heat stress; and (3) increased in outbreak of insect pests and diseases. Meanwhile, the variability in rainfall (including the El Niño Southern Oscillation) results in: (1) increased frequency of drought, floods, and tropical cyclones (associated with strong winds), causing damage to crops; (2) changes in rainfall patterns affecting current cropping pattern, crop growing season, and sowing period; and (3) increased runoff and soil erosion resulting in declining soil fertility and crop yields (IPCC, 2001).

Tables 1 and 2 show the varying estimates of climate change impacts resulting in yield reduction of selected Philippine agricultural crops (rice, corn, banana, cotton, sugarcane, tomato and coffee)[1] and production losses due to damages from the onslaught of climate-induced events, such as typhoons, floods, drought/El Niño, La Niña, and pests and diseases. For example, rice yields are expected to result in a 15% to 27% for a temperature increase of 2°C (Escaño and Buendia, 1994) because of heat stress, decrease in sink formation, shortening of growing period, and increased maintenance for respiration. SEARCA (2005) estimated the yield reduction coefficients[2] would range from 1% to 100% due to typhoon, flood, drought and pest and diseases for selected Philippine agricultural commodities. Typhoon/flood damages in rice fields are estimated to result in losses of about 2.6-62.54%. Losses due to droughts are estimated 1.5%, while losses due to pests and diseases are seen at about 10% (Rincon and Virtucio 2008; SEARCA 2005). Delos Santos *et al*. (2007) stressed the impacts of extreme climatic events on corn production in the Philippines.

Based on the reports of the farmers, up to 70% of corn crops can be damaged by typhoons, while flooding can wipe out the entire corn farms (Table 2). Meanwhile, drought and La Niña episodes can result in yield losses of 50%-70% and 16%, respectively. On the other hand, Global Circulation Models predicted that corn yields would decline by 12.64% for the first crop of PS 3228 variety and 19% for the first crop of sweet corn (Republic of the Philippines, 1999).

Such uncertainties and risks further stress the importance of assessing the impacts of climate change to Philippine agriculture and the overall economy. This assessment of climate-induced impacts will provide a useful vehicle for practical policy analyses and targeted climate-change adaptation and mitigation strategies and measures. To date, there is no study yet that uses the computable general equilibrium (CGE) model to estimate economy-wide implications of climate change in Philippine agriculture.

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[1] These crops were selected because they are the commodities with reported estimates of yield reduction due to climate change. Other agricultural commodities were not included in this paper due to unavailability of literature citing estimates of yield reduction due to climate change as of January 2012.

[2] Reduction coefficient (RC) is defined as: RC = (1-RT)*(1-RF)*(1-RD)*(1-RP&D), where RT, RF, RD and RP&D are reduction coefficients for typhoon, flood, drought, pests & diseases. RC is synonymous to the measure of risk due to climate induced events. Yield loss = Potential yield * Reduction Coefficient

Table 1. Reported yield reduction (%) and yield reduction coefficients (%) of selected agricultural crops in the Philippines.

Commodity	Yield Reduction (%)	Yield Reduction Coefficient (%)[a]			
		Typhoon	Flood	Drought	Pest & Diseases
Rice	15-27[b]	10	30-80	15	10
Corn	12-19[c]	80-100	85	90	25-90
Banana			85	90	1-30
Cotton			85	90	20-99
Sugarcane			85	90	5-80
Tomato			85	90	10-70
Coffee			85	90	5-60

Source: [a]SEARCA (2005), [b]given 2^0 C increases in temperature (Escaño and Buendia, 1994), [c]Republic of the Philippines (1999)

Table 2. Production losses (%) of selected agricultural crops in the Philippines.

Commodity	Losses (% Damages)			
	Typhoon/Flood	Drought/ El Niño	La Niña	Pest & Diseases
Rice	2.6[a], 62.5[b]	1.5[a]		10.0[b]
Corn	70.0[c], 75.0[b]	27.0-70.0[c] , 87.0[b]	16.0[c]	65.8[b]
Banana	5.5[b]	4.4[b]		9.4[b]
Cotton	76.7[b]	87.0[b]		72.7[b]
Sugarcane	18.3[b]	47.5[b]		30.0[b]
Tomato	43.9[b]	32.5[b]		27.0[b]
Coffee	44.2[b]	43.6[b]		25.7[b]

Source: [a]Rincon and Virtucio (2008), [b]SEARCA (2005), [c]Delos Santos *et al*. (2007)

The earliest CGE models of the Philippines were done by Clarete (1984) on trade policy and Habito (1984) on fiscal policy and income distribution. Since then, quite a number of models have been constructed that evaluated the impacts on welfare, poverty, outputs, prices, international trade, consumption, employment, pollution emissions, income distribution, food security, and agriculture, among others. For Philippine agriculture, CGE models were employed to assess the trade policies and impacts of avian influenza outbreak (Rodriguez *et al*., 2007); impacts of Philippines-USA free trade agreement (Rodriguez and Cabanilla, 2006); biofuel (Rodriguez and Cabanilla, 2008); agricultural policies (Habito, 1986; Clarete and Warr, 1992), poverty (Cororaton and Corong, 2006), and welfare (Coxhead and Warr, 1992).

This research is the first to assess the economy-wide estimates of climate-induced impacts on Philippine agriculture. Specifically, this research determined the extent of climate-induced impacts on the different subsectors of Philippine agriculture, and assessed the total macroeconomic impact of climate-induced changes in agricultural production.

METHODOLOGY

Overview of the Model

CGE model is a useful tool for analyzing the likely extent and induced distributional impacts of climate change on all the sectors of the economy and the different subsectors of Philippine agriculture. The tool used in the analysis was based on the ORANI-G, a generic single-country CGE model using the Philippine input-output (IO) data. This CGE model is named AGRIK.

The ORANI was designed for comparative-static simulations. The ORANI applied general equilibrium (AGE) model of the Australian economy is widely applied and adapted by economists and academicians in the government and private sectors for practical policy analysis, e.g. study of macroeconomic and sectoral shocks addressing competition and trade policies (Horridge, 2003). ORANI-G has been adapted to build models of South Africa, Pakistan, Sri Lanka, Fiji, South Korea, Denmark, Vietnam, Thailand, Indonesia, Philippines, and China. In particular, the Philippine's TARFCOM model is an adapted CGE model of Orani-G with Philippine data (Rodriguez and Cabalu, 2005).

The ORANI-G–based model was used in general equilibrium modeling because of the following advantages. First, the model allows for direct implementation of production and consumption shocks in the analysis. Second, it contains equations that explicitly link agriculture, manufacturing, and trade sectors to other industries in the economy. Finally, the model computes macroeconomic variables (e.g. gross national product (GNP), imports and exports, among others) that allow an overall assessment of the impacts. In particular, the theoretical structure of ORANI-G consists of equations describing producers' demands for produced inputs and primary factors, producers' supplies of commodities, demands for inputs to capital formation, household demands, export demands, government demands, relationship of basic values to production costs and to purchasers' prices, market-clearing conditions for commodities and primary factors, and numerous macroeconomic variables and price indices. Horridge (2003) presented a detailed guide of the ORANI-G model, its structure, assumptions and drawback, key relationships, closures, etc.

The AGRIK model includes 25 industries and 25 commodities, 15 of which are agricultural. Moreover, there are two sources (domestic and imported) and two occupation types (skilled and unskilled). Producers were assumed to be price takers operating in competitive markets for both their outputs and inputs. Furthermore, the model used the assumptions of constant returns to scale and marginal cost pricing to eliminate quantity variables from the industry zero pure profits condition. Each industry produces a mixture of all the commodities using domestic inputs and imported commodities, labor types, land and capital. This mixture varies according to the relative prices of commodities. In addition, commodities destined for export were distinguished from those which are for local use. There is no substitution between produced inputs, primary factors and other inputs or between inputs of different commodity categories. However, there is substitution between aggregate labor, capital and agricultural land, and between alternative sources (i.e. domestically produced goods and imports) of produced inputs of a given commodity category. The 25 industries are also the investors themselves. Capital was assumed to be produced with inputs domestically produced and imported commodities and no primary factors were used directly as inputs to capital formation. Furthermore, the model includes market-clearing equations for locally-consumed commodities, both domestic and imported.

The Database of the AGRIK Model

The data used in the AGRIK model was based on the 2004 Philippine input-output (IO) table from the Global Trade Assistance and Protection (GTAP) database (version 7), which has 57 GTAP commodities (Corong, 2008). The 2004 Philippine IO was an updated 2000 IO table of the country with 240 commodities. The IO table contains data on payments made by various agents on the commodities and factor services provided by the other agents. The 2004 IO table from GTAP database has 57x57 sectors, which was aggregated into 25x25 sectors in the AGRIK model, following the commodity definition of the 2000 Philippine IO. Other data used in the model were obtained from the National Statistics Coordination Board (NCSB), the Bureau of Agricultural Statistics, and the Food and Agriculture Organization of the United Nations Statistical Database.

Figure 1 shows the structure of the information contained in the IO table. Demanders identified in the column headings (i.e. the absorption matrix) include:

- domestic producers divided into *I* industries;
- investors divided into *I* industries;
- a single representative household;
- an aggregate foreign purchaser of exports;
- government demands; and
- changes in inventories.

V1BAS (*c*, *s*, *i*) represents the flow of commodity *c* in basic value from source *s* to industry *i* for intermediate use. *V2BAS* (*c*, *s*, *i*) represents the flow of commodity *c* in basic value from source *s* to industry *i* for investment. *V3BAS* (*c*, *s*) represents the flow of commodity *c* in basic value from source *s* for household consumption. *V4BAS* (*c*) represents the flow of export commodity *c* in basic value. *V5BAS*(*c, s*) represents the flow of commodity *c* in basic value from source *s* for government consumption. *V6BAS* (*c, s*) represents the inventories of basic flow of commodity *c* in basic value from source *s*. *V1MAR (c, s, m)* is the value of margin type *m* used to deliver commodity type *c* from sources *s* to producers (user 1). *V2MAR (c, s, m)* is the value of margin type *m* used to deliver commodity type *c* from sources *s* to investors (user 2). *V3MAR (c, s, m)* is the value of margin type *m* used to deliver commodity type *c* from sources *s* to households (user 3). *V4MAR (c, s, m)* is the value of margin type *m* used to deliver commodity type *c* from sources *s* for exports (user 4). *V5MAR (c, s, m)* is the value of margin type *m* used to deliver commodity type *c* from sources *s* to government (user 5). *V1TAX* (*c*, *s*, *i*) represents the sales tax imposed on commodity *c* from source *s* for intermediate use by industry *i*. *V2TAX* (*c*, *s*) represents the sales tax imposed on commodity *c* from source *s* for investment use by industry *i*. *V3TAX* (*c*, *s*) represents the sales tax imposed on commodity *c* from source *s* consumed by households. *V4TAX* (*c*) represents the sales tax imposed on export commodity *c*. *V5TAX* (*c*, *s*) represents the sales tax imposed on commodity *c* from source *s* for government consumption. *V1LAB (i*, *o*) represents the wage bill by industry *i* by occupation. *V1CAP (i*) represents the capital rentals by industry *i*. *V1LND (i*) represents the land rentals by industry *i*. *V1PTX* is an *ad valorem* production tax while *V1OCT (i*) represents the other costs incurred by industry *i*. The MAKE *(c*, *i*) represents the make matrix at the bottom of Figure 1 by commodity *c*, by industry *i*, i.e. the value of output of each commodity by each industry. *V0TAR* (*c*) represents the tariff revenue by commodity *c*.

Updating the 2004 Philippines Input-Output Table

The 2004 Philippine IO above may not be appropriate for policy analysis because it no longer reflects the present structure of the Philippine economy, which went through significant structural changes from 2004 to 2009.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labor	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = Number of Commodities
I = Number of Industries

S = 2: Domestic, Imported
O = Number of Occupation Types

M = Number of Commodities used as Margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

Fig. 1. The database (Horridge, 2003).

Appendix Table 1 shows the percentage changes in real aggregates from 2004 to 2009 from the demand and supply sides of the economy. The expenditure side includes household and government final consumption expenditures, capital formation, exports and imports, while the supply side includes employment and population (or number of household). Gross value added of each major industry was used for the industry output. Since the employment data is more aggregated for the agriculture sector, it is assumed that the changes in productivity within this sector are the same. Therefore, following Buetre and Ahmadi-Esfahani (2000), the Philippine IO table was updated from 2004 to 2009.

The procedure outlined in Buetre and Ahmadi-Esfahani (2000) in updating the database followed the simulation technique based on Dixon and McDonald (1993), which employed the CGE model. This macroeconomic historical simulation requires the following variables to be included in the database:[3] real household consumption (x3tot), aggregate real investment expenditure (x2tot_i), export volume index (x4tot), import volume index (x0cif_c), and aggregate real government demands (x5tot) from 2004 to 2009 as shown in Appendix Table 1.

This inclusion requires the adoption of new closure[4]. In this regard, the following macroeconomic variables were endogenized:

- a1primgen - a general technological change or total factor productivity
- ff_accum - a general shifter for aggregate investment
- twist_src_bar - a general twister for import
- f4q_general - a general shifter for exports
- f5tot2 - a general shifter for aggregate 'other' demand.
-

Moreover, the following shocks were introduced:

- employment (employ_i) = 10.91. This is the percentage change in aggregate employment in the Philippines during the period.
- number of households (q) = 19.86. This allowed for the changes in consumption to be measured in terms of per household basis.
- consumer price index (p3tot) = 32.67. This allowed the actual change in aggregate consumer price to be imposed exogenously, leading to an updated database expressed in 2009 values.

Simulation Scenarios

Two simulation scenarios were implemented in the CGE application. The agricultural production scenario (1st) highlights the possible climate-induced impacts on the Philippine economy and on the selected agricultural subsectors. In the first simulation, production shocks were simultaneously employed for rice (-18%), corn (-16%), sugarcane (-32%), banana (-6%), and other crops (-15%). These assumptions were based on the information presented in Tables 1 and 2.

On the other hand, the fishery policy-response scenario (2nd) that would target an increasing production in the fishery sector (ocean fishing, freshwater/coastal fishing, and aquaculture) is viewed as a potential policy response given climate change impacts on the selected subsectors of Philippine agriculture, i.e. 1st simulation scenario. This second scenario is a possible policy response to climate change impacts since the Philippine fishery sector is less vulnerable to the impacts of climate change compared with those in 137 other economies (Allison *et al.*, 2009). Furthermore, the Philippine Government's increased provision of grants in the form of agri-fishery inputs, equipment and facilities, including farm-to-market road projects, are expected to further boost the development of the agricultural and fishery sector and increase the productivity of fisherfolks and small farmers to selected provinces and local government units in the country. In the fishery policy-response scenario, it was assumed that fishery production could be increased by 10%.

Given the two scenarios, CGE model was employed to estimate the changes on the following macroeconomic variables: real gross domestic product (GDP) at factor cost, consumer price index (CPI), export quantity, import quantity, employment, and average return to land (rent). Likewise,

[3] These variables are estimated from the respective changes in the expenditures on commodities in each of the five categories in the final demand, hence usually treated as endogenous in the model.
[4] A closure must be satisfied wherein the number of endogenous variables must equal the number of equations so that the CGE model will run and the equation system can be solved using GEMPACK.

changes in the sectoral activity-level or value added for the 25 sectors of the Philippine economy were estimated. Fifteen of the 25 sectors in the CGE model comprised the agriculture, fishery and forestry sectors.

Since the AGRIK model discussed above has more variables than equations, closure rules were imposed so that the number of equations is equal to the number of endogenous variables. In solving the CGE model, both the short-run or long-run closure rules can be employed. In the short-run closure, capital stocks are held fixed, implying that it is not affected easily by the short run shocks. Likewise, real wages are held fixed in the short run closure, accompanied by an endogenous level of aggregate employment. This assumes that firms do not substitute between labor of different types. A short-run closure rule assumes that a) unemployed resources exist and b) there will be a short period of time (1-3 years) needed for economic variables to adjust to new equilibrium (Horridge, 2003). In other words, short-run influence connotes "a short period of time (1-3 years) needed for economic variables to adjust to new equilibrium." On the other hand, the long-run closure rule allows the real wage rate to adjust to an exogenously determined level of aggregate employment. This long-run scenario assumes that the economy is operating under full employment.

Given high unemployment in the country (7.5% in April 2013), a long-run scenario was not adopted in the CGE application. While in terms of time period, the impacts of climate change on agriculture and economy is significant in the long-run; however, given the timescale of the simulations employed and employment condition of the country, a short-run closure was more appropriate to use. Hence, the most appropriate assumption, based on the given needs or timescale of the proposed simulations above, is the use of short-run closure. Hence, all the results below were treated as representatives of the simulated short-run influence of climate-induced impacts on the Philippine agriculture and economy.

Short-run closure was adapted in the implementation of the AGRIK model. The macro variables are *swapped* as follows:

- disconnecting government from household consumption by treating *x5tot* as exogenous variable instead of f5tot2;
- household consumption *x3tot* as exogenous variable rather than w3lux;
- inventory changes *delx6* as exogenous variable rather than fx6; and
- average *real wage* as exogenous variable rather than the overall wage shift, f1lab_io.

The AGRIK model was implemented using the General Equilibrium Modelling PACKage (GEMPACK) system. GEMPACK is a flexible system for solving CGE models and facilitates the automation process of translating the model specification into a model solution program.

RESULTS AND DISCUSSION

On the macro level, simulation results show that climate-induced impacts are likely to reduce aggregate output. This can be seen from the 1.83% projected decline in real GDP accompanying the production shock (simulation 1). Results from the combination of production shock and fishery policy response shock (simulation 2) indicated a possible 1.63% reduction in aggregate output (Table 3).

A decline in agricultural production is expected to raise the general price level (as measured by consumer price index) by 0.15%, while increasing the production of the fishery sector given climate induced impacts on agricultural production is seen to reduce aggregate prices by 1%. Climate-induced impacts would mostly affect the country's quantity of export and import, as well as employment, though the country would be benefiting slightly from the fishery policy response of increasing production. The decline in agricultural production due to climate change was reflected in the reduction of quantity exported by 6.54% and quantity imported by 1.93%. Likewise, the country's employment will decrease by 4.91% with the assumed reduction in selected agricultural production.

Table 3. Simulated macroeconomic effects, in percent deviation from the base.

Variables	Simulation 1 Agricultural production	Simulation 2 Agricultural production + fishery policy response
Real GDP at factor cost	-1.83	-1.63
Consumer's price index	0.15	-1.00
Export quantity	-6.54	-5.72
Import quantity	-1.93	-1.89
Employment	-4.91	-4.36
Average return to land	73.26	75.27

Given reduction in agricultural production due to climate change and targeted fishery policy response, the percent deviation from the base in export quantity is lower at 5.72% decline, a decrease of 1.89% in import quantity, and a decrease of 4.36% in employment. In addition, land rent is expected to increase by 75.27%, which might trigger improvement in production efficiency and further input intensifications (Table 3). Simulation 2 results indicated that the fishery policy response could increase real GDP, employment, export and import in the fisheries subsectors.

Detailed disaggregation of the results shows a similar pattern. The reduction in activity level or value-added was most significant in corn, banana, sugarcane, manufacturing, and rice sectors (Table 4). Value-added for forestry rose slightly by 0.12%. In simulation 1, 23 of the 25 sectors will have a decrease activity level. On the other hand, simulation 2 caused the value-added of 18 sectors to decline. The fisheries sectors (ocean fishing, freshwater/coastal fishing, and aquaculture) are the only sectors that gained positively from simulation 2. Moreover, there were slight increase in the value-added for forestry (0.29%), mining and quarrying (0.02%) and construction (0.01%) sectors.

Given the structure of the Philippine economy, the simulation results show that the decrease rate of most of the sectors in simulation 2 is lower than that in simulation 1. The model implies that with fishery policy response, the value-added created in the three subsectors of the fishery will have multiplier effects in the economy and the associated subsectors of the country. For example, Table 4 shows that given simulation 2, transport subsectors will benefit slightly from fishery policy response since without it, the reduction in value added will be higher at 0.44% compared with 0.13% with the fishery policy response.

CONCLUSION AND RECOMMENDATIONS

Overall, climate-induced impacts will result in a net loss to the Philippine economy and its key agricultural sectors in the short run. Since production would be greatly affected and would have ripple and multiplier effects in the economy, it is imperative for Philippine farmers to employ adaptation measures to lessen the impacts of climate change.

Therefore, boosting the fisheries subsectors may lessen the impact of climate change on the Philippine economy. In 2009, commercial fisheries contributed PhP 58M of the total fish (27%) production, municipal fisheries contributed PhP 75M (35%), and aquaculture contributed about PhP 81M (38%) (BFAR, 2009). Since climate change would have an impact on the greater number of municipal fishing operators, an increase in the capacity of commercial fishing and aquaculture operators may be encouraged. In the country, climate change shortens fishing season[5] as heavy rains and strong waves now begin as early as late March or early April.

The use of organic farming practices is one of the strategies being advocated by the Department of Agriculture in response to climate change. Some government subsidies may be needed to promote indigenous and diversified farming practices in the countryside. Furthermore, going local and buying local produce may benefit the domestic economy in the short run. Finally, government should establish safety nets for those stakeholders affected by declining employment and reduced food crop production. Priorities should be on the most affected subsectors - banana, corn, sugarcane, rice, and fiber products.

Table 4. Simulated sectoral activity level/value-added effects, in percent deviation from the base.

Sectors	Simulation 1 Agricultural production	Simulation 2 Agricultural production + fishery policy response
Rice	-4.83	-4.48
Corn	-7.32	-7.09
Vegetable and oil seeds	-2.49	-2.22
Fruits and nuts	-2.49	-2.22
Sugarcane	-6.05	-5.76
Abaca	-3.72	-3.44
Cotton and other fiber crops	-3.72	-3.44
Banana	-7.55	-7.25
Other crops	-2.49	-2.20
Livestock	-3.11	-2.83
Other livestock products	-3.64	-3.40
Forestry	0.12	0.29
Ocean fishing	-0.17	9.86
Freshwater/coastal fishing	-0.17	9.86
Aquaculture	-0.17	9.86
Mining and quarrying	-0.05	0.02
Manufacturing	-5.54	-5.18
Electricity, gas and water	-1.83	-1.70
Construction	-0.03	0.01
Trade	-2.01	-1.86
Transportation, communication and storage	-0.44	-0.13
Finance	-0.39	-0.28
Private services	-0.45	-0.08
Government services	-0.03	-0.01
Dwellings	0.00	0.00
No. of sectors with lower activity-level/value added	23	18

[5] Heavy rains and strong waves in the Philippines coincide with the rainy/typhoon season which commonly start in June.

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Appendix Table 1. The Philippines macroeconomic data for historical simulations.

Variable	2004	2009	% Change
Household final consumption expenditure	903,814	1,152,6580	27.5
Government final consumption expenditure	75,455	101,163	34.1
Capital formation	234,065	243,052	3.8
Exports	539,950	574,284	6.4
Imports	628,911	621,543	(1.2)
Employment (1,000 persons)	31,613	35,061	10.9
Population	76,946,500	92,226,600	19.9
Gross national expenditure	1,252,331	1,654,936	32.2
CPI (1994 = 100)	121	160	32.7

Sources: Philippine Statistical Yearbook (2004, 2010)
Note: Expenditures are in million Pesos, constant 1985 prices.

COMMUNITY BASED AGRO-TOURISM AS AN INNOVATIVE INTEGRATED FARMING SYSTEM DEVELOPMENT MODEL TOWARDS SUSTAINABLE AGRICULTURE AND TOURISM IN BALI

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ABSTRACT

Bali economic growth is based on agriculture, small-scale industry, and tourism sectors. Agro-tourism of *Salak Sibetan* Plantation under local authority, an existing community-based development in eastern part of Bali, is descriptive qualitatively analyzed. Based on agro-tourism typology, it is identified as a working farm passive contact agro-tourism that provides farmhouse bed and breakfast, as well as a working farm indirect contact agro-tourism that offers some attractions (e.g. visiting *salak* plantation and picking of fresh fruit, visiting a winery and crispy chip demonstrations and tasting). Even though it was supported by other stakeholders (government, tourism industries, NGOs, and universities) since 1995, it was gradually developed. Village Ecotourism Network in collaboration with the manager for Farmer Group of Dukuh Lestari and local guides sold these attractions, but it has few numbers of visitors. The conditions might be due to limited capacity of local community in agro-tourism, limited budget to provide many standard agro-tourism facilities, lack of adequate promotion, and limited agro-tourism landscaping. To improve agro-tourism development and contribution to sustainable Bali economic growth, appropriate capacity building programs on agro-tourism for local community, supported by government budget and/or corporate social responsibility programs will be helpful and useful.

Key words: local authority, *salak sibetan*, sustainable agro-tourism

INTRODUCTION

Tourism represents, for many countries, a powerful tool for social and economic development and reduction of poverty, through the provision of jobs and enterprises, infrastructure development and export earnings. Well-designed and managed tourism can not only make a significant contribution to the three dimension of sustainable development, but also has close linkages to other sectors and can create decent jobs and generate trade opportunities (Gutierrez, 2012). However, tourism cannot be self- supporting since it depends on the availability of ecosystem services (Ahmad, 2012). The economic development of Bali Province is based on primary (agriculture), secondary (small-scale industry) and tertiary (including tourism) sectors that contributes about 18.08%, 15.57%, and 66.35% respectively to the Bali economic growth in 2011 (Regional Development Plan Agency of Bali Province, 2012). In order to accelerate and expand the economic development in Indonesia between 2011 and 2025, Bali and Nusa Tenggara become the economic corridor on “The Gateway of Tourism and Supporting of National Food” due to 40% of international flights were directly to Bali, 15% of national hotels capacity were in Bali and Nusa Tenggara, and

21% of gross domestic product was contributed by the hotels (The Coordinating Ministry for Economic Affairs, 2011).

The development of Bali tourism is based on the Balinese culture, written in the Regional Regulation No 2/2012 as the improvement of Regional Regulation No. 3/1991 and Regional Regulation of Bali Province No. 3/1974 (Bali Government Tourism Office, 2012). Balinese culture, including "Balinese agriculture", is very much based on Hindu philosophy (Ardika, 2012). The operational foundation of economic development in Bali is *Tri Hita Karana* (*Tri* = three, *Hita* = happiness, *Karana* = causes). These include: the harmonious relationship between human beings and God, as the creator of the world; the harmonious relationship among human beings themselves; and the harmonious relationship between human beings and the environment (Regional Development Plan Agency of Bali Province, 2012). Present statistics within the Bali tourism sector show that direct foreign and domestic tourist arrival to Bali in 2011 was 2.76 million persons and 5.68 million persons respectively (Bali Government Tourism Office, 2012) and a number of other tourists, indirectly come to Bali, was unidentified. About a hundred trillion Indonesian rupiah of income was gained from Bali tourism, 10% of it was spent for food and horticultural product requirement within the sector operation. However, only 2.2 trillion Indonesian rupiah of the agricultural product was produced in Bali, whereas the remaining must have been imported from outside of Bali. Even though the room occupancy rate in 2011 was only 62.15% (Bali Government Tourism Office, 2012), many fertile agricultural land in Bali such as within Badung and Gianyar Regencies as well as Denpasar City have been converted into tourism facilities. These are many challenges facing sustainable agriculture development in Bali. In this regard agro-tourism development is one of Bali tourism innovative development strategies (Bali Government Tourism Office, 2012) that integrate agriculture and tourism sectors.

There are two models of agro-tourism development namely capital based agro-tourism and community based agro-tourism. There are many capital based agro-tourism objects developed by Balinese entrepreneur such as Bagus Agro Pelaga at Pelaga Village - Badung Regency that supplies organic agricultural products like vegetables, cutting flowers, and fruits (Utama, 2007). It is supported by various facilities that consists of restaurant, bar, meeting room, supermarket, wholesale shop, children playground, tracking path, fishpond, livestock (bali cattle farming). It offers two packages of visiting organic farm attraction, package one is by IDR120,000 per person for entrance charge, welcome drink fresh strawberry juice, circling strawberry and vegetable farms, buffet lunch, traditional cake with coffee or tea, includes 21% tax and service; and package two is by IDR45,000 only per person for entrance charge, welcome drink fresh strawberry juice, circling strawberry and vegetable farms, includes 21% tax and service.

Other capital based agro-tourism destinations are Trisna Bali Agro-tourism at Penglumbaran Village - Bangli Regency (http://gourmetpigs.blogspot.com); Alam Bali Kopi Luwak and Natural Spices at Sebatu Village – Gianyar Regency (http://www.balikopiluwak.net); Oka Agro-tourism at Susut Village – Bangli Regency (http://www.tripadvisor.com); Abian Sari Agro-tourism at Kintamani – Bangli Regency (http://www.foodspotting.com); Satria Agro-tourism at Basangambu sub village – Gianyar Regency (http://satriaagrowisata.baliklik.com); Santi Agro-tourism at Temen sub-village – Gianyar Regency (http://wensdelight.blogspot.com); Agro-tourism Bali Pulina (http://www.yukpegi.com); Buana Amertha Sari (BAS) Agro-tourism at Kintamani – Bangli Regency (http://www.cikopi.com) that essentially produce and offer Luwak coffee, processed from the red coffee beans that the Luwak (Asian Palm Civet) eats and passes through their system undigested and finally passed out of their system. The beans are then washed, lightly roasted and grounded and made into coffee powder. Visitors can taste this nice coffee by paying approximately IDR50,000 per cup. Agro-tourism of *Salak Sibetan* Plantation, which is managed by Farmer Group of Dukuh Lestari at Sibetan Village – Karangasem Regency, is an example of community based agro-tourism development.

At present, the information of agro-tourism contributions in many destinations above is still limited since agro-tourism is a new tourism development model. Agro-tourism contributes a lot to the improvement of economic life of the local communities. The contributions are in the form of agricultural products sales, various hand-made souvenirs or handicrafts sold to tourists, opportunities for establishment of food stalls or restaurants and certain types of accommodation such as home-stay, bungalow, villa, and hotel, as well as village development (Utama, 2007).

This paper aims to synthesize the concept of agro-tourism and its sustainability as well as describe an existing community-based agro-tourism as an innovative integrated farming system development model towards sustainable agriculture and tourism in Bali.

METHODOLOGY

The location of this research is "Agro-tourism of *Salak Sibetan* Plantation" in Sibetan Village (Dukuh sub-village), Bebandem District, Karangasem Regency, eastern part of Bali Island. The agro-tourism destination offers visiting *salak* plantation and picking of *salak* (*Salacca zalacca*), visiting *salak* cottage industries, and other supporting attractions. Primary and secondary data was collected by conducting in-depth interview with 11 key informants. The data are agro-tourism environment (area, agricultural uniqueness, number of farmer, existing institution), history of agro-tourism development (policy, stage, stakeholders contribution, supporting fund and source), requirement of agro-tourism development (location, attractions, infrastructure and facilities, marketing target), benefit, and barriers of agro-tourism development. These informants include representatives from the Food Crop Agricultural Agency of Bali Province (two persons), Culture and Tourism Agency of Karangasem Regency (one person), Agricultural Agency of Karangasem Regency (one person), Head of the village (one person), Farmer Group of Dukuh Lestari (one person), Co-operative of *Banjar Adat* Dukuh (one person), Culinary Group of Agro Dukuh Lestari (one person), CV Dukuh Lestari for salacca wine industry (one person), Werdhi Guna Food for crispy chips, taffy, and candy of *salak* industry (one person), and *salak* plantation package (one person). Existing literatures within the agro-tourism development context were critically reviewed. Qualitative method was used to analyze the data descriptively.

RESULTS AND DISCUSSION

General Concept of Sustainable Agro-tourism

Sustainable tourism is tourism that takes full account of its current and future economic, social, and environmental impacts, addressing the needs of visitors, the industry, the environment and the host community. Sustainable tourism as "tourism which leads to management of all resources in such a way that economic, social and aesthetic needs can be filled while maintaining cultural integrity, essentials ecological processes, biological diversity and life support systems" (UNEP and WTO, 2005). Meanwhile, SEARCA (1995) defined sustainable agriculture as a holistic farming system management that requires economically viable, ecologically sound and friendly, socially just equity and acceptable, and culturally appropriate whose overall goal is to improve the quality of life. Economically viable agricultural systems have a reasonable return on investment of labor and cost involved and ensures a decent livelihood for the farm family. Economic viability also means minimal or no cost of externalities by the farming operation. Ecologically sound agricultural systems are well integrated into the wider ecological system and the focus is on maintenance and enhancement of the natural resource base. It is also biodiversity oriented. Practices which cause negative environmental impacts are avoided. Socially just agricultural systems respect the dignity and rights of individuals and groups and treat them fairly. The system allows access to information, market and other farm-related sources, especially land. Culturally appropriate agricultural systems give due consideration to cultural values, including religious belief and traditions in the development of the agricultural system, plans and programs. It recognizes the knowledge systems and visions of the farmers who are considered partners in the development processes.

Agricultural system based on holistic science not only view agriculture in terms of farming systems and system approach and their relationships - biophysical, social, economic, cultural and political factors, but also considers the dynamic interactions among on-farm, off-farm and non-farm including tourism activities and recognizes that these activities complement each other. Agro-tourism is an innovative agricultural activity related to both tourism and agriculture.

Agro-tourism is an alternative form of tourism in Bali. According to Joshi and Bhujbal (2012), agro-tourism is a specific form of rural tourism with close relation to nature and country side of rural areas and direct relationship to agricultural activities. The UNDP (Utama, 2007) interprets that rural tourism is any form of tourism that showcases the rural life, art, culture and heritage in a rural location, thereby benefiting the local community economically and socially as well as enabling interaction between the tourists and the locals for a more educational tourism experience which can be termed as rural tourism with essentially any activity which takes place in the country side. Rural tourism may not be designed to generate a supplemental income for the farmer, but may be a business venture of travel and tourism professionals. However, in this regard agro-tourism and ecotourism are closely related to each other. Cruz (2003) and The International Ecotourism Society (Rubuliak, 2006) define ecotourism simply as “responsible travel to natural areas that conserves the environment and improves the well-being of local people”. Ecotourism is generally provided by the tour companies, whereas in the agro-tourism farmers offer tours to their agriculture farm and providing entertainment, education and fun-filled experiences for the urban peoples (Maruti, 2009). The philosophy of agro-tourism is inspired to improve the farmers’ earnings and the quality of rural society lives which then expectedly represents opportunity to educate the societies on agriculture and ecosystems (Utama, 2007). Agro-tourism means that tourist activity whose aims is not only to familiarize oneself with farming activity and recreation in an agricultural environment (Sznajder *et al*., 2009) but also to help farmers to get some benefit by help of capitalization their own resources from agriculture, which is the main profit source (Mazilu and Iancu, 2006). It aims basically at providing alternative solutions towards enhancing farmers’ activities (employment opportunities for rural community) by diversifying farm operation and offering some kind of services and agro-touristic goods to visitors and finally improving farmers’ income/salaries (Dritsaki, 2009; Kuehn *et al*., 2000; Maruti, 2009; and Prince Edward Island Department of Agriculture and Forestry, 2000). Agro-tourism operating venues may need many more products, resulting in new markets and new income by supplying their new farm business with popular products that they do not produce themselves (Maruti, 2009).

Agro-tourist activities would have the added benefit of promoting sustainable agricultural practices (Catalino and Lizardo, 2004). Within Taiwan, approximately 8.2 million people visited leisure farms and the total revenue of such farm was estimated to exceed 4.5 billion New Taiwanese dollars (approximately 133,809,000 US dollars) (Hsu, 2005). In USA, it has been estimated that 62 million Americans visited farms one or more times in 2000, which corresponds to almost 30% of the population. Income from the agro-tourism provides farmers with approximately 800 million US dollars per year. Even though the percentage of farm with income from at the national level is only about 2%, in some Midwest States, 7% of farms receive income from this activity (Carprio *et al*., 2006).

Pizam dan Pokela classified agro-tourism activities into farming and non-farming activities (Hsu, 2005), whereas Wood (2006) classified them into on-farm and off-farm activities. Sznajder *et al*. (2009) differentiated between traditional agro-tourism and modern agro-tourism. The former is only to offer the visitors of short term accommodation and on-farm resources, and the farmer gets a small additional income. The farmers within the latter seem have more initiative to offer many more agro-touristic goods and services and they hope to get supplemental farm income significantly. Kuehn *et al.* (2000) mentions that three main components of agro-tourism development: small business, agricultural events such as festival as a creative expression of the local community and farmers' market as a tourist's window in to local community, and regional agro-tourism planning. Agro-tourism is that agribusiness activity, when a native farmers or person of the area offers tours to their agriculture farm to allow a person to view them growing, harvesting, and processing locally grown foods, such as coconuts, pineapple, sugar cane, corn, or any agriculture produce the person would not encounter in their city or home country. Often the farmers would provide a home stay opportunity and education (Maruti, 2009).

A typology for defining agro-tourism is drawn within Figure 1.

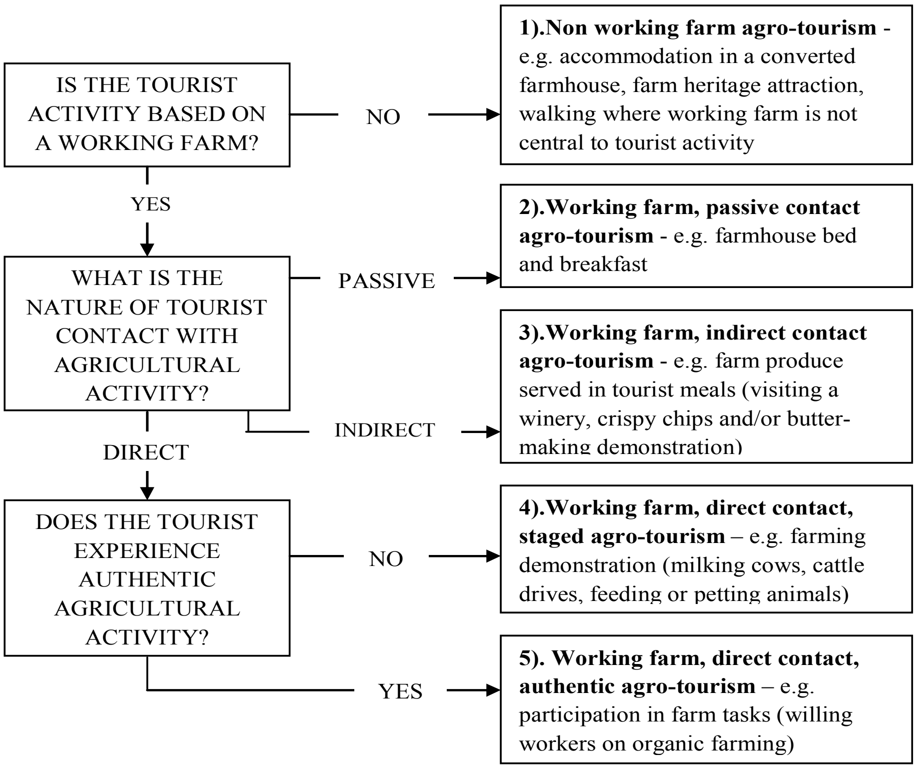

Fig. 1. A typology for defining agro-tourism (Phillip *et al.*, 2009)

By considering activities and products systematically according to these three discriminators, five discrete types of agro-tourism can be identified. Non working farm (NWF) agro-tourism could actually be identified as generic rural tourism, realized through agricultural heritage or imagery (e.g. accommodation in the converted farm house), farm heritage attraction (e.g. horse riding), and arguably include farmers markets and farmland access (e.g. walking where the working farm is not central tourist activity). In the working farm, passive contact (WFPC) agro-tourism, the working farm provides the context for tourism but the relationship between tourism and agriculture goes no deeper than that (farmhouse bed and breakfast; outdoor activities). Working farm, indirect contact (WFIC) agro-tourism begins to integrate agriculture on the farm with the tourism product (e.g. visiting a winery or butter-making demonstration). Working farm direct contact, staged (WFDCS) agro-tourism realized through reproduction and/or organization of agriculture for tourism (e.g. farming demonstration). Under working farm direct contact, authentic (WFDCA) agro-tourism tourists experience physical agricultural activities first-hand, for example, pick your own facilities or participation in farm tasks (Phillip *et al*., 2010).

The Development of Agro-tourism of *Salak Sibetan* Plantation

According to Sudibya (*in* Utama, 2007), a number of regencies in Bali have the potential to be developed into agro-tourism destinations, for instance: (a) Bangli Regency has the potential for orange and lemon agro-tourism which can be combined with the two nearest tourism sites such as Batur Mount and Batur Lake; (b) Buleleng Regency, particularly Pancasari Village has the potential to be developed as strawberry, vegetables, and flowers agro-tourism; (c) Tabanan Regency can be intensified to develop a park named Eka Karya Botanical Garden and Horticulture which can be combined with rice field view in Baturiti, Bedugul; and (d) Karangasem Regency, exactly in Sibetan Village has the potential to develop *salak* (light brown snake skin fruit) agro-tourism combined with panorama and surrounding natural environment.

The Farmer Group of Dukuh Lestari was historically established from re-transplanting group which reached for second winner in 1987. The first NGO, namely Asta Dewata, was strongly concerned to develop *salak* sibetan as an agro-tourism destination. Within the area of 123 ha of the *salak* plantation which is located at Dukuh sub-village and managed by 39 farmers under the Farmer Group of Dukuh Lestari was designed as community based Agro-tourism of *Salak Sibetan* Plantation by the Government of Karangasem Regency since 1995. In 1997, the farmer group received supporting facilities such as *salak* seedling and good agriculture practices from NGO of Kehati - Jakarta. In the next two years, the NGO of Wisnu - Bali facilitated the farmer group to access fund aid in the amount of IDR50 million from Kehati, that was used to establish six packages of *salak* plantation, construct tracking path, *salak* seedling, training for processing industry, and capacity building of local farmers.

Existing Condition, Fascination, and Supporting Facility

Agro-tourism of Salak Sibetan Plantation is located in Sibetan Village (Dukuh sub-village), Bebandem District, Karangasem Regency, within coordinate point of $115^o30'58''$-$115^o31'45''$(EL) and $08^o26'47''$-$08^o27'46''$(SP). The village area and population are around 1,038.81 ha and 8,642 persons, respectively. It has a tropical climate, with temperature of 30^oC and a rainy season from October to March and dry season from April to September. Average annual rainfall range between 1,567 and 2,000 mm, depending on the elevation of 500 to 700 m above sea level. It is close to Candi Dasa beach tourism resort and Agung Mount whose highest peak 3,142 m above sea level. The distance from the location to administrative and economic centers are: (a) three km to Bebandem district, (b) 12 km to Amlapura (the capital of Karangasem regency), (c) 29 km to Padangbai seaport, (d) 80 km to Denpasar (the capital of Bali Province), and (e) 85 km to International Ngurah Rai Airport. The access to the destination can by minibus, bus, and motorbike. It has 815.8 ha of *salak* (Snake Fruit) (*Salacca zalacca*) plantation, managed by 1,116 farmers whose production around of 209 t y^{-1}.

Presently, the main interest of the agro-tourism is direct market tourism on six packages of *salak* plantation. Each package of *salak* plantation provides approximately three hectare of productive *salak* trees with permanent tracking path that offers picking fruit attraction from December to March., Each visitor must pay entrance charge of IDR10,000 to IDR15,000 depend on the number of group member and he/she can u-pick two fresh *salak* fruit only whose directly consumed inside of the farm. He can also u-pick more and paid it by IDR5,000 to IDR8,000 kg^{-1} depends on its available. The supporting attractions are education and experiences tourism (e.g. visiting wine processing and wine tasting by cost of IDR10,000 for domestic visitor and IDR15,000 for foreigner and package two for willing worker on wine processing by cost of IDR1,500,000 at CV Dukuh Lestari and visiting the crispy chips, taffy and/or candy-making demonstrations at Werdhi Guna Food industry; making *atte* and bamboos handicraft; visiting inheritance building of Jero Dukuh Sakti who first developed the *salak* plantation; looking into beautiful natural mountain panorama, and staying at a farmer's/villager's house) and recreation and event tourism (e.g. watching Bali traditional dances and playing traditional music instruments).

The supporting facilities for the agro-tourism destination are five standard homestays within villagers house, food and beverage services by Culinary-tourism Group of Agro Dukuh Lestari, hot mixed road, parking area (450 m^2), tracking path, a unit of bathroom and toilet at parking area and each other public area, fresh water by Drinking Water Regional Company of Tirta Dewata, electricity, and good signal for mobile phone.

Stakeholders Contribution

The stakeholders of the agro-tourism development consist of six groups namely government, tourism industries and NGOs, local communities, tourists or visitors, and universities. They play roles differently and shall work simultaneously in applying the principles of sustainable agro-tourism development. Brief descriptions of their roles are explained as below.

Government comprises local governments at provincial and regency levels. The roles of government as stakeholders are to provide policies and site plan and other planning documents, and functioned as regulator. Bali Provincial Government through Food Crop Agricultural Agency has contribution in developing organic farming system in Sibetan. The 11 ha *salak* plantation managed by Farmer Group Mekar Sari in Sibetan Village was organically certified by LeSOS (registered organic certification organization in Indonesia) in 2009 (Food Crop Agricultural Agency of Bali Province, 2013). In 2012, the plantation was expanded to be 50 ha by the government. National Program for Community Empowerment (PNPM) of Tourism Autonomy in Sibetan was developed and facilitated by the Technical Team of Culture and Tourism, Karangasem Regency in 2012. Groups target as benefit receiver are Farmer Group of Agro Dukuh Lestari, Co-operative of Banjar Adat Dukuh, and Culinary-tourism Group of Agro Dukuh Lestari with supporting fund of IDR70 million (approximately USD7,179.49). The budget is allocated to improve human capacity through food & beverage and local guide trainings and to provide supporting facilities in kind of mountain bike and brochures.

Tourism industries comprise home stay/hoteliers, restaurant owners, travel agents, and other related tourism entrepreneurs. Tourism industries play role in providing investments on main and supporting tourism facilities, small-scale infrastructures, and other tourists' demands (Utama, 2007). According to the Agro-tourism of *Salak Sibetan* Plantation, Werdhi Guna Food aims to produce as well as demonstrate the making of salacca crispy chips, taffy and candy. It was direct aid program by Australian Consulate – General Bali in collaboration with NGO of Kalimajari-Denpasar in 2006. It also acts as the Community Technology Centre (CTC) in Sibetan Village. The other industry is CV. Dukuh Lestari, as a registered industry to produce and demonstrate the making of salacca wine since 2006. Culinary-tourism Group of Agro Dukuh Lestari is to provide visitors many kinds of native food and beverage. Villages Ecotourism Network (JED) plays role to manage the agro-tourist market.

Local communities comprise *Desa Adat* (customary village legal body), farmers who own the land, and other societies residing in the area where tourism developed. Farmer Group of Agro Dukuh Lestari manages the *salak* plantation and Co-operative of *Banjar Adat* (customary sub-village legal body) Dukuh aims to serve the farmers' requirement related to *salak* farming and provide visitors many kinds of souvenirs including *salak* fruit that they would like to purchase.

Tourists or visitors comprise domestic and foreign tourists who intend to experience a high quality of tourism activities and attractions while universities comprise Agriculture Department, Tourism Department, and Tourism Higher Schools which provide qualified human resources, research results on agriculture and tourism by issuing scientific recommendations to form new and alternative tourism development models (Utama, 2007).

Marketing Management and Profit

Market target of the agro-tourism is foreigners and domestic (local) tourists. Based on guest book, many countries for tourist arrival to Agro-tourism of *Salak Sibetan* Plantation were recorded since 2002. These were Cambodia, Philippines, Thailand, South Korea, China, Japan, Malaysia, Timor Leste, Australia, Germany, Norway, France, Belgium, Netherland, Holland and USA. Additionally, local tourists come from Northern Sumatera, Jakarta, West Java, Central Java, Yogyakarta, East Java, East Kalimantan, Bali, Nusa Tenggara and Papua.

The number of visitors targeted to visit *Salak Sibetan* Plantation Agro-tourism are 300 persons of domestic tourist and 160 persons of foreigner annually (Culture and Tourism Agency, Karangasem Regency, 2012). In actuality, the number of visitor showed in Figure 2 was fluctuated during 2007 to 2012 (JED, 2012). The number of tourists who visited *Salak Sibetan* Plantation Agro-tourism was very few and very far from the annual targeted number. Many constraining factors faced by the agro-tourism development includes the limited capacity (competency) of villagers in agro-tourism, the limited budget to provide the many standard agro-tourism facilities, the less of promotion, and the limited agro-tourism landscaping. Utama (2007) mentions that the hardest barriers of agrotourism development in Bali is inadequate infrastructure, other barriers are limited public facilities, imperfect human resource skills, scarce investments, and insufficient government supports.

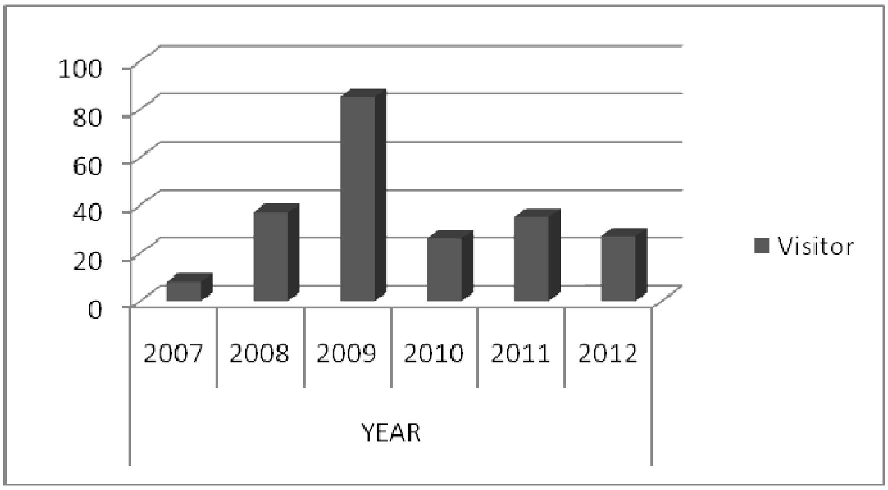

Fig. 2. The number of tourists visited to agro-tourism of *Salak Sibetan* plantation 2007-2012

As a modification to agro-tourism household (Brscic, 2006), Figure 3 presents the demand and supply of products and services of Agro-tourism of *Salak Sibetan* Plantation. Based on Figure 3, Village Ecotourism Network (JED) leads the agro-tourist market. Beside Sibetan Village (Karangasem Regency), the JED also organizes three other villages i.e. Kiadan-Plaga (Badung Regency), Tenganan-Pegringsingan, (Karangasem Regency) and Ceningan at Klungkung Regency (JED, 2012). Most of the tourists who visited Agro-tourism of *Salak Sibetan* Plantation were served by JED. JED also made contract agreement with 14 tour operators and private tourist agencies in offering products and services that are potentially demanded by agro tourist market. Furthermore, JED under collaboration with Agro-tourism of *Salak Sibetan* Plantation manager and local guides sold *salak* plantation package and many other attractions. There are six packages of *salak* plantation that are offered by Farmer Group of Agro Dukuh Lestari. Entrance fee to visit a package of *salak* plantation is IDR15,000 (approximately USD1.54) per person. The more visitors, the cheaper entrance fee, and they can u-pick some fresh *salak* fruits. If the number of visitor group is 6-10 persons, the entrance fee must be paid by visitor is IDR12,500 (approximately USD1.28) per person; whereas a group of visitor whose member is more than 10 persons, the individual entrance fee is IDR10,000 (approximately USD1.03). If the visitors are interested in harvesting more *salak* fruit, the owner helps to harvest and leads the visitors to pay it at Co-operative of Banjar Adat Dukuh.

The local guide offers many other attractions such as salacca winery, crispy chips, taffy and/or candy-making demonstrations; visiting inheritance building of Jero Dukuh Sakti who first developed the salak plantation; cane and bamboo handicraft; enjoying to native (traditional) foods and beverages. The visitor who wants to stay for some days also offered to overnight on-farm bed within villager house.

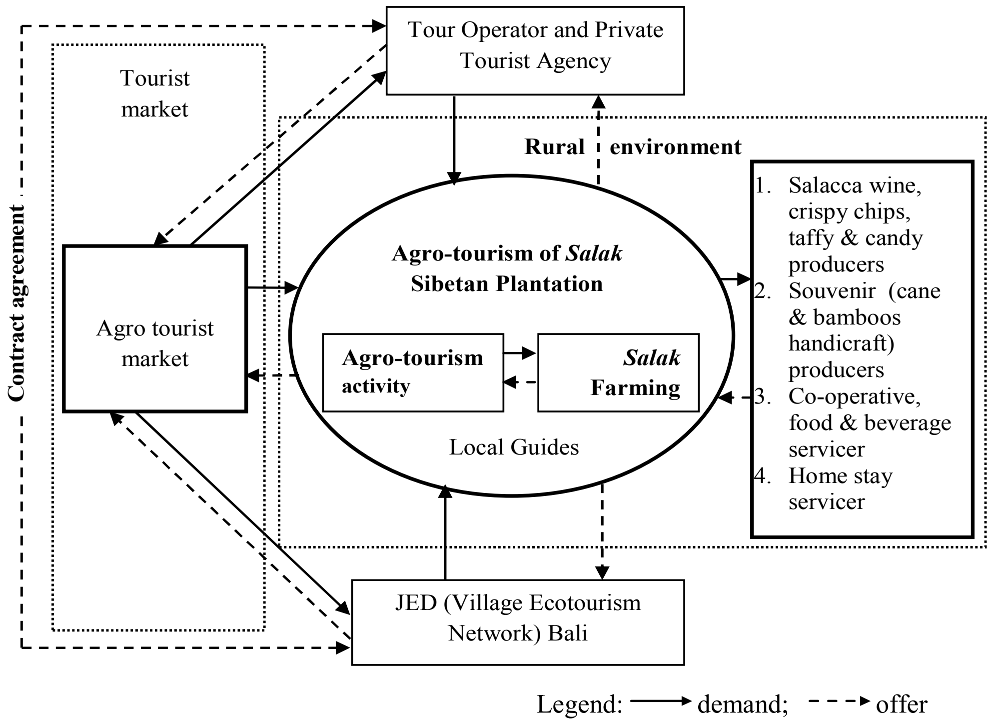

Fig. 3. Demand and offer of products and services of agro-tourism of *Salak Sibetan* plantation

Based on financial report in 2012, JED generated annual profit of IDR34,182,222 (approximately USD3,505.87) from total revenue of IDR227,833,085 (approximately USD23,367.50). The revenue was also allocated to cost all of tour packages in amount of IDR43,993,550 (approximately USD4,512.16); contribution fee to four villages (Kiadan-Plaga, Tenganan-Pegringsingan, Ceningan, and Sibetan) in amount of IDR79,690,000 (approximately USD8,173.33); and the remained cost is to pay the management fee, administration and non-operational costs. In this moment, Sibetan village has received contribution fee in amount of IDR9,600,000 (approximately USD984.62) only. The income was saved in Co-operative of Banjar Adat Dukuh as reserve funds to serve the nearest future guests, to cover additional customary ceremonies cost, to improve agro-tourism facilities.

CONCLUSIONS AND IMPLICATIONS

In concept, agro-tourism is a special form of rural tourism and it could be differentiated with ecotourism. In agro-tourism, the farmer as an innovator offers various kinds of services and agro-tourism products whereas in ecotourism they are provided by the tour companies. The agro-tourism market of *Salak Sibetan* plantation is actually managed by Village Ecotourism Network. The implementation of both concepts was synergized.

The development of community-based agro-tourism of *Salak Sibetan* plantation during 18 years seemed very slow, might be due to limited of villager capacity (community competency) in agro-tourism, limited budget to provide many more standard agro-tourism facilities, lack of promotion, the agro-tourism profit leaked to ecotourism companies, and limited agro-tourism landscaping. Nevertheless, it is potentially sustainable when sustainability criteria (economically viable, environmentally sound, socially just and culturally appropriate) are fulfilled.

To continually support the sustainable agro-tourism of *Salak Sibetan* plantation, the government should intensively and consistently facilitate the local community especially through capacity building programs related to agro-tourism development. Some corporate social responsibilities (CSRs) activities might become additional financial sources to accelerate and improve the community-based agro-tourism development, sustainably.

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A COMPARATIVE STUDY OF VEGETATIVE AND REPRODUCTIVE GROWTH OF LOCAL WEEDY AND CLEARFIELD® RICE VARIETIES IN MALAYSIA

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ABSTRACT

The movement from transplanting to direct seeding has brought weedy rice problems in Malaysia's rice granary areas. Weedy rice (*Oryza* spp.) is very difficult to control compared to other weeds due its close genetic relationship to the cultivated rice (*Oryza sativa* L.), therefore it cannot be controlled with conventional rice herbicides. Recently, a new technology for controlling weedy rice in rice fields which is known as Clearfield® Production System has been introduced by discovering the combination of herbicide imidazolinone and resistant trait containing variety. Two cultivars have been released by Malaysia known as MR 220CL1 and MR 220CL2 which were derived from crosses between CL1770 from Louisiana State University with a Malaysian local rice variety, MR 220. The objective of the study is to understand the growth patterns (vegetative and reproductive) of four different weedy rice morphotypes and two variants of Clearfield® rice in Malaysia. Weedy morphotypes were observed being significantly taller in all growth stages compared to Clearfield®. Tillering abilities of weedy morphotypes were not different from Clearfield® variants except for WR4 at 60 days after seeding (DAS). Flowering and maturity periods observed in weedy morphotypes were ranged widely where all weedy morphotypes flowered 10 to 20 days later than the Clearfield® rice varieties. Understanding all these morphological and physiological characteristics of weedy rice is useful to improve the weedy rice management and good agricultural practices for better control of escaped weedy rice in the Clearfield® planting areas.

Key words: *Oryza sativa* L., *Oryza* spp., Imidazolinone, MR 220CL1, MR 220CL2

INTRODUCTION

Rice is one of the major food source for more than half of the population in the world (Gealy et al., 2003) and it is the third most important crop in Malaysia (Karim et al., 2004) covering an area of about 402,800 ha. in Peninsular Malaysia while in Sabah and Sarawak is about 200,000 ha. (Ahmed et al., 2012). Currently, the national rice self sufficiency level (SSL) in Malaysia is only at about 70% (Sharif, 2013) which is not parallel with the increasing of country's population. The country requires about 1.85 million t/ha (tons per hectares) of rice a year in order to satisfy domestic requests but our country can only produce rice yield about 1.2 million tons (Hamid, 2008). Due to this, increasing rice production will keep on being a main focus in agriculture sector for Malaysia.

In rice cultures, many constraints are experienced by the farmers in obtaining high yields. Weeds have become the major yield - limiting constraint in rice production after the shift in methods of rice culture from transplanted rice to direct seeded rice (Olofsdotter et al., 2000). In Malaysia, weedy rice (*Oryza* spp.) had been appearing as a serious weed in recent years resulting in harvesting problem, loss of yield and quality by competing with the crop for water, light, nutrients, carbon dioxide and space (Hamid, 2008). Weedy rice seeds also can contaminate the harvested grain. Karim et al. (2004), reported about 10 – 35 % reduction in grain yield is caused by the competition of weeds with rice. In Peninsular Malaysia, loss of yield due to weedy rice infestation is estimated about RM 90 million per season in 2004 (Azmi, 2013).

Weedy rice generally includes species of genus *Oryza* which grows naturally and vigorously in and around rice fields (Suh et al., 1997). Therefore, it is very hard to control weedy rice in cultivated rice area since it is classified in the same genus and species as cultivated rice (Choudhary et al., 2011) and shares a lot of similarities in morphological, biochemical and physiological characteristics (Shivrain et al., 2007). However, there are several morphological and physiological differences between weedy rice and cultivated rice such as different in sizes, heights, leaf color, tillering capacity, panicle appearance, red pericarp, flowering, seed dormancy, longevity and shattering capacity (Kanwar et al., 2013; del Mar CatalaForner, 1995)

The introduction of herbicide-resistant rice offers farmers a good opportunity to manage weedy rice and other weeds and it is one of the latest technology used to control weedy rice problem in Malaysia (Azmi et al., 2012a). 'Liberty Link' rice was the first transgenic rice developed. However, due to concerns in the international market on genetically modified rice, it was not commercialized. Clearfield® rice, which was intentionally mutated to tolerate imidazolinone (IMI) herbicides without the insertion of any foreign gene was developed by Louisiana State University (LSU) Agricultural Center breeders and it was commercialized in 2002 (Shivrain et al., 2007). Imidazolinone herbicides control weeds by inhibiting the plant specific enzyme acetohydroxyacid synthase (AHAS). Enzyme AHAS involves in the biosynthesis pathway of the branched – chain amino acids; valine, leucine and isoleucine. This inhibition causes a disruption of protein synthesis, which constraints synthesis of DNA and growth of cell (Chin et al., 2007).

In Malaysia, development of local rice varieties tolerant to IMI started in 2003. Malaysian local rice variety MR 220 was backcrossed with donor Clearfield Rice Line IMI-TR No. 1770 introduced from LSU to get two inherited potential lines (B55 and B64A) that were tolerant to IMI. The new tolerant lines were released as MR 220CL1 and MR 220CL2 have been launched in 2010 at FELCRA Seberang Perak (Azmi et al., 2012b). Analysis of DNA between MR 220 with MR 220CL1 and MR 220CL2 showed 98.5% and 92.5% of genetic similarity respectively (Sudianto et al., 2013). The combination of certified IMI tolerant seeds (Clearfield®) with IMI herbicide (OnDuty®) and stewardship guidelines are known as Clearfield® Production System (CPS) (BASF, 2010). CPS can control the weedy rice with a single imizapic / imizapyr application at 214 g ha^{-1} applied at 0-7 days after sowing (Azmi et al., 2010). Clearfield® cultivars provide effective control of weedy rice and other noxious paddy weeds. The cultivars will help to reduce the cost of weed management in rice cultivation, yield a higher quality of rice. In addition, the use of the cultivars can reduce the amount of herbicides released into the environment and the ecosystem since imidazolinone herbicides are applied in much lesser volumes (Azmi, 2013). Satisfying outcome from fields planted with Clearfield® rice has been reported by BASF Malaysia which is double from 3.5 to 7 metric t/ha (Sudianto et al., 2013).

However, there are also concerns about the impact of releasing herbicide resistant rice in field for a long period of time. One of the concern is the possibility of transferring the resistant gene to compatible weedy *Oryza* species (Olofsdotter et al., 2000) which is likely to take place as the incidence of natural hybridization. This could produce herbicide resistant weedy rice and leads to the problem of controlling the weedy rice using herbicide. The risk of outcrossing between Clearfield®

and weedy rice in Asia is expected to be multiple times higher since rice monoculture is practiced broadly with 2-3 rice plantings per year compared to North America or other regions which apply diversified cropping systems (Sudianto et al., 2013). Therefore, it is very difficult and challenging to maintain the higher yields of Clearfield® rice without considering the evolution possibility of resistant weedy rice in the Clearfield® rice fields. Results from the recent study by Busconi et al. (2012) clearly show that Clearfield® herbicide resistant weedy rice plants were present in the field after 5 years of Clearfield® rice cultivation in Italy. Same findings on the occurrence of IMI – resistant weedy rice outcrosses were also reported on previous study by Shivrain et al. (2009) in Arkansas, U.S.A., Villa et al. (2006) in Brazil and Zhang et al. (2006) in Louisiana, U.S.A. The average of natural outcrossing rate in Brazil rice fields is 0.065% while the rate in the U.S.A. rice fields ranges from 0% to 1.26% (Sudianto et al., 2013).

The purpose of this study was to increase understanding on growth characteristics of different morphotypes of local weedy rice in comparison to Clearfield® rice varieties. It is very important to understand the vegetative and reproductive growth trend of weedy rice thus the escaped weedy rice can be controlled effectively as they are difficult to recognize in the Clearfield® rice field. Most importantly is to identify if there is any potential of hybridization between Clearfield® rice varieties with local weedy rice in the future.

MATERIALS AND METHODS

The growth development of four local weedy morphotypes and two varieties of Clearfield® rice were conducted in the glass house. Weedy rice morphotype samples were collected by random sampling from rice field area of Tanjung Karang and Kuala Rompin, Malaysia with no known history of planting Clearfield® rice and were classified by plant morphological characteristics (Table 1) according to the Standard Evaluation System for Rice (IRRI, 2002).

Seeds of Clearfield® rice varieties, MR 220CL1 and MR 220CL2 were obtained from the Malaysian Agricultural Research and Development Institute (MARDI) Seberang Perai. Each weedy morphotype was termed as WR for easy reference in the future while Clearfield® varieties were termed as CL.

Table 1: Description of weedy rice morphotypes found in Selangor and Pahang rice granaries and Clearfield® rice varieties. Numbers in parenthesis is corresponding to IRRI (2002) morphological rice descriptors.

Morphotype / Variety	Grain shape (length-width ratio)	Plant height	Panicle type	Awn	Lemma and palea colour
CL1	Slender (1)	Semidwarf	Intermediate	Awnless (0)	Straw (0)
CL2	Slender (1)	Semidwarf	Intermediate	Awnless (0)	Straw (0)
WR01	Slender (1)	Tall (9)	Compact (1)	Straw (1)	Straw (0)
WR02	Slender (1)	Tall (9)	Compact (1)	Awnless (0)	Straw (0)
WR03	Slender (1)	Tall (9)	Open (9)	Awnless (0)	Brown tawny (4)
WR04	Medium (3)	Tall (9)	Compact (1)	Awnless (0)	Brown tawny (4)

In the laboratory, the seeds of CL variants and WR morphotypes were soaked in water for 24 hours in order to produce pre-germinated seeds. The seeds then were sown in seedling trays with a one to one ratio of rice husk and top soil as a media and allowed to grow for 14 days. Germination rate was calculated for each morphotypes of weedy rice and Clearfield® varieties. Plastic pots (0.30 m deep, 0.27 m diameter, without bottom holes) were prepared by pouring 8.0 kg well – puddle clay soil of Lating series per pot. The soil was obtained from Kuala Rompin rice field. Three seedlings from rice's WR morphotype and CL rice variants were transplanted in the prepared pots and were arranged in randomized complete block design (RCBD) with three replications. Each replication has six treatments consisting of 2 CL rice variants and 4 morphotypes of WR and each treatment has three subsamples. NPK green (15:15:15) fertilizer was applied at 14 days after seeding (DAS), 35 DAS and 65 DAS at a rate of 200 kg ha^{-1} to supply elements required for plant growth and productiveness. Each individual plant of WR and CL rice were kept flooded at about 3 cm of water depth daily. Crop management was done according to the standard cultivation guidelines.

Growth and development of WR and CL rice plants were observed and examined closely from the stage of seedling to maturity. Two vegetative descriptors (plant height and numbers of tiller) were evaluated and recorded at 20, 30, 40, 50, 60 and 70 days after seeding (DAS). Plant height was measured based on the length from the soil surface to the top of the upper most leaf. In addition, five reproductive descriptors (booting stage, beginning of anthesis, 50% anthesis, maturity stage and anthesis duration) for *Oryza sativa* were also evaluated and recorded following the Standard Evaluation System for Rice (IRRI, 2002). The seeds then were harvested at maturity. Twenty seeds were randomly selected from each treatment of each replication and were digitally photographed. The grain length and width were measured in millimeters using the program QuickPHOTO MICRO 2.3 and the data were recorded. Grain shape was also determined from dividing the average length of the grain by the average width.

Data were subjected to Analysis of variance (ANOVA) and mean comparison between each morphotypic group was conducted by Least Significant Difference (LSD) test using computer program SAS version 9.2 (SAS, 2001). The significance differences were considered when $p \leq 0.05$.

RESULTS AND DISCUSSION

Vegetative Phase

The results obtained in this study showed a great diversification of growth and development between weedy morphotypes and Clearfield® varieties in both vegetative and reproductive phase. Regarding plant height, all WR morphotypes were significantly taller ($P \leq 0.05$) than CL varieties for the entire vegetative phase (Fig. 1). All WR morphotypes were 17-26%, 16-20%, 16-23%, 13-23%, 21-26% and 35-40% taller than the CL varieties at 20, 30, 40, 50, 60 and 70 DAS respectively. WR morphotypes showed a higher plant heights ranging from 134.2 ± 2.5 cm to 138.7 ± 8.3 cm at 70 DAS while plant heights for CL varieties were 98.2 ± 2.1 cm and 103.6 ± 1.3 cm at 70 DAS.

Similar results were reported by Noldin et al. (1999), ElenaR et al. (2007), Choudhary et al. (2011) and Ahmed et al. (2012) where all WR morphotypes were significantly taller than commercial rice varieties. At 70 DAS, CL2 variant was significantly the shortest plant whereas WR1 was significantly the tallest plant (35.21% taller than CL2). All WR morphotypes WR1, WR2, WR3 and WR4 showed no significant differences in height among them as well as CL varieties, CL1 and CL2 also showed no significant differences in height among the varieties at 70 DAS.

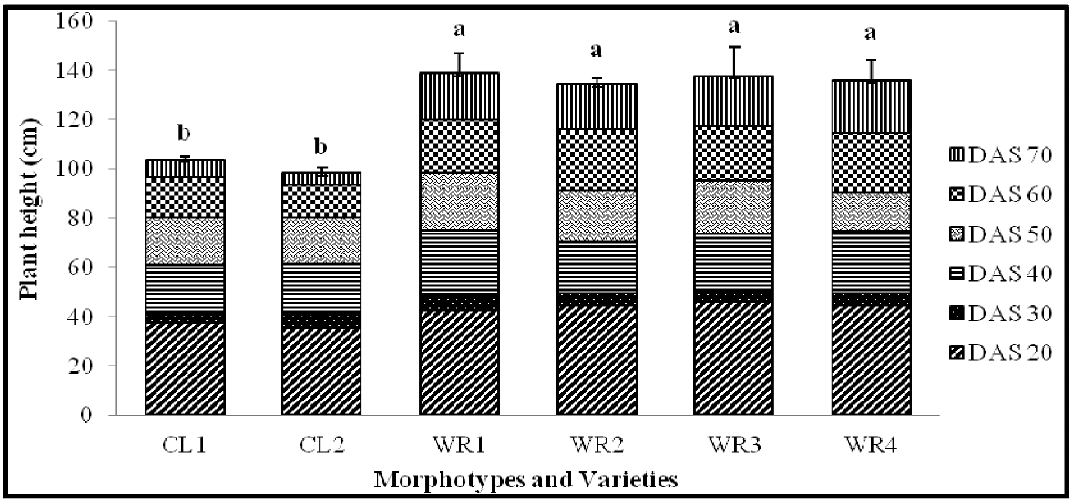

Fig. 1. Cumulative plant height of weedy rice morphotypes and Clearfield® rice varieties at 20, 30, 40, 50, 60 and 70 days after seeding (DAS). Bars showed standard deviation at 70 DAS. Means with the same letter represent values that do not differ significantly at the 5% level of probability using LSD test.

Tall characteristic of WR makes them compete more efficiently for light, nutrients and space in the rice fields compared to commercial rice varieties (Kwon et al., 1992). In this case, taller WR plants are capable of getting more sunlight and shade their adjacent rice plants and therefore it is known to reduce total rice yield more than the shorter weed plants (Chauhan and Johnson, 2010; IRRI et al., 2010). However, taller WR plants can be effectively identified and controlled during the post emergence period due to height differences between WR and commercial cultivated rice varieties (Fogliatto et al., 2011; Ahmed et al., 2012). Therefore, it is suggested to control the WR early before it becomes taller than cultivated rice in order to prevent high losses in grain yields. According to Ahmed et al. (2012), WR that has grown taller than cultivated rice can be controlled by applying methods such as manual roguing or treated with foliar systemic herbicides. Additionally, the height differences between WR and commercial cultivated rice varieties are probably because of heterosis pressure which exists in some of the WR morphotypes (Zainuddin et al., 2010).

There was a higher variation of plant height in WR compared to CL rice. The standard deviation values of plant height indicated that a high variation existed within WR morphotypes (2.5 to 11.9 at 70 DAS) those values for CL varieties were more consistent (1.3 and 2.1 at 70 DAS). This heterogeneous characteristic of weedy rice makes them difficult to be fully identified in the rice fields as some of these WR morphotypes might possess the same plant height of cultivated varieties.

Tillering is a very important agronomic trait that contributed in improving of yields significantly**.** The number of tillers produced is depend on both genetic and environmental factors. Chauhan and Johnson (2010) reported that cultivated rice with high tillering capacity could compete with WR effectively even though they are semidwarf in stature. In this study, the result showed there was no significant difference in number of tillers between both CL and WR varieties (WR1,WR2 and WR3 except for WR4) at 60 DAS ($p \leq 0.05$) (Fig. 2). Number of tillers for WR morphotypes and CL varieties used in this study reached their maximum at 60 DAS and then started to decrease at 70 DAS. Decreases in number of tillers were probably due to death of nonbearing tillers because of intraspecific competition among themselves in getting nutrients and sunlight (Kwon et al., 1992).

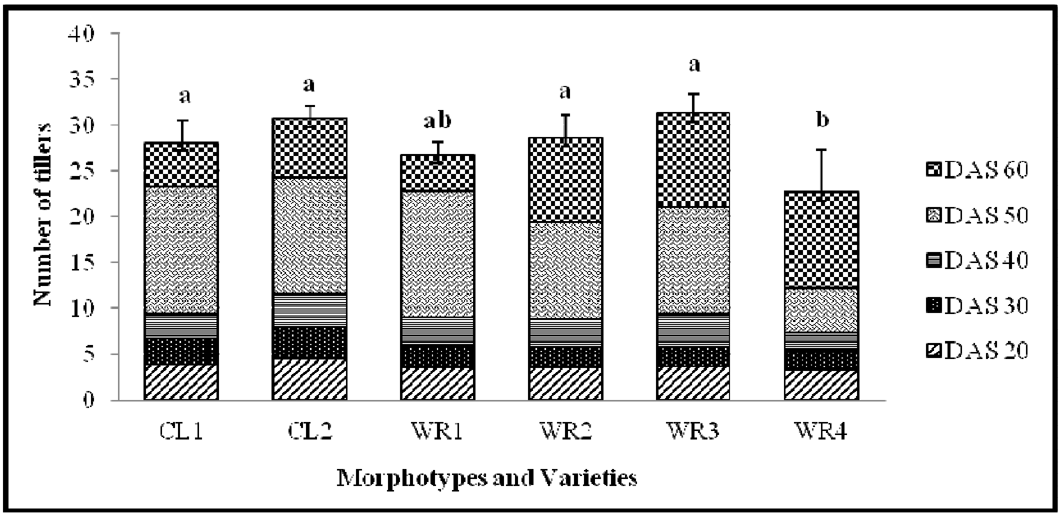

Fig. 2. Cumulative number of tillers produced by weedy rice morphotypes and Clearfield® rice varieties at 20, 30, 40, 50 and 60 days after seeding (DAS). Bars showed standard deviation at 60 DAS. Means with the same letter represent values that do not differ significantly at the 5% level of probability using LSD test.

There was no significant difference in number of tillers between CL1 and CL2 varieties were observed at all growth stages ($p \leq 0.05$). Among WR morphotypes, no significant difference in number of tillers were observed at initial vegetative stage (20 to 40 DAS). However, at later stage of 50 DAS and 60 DAS, there was a significant difference in number of tillers were observed among WR morphotypes. WR4 significantly produced minimum number of tiller (22.67 ± 4.6) whereas WR3 significantly produced highest number of tiller (31.33 ± 2.0). This proves that weedy morphotypes tend to have a vigorous growth only at initial growth stage but fails to produce more productive tillers at later growth stage.

Reproductive Phase

The reproductive phases of WR morphotypes and CL varieties were separated into booting, anthesis and maturity stage. WR morphotypes showed a wide range of flowering period where all flowered about 10 to 20 days later than CL rice varieties. This could reduce the opportunity for gene flow to occur to become low since the flowering periods are not synchronized. WR morphotypes reaching booting stage between 86.0 ± 2.4 and 95.4 ± 5.3 DAS whereas CL rice varieties reached this stage at 76.2 ± 2.7 and 78.7 ± 2.8 DAS (Table 2). Anthesis started within 3-4 days in CL rice varieties whereas that was started from 5 up to 7 days in WR morphotypes. CL varieties reached maturity at 101.4 ± 3.1 and 106.3 ± 3.2 DAS in contrast with WR morphotypes that reached this stage later, which are between 116.3 ± 2.9 and 126.0 ± 5.4 DAS. Early maturity of CL rice varieties will act as identification method during harvesting period.

All WR morphotypes required more time to complete their anthesis period (23.2 to 26.4 days) compared to CL rice varieties (21.4 and 22.9 days). High standard deviation values recorded in WR morphotypes at each reproductive growth stage presented more heterogeneous flowering and maturation than among CL rice varieties.

The uneven flowering and maturation observed in all weedy morphotypes act as a competitive strategy to overcome unfavorable weather circumstances. Similar findings were also observed by Ahmed et al., (2012). This characteristic ensures the progeny to have a better performance in the rice fields and can continuously produce seeds from different morphotypes (ElenaR et al., 2007).

Table 2. Days after seeding (DAS) for different growth stages in Clearfield® rice varieties and local weedy rice morphotypes (Means ± standard deviations are shown)

Morphotypes/ Varieties	Booting stage	Beginning of anthesis	50% anthesis	Maturity stage	Anthesis duration
CL1	78.7 ± 2.8	83.4 ± 2.5	89.5 ± 2.0	106.3 ± 3.2	22.9
CL2	76.2 ± 2.7	80.0 ± 2.3	84.6 ± 1.2	101.4 ± 3.1	21.4
WR01	86.0 ± 2.4	93.1 ± 2.3	98.2 ± 2.3	116.3 ± 2.9	23.2
WR02	90.3 ± 4.7	95.7 ± 3.4	103.3 ± 4.2	121.5 ± 4.2	25.8
WR03	95.4 ± 5.3	100.9 ± 5.1	106.8 ± 2.3	126.0 ± 5.4	25.1
WR04	91.6 ± 3.1	97.1 ± 3.4	104.1 ± 3.4	123.5 ± 3.1	26.4

Grain length, width and shape

The results obtained in this study showed significant difference of grain length between CL varieties and WR morphotypes at $p \leq 0.05$ (Fig. 3). No significant differences of grain length among CL varieties were observed but there was a significant difference among WR morphotypes ($p \leq 0.05$). CL1 was significantly the longest grain (10.34 ± 0.1 mm) and WR4 was significantly the shortest one (7.75 ± 0.2 mm).

In the case of grain width, there was no significant difference observed between CL varieties with WR1 and WR2 but there was a significant difference of the parameter between CL varieties with WR3 and WR4 ($p \leq 0.05$) (Fig. 4). WR1 was significantly the narrowest grain (2.36 ± 0.03 mm) and WR4 was significantly the widest one (2.78 ± 0.06 mm). For grain shape (length/width ratio) (Fig. 5), both CL1 and CL2 have a ratio of 4.35 and 4.25 respectively while WR morphotypes have a ratio from 2.79 to 3.36.

The length and width of a rice grain are important morphology that determines the class of the rice. The ratio of the length and the width is used internationally to define the shape of the variety. According to IRRI (2002), there are four classes of the rice based on grain length: short (5.5 mm or less), medium (5.51 to 6.6 mm), long (6.6 to 7.5 mm) and extra long (more than 7.5 mm). In this study, all CL varieties and WR morphotypes were classified as extra long grain.

For grain shape, there are four shapes of the rice based on IRRI (2002): slender (over 3.0 mm), medium (2.1 to 3.0 mm), bold (1.1 to 2.0 mm) and round (less than 1.1 mm). In this study, all CL varieties and WR morphotypes except for WR4 were observed as having a slender in shape while WR4 was observed as having a medium in shape.

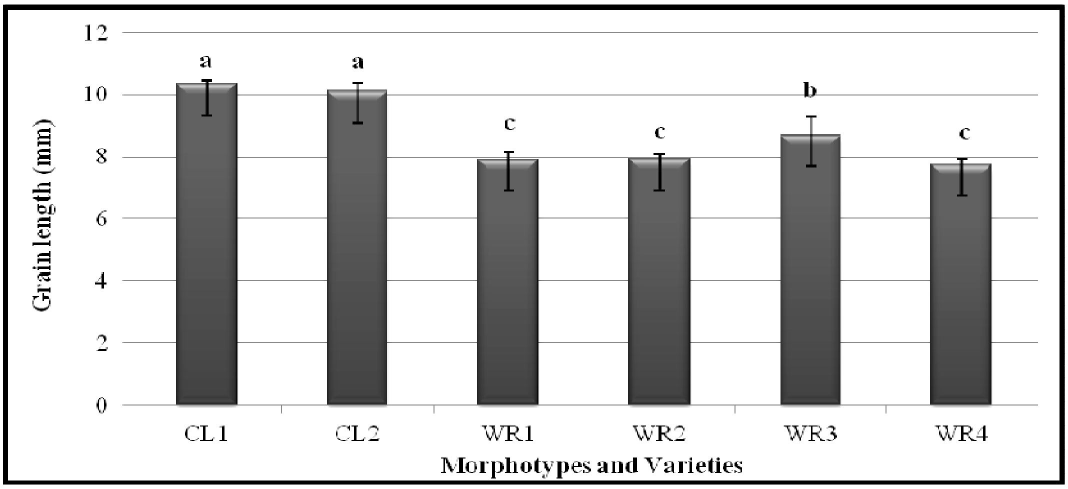

Fig. 3. Means of grain length of weedy rice morphotypes and Clearfield® rice varieties. Means with the same letter represent values that do not differ significantly at the 5% level of probability using LSD test

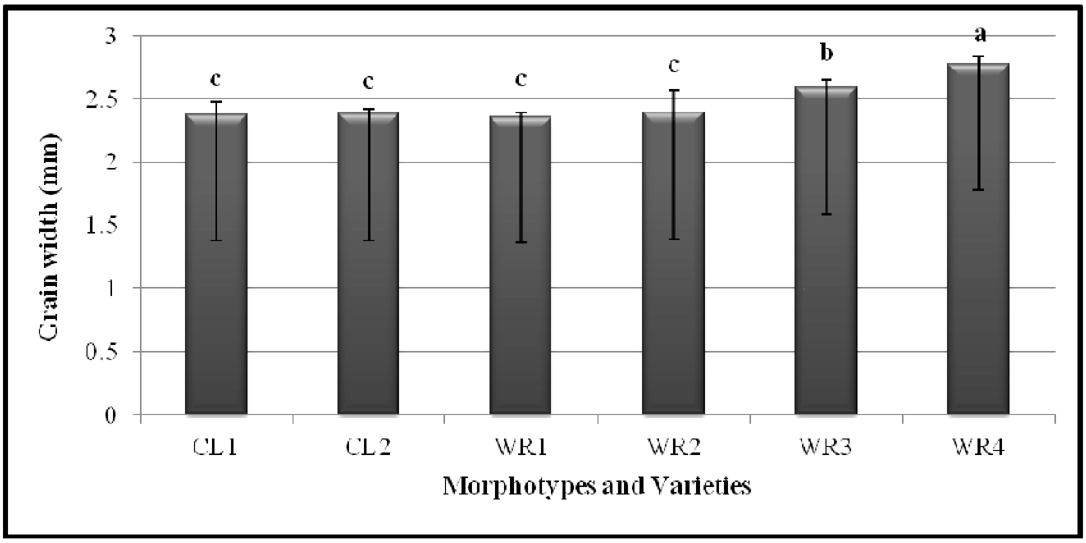

Fig. 4. Means of grain width of weedy rice morphotypes and Clearfield® rice varieties. Means with the same letter represent values that do not differ significantly at the 5% level of probability using LSD test

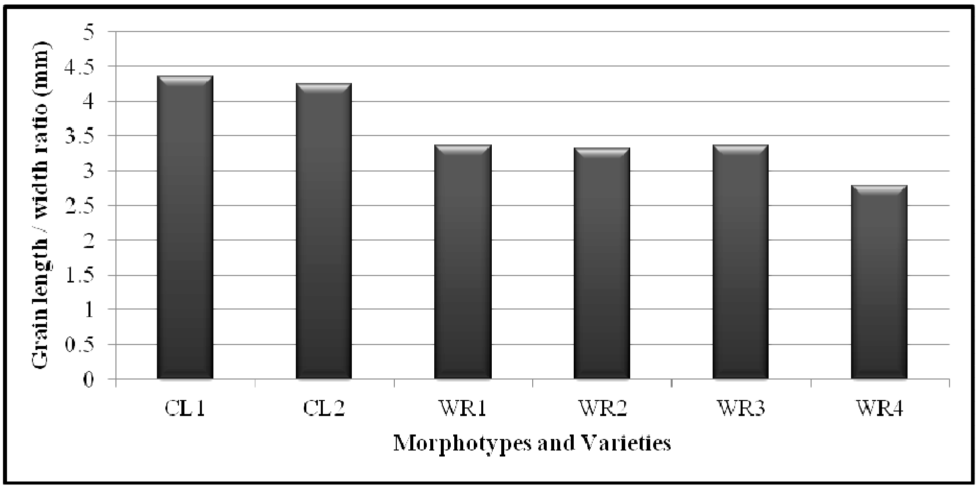

Fig. 5. Grain length / width ratio of weedy rice morphotypes and Clearfield® rice varieties.

CONCLUSION

From this study, all weedy morphotypes were observed being significantly taller than Clearfield® varieties in all growth stages. However, no significant differences in number of tillers were observed between Clearfield® variety and all weedy morphotypes except for WR4 at 60 DAS. All weedy morphotypes flowered 10 to 20 days later than the Clearfield® varieties. The results obtained from this study provide useful information to develop suitable weed management practices to control escaped weedy rice in the Clearfield® rice fields. Besides that, the information obtained on flowering periods will be useful in designing the gene flow studies among them in the future since the possibilities of outcrossing between Clearfield® rice and weedy rice in Asia are expected to be multiple times higher than other regions. More studies on vegetative and reproductive growth development urgently need to be carried out on other morphotypes of weedy rice to clearly understand and make a good comparison among all the weedy morphotypes existing in rice fields.

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CHICKEN MANURE COMPOSTS AS NITROGEN SOURCES AND THEIR EFFECT ON THE GROWTH AND QUALITY OF KOMATSUNA (*Brassica rapa* L.)

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ABSTRACT

Environmental issues on the excessive use of chemical fertilizer and energy shortage in recent years have led to the renewed interest in using organic materials. The return of animal manure into crop fields is considered to be one of the most effective methods in reducing the use of industrially produced chemical fertilizer as well as utilizing the mineral nutrients in crop production waste. The use of animal manure as fertilizer, due to the availability of the nutrients contained in organic materials, has been of concern to agronomists and promoted in recent years in an attempt to increase the amount of soil organic matter and eventually to improve land productivity. The study was conducted in two consecutive experiments to observe the effect of five chicken-manure composts with different nitrogen content and to investigate their residual effect on crop yield and its quality. Chicken-manure composts (Ch-1 to Ch-5) were applied to 2 kg soil of Andisol in pot experiments and Komatsuna (*Brassica rapa* L.) vegetable was used as a sink of mineralized-N from chicken-manure composts. Unmanured pot was used as control, whereas pot fertilized with urea was used as standard of comparison for chemical fertilizer. Potassium chloride (KCl) and triple super phosphate (TSP) were added in the urea treatment to assure good initial growth. In the second experiment, KCl and TSP were added again at the same rate to the urea pot (U-1). However, compost was not applied in the second batch of chicken-manure compost treatments. The addition of chicken-manure composts resulted in significant differences in yield compared with control, but Ch-3 and Ch-5 did not have significant differences with urea. The residual effect of the chicken manures still resulted in increased Komatsuna yield for Ch-3 and Ch-5, and it enhanced yield significantly compared to residual urea (U-1); whereas the other treatments exhibited lower yield than those in the first batch of experiment. The increase in Komatsuna yield of Ch-3 and Ch-5 treatment in the second batch of the experiment might be caused by the higher N mineralization rate wherein residual inorganic N remained in the soil after the first batch of the experiment. Nitrate accumulation in plant was induced by increased N mineralization in soils. The application of Ch-3 and Ch-5 and urea increased greatly nitrate accumulation in Komatsuna plant, while Ch-1, which had slower N mineralization, induced smaller nitrate accumulation. The content of glucose and reducing sugar tended to be lower with the increase of the nitrate content in Komatsuna.

Key words: mineralization, chicken-manure compost

INTRODUCTION

Environmental issues on the excessive use of chemical fertilizer and energy shortage in recent years have led to the renewed interest in using organic materials, such as animal manure (Huang and Uri, 1994; Chambers, Smith and Pains, 2000). The returning of animal manure into crop fields is considered to be one of the most effective methods in reducing the use of industrially produced chemical fertilizer as well as utilizing the minerals nutrients in the wastes for crop production.

Animal manure usually contains a large amount of nitrogenous compounds, which are easily mineralized to ammonia or nitrate (University of Minnesota Extension, 2002). In other words, animal manures have been used as a means to improve the chemical, microbiological, and physical aspects of soil fertility and to increase crop production (Khaliq *et al*., 2006; Palm *et al*., 2001; Soumare *et al*., 2003;), which the returning of animal manure into soil were not the only means of adding nitrogen, but the most important means to add other nutrients (Andrew and Foster, 2007; Commoner, 2009; Mahmoud *et al*., 2009; Parr and Colacicco, 1987). Furthermore, animal manure have an ecological advantage in the development of sustainable agriculture (Khaliq *et al*., 2006). However, mismanagement of manure can have a substantial impact on our water, soil, and air resources. When used appropriately, manure has nutritive and economic value (Colaccio, 1982; Khaliq *et al*., 2006; Schmitt and Rehm, 1992).

Based on the above explanation, it is expected that animal manures can offset the use of chemical fertilizer which consume high cost oil energy. However, the value of animal manures is determined by the content of available nutrients for crop growth and of contributing to "extra" effects on crop production. In most circumstances, the uptake of nitrogen by a growing plant and the accumulation of mineral nitrogen in soil are both preceded by, and dependent on nitrogen mineralization. Mineral N is uptaken by plants in the forms of NO_3^--N and NH_4^+-N (Marschner, 2003). The differences in plant yield responses to the various forms of N fertilizer are due mainly to the differences in the N losses from the soil (Seidel *et al.,* 2007) rather than differences in the type of N form uptaken (Abassi *et al.,* 2005). Greenhouse-incubated soil provides a means by which estimates of greenhouse rates of mineralization. Despite its simplicity, artefacts may be introduced by the method which alters the rate of mineralization, or other nitrogen transformation. Furthermore, these artefacts (such as the change of soil water potential) can affect the magnitude of opposing process such as immobilization and denitrification, or in fact the rate of mineralization itself (Cassman and Munns, 1980).

This study was conducted in two consecutive experiments under greenhouse conditions and the various chicken-manure composts were used to observe the effect of chicken-manure composts as N source and their residual N effects on yield and quality of the crop compared with chemical fertilizer (urea).

MATERIALS AND METHODS

Five types of chicken manure compost with varying nitrogen content (Table 1) and soil of Andisol were used in these experiments. The chemical fertilizer as basal fertilization were KCl and triple superphosphate (TSP).

Table 1. The chemical properties of various composted chicken manure

Compost	Total N (%)	Org. C (%)	C/N	pH (H_2O)	NH_4-N (mg/100g)	NO_3-N (mg/100g)
Ch-1	2.31	26.5	11.5	9.1	38.4	0
Ch-2	3.43	29.3	8.54	7.0	365	0
Ch-3	6.53	31.3	4.79	7.7	441	0
Ch-4	3.90	29.2	7.48	8.0	421	0
Ch-5	6.16	33.9	5.50	6.8	261	0

Nitrogen mineralization and crop yield

The first batch of the experiment was carried out to observe the effect of chicken-manure composts with different N content on the N mineralization, yield and quality of crop. The chicken-manure compost was equivalent to 1 g of N per pot added to each pot of 2.5 kg moist soil of Andisol ($\simeq$ 2 kg oven-dry weight). Pots without manure were used as control (Ch-0), whereas pot fertilized with urea was the standard of comparison for inorganic fertilizer. The amount of nitrogen as urea, K_2O as potassium chloride, and P_2O_5 as triple super phosphate added to soil are 0.5 g pot^{-1}, respectively. The treatment was conducted in four replications and one pot was not sown with Komatsuna seeds to observe nitrogen mineralization under greenhouse conditions.

The chicken manure composts were thoroughly mixed with moist soil in each pot at the beginning of the experiment, and then incubated for a week before sowing. To substitute the loss of soil moisture during incubation, water was added to each pot until the initial soil weight was reached. On sowing, 20 seeds of Komatsuna (*Brassica rapa* L.) were sown per pot at a depth 0.5 cm to act as a sink for mineralized N. On the following week, Komatsuna plants were thinned out and five plants were retained in each pot. Soil inorganic N in the pot which was not sown with Komatsuna seeds was determined at 1, 7, 14, 21, 28, 35, 42, 49, 56 days after compost incorporation. Mineral N was extracted from moist soil with 1 *N* KCl and determined by Flow Injection Analysis (FIA).

At harvest, the shoots of Komatsuna cut and weighed, and then two plants for each pot cleaned of adhering soil by flotation in distilled water, weighed and dried at 60^{o} C and milled into powder for chemical analysis. The shoots of three Komatsuna plants were cut and separated between leaf and stem. For each of them were cut into small pieces manually and weighed with the same proportion, and then analyzed immediately for nitrate contents, glucose and reducing sugar. The contents of reducing sugars were determined by micro-copper titrimetric method.

At the end of pot experiment, the roots of plants were taken with care, washed with distilled water, and then weighed the fresh-weight and the dry-weight of 60^{o} C. At the beginning of pot experiment and after harvesting, the soils were taken and a part of these soils immediately analyzed in moist condition for inorganic N content (NH_4^+-N and NO_3^--N), while another part of the soil sample was dried at 35^{o} C for chemical analysis.

Residual effect of chicken manure composts

After harvest of the first batch (56 days after sowing), the soil in each pot was mixed thoroughly and roots were removed. Komatsuna seeds were sown as in the first batch of pot experiment. Compost was not applied in the chicken-manure compost treatments of the second batch of pot experiment. In another urea treatment (Treatment U-2), urea was added using the same amount of N applied in the earlier experiment, but in the urea pot of U-1 was only added again by KCl and TSP as same rate as the above mentioned. Basal fertilizer of KCl and triple super phosphate were likewise added using the same amount as in the earlier experiment in treatment U-2 to assure the initial growth of plant.

Experimental Design and Statistical Analysis

A completely randomized design with four replications, was used in all experiments. One pot was not sown with Komatsuna seeds to observe nitrogen mineralization under greenhouse conditions. The effect of chicken-manure composts on yield, dry matter of Komatsuna, N uptake, and the content of nitrate, glucose, and reducing sugar were processed by analysis of variance. The significance of the treatment differences for those parameters mentioned above was assessed by Tukey test (5%).

RESULTS AND DISCUSSION

Nitrogen Mineralization from Chicken-manure Composts

Various chicken-manure composts applied to soil provided varying levels of N mineralization during incubation under greenhouse conditions (Fig. 1). During the first week of mineralization, NH_4^+-N concentration in the soil applied with N-rich manure composts, increased rapidly than the others. The increase in NH_4-N concentration was due to the mineralization of soluble organic compounds. A decrease of inorganic N in soil during incubation resulted by the decrease of NH_4^+-N that was not accompanied by a parallel increase of NO_3^-N (data was not shown).

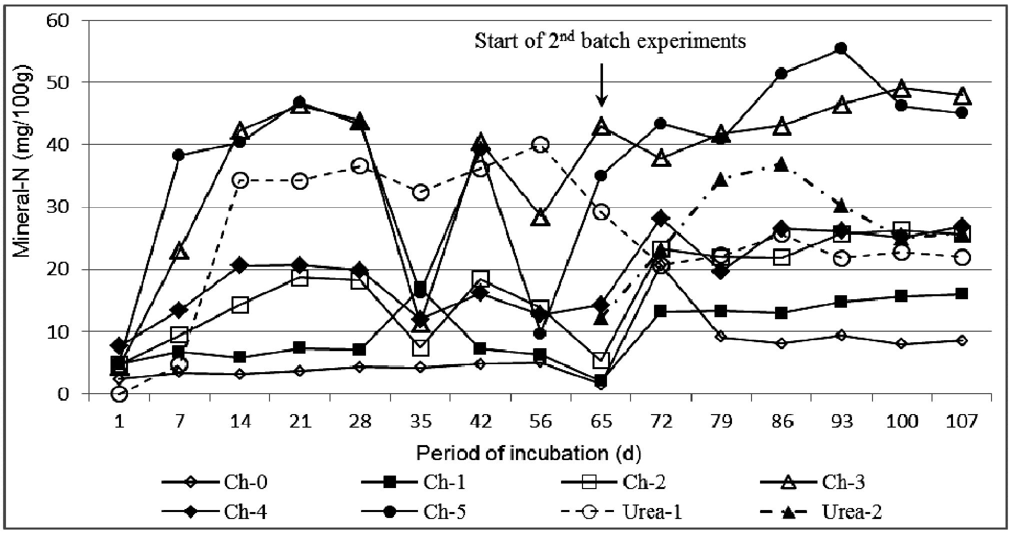

Fig. 1. Nitrogen mineralization of various chicken-manure composts during incubation under greenhouse conditions

The mineralization rate of chicken-manure compost during incubation period depended on the N content of the organic compound of composts. Comparison of results among the treatments of chicken-manure compots showed considerable and consistent differences in decomposition rates. Either in the first batch or in the second batch of the experiment, the most rapid decomposition of chicken-manure compost was recorded for Ch-3, Ch-4, and Ch-5, but the treatment of Ch-1 had the slowest N mineralization rate. The slowest N mineralization rate of Ch-1 was probably due to the smaller amount of mineralizable N in Ch-1 which resulted in smaller amount of available N. The critical N content required for immediate net mineralization of N to occur was calculated at 1.73% and the critical C/N ratio was 20 (Frankenberger and Abdelmagid, 1985; Iritani and Arnold, 1960). The N contents of the chicken-manure composts studied here were all above this critical N concentration and all had C/N ratios below 20. It was thus expected that the N mineralization of the composts studied would correlate well with their initial N content or C/N ratio. Our results, however, only partly followed such a trend, for example the proportion of the N released from Ch-1 much less than that released from Ch-2 and Ch-4 although the composts had similar C/N ratios. It was probably due to the inclusion of compost with a large unmineralizable or recalcitrant compounds. Total N content of Ch-3 and Ch-5 were almost three times higher than that of Ch-1. Apparently, the higher N content of Ch-3 and Ch-5 resulted more immediate N mineralization as compared to the other treatments. The higher mineralization rate of Ch-3 and Ch-5 is presumably due to the higher content of decomposable organic matter. These organic matter are more effectively attacked by soil microorganisms for their energy or nutrient supply. The N amount of Ch-1 mineralized after 21 days was very low, 5.6% of added N to soil and then became decreased in the second batch of the experiment. This manure compost therefore have a very low N fertilizer effect in soil in the short-term. However, treatment of Ch-3 and Ch-5 showed a high N mineralized and a longer presence in soil during two consecutive experiments. Therefore it considered they have a high N fertilizer effect and displayed a comparable effect with urea (U-2 treatment). Ammonium in soils were generally low. This lack of major NH_4^+-N accumulation indicated that the condition for nitrification was always favourable, even in manured pots.

Yield and Dry-matter of Komatsuna

The applied chicken-manure composts with various nitrogen (N) contents ranged from 2.3% - 6.5% (Table 1). Since the amount of applied N did not differ among the treatments, the results were comparable. Incorporation of chicken-manure composts into the soil resulted in the increase of Komatsuna yield (Fig. 2).

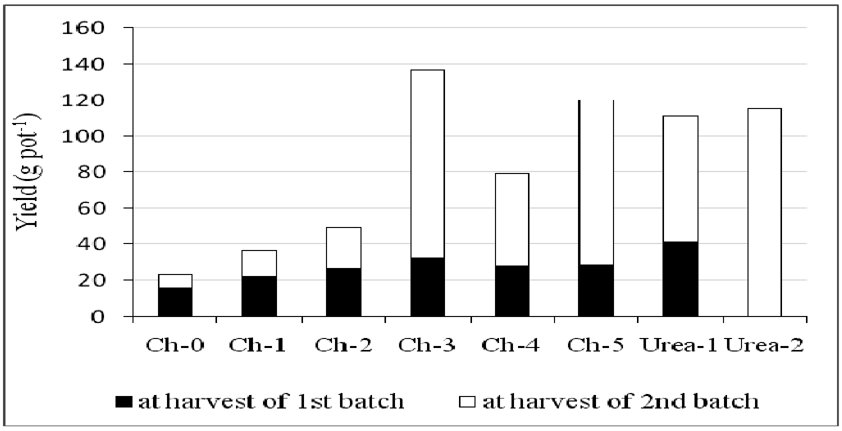

Fig. 2. Yield of komatsuna as affected by chicken-manure composts at harvest of first and second batch (residual effect).

As shown in Fig. 2, in the first batch of the experiment the urea treatment (U-1) displayed the highest yield (41.23 g pot^{-1}) followed by the treatment of Ch-3 (32.03 g pot^{-1}) , Ch-5 (28.50 g pot^{-1}), Ch-4 (27.83 g pot^{-1}), Ch-2 (26.53 g pot^{-1}) and Ch-1 (22.43 g pot^{-1}); while the lowest one was control soil, Ch-0 (15.93 g pot^{-1}) and it showed poor growth of Komatsuna. The low yields harvested from the soil without manure (control treatment) are due to the insufficient supply of plants in nitrogen, leading at first to limitation of carbon assimilation, resulting in reduction of plant productivity (Shangguan et al., 2000; Lawlor, 2002).

The residual chicken-manure composts resulted in higher yield of Komatsuna than those in the first batch, mainly for Ch-3 (105 g pot^{-1}), Ch-5 (91.13 g pot^{-1}), Ch-4 (51.27 g pot^{-1}), and U-1 (69.90 g pot^{-1}). However, they did not increase the yield in other treatments of chicken-manure compost (Fig. 2). Residual effects of Ch-3 and Ch-5 increased the yield of Komatsuna more appreciably than residual urea (U-1 treatment). Komatsuna in soil without manure (Ch-0) demonstrated N deficiency symptoms, such as yellowing leaves and retarded growth of plants

In the first batch, dry-matter yield of Komatsuna was significantly affected by the incorporation of chicken-manure composts when compared with the Ch-0, but there was no significant difference among the treatments and those were also not significantly different with urea (Fig. 3).

Dry-matter yield of Komatsuna was significantly influenced by the residual chicken-manure composts (Fig. 3). The dry-matter content of Komatsuna in treatments of Ch-3 (9.27 g pot^{-1}) and Ch-5 (8.61 g pot^{-1}) were significantly higher than the residual urea of treatment of U-1 (6.55 g pot^{-1}), but it was not significantly different with treatment U-2 (8.72 g pot^{-1}). It is due to a less residual N of treatment U-1 remained in the soil after the first batch of the experiment than that of treatment of Ch-3 and Ch-5 (Table 2), and it correlated with the faster release of N of treatment of U-1 to the soil than that from treatment of Ch-3 and Ch-5. The treatment of Ch-3 and Ch-5 showed a longer presence in soil during two consecutive experiments (Fig. 1) and showed a comparable effect with treatment of U-2. The less residual N in soil at the end of first batch of experiment resulted in insufficient supply of N for plants in the second batch.

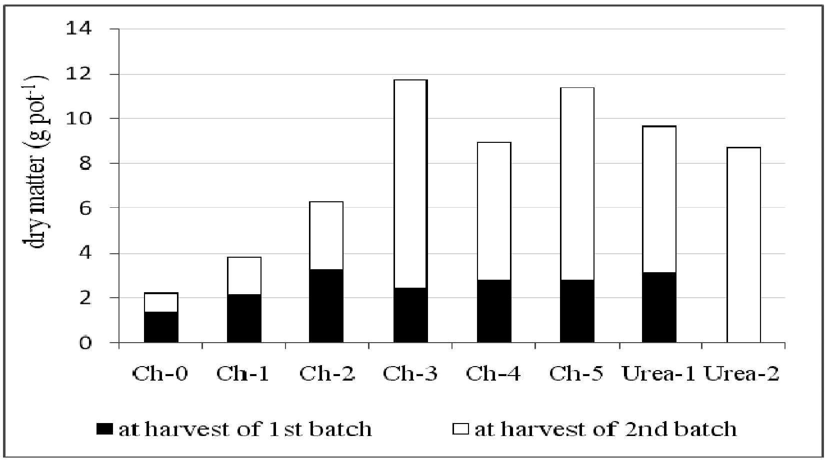

Fig. 3. Dry-matter content of Komatsuna at harvest as affected by chicken-manure composts (first and second batch).

Nitrogen Uptake of Komatsuna

The N uptake of Komatsuna was influenced by the incorporation of various chicken-manure composts (Fig. 4.) The N uptake of Komatsuna in the soil with chicken-manure composts was significantly higher than that of unmanured soil (Ch-0), except for Ch-1.

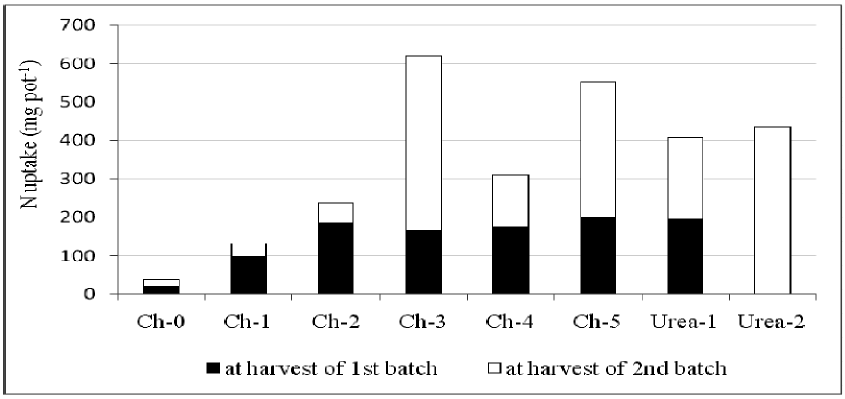

Fig. 4. Nitrogen uptake by Komatsuna at harvest as affected by chicken-manure composts (first and second batch).

Organic materials are subject to considerable changes due to physical, chemical, and biological processes taking place in soil. Rowel and Hadad (2014) stated that animal manures contribute more to the soil than just nitrogen, phosphorus, and potassium. It builds organic matter in soils and improves soil structure. This modification of soil structure helps improve water holding capacity, aeration, friability, and drainage. These conditions are necessary for satisfactory plant growth (Eimhoit et al., 2005; Mbhata, 2008).

The recovery of N by crops are affected by plant species, soil, climatic, and management practices (Allison, 1973). Nitrogen recovery determined by difference method also varied statistically, and its correlation coefficient with the N content of chicken-manure composts was significant. The apparent recovery (R_n) of material-N added to soil by the crop should be related to the level of material-N in a characteristic way. R_n is defined by :

$$R_n = (U_c - U_0)/N_m \quad \text{.......................................} \quad (1)$$

Where, U_c is the uptake of N by the whole plant excluding fibrous roots when an amount N_m of material-N is applied and U_0 is the corresponding uptake when no material or fertilizer is applied.

Nitrogen uptake (Table 2) showed that Ch-3 and Ch-5 were higher than residual urea (treatment of U-1), but these did not show significant difference with treatment U-2. Nitrogen uptake of the other treatments of chicken-manure composts, containing lower N (2.3% - 3.6%) were low, and among them did not indicate significant difference. The amount of residual inorganic nitrogen in soil before the sowing of the second batch (at the end of the first batch of the experiment) ranged from 1.46% (Ch-1 treatment) to 61.70% (Ch-3 and Ch-5 treatment) (Table 2). A higher residual N level from Ch-3 and Ch-5 after the first batch of the experiment correlated with the slower release of N to the soil than that from chemical fertilizer (urea). As would be expected, plant N content was influenced by the application of chicken-manure composts to the soil as the source of N. The effect of different N compounds of chicken-manure composts upon plant composition was also related to the release of N. The higher mineralization rates of them in soil, such as treatment of Ch-3 and Ch-5, tended to give a higher N contents of plant and N uptake of plant than did the slower mineralization rates, such as treatment of Ch-1. According to the yield of Komatsuna as mentioned above, the yield of Komatsuna in the unmanured treatment was very low (15.93 g pot^{-1}) than the other treatments. Thus, it is logical to conclude that N was the most growth limiting factor in this soil.

Table 2. Availability of residual nitrogen of chicken-manure and urea in soil

Treatment	Nitrogen Content	Residual N in soil at harvest of 1^{st} batch		Total N Uptake* ($mg\ N\ pot^{-1}$)	N Recovery (%)
		$mg\ N\ pot^{-1}$	A (%)		A
Ch-0	0	-	-	15.43 a	-
Ch-1	2.31	14.60	1.5	31.68 a	1.6
Ch-2	3.43	74.00	7.4	50.21 a	3.5
Ch-3	6.53	617.00	61.7	456.00 b	44.1
Ch-4	3.90	227.00	22.7	137.00 ab	12.2
Ch-5	6.16	617.00	61.7	352.00 b	33.7
U-1	46	396.00	39.6	214.00 ab	19.9
U-2	46	-	-	436.00 b	42.1

A : based on the amount of N applied in the first experiment

* Means followed by the same letters referring to the respective indices are not significantly different.

Quality of Plant Production

Nitrogen content in vegetative parts, such as leafy vegetables, is present in an inorganic or simple organic form (as nitrate, nitrite, free amino, etc.). The accumulation of nitrate in plants is affected by either the availability of nitrate in soil and the plant's ability to convert nitrate by assimilation processes to higher products (Maynard and Barker, 1979 *in* Haynes, 1986). The entire nitrate content, absorbed by plants, was not assimilated in the plant metabolism and was partly accumulated in the vacuola of plant cells (Rufty et al.,1982).

The nitrate content of shoots (Fig. 5) varied greatly among the treatments. It is suggested that nitrate content of shoots was attributed to the differences of N availability of chicken-manure composts and by the N uptake. Generally, higher fresh and dry-yield of Komatsuna plants as in treatments of Ch-3 and Ch-5 were accompanied with increasing nitrate concentration of plant. Nitrate accumulation in plants occurs as a result of nitrate accumulation in the soil due to the activity of soil nitrifying organisms (Hanafy et al., 2000).

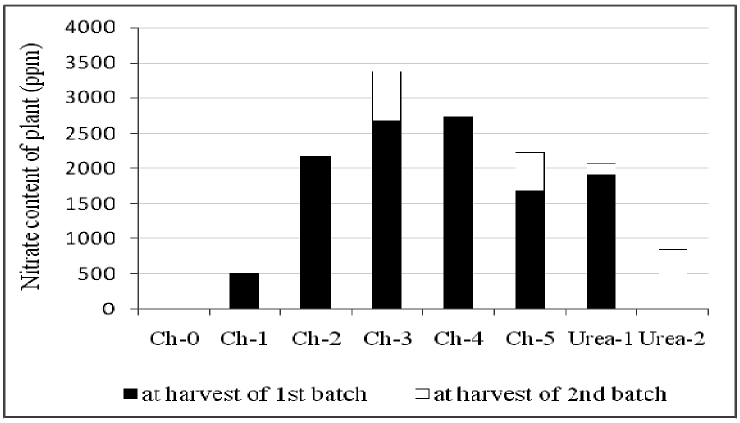

Fig. 5. The effect of chicken-manure composts on nitrate content of Komatsuna (*Brassica rapa L.*) at harvest (first and second batch).

In the second batch of the experiment, the nitrate content of the shoots became lower compared to the first batch, although treatment of Ch-3, Ch-5, and U-1 still showed a high nitrate content than the other treatments. The higher plant nitrate from Ch-3 and Ch-5 treatments might be due to the large residual N and the longer presence of N in soil. This is in accordance with Barker's statement (1975 *in* Haynes, 1986) that much nitrate is accumulated in plants from organic manures as from inorganic fertilizer if adequate time is allowed for mineralization. Organic manures that mineralize slowly lead to less nitrate accumulation in vegetables than materials that mineralize rapidly and therefore release more NO_3^--N in soil. The plant quality depends on the magnitude of nitrate accumulation. The high concentration of nitrate in plant could be toxic for health (European Food Safety Authority, 2008).

The content of glucose and reducing sugar (Fig. 6 and 7) tended to be lower with the increase of nitrate content. The glucose and reducing sugar content of shoots in the first batch of the experiment were 0.08-1.36% and 0.15-0.54%, respectively. By adding urea, the glucose content was the lowest one than the chicken-manure compost treatments. While the lowest reducing sugar content was also achieved with U-1 application, followed by Ch-3.

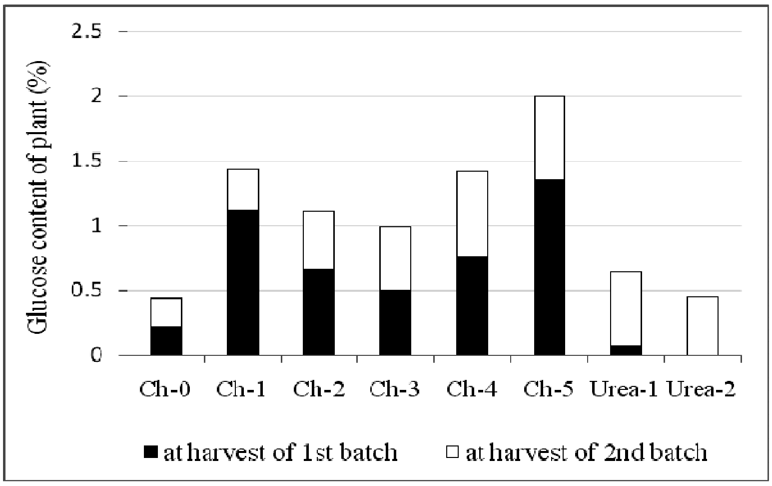

Fig. 6. The effect of chicken-manure composts on glucose content of Komatsuna at harvest (first and second batch)

The higher the nitrate content of the plant, the lower the glucose or reducing sugar content because the assimilation of nitrate in plant metabolism requires energy from the process of carbohydrate formation, the glucose and reducing sugar content would therefore be lower. Buwalda and Warmenhoven (1999) worked on lettuce and mentioned that the concentration of nitrate and the sum of sugars and organic acids in the shoots of lettuce showed a strong negative correlation. These decrease in total sugar concentrations might be explained that plants used most of the carbon in structural growth, but incorporated relatively less carbon in soluble organic compounds. In this way, nitrate accumulation in the vacuoles will increase to compensate for the shortage of sugars to replace the decline in osmotic value (Hanafy et al., 2000). Thus, NO_3 accumulation was inversely related to the accumulation of sugars (Seginer et al., 1998). In addition, plants that contain adequate concentrations of sugars are able to assimilate nitrate at a faster rate than comparable plants containing lower concentrations of sugars (Kirkby, 1981).

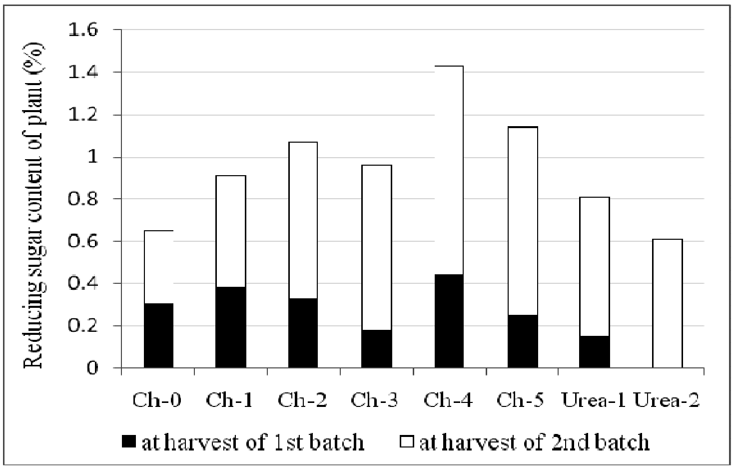

Fig. 7. The effect of chicken-manure composts on reducing sugar content of Komatsuna at harvest (first and second batch).

CONCLUSION

The difference in nitrogen content of chicken-manure composts has an influence on plant yield and quality of product. The high nitrogen content of chicken-manure compost contributed to higher yield of Komatsuna (*Brassica rapa* L.). Chicken-manure compost with high N content (6% N) had a high N fertilizer effect and displayed a comparable effect with urea on crop growth and yield. The higher N uptake and yield tended to increase the content of nitrate in Komatsuna plant and to decrease the glucose and reducing sugar content of Komatsuna. In contrast, chicken-manure compost with low N content (2.3% N) showed a lower effect than urea. The best treatment to give high yield of Komatsuna (*Brassica rapa* L.) and to reduce application of nitrogen chemical fertilizer was chicken-manure with high nitrogen content (Ch-3 and Ch-5).

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GRAIN YIELD AND, NUTRIENT AND STARCH CONTENT OF SORGHUM (*Sorghum bicolor* (L.) Moench) GENOTYPES AS AFFECTED BY DATE OF INTERCROPPING WITH CASSAVA IN LAMPUNG, INDONESIA

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ABSTRACT

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the cereal crops utilized as source of food, feed and bioethanol production. Intercropping with cassava is a promising means of developing sorghum plants in Lampung province of Indonesia. However, little information on sorghum intercropped with cassava has been documented. The study sought to evaluate the effect of planting dates on grain yield and content N, P, K and seed starch of several sorghum genotypes intercropped with cassava. A field experiment was conducted in Waway Karya of East Lampung, Lampung Province-Indonesia in 2009-2010. The treatments were arranged factorially with split-plot in randomized block design with three replications. The main plot was planting dates consisting of three levels, that was, 0, 2 and 4 weeks after planting cassava. Sub-plot was sorghum genotypes including Kawali, Mandau, B-76 and B-92. Fertilizers used were urea, SP-36 and KCl. Sorghum plants were intercropped with cassava and planted in interrows of cassava, while cassava was planted with row spacing of 80 cm x 60 cm. Sorghum plants intercropped with cassava and planted at 2 and 4 weeks after planting cassava resulted in lower grain yield and content of nutrient and seed starch compared to that planted at the same date of cassava planting. The highest reduction occured at the planting date of 4 weeks after planting cassava, that was, 72.9% for sorghum grain yield. The reduction in N, P and K content of sorghum plants caused by 4-weeks delayed planting was 14.5, 26.7 and 41.9%, respectively, while the reduction of seed starch content was only 6.0%.

Key words: cassava canopy, competition, nutrient content, panicle, planting date, shade, starch

INTRODUCTION

The demand for food in Indonesia, especially rice is continously increasing in paralell with the increase of Indonesian population. It is predicted that Indonesian population in 2030 will be 425 million, so the need for rice is 59 millions ton (Suswono, 2012). Thus, increasing rice production still becomes a major concern in Indonesian agricultural development . Most of Indonesian rice production is dominated by lowland rice. In fact, the area of paddy field in Indonesia is decreasing due to land conversion for nonagricultural purposes. This leads to weaken the food security in Indonesia. Therefore, many efforts have been done to increase the food security such as developing other food-producing plants besides rice plants. Recently, sorghum has started to be developed intensively in Indonesia, since it is potentially utilized as sources of food, feed and fuels (Rooney and Waniska, 2000).

Lampung is one of provinces in Indonesia located in Sumatra Island. Agricultural land in Lampung is dominated by upland agriculture, so lack of water frequently limit crop productivity. Food crops such as rice, corn and cassava are major food crops in Lampung-Indonesia and are cultivated mostly in monoculture systems. Actually, intercropping cassava with other food crops is still possible since growth and development of cassava canopy at early growth stages are very slow (Kamal, 2009). On the other hand, slow growth of cassava canopy at early stage potentially creates the problem of soil erosion and weed control. Coolman and Hoyt (1993) reported that intercropping could be more eficient than monoculture in utilizing limited resources. Moreover, intercropping systems are frequently effective to reduce damage associated with insect and pathogen attacks besides weed control. Lithourgidis et al. (2011) indicated that intercropping is an alternative way for sustainable agriculture.

Ecologically, sorghum plants could grow in wide ranges of environmental conditions. Sunyoto and Kamal (2009) reported that sorghum could grow well under agroclimate conditions of Lampung-Indonesia although their yield was affected by planting dates and sorghum genotypes. In general, sorghum that is cultivated in the dry season produces higher yield compared to that cultivated in wet (rainy) season. The study reported by Netondo et al. (2004) indicated that sorghum plants are relatively highly tolerant to drought. Thus, it could be used for optimizing biomass production in upland agriculture frequently subjected to water shortage.

Sorghum plants basically could be cultivated on monoculture and intercropping systems. However, the development of sorghum in Lampung- Indonesia by monoculture system will face the problem of land use competition with other food crops such as rice, corn and cassava. Thus, intercropping is a promising means of developing sorghum plants in Lampung-Indonesia, especially intercropped with cassava. Lampung is the biggest cassava producer in Indonesia, accounting for more than 30 % of Indonesian cassava production (BPS, 2012). Many reports show that sorghum plants could be intercropped with corn, soybean, cowpea and peanut (Langat et al., 2006; Mohammed et al. 2006; Egbe, 2010; Musa et al. 2011). However, little information about intercropping sorghum plants with cassava was documented. Hamim et al. (2012) reported that planting time of sorghum on intercropping with cassava determines sorghum grain yield.

This study sought to evaluate the effect of planting dates on grain yield and content of N, P, K and seed starch of several sorghum genotypes intercropped with cassava.. Better understanding of morphophysiology of sorghum plants intercropped with cassava would be useful in developing sorghum plants through intercropping.

MATERIALS AND METHODS

Experimental Site

The field experiment was conducted in the district of Waway Karya, East Lampung, Lampung Province, Indonesia in 2009-2010. The experimental site was located 70 m above sea level with a rainfall of 120 mm month^{-1}, and it was considered as rain-fed agricultural land with the soil pH of 5.8.

Experimental Design

Four sorghum genotypes used were Kawali, Mandau, B-76 and B-92, and cassava cuttings of UJ5 cv. were used in this experiment. These four sorghum genotypes have different yield potential. Fertilizers used included urea, SP-36 and KCl. Herbicide, glyphosate, was used to control weeds, while carbosulfan (25.5%) was used to control insect pests.

The treatments consisting of planting dates and sorghum genotypes were arranged in factorial with split plot in Randomized Complete Block Design with three replications. The main plot was sorghum planting dates, while the sub-plot was sorghum genotypes. Planting dates consisted of three levels, that was, 0, 2 and 4 weeks after planting cassava. Sorghum genotypes consisted of Kawali, Mandau, B-76 and B-92.

Cultural Practice

Before planting, soil was sprayed by herbicide (glyphosate) with the dosage of 2 L ha^{-1}. One week later, soil was plowed and plotted. Each plot was 5 by 4 m in size, and interplot had the distance of 60 cm. Cassava was planted with row spacing of 80 cm x 60 cm, so each plot had 6 rows of cassava. The dosage of urea, SP-36 and KCl was 300, 100 and 100 kg ha^{-1}, respectively. Urea and KCl were split; ½ dosage was applied at 3 weeks after planting, and another half-dosage was applied at 14 weeks after planting. SP-36 was applied once at 3 weeks after planting. During the experiment, pesticide was not used to controll pest and disease in cassava.

Sorghum seeds were planted in each plot manually after planting cassava. Sorghum were planted as an intercrop between cassava rows with the distance of 20 cm in rows , and the distance of cassava and sorghum rows was 40 cm. The number of sorghum rows in each plot was 5 rows and each of which had 24 hills.

Sorghum plants intercropped with cassava were planted in different planting dates, that was, the same time of planting cassava (0 week), 2 weeks after planting cassava (2 WAP) and four weeks after plating cassava (4 WAP). The dosage of urea, SP-36 and KCl was 200, 100 and 100 kg ha^{-1}, respectively. SP-36 and KCl were applied once at 2 weeks after planting, while Urea was splitted, that is, ½ dosage was applied at 2 weeks after planting and another half-dosage was applied at 5 weeks after planting. During the experiment sorghum plants sometimes were irrigated to prevent them from water stress. Pest and diseases were controlled by pesticide application. Aphids and leaf blight were observed although their attack was relatively light.

Data Collection and Analysis

The variables observed were plant height, leaf number, stem diameter, biomass production, panicle length, seed number, seed size, grain yield, of N, P and K content in sorghum leaves, and seeed starch content. For nutrient analysis, sorghum leaves were sampled at maturity (harvesting time). The content of N was determined by Kjeldahl method, while P content was determined by spectrophotometry (Spectronic 20- Milton Boy Co.) and the reading was taken at 693 nm. K content was determined by flame photometry (Model PFP7-Jenway). Nutrient analysis was according to the method described by Agus et al. (2005).

Starch content was analyzed by a modified Somogy method as explained before (JICA, 1983). Ten grams of sorghum seed powder was placed in a 300 mL Erlenmeyer flask where 20 mL of HCl (25%) and 200 mL distilled water were added. The Erlenmeyer flask was closed and allowed to hydrolyze for 2-3 minutes. The solution was neutralized by adding NaOH (20%) until the pH of 6.8-7.0 was reached. The solution was diluted 500—1000x and 10 mL of sample was placed into a 100-mL Erlenmeyer flask where 10 mL of Reagent A and 10 mL of distilled water were added. The solution was allowed to boil for 3 minutes and left to cool. Thereafter, 10 mL of reagent B and 10 mL of Reagent C and some drops of amylum indicator (1%) were added. Finally, the sample was titrated by using Na_2SO_3 0.1 N solution. Based on the amount of Na_2SO_3 0.1 N used, starch content was calculated (JICA, 1983).

All data were subjected to Analysis of Variance (ANOVA). The difference of treatment means was determined by Fisher's LSD test at the significant level of 5% (P=0.05).

RESULTS AND DISCUSSIONS

Sorghum growth

The results of the experiment revealed that planting dates significantly influenced growth of sorghum plants intercropped with cassava although its effect depended on sorghum genotypes. Planting dates of 2 and 4 weeks after planting cassava resulted in lower plant height (Table 1), leaf number (Table 2), stem diameter (Table 3) and biomass production (Table 4) compared to that in the planting date of 0 week (the same date of planting cassava).

In general, the delay of sorghum planting dates up to 2 and 4 weeks after planting cassava reduced plant height, leaf number, stem diameter and biomass production although the magnitude of reduction depends on sorghum genotypes, especially at 2 WAP. However, at 4 WAP all sorghum genotypes showed great inhibition and no significant growth difference. The reduction of sorghum growth in intercropping with cassava was most likely due to interspecific competition. At the planting dates of 2 and 4 weeks after planting cassava, the development of cassava canopy exceeded sorghum plants. Thus, sorghum plants suffered from low light intensity caused by shade of cassava canopy, which in turn reduced sorghum growth.

Similar results were reported by Hamim et al. (2012) indicating the reduction of sorghum growth in intercropping with cassava, while Suwarto et al. (2005) reported the reduction of maize growth in intercropping with cassava. Mouneke et al. (2007) also reported that the difference in canopy development frequently creates interspesific competition for sunlight in intercropping systems, resulting in growth inhibition.

In terms of sorghum genotypes, Kawali consistently showed the superiority of plant height, leaf number, stem diameter and biomass production compared to other sorghum genotypes.

Table 1. Effect of planting dates and genotypes on plant height and weight of 1000 seeds of sorghum plants intercropped with cassava

Treatments	Plant height (cm)	Weight of 1000 seeds (g)
Planting dates (weeks after cassava planting)		
0	134.17a	25.72a
2	114.57ab	22.38a
4	111.08bc	24.25a
Sorghum genotypes		
Kawali	122.22a	24.73a
Mandau	114.57a	22.52a
B-76	124.49a	24.07a
B-92	120.87a	22.34a

* The numbers followed by the same letters in the same columns and treatments are not significantly different with LSD test at P=0.05.

Table 2. Leaf number of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Leaf number (number per plant)			
	Kawali	**Mandau**	**B-76**	**B-92**
0 WAP	14.00c C	12.27b B	11.47b AB	11.07b A
2 WAP	12.53b C	11.53b B	11.13b AB	10.60b A
4 WAP	9.73a A	9.67a A	9.33a A	9.13a A

* WAP = weeks after planting cassava
** The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Table 3. Stem diameter of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Stem diameter (cm)			
	Kawali	**Mandau**	**B-76**	**B-92**
0 WAP	2.52c C	1.92c AB	1.78c A	1.68c A
2 WAP	1.64b B	1.35b A	1.24b A	1.21b A
4 WAP	1.09a A	1.07a A	0.99a A	0.93a A

* WAP = weeks after planting cassava
** The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Table 4. Biomass production of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Biomass production (g/plant)			
	Kawali	**Mandau**	**B-76**	**B-92**
0 WAP	288.29b C	196.26b AB	253.13b BC	187.60b A
2 WAP	257.59b B	140.31ab A	143.75a A	154.92ab A
4 WAP	97.21a A	105.57a A	123.10a A	88.19a A

* WAP = weeks after planting cassava
**The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Sorghum yield component and grain yield

The interaction effect of planting dates and genotypes on yield components of sorghum plants intercropped with cassava was also found (Table 5, 6 and 7). The performance of sorghum yield components planted at 2 and 4 weeks after planting cassava were lower than that planted at 0 WAP although the magnitude of the reduction depends on sorghum genotypes, especially at 2 WAP. On the average, the reduction of panicle length, panicle weight and seed number caused by the delay of sorghum planting dates of 2-4 WAP was 3.5-19.1%, 26.2-69.3% and 25.1-71.3%, respectively. It seems that seed number was the most sensitive sorghum yield component to shading caused by cassava canopy. In contrast, weight of 1000 seeds was not significantly affected by planting dates of sorghum plants intercropped with cassava (Table 1). This is in agreement with the previous study reported by Hamim *et al.* (2012). The result of the study reported by Kamal (2007) indicated that the treatment of 50% shade suppressed growth and development of rice yield components. The reduction of sorghum yield components caused by 2- and 4-week delayed planting was related to the inhibition of sorghum growth. As mentioned earlier, the canopy of cassava created shading on sorghum plants, which in turn, reduced photosynthetic rate and resulted in lower assimilate supply for sorghum yield component development.

Table 5. Panicle length of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Panicle length (cm)			
	Kawali	Mandau	B-76	B-92
0 WAP	23.27b C	21.73b BC	19.37b AB	17.60a A
2 WAP	22.80b B	21.20b B	18.07ab A	17.00a A
4 WAP	17.11a A	16.57a A	16.50a A	16.13a A

* WAP = weeks after planting cassava
** The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Table 6. Panicle weight of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Panicle weight (g)			
	Kawali	Mandau	B-76	B-92
0 WAP	73.61b C	42.75b AB	55.57b BC	36.03b A
2 WAP	60.90b B	24.89ab A	33.73a A	33.87b A
4 WAP	15.23a A	16.12a A	19.53a A	12.87a A

* WAP = weeks after planting cassava
** The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Table 7. Seed number of different sorghum genotypes as affected by date of intercropping with cassava

Sorghum planting date	Seed number (no. panicle^{-1})			
	Kawali	Mandau	B-76	B-92
0 WAP	2146.47c B	1474.73c A	1485.33c A	1248.80b A
2 WAP	1689.20b B	901.00b A	1073.60b A	1098.73b A
4 WAP	506.60a A	414.93a A	489.73a A	414.67a A

* WAP = weeks after planting
** The numbers followed by the same-small letters in the same column and the same capital letter in the same rows are not significantly different with LSD test at P=0.05.

Since adequate supply of assimilate was highly required for sorghum grain filling (Huang and Ma 1995), the reduction of assimilate supply caused by shading decreased sorghum grain yield. Thus, it is not surprising that sorghum grain yield at 2 and 4 weeks after planting cassava was lower than that at the planting date of 0 week (Fig. 1).

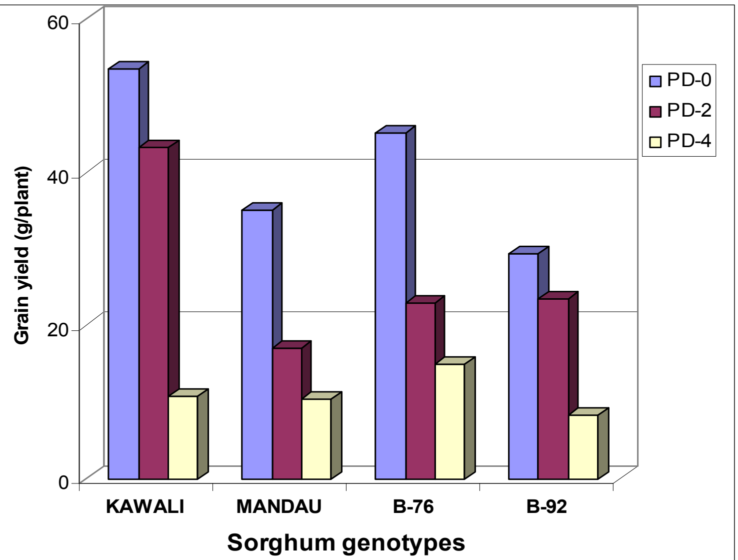

Figure 1. Grain yield of some sorghum genotypes intercropped with cassava at different planting dates
(PD-0= 0 week after cassava planting; PD-2= 2 weeks after cassava planting; PD-4= 4 weeks after cassava planting)

Sorghum genotype of Kawali indicated the highest grain yield compared to other genotypes (Fig. 1). This was substantiated with the data of sorghum growth and yield components in which Kawali consistently showed better growth and greater yield components than other genotypes.

Interestingly, Kawali also showed less reduction of grain yield at the planting date of 2 weeks after planting cassava compared to other shorgum genotypes.

However, at the planting date of 4 weeks after planting cassava all sorghum genotypes indicated similar reduction of grain yield. This means that depressive effects of cassava on sorghum grain yield at 4 WAP was much more pronounced than that at 2 weeks after planting cassava. Thus the delay of sorghum planting dates up to 4 weeks after planting cassava was not recommended in intercropping systems of sorghum and cassava.

Nutrient and starch content

The planting dates of sorghum intercropped with cassava significantly influenced N, P and K nutrient levels (Table 8), while the interaction effect of planting date and sorghum genotype on nutrient content was not significant. The planting dates of 2 and 4 WAP consistently resulted in lower content of N, P and K compared to that at the planting date of 0 WAP. This reduction of nutrient content was most likely attributed to the inhibition of sorghum growth caused by the delay of sorghum planting dates in intercropping with cassava. Epstein and Bloom (2005) reported that the inhibition of plant growth can lead to the inhibition of nutrient uptake since nutrient uptake is related to plant metabolism (Mengel and Kirby, 1987). The differences in sorghum genotypes also resulted in nutrient content differences (Table 8). Many studies showed that nutrient uptake is affected by genetic factors (Mengel and Kirby, 1987; Kamoshita *et al*., 1995; Hirei *et al*., 2001; Setiawan and Kamal, 2008). Sorghum genotype of Kawali also demonstrated superiority of N and P content compared to other sorghum genotypes (Table 8).

Table 8. Effect of planting dates and genotypes on nutrient content of sorghum plants intercropped with cassava

Treatments	Nitrogen (N) content (%)	Phosphorus (P) content (%)	Potassium (K) content (%)
Planting dates (weeks after cassava planting)			
0	1.79a	0.15a	0.31a
2	1.70a	0.13b	0.23b
4	1.53b	0.11b	0.18b
Sorghum genotypes			
Kawali	1.81a	0.16a	0.29a
Mandau	1.69ab	0.14ab	0.23a
B-76	1.62b	0.12bc	0.20a
B-92	1.58b	0.10c	0.23a

* The numbers followed by the same letters in the same columns and treatments are not significantly different with LSD test P=0.05.

The content of starch in sorghum seeds was also affected by planting dates of sorghum plants intercropped with cassava. Planting dates of 2 and 4 weeks after planting cassava (PD-2 and PD-4) resulted in lower starch content of sorghum seeds compared to that of planting date of 0 week (PD-0) after planting cassava (Fig. 2). As mentioned earlier that planting dates of sorghum intercropped with casava at 2 and 4 weeks after planting cassava suffered from shading caused by cassava canopy development, which in turn reduce assimilate supply during grain filling period. As a result, starch accumulation in the seeds of sorghum planted at 2 and 4 weeks after planting cassava was lower than that at planting date of 0 week (PD-0) after planting cassava. The result of the experiment dealing with shading in rice plants indicates that rice plants grown under shade condition produces less starch compared to rice plants grown under full-sun condition (Laut et al., 2000), while Huber and Israel (1982) reported that changes in starch and sucrose content under shade are related to the activity of SPS enzyme which catalyzes the synthesis of sucrose-P from UDP Glucose. Among sorghum genotypes, Kawali showed the highest seed starch content compared to other genotypes (Fig. 2), suggesting that Kawali consistently indicates the superiority of growth, nutrient uptake, yield components, grain yield and starch content.

Compared to grain yield reduction caused by the delay of planting dates (Fig. 1), the reduction of starch content in sorghum seeds at the planting dats of 2 and 4 weeks after planting cassava was lower (Fig. 2). This is related to grain-developing process which involves yield component formation and development. Thus, the reduction of sorghum yield components such as panicle weight and length, and seed number result in lower grain yield. In terms of seed starch content, the amount of assimilate produced during grain filling is critical since the number of sorghum seeds is already set earlier. Huang and Ma (1995) stated that the dry matter accumulation in shorghum seeds was mostly supplied by the assimilate produced during reproductive stage. Thus, the difference of starch content in shorghum seeds was not as big as the difference in grain yield.

From the stand point of nutrient uptake, the reduction of sorghum grain yield caused by the delay of sorghum planting dates of 2 and 4 weeks after planting cassava (Fig. 1) was in parallel with the reduction of N, P and K content caused by 2- and 4-week delayed planting (Table 8). The result of correlation analyses revealed that sorghum grain yield was highly correlated with N(r=0.855**), P(r=0.745**) and K(r=0.832**) uptake.

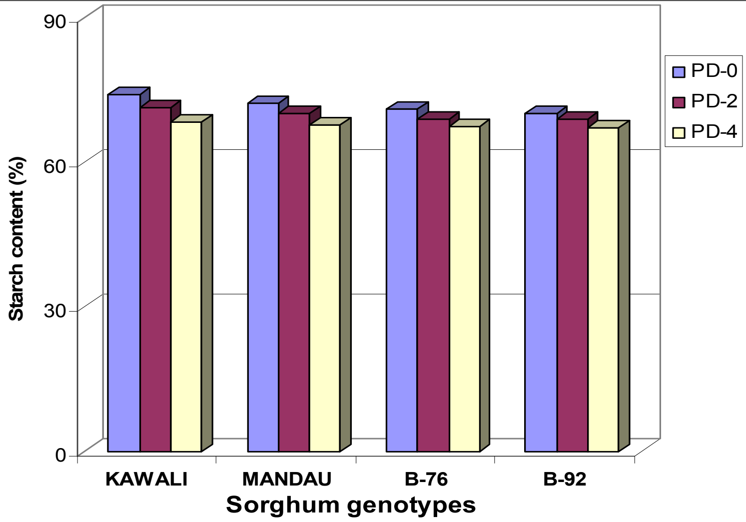

Figure 2. Starch content in sorghum seeds intercropped with cassava at different planting dates

(PD-0= 0 week after cassava planting; PD-2= 2 weeks after cassava planting; PD-4= 4 weeks after cassava planting)

Since the involment of N, P and K in plant growth and development is highly significant (Epstein and Bloom, 2005; Taiz and Zeiger, 2010), the reduction of N, P and K uptake could reduce the production of sorghum yield components and grain yield. In other words, data of correlation coefficient (Table 9) substantiated the results of the experiment presented earlier (Table 1, 2 ,3, 4, 5,6,7, 8 and Fig. 1 and 2).

Table 9. Correlation coefficient of growth variabel with yield components, nutrient uptake and starch content of sorghum plants intercropped with cassava

Variables	**Plant height**	**Leaf number**	**Stem diameter**	**Biomass production**	**Panicle Length**	**Panicle weight**	**Seed Number**	**Weight of 1000 seeds**	**Grain yield**	**N uptake**	**P uptake**	**K uptake**	**Starch content**
Plant Height	1.000	0.616*	0.813**	0.783**	0.496	0.752*	0.751*	0.406	0.808**	0.706*	0.608*	0.720*	0.692*
Leaf Number		1.000	0.919**	0.891**	0.933**	0.916**	0.957**	0.286	0.897**	0.850**	0.761**	0.772**	0.976**
Stem Dianeter			1.000	0.808**	0.791**	0.887**	0.925**	0.241	0.909**	0.852**	0.780**	0.850**	0.973**
Biomass Production				1.000	0.799**	0.988**	0.962**	0.592	0.992**	0.836**	0.692*	0.807**	0.902**
Panicle Length					1.000	0.808**	0.835**	0.317	0.787**	0.685**	0.570	0.607*	0.909**
Panicle Weight						1.000	0.977**	0.538	0.989**	0.818**	0.701*	0.775**	0.907**
Seed Number							1.000	0.387	0.974**	0.897**	0.798**	0.834**	0.951**
Weight of 1000 seeds								1.000	0.545	0.231	0.053	0.316	0.306
Grain yield									1.000	0.855**	0.745*	0.832**	0.914**
N uptake										1.000	0.915**	0.957**	0.876**
P uptake											1.000	0.884**	0.788**
K uptake												1.000	0.841**
Starch content													1.000

* indicates significant correlation; ** indicates highly significant correlation

CONCLUSION

Sorghum plants intercropped with cassava and planted at 2 and 4 WAP resulted in lower grain yield and content of nutrient and seed starch compared to that planted at the same date of cassava planting (0 WAP). Intercropping at 2 and 4 WAP reduced sorghum grain yield, sorghum seed starch content and N, P and K content. But the reduction of sorghum yield component planted at 2 WAP depended on sorghum genotypes. Sorghum plants could be intercropped with cassava as long as they were planted at the same date of cassava planting. The sorghum genotype of Kawali showed the highest grain yield and content of nutrient and seed starch content. It seems that the reduction of sorghum grain yield, nutrient uptake and seed starch content caused by 2- and 4 week-delayed planting in intercropping with cassava was related to shading caused by cassava canopy development.

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IMPACT OF INFRASTRUCTURE ON PROFIT EFFICIENCY OF VEGETABLE FARMING IN WEST JAVA, INDONESIA: STOCHASTIC FRONTIER APPROACH

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ABSTRACT

Infrastructure plays an important role in increasing farm profit, since it reduces transaction costs which affect input and output price. The vegetable farming profit is relatively high although it varies, due to different infrastructure conditions. The study was conducted to analyze the level of profit efficiency due to various infrastructure conditions and to reveal the determinants of vegetable farming profit. The research was conducted in West Java, Indonesia with 192 sample farming activities. The results indicate that vegetable farming was not yet efficient, with an efficiency level of 0.53, and around 70 percent of farming activities having an efficiency level below 0.7. Factors that influenced significantly profit were seed price, chemical fertilizers, wage, and non-land capital formation. The increase of crop diversification, land conservation technology, seed technology, number of credit, farmer's education, and market access to input market are very effective in increasing vegetable farming profit efficiency.

Key words: efficiency level, translog profit function, transaction cost, technology, credit, market access, irrigation , profit loss

INTRODUCTION

Infrastructure plays an important role on agricultural development in Indonesia, but it is still poor and decreases in condition over time. The poor infrastructure conditions of the agricultural sector are caused by a low infrastructure budget from the government. A large portion of government expenditure is allocated to agricultural subsidy. Agriculture expenditure from 2001 to 2008 has increased significantly by 25.5 percent annually, but the share on irrigation has decreased by 11.57 percent annually. On the other hand, the share of subsidy increased by 11.08 percent annually. A similar case happened in 2008, where only 15 percent of the total agricultural expenditure was spent on irrigation. Meanwhile, almost half of the total agricultural expenditure (around 55%) is on an agricultural subsidy program. More than half (52 percent) of this, was on a form of fertilizer subsidy, while the rest (48 percent) was on a seed subsidy, raskin (rice for poor), and agricultural credit. In 2009, the social donation on the agricultural sector budget was still high (42 percent). Meanwhile, the budget for capital (11 percent) decreased significantly compared to 2008, which reached 18 percent. This condition shows the phenomena of under-investment and mis-investment (Armas et al., 2012 and Daryanto, 2009).

Infrastructure has affected access to input and output market, which in turn affects input and output price (Minten 1999). In the agricultural sector, the effect of infrastructure on output price is relatively higher than that of other sectors since agricultural products are perishable and bulky. The different prices of both input and output due to different infrastructure conditions affect farming efficiency and profit . In addition to infrastructure, fixed asset is also another factor determining profit and farming efficiency. Several studies indicate that infrastructure (in the broad definition) and fixed asset affect profit and efficiency (Rahman, 2003; Bravo-Ureta et al. 2006; Kolawole, 2006; Hyuha et al. 2007; Ogunniyi, 2008; Wadud and Ar Rashid, 2011; van Hoang and Yabe, 2012).

Infrastructure has to be improved since it increases production through an increase in agricultural productivity. Forms of infrastructure included in the analysis were roads, irrigation, research and technology, and agriculture financing. Better infrastructure leads to a more conducive business environment, which can increase private capital formation at the farming level. Therefore, infrastructure can affect the agricultural sector growth directly or indirectly through farming capital formation. It is important to analyze the effect of infrastructure on agricultural development, especially on the increase of farming efficiency.

Vegetable farming is considered of high-value, since it tends to be commercialized. The main characteristic of commercial farming is that it tries to achieve the highest profit by considering resource allocation, and available internal and external resources . The internal resources refer to land, labour, and managerial skills. The external resources include various infrastructure conditions leading to varied transaction costs. This can influence both input and output prices. The price differences cause profit variation (Ridwan et al., 2010). Therefore, analyzing the reason for variation in farming profit is interesting and important. What are the determinants of farming profit? What is the vegetable farming efficiency level and the factors that affect efficiency level? The objectives of this research are (1) to analyze the determinants of vegetable farming profit, (2) to analyze the efficiency and determinants of vegetable farming profit efficiency.

THEORETICAL FRAMEWORK

Adequate infrastructure can decrease transaction cost, which can prevent maximum profit. The effect of transaction cost traced through the effect of infrastructure can be analyzed by measuring the profit efficiency.

Transaction cost is the cost bare by the institution caused by imperfect information, opportunistic behavior, and bounded rationality of actors. Transaction cost occurs because of the assymetric information causing market failure. In market failure, the price faced by market institution varies. The price paid by the consumer is not similar with the price received by the producer due to transaction costs. Transaction cost includes transportation cost, communication, search, negotiation, selection, coordination, monitoring, and implementation (Hoff and Stiglitz, 1993). Transaction costs will eventually cause an inefficient economic activity.

When transaction cost exists, technical efficiency may not change, but not the allocative efficiency which considers relative input and output price. Transaction cost changes the relative price (increase or decrease) that leads to change in allocative efficiency. One of the approaches in measuring farming efficiency when transaction cost exists is to utilize profit efficiency (Sadoulet and de Janvry 1995).

Profit efficiency is defined as the ability of a firm to reach the highest profit level at a certain price and fixed input usage (Kumbhakar and Lovell, 2000; Sadoulet and de Janvry, 1995).

The highest or maximum profit function that can be obtained is called the profit frontier. The stochastic frontier of profit function can measure the profit efficiency level for each farm directly, as seen in Figure 1. Meanwhile, profit inefficiency is the profit loss caused by not operating in the profit frontier. In Figure 1, if the farm is operated at point F, it has not reached the efficient profit with the inefficient ratio of the distance ratio, MF/MP. The larger the gap between profit and frontier profit curve, the more inefficient the farm. It also shows the average profit curve which does not include the profit inefficiency (Fig. 1).

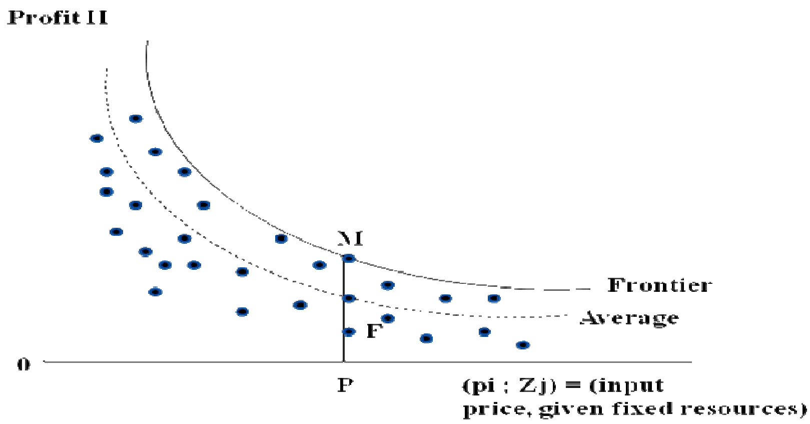

Fig. 1. Profit frontier and average function. (Sadoulet and de Janvry, 1995)

Profit function is derived from the production decision in which the farmer will allocate input to produce output at the maximum level of profit. If the producer faces the input price *w* and output price *p*, and assuming maximum profit $\pi = p.y - w.x$ using x input to produce y output, then the profit frontier illustration can be seen in Figure 1. The profit frontier function is as follows (Kumbhakar and Lovell, 2000):

$$\pi (p,w) = \max_{y,x} \{ p.y - w.x; (y,x) \in GR\} \quad \text{[01]}$$

The profit frontier function has several assumptions, which include: (a) a non-decreasing output price *p*, if p'≥ p, (b) a non-increasing input price *w*, if w' ≥ w, (c) homogenous in first order on output price *p* and input price *w*, and (d) convex on output price *p* and input price *w*.

Especially on a single output case, the profit frontier curve can be normalized by output price. Because profit function is homogenous at the first degree on (p,w), it is therefore possible to divide maximum profit with p where p > 0. The normalized profit frontier function with output price is as follows:

$$\pi^* (w/p) = \pi (p,w)/p = \max_{y,x} \{ p.y - w.x; (y,x) \in GR\} \quad \text{[02]}$$

The normalized profit function with output price is characteristicly non-increasing, convex, and homogenous at zero degree at output price *p* and input price *w*. If there is a fixed input, the profit function is therefore called the profit variable. The frontier variable profit function is as follows:

$$v\pi (p,w,z) = \max_{y,x} \{ p.y - w.x; (y,x,z) \in GR\} \quad \text{[03]}$$

The profit variable is the total revenue minus the variable cost with output price *p*, input price *w*, and fixed input *z*.

The profit efficiency is the condition when technical, allocative (price) efficiency, and scale efficiency are achieved. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency which reflects the ability of a firm to use input for optimal proportion, given their respective prices and production technology. Scale efficiency is the condition when all firms are operating at an optimal scale (Farrel, 1957). The function of profit efficiency is:

$\pi E (y,x,p,w) = (p.y - w.x)/ \pi (p,w); \pi (y,x) > 0$ ………………..………………………...…..…[04]

Profit efficiency is the ratio between actual profit (p.y-w.x) with maximum profit π(p,w). In Figure 2, the producer faces price (p^A, w^A) and profit efficiency πE (y,x,p,w) = 1 at the input output combination at point E, and πE (y,x,p,w) < 1 for the other input output combination points. The profit efficiency measurement has an upper limit and the upper limit will only be reached when the producer maximizes his profit. Profit efficieny is not limited at zero since actual profit can be negative.

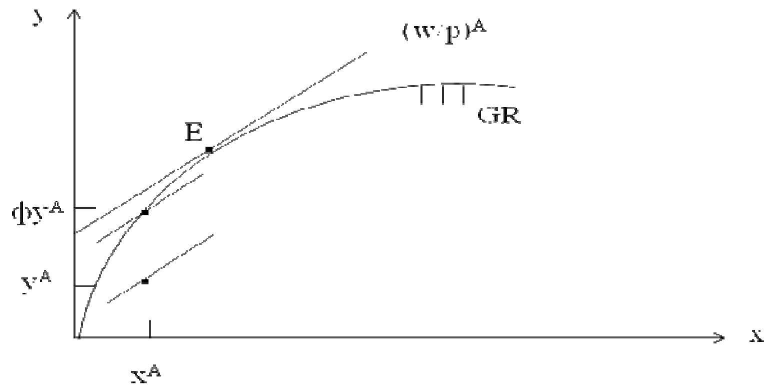

Fig. 2. Profit efficiency measurement. (Kumbhakar and Lovell, 2000)

RESEARCH METHOD

Research Area and Data

This reseach is an empirical study of vegetable farm level in central vegetable production areas at Bandung and Garut Regency, West Java. The decision of choosing sub-regency and village was based on two criteria: (1) central production and (2) infrastructure availability. Based on these criteria, the research was located at Pangalengan and Kertasari Sub-regency in Bandung Regency, and Pasirwangi and Cikajang Sub-regency in Garut Regency. The number of villages chosen was 12 villages, consisting of 8 villages in Bandung Regency and 4 villages in Garut Regency.

The data consisted of primary and secondary data. The primary data consisted of vegetable farm input-output during the planting season 2010/2011, input and output price, distance between land and economic center, road conditions, irrigation, farming technology, conservation technology, land slope, access to input and output market, farm credit, fixed assets in five years (2006-2011), and farmer's characteristics. The number of farm samples was 192, with 118 samples in Bandung Regency and 74 samples in Garut Regency. Stratified random sampling was conducted to determine samples. The stratification was based on land area, where the strata were: strata 1 (< 0.5 Ha), strata 2 (0.5-1.0 Ha), and strata 3 (> 1 Ha), wherein stata 1 consisted of 82 samples, strata 2 52 samples, and strata 3 58 samples.

Road infrastructure, seed technology, and land conservation technology index were used in this research following Iyengar and Sudarshan, as was applied by Ashok and Balasubramanian (2006) as follows:

$$Y_{id} = (X_{id} - MinX_{id})/ (MaxX_{id} - MinX_{id}) \quad \ldots\ldots\ldots\ldots\ldots\ldots[05]$$

where X_{id} = i^{th} infrastructure of d^{th} farmer. The index number range was between 0 and 1. Meanwhile, the crop diversification index used the Simpson diversification index:

$$SID = 1-\sum(a_i/A)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots[06]$$

where SID = Diversification index, a_i = i^{th} plant area, and A = total area. The index number range was between 0 and 1.

Stochastic Frontier Profit Function Model

The profit function model used was the transcendental logarithmic (translog) profit function with stochastic frontier approach. Based on previous studies, stochastic frontier is the best and most applied in the agricultural sector. With this model, besides the predicted factors affecting vegetable farm profit and profit efficiency level, other factors affecting vegetable profit efficiency can be simultaneously predicted. The simultaneous model was carried out in one step and was introduced by Coelli et al. (1998). Maximum Likelihood Estimation (MLE) was used in estimating the parameter making the results unbiased.

The vegetable profit function was affected by output price, variable input price, and several fixed inputs. In this research, profit function was predicted to be affected by potato price (Py), seed price (Ps), chemical fertilizer price (Pf), organic fertilizer price (Po), wage (Pw), and insecticide cost (Pp). As an important component of cost structure in vegetable farming, both input and output price were affecting vegetable farming profit. The hypothesis was that input price negatively affected profit since it increased vegetable farming cost, while output price positively affected on-farm profit. . The profit and input price variable was normalized with output price based on potato price since it is the main commodity of the sample farmer. Meanwhile, the fixed input assumed to affect profit were land area (Za) and non-land capital accumulation (Zc). Land area was the indicator of farm size, the hypothesis was that the larger the land area the larger the profit was. Meanwhile, non-land capital accumulation, such as building and equipment, was believed to have a positive effect on farm profit. Non-land capital accumulation would increase farm capacity since having new assets would be more productive compared to old ones.

Meanwhile, variables predicted to affect vegetable farm profit inefficiency were irrigation infrastructure, crop diversification, land conservation, seed technology, credit, farmers' formal and non-formal education, and access to input market. All variables were predicted to have a negative effect on vegetable farm profit inefficiency. Those variables affected vegetable farm production efficiency and at a constant price, increased production efficiency would increase profit efficiency. The access to input market could influence input and output relative price which affected profit efficiency. The vegetable farm translog profit function model specification could be formulated as follows:

$$\ln\pi' = \alpha_0 + \sum_{i=1}^{5}\alpha_i \ln p_i' + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5}\tau_{ij}\ln p_i' \ln p_j' + \sum_{i=1}^{5}\sum_{k=1}^{2}\emptyset_{ik}\ln p_i' \ln z_k +$$

$$\sum_{k=1}^{2} \beta_k \ln z_k + \frac{1}{2} \sum_{k=1}^{2} \sum_{l=1}^{2} \mu_{kl} \ln z_k \ln z_t + v - u \quad \text{...[07]}$$

Meanwhile, the vegetable farm profit inefficeincy function could be written as follows:

$$u = \delta_0 + \sum_{i=1}^{8} \delta_i w_i + \omega \quad \text{...[08]}$$

where:

π' = Normalized profit with output price (Py)

p_i' = Normalized input price with output price (Py), which is:

$i_1 = P_s$, seed price (Rp/kg); $i_2 = P_f$, chemical fertilizer price (Rp/kg); $i_3 = P_o$, organic fertilizer price (Rp/kg) ; $i_4 = P_w$, wage (Rp/HOK); $i_5 = P_p$, insecticide cost (Rp)

z_k = Fixed input, consists of:

$k_1 = z_a$, farm area land (Ha); $k_2 = z_c$, non-land capital accumulation (Rp)

v = Random variable related to external factor

u = Random variable related to internal factor which influenced profit efficiency level

δ_i = Estimated parameter coefficient

w_i = Variable influencing inefficiency, consists of:

w_1 = irrigation index[1]; w_2 = crop divesification index; w_3 = land conservation index; w_4 = seed technology index; w_5 = credit (Rp); w_6= farmers' formal education level (1 = not graduate elementary school; 2 = graduate elementary school; 3 = graduate junior high school; 4 = graduate senior high school; 5 = diploma; and 6 = undergraduate/post-graduate); w_7 = *dummy* farmers' non-formal education (1 = attended; 0 = not attended); w_8 = input market access index

The stochastic frontier profit efficiency model could be calculated using this formula:

$$PE_i = E\,[\mathrm{Exp}\,(-u_i)|e_i] = E\,[\mathrm{Exp}\,(-\delta_0 - \sum_{i=1}^{n} \delta_i w_i)|e_i] \quad \text{...[09]}$$

Where PE was the ith farm profit efficiency with values between 0 and 1, and had a negative relation with profit inefficiency level. After farm profit efficiency level was known, the profit loss could be calculated using the following formula:

PL = maximum profit (1 – PE) ...[10]

Where PL was the profit loss and PE was the profit efficiency. The maximum profit per hectare could be calculated by dividing the actual profit per hectare with the efficiency level.

Hypothesis on the effect of inefficiency was conducted to test the goodness of fit of the model by looking at the variance σ^2, where $\sigma^2 = \sigma_v^2 + \sigma_u^2$, with the null hypothesis or Ho; $\sigma^2 = 0$, and H_1; $\sigma^2 > 0$. The other hypothesis tested was the value of gamma (γ), where $\gamma = \sigma_u^2/\sigma^2$, Ho : $\gamma = \delta_1 = \delta_2 = \delta_n = 0$ stating that profit inefficiency effects do not exist in the frontier profit function model. The better test used to test for the existence of inefficiency was using the one side generalized likelihood-ratio test using the following formula:

$$LR = -2\{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \quad \text{...[11]}$$

[1] Irrigation index was constructed by land distance multiplied by type of irrigation in score (technical irrigation, semi-technical irrigation, and non irrigated land)

Where L (H_0) and L (H_1) were the value of likelihood function from the null and alternative hypotheses. Ho was rejected if LR > χ2 restricted, and accepted if LR < χ2 restricted.

RESULTS AND DISCUSSION

A vegetable farm profit varied with an average of 101.8 million rupiah per hectare per year. A large variation also occurred on insecticide cost (Rp), land area (Za), and non-land capital accumulation (Zc) (Table 1). These variations may be due to the large gap in land holding causing a larger gap in other variables related to land area, directly or indirectly.

Table 1. Statistical description of variables in the translog profit funtion in vegetable farms in West Java, 2010/2011

Variable	Mean	Std. Dev.	Minimum	Maximum
Profit (π)	101,843,578.16	95,983,248.60	0.00	523,747,619.05
Output price (Py)	4,342.81	1,016.85	2,000.00	8,000.00
Seed price (Ps)	11,937.68	3,240.28	2,550.00	20,100.00
Chemical fertilizer price (Pf)	2,211.79	341.33	1,492.65	3,080.12
Organic fertilizer price (Po)	362.75	86.98	160.00	600.00
Wage (Pw)	16,518.67	3,697.02	9,042.25	29,772.20
Insecticide cost (Pp)	1,974,068.45	2,979,969.72	60,000.00	18,082,150.00
Land area (Za)	0.81	1.90	0.04	18.00
Non-land capital (Zc)	16,969,313.37	47,228,973.66	0.00	533,000,000.00

Factors Affecting Vegetable Farm Profit

According to estimation results (Table 2), the value of generalized-likehood (LR) frontier stochastic profit function is 225.15, with significance at α = 1%. The parameter estimated coefficient sigma squared (σ^2) and gamma (γ) are statistically significant at α = 1%. Parameter gamma coefficient (γ) is 0.9939, which can be interpreted that 99 percent profit variation is caused by efficiency difference and the rest is caused by external factors which are not included in the model. The value of γ is significant and close to one, indicating that the factor affecting profit inefficiency is important.

The estimation result in Table 2 indicates that all the coefficient signs and significance support the hypothesis. These variables include seed price, chemical fertilizer price, and non-land fixed assets which indicate that these variables are important parameters influencing vegetable farm profit. If seed price and chemical fertilizer price increase (decrease), farm profit will decrease (increase), ceteris paribus. Therefore, a policy which can causes a decrease in seed price and chemical fertilizer will effectively increase farm profit.

Meanwhile, organic fertilizer price, despite support of the hypothesis having a negative coefficient, the effect is less significant. Interestingly, wage has a positive sign which does not support the hypothesis and significance (α < 1%). It means that an increase in wage will increase farm profit. This indicates that wage is an important variable in vegetable farming and is still relatively low. The wage variable analyzed is the composite wage consisting of male and female wage. The average composite wage is Rp 16,519 per day work or Rp 3,300 per hour with five hours work per day.

The increase in productive non-land asset utilization will cause an increase in farm profit. This indicates that capital formation is important in farm management since it increases profit. Although farm land has a positive relation with profit, the influence is not significant. In relation to land function, this result must be carefully explained. It does not necessarily mean that land area is not important in increasing farm profit, but there are other variables that have more influence than land area. Insecticide cost is not significant even though the sign is not as predicted. Pesticides are needed in vegetable farming, but the proportion to total cost is relatively small, around 13 percent.

Table 2. Estimation result of vegetable farming profit function parameter in West Java at 2010/2011 using MLE

Variable	Coefficient	Standard Error	t ratio
Constant	-3.7771	3.3483	-1.1281
LPs	-1.9449**	1.0609	-1.8332
LPf	-10.7952***	1.2433	-8.6829
LPo	-0.5209	1.1968	-0.4352
LPw	9.8882***	1.1910	8.3025
LPp	0.5065	1.1380	0.4451
1/2LnPs*LnPs	-0.3538	0.7796	-0.4539
1/2LnPf*LnPf	-7.6612***	1.0570	-7.2483
1/2LnPo*LnPo	0.0752*	0.0475	1.5834
1/2LnPw*LnPw	-1.3235*	0.9462	-1.3988
1/2LnPp*LnPp	0.0304	0.3026	0.1005
LPs*LPf	2.1996***	0.8647	2.5436
LPs*LPo	0.1372	0.4935	0.2781
LPs*LPw	-1.1580*	0.8522	-1.3589
LPs*LPp	1.8335***	0.4167	4.4002
LPf*LP0	0.2455	0.5631	0.4360
LPf*LPw	4.0405***	0.9740	4.1482
LPf*LPp	-0.4298	0.5128	-0.8380
LPo*LPw	-0.3460	0.6082	-0.5690
LPo*LPp	0.0905	0.2500	0.3621
LPw*LPp	-1.5577***	0.4813	-3.2365
LPs*LZa	-0.0638	0.2549	-0.2504
LPs*LZc	-0.1123**	0.0584	-1.9217
LPf*LZa	0.5188*	0.3629	1.4299
LPf*LZc	0.0811	0.0786	1.0315
LPo*LZa	-0.0197	0.1789	-0.1102
LPo*LZc	0.0698*	0.0436	1.6011
LPw*LZa	-0.1734	0.2899	-0.5980
LPw*LZc	0.0142	0.0354	0.3997
LPp*LZa	-0.0127	0.1356	-0.0936

Variable	Coefficient	Standard Error	t ratio
LPp*LZc	-0.0215	0.0341	-0.6307
LZa	0.0200	0.8696	0.0230
LZc	0.4509*	0.2945	1.5311
1/2LnZa*LnZa	-0.0248	0.0772	-0.3211
1/2LnZc*LnZc	0.0027	0.0032	0.8301
LZa*LZc	0.0106	0.0094	1.1203
Parameter Variance:			
Sigma squared (σ^2)	22.5693***	2.0753	10.8751
Gamma (γ)	0.9930***	0.0024	410.9335
Log Likelihood	-239.79	LR	225.1469***

***significant at α = 1% **significant at α = 5% *significant at α = 10%

Vegetable Farming Profit Efficiency Level

Profit efficiency is derived from the translog profit function using a stochastic frontier approach. The vegetable farm profit efficiency level estimated using MLE is shown in Table 3.

Table 3. The range of vegetable farm profit efficiency according to land area in West Java, 2010/2011

Efficiency Level	Strata 1		Strata 2		Strata3		TOTAL	
	n	%	n	%	n	%	n	%
<0.1	5	2.60	1	0.52	1	0.52	7	3.65
0.1-<0.2	14	7.29	3	1.56	1	0.52	18	9.38
0.2-<0.3	9	4.69	3	1.56	2	1.04	14	7.29
0.3-<0.4	13	6.77	3	1.56	5	2.60	21	10.94
0.4-<0.5	13	6.77	5	2.60	3	1.56	21	10.94
0.5-<0.6	5	2.60	9	4.69	8	4.17	22	11.46
0.6-<0.7	10	5.21	8	4.17	13	6.77	31	16.15
0.7-<0.8	9	4.69	11	5.73	19	9.90	39	20.31
0.8-<0.9	4	2.08	9	4.69	6	3.13	19	9.90
Total	82	42.71	52	27.08	58	30.21	192	100.00
Average	0.4175		0.5874		0.6243		0.5260	
Min	0.0000		0.0338		0.0861		0.0000	
Max	0.8858		0.8946		0.8660		0.8946	
Std. Dev.	0.2325		0.2202		0.1810		0.2338	

The average profit efficiency of vegetable farming is low (0.53). Kumbakar and Lovell (2002) have set efficiency criterion at 0.7, it can be concluded that with this rate of efficiency, the vegetable farming in West Java is still inefficient. The range of efficiency index is relatively large from 0 - 0.89. The average vegetable farm profit efficiency level is 0.53, with a tendency to increase with larger land area. The average profit of vegatable farming is relatively high, reaching up to 101.8 million rupiah per hectare per year.

Using the efficiency index criterion of 0.7, only 30.21 percent from all farms is efficient, with a larger portion belonging to strata 3 (13.02 percent) while strata 1 had 10.42 percent and strata 2 only 6.77 percent (Fig. 3). According to the land classification, 22 percent is from the total farms, wherein profit is efficient at strata 1 (small land are). This shows that on small land area there is a possibility to reach a higher efficiency level (small but efficient).

Farms with a 0.5-0.7 efficiency level range are at 27.60 percent, which spreads on every strata and the highest on the large land area (strata 3). Strata 1 (small land area) comprises 7.81 percent while strata 2 and 3 are at 8.85 percent and 10.94, respectively. Overall, farms with less than a 0.5 efficiency level are dominant at 42.19 percent, and the highest percentage belonging to strata 1 (small land area) at 28.13 percent, while strata 2 is at 7.81 percent and strata 3 6.25 percent. Based on the profit efficiency level, it can be concluded that most vegetable farms are not efficient. Most of the inefficient farms belong to strata 1 (small land area). The larger the land farmers own, the higher the profit efficiency level.

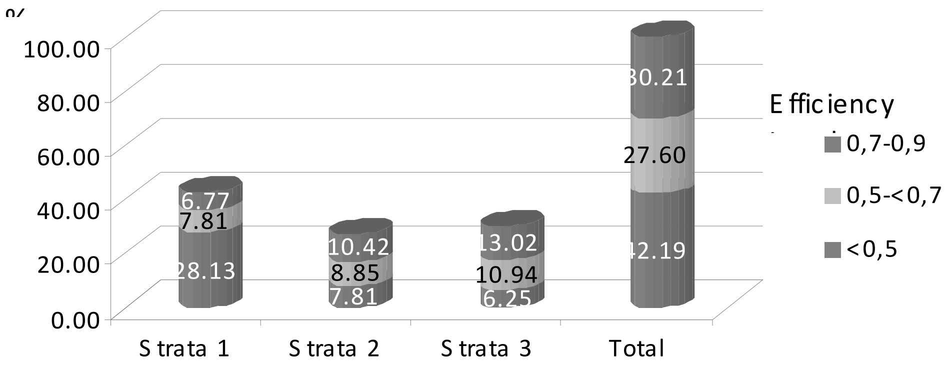

Fig. 3. Farms profit efficiency according to strata in vegetable farms in West Java, 2010/2011

The low profit efficiency level indicates two things: (1) a relatively high profit loss, and (2) big opportunities to increase profit efficiency by analyzing the source of inefficiency.

Source of Profit Inefficiency in Vegetable Farms

Descriptive statistics of every variable affecting profit inefficiency is shown in Table 4. Most of the observed infrastructure indices are less than 0.5, even conservation technology indices and access to input market are less than 0.1.

An estimation of results of factors affecting vegetable farm profit inefficiency are shown in Table 5. All predicted parameters have an expected sign according to the hypothesis, which is negatively affecting inefficiency. The significance level of all parameters, except for irrigation index, is relatively high with a value of less than 1 percent. This indicates that all variables, except for irrigation infrastructure, are very important and affect profit efficiency. In other words, these variables can diminish the inefficiency effect on vegatable farm profit.

Table 4. Descriptive statistics of profit inefficiency parameter in vegetable farms in West Java, 2010/2011

Variable	Mean	Std. Dev.	Minimum	Maximum
Irrigation index (IRIG1)	0.2333	0.2989	0.0000	1.0000
Crop diversification index (SID)	0.5185	0.1050	0.4444	0.6667
Land conservation index (IKON)	0.0431	0.0976	0.0003	1.0000
Seed technology index (ITEKB)	0.3139	0.2861	0.0000	1.0000
Credit[2] (CRED)	4,080,000.00	8,330,000.00	100,000.00	50,000,000.00
Formal education level (EDF)	2.5625	1.0316	1.0000	6.0000
Non-formal education index (EDNF)	0.3802	0.4867	0.0000	1.0000
Access to input market index[3] (AKSIIn)	0.0322	0.1021	0.0000	1.0000

Table 5. Estimation result of vegetable farm profit inefficiency effect in West Java, 2010/2011

InefficiencyVariables	Coefficient	Standard Error	t ratio
Constant	-3.0022***	1.0384	-2.8911
Irrigation Index (IRIG1)	-0.4097	1.0717	-0.3823
Diversification Index (SID)	-7.5507***	1.7594	-4.2916
Conservation Index (IKON)	-5.2317***	1.4532	-3.6001
Seed Tech. Index (ITEKB)	-6.9832***	0.9905	-7.0503
Credit (CRED)	-2.17E-07***	2.01E-08	-10.7853
Formal Education Level (EDF)	-3.9869***	0.2429	-16.4152
Non Formal Education Dummy (EDNF)	-4.0227***	0.8672	-4.6384
Access to Input Market (AKSIIn)	-9.7499***	0.8794	-11.0865

Note : *** significant at $\alpha = 1\%$

Irrigation infrastructure has a negative effect on inefficiency, but the effect is insignificant, different from Rahman (2003), Wadud and Ar Rashid (2011), and van Hoang and Yabe (2012), which show that irrigation infrastructure significantly affect profit efficiency. The average irrigation index is relatively small (0.23) with a high standard deviation of 0.3.

Crop diversification in vegetable farming is already high with a value of 0.52 and farmers in average have planted two crops annually. Crop diversification will impact vegetable productivity, therefore crop diversification will impact farming efficiency. The same was also observed in studies by Rahman (2003), Kolawole (2006), and van Hoang and Yable (2012) which

[2] The credit was measured with the value of loan occupied by the farmer

[3] Market access was measured by an index that is constructed from the input market distance (km) multiplied by the time needed to reach input market (minutes)

emphasized soil fertility. In related to crop diversification, one of the objectives of diversification is to improve and maintain soil fertility. Bravo-Ureta et al. (2006) showed that output diversification can increase a farmer's income. Contrarily, Hyuha et al. (2007) indicated that in the case of paddy farming, profit efficiency is higher for specialized farmers.

The objective of land conservation activity is to maintain and increase land fertility which is important in farming activity. Land fertility will have an impact on input utilization productivity, which will eventually affect farming profit. This research shows that land conservation has a negative and significant effect on profit inefficiency. Bravo-Ureta et al (2006) also found that land conservation can increase a farmer's income. This is result also supported by research conducted by Rahman (2003), Kolawole (2006), and van Hoang and Yabe (2012) which showed that land fertility affects profit efficiency. Ogunniyi (2008) also found that the usage of tillage is one factor which can increae profit efficiency.

The average land conservation index in vegetable farming is relative low with a value of 0.04, with the index ranging from 0 to 1. Therefore, efforts in increasing land conservation must be conducted more extensively. Besides land conservation in the form of terracing, other conservation methods can be conducted by farmers, with the assistance of facilitators and motivation from the government through extension workers.

Seeds are an important input factor and determine producitivity and farming production. The need of seeds does not only concern the quantity, but more importantly the quality. Seed quality is produced through hybrid technology. Accessability to seed technology and affordable prices can allow farmers the incentive to adopt good technology. The adoption of good technology, such as the application of certified seeds, can influence the cost per output which affects farming profit. Therefore, seed technology will impact profit efficiency.

This research shows that seeds have a negative and significant effect on vegetable profit inefficiency, meaning that vegetable profit efficiency is affected by hybrid seed technology utilization. The utilization level of hybrid seeds in vegetable farming is still relatively low as indicated by the average of seed technology index of 0.3, with a scale of 0 to 1. The low seed technology index is caused by the limited availability of good seeds and unaffordable prices. Therefore, steps must be taken to increase seed availability so it can be accessed by farmers at an affordable price.

Agricultural credit is important since it increases input utilization efficiency, influencing farming productivity. At a certain input and output price, increase in productivity caused by credit support can increase farming profit. This research shows that agricultural credit has a negative and significant effect on profit inefficiency. The increase in credit amount can increase farming profit efficiency. Other research also supporting our result include Hyuha et al. (2007), Kolawole (2006), Abu and Asember (2011), and Ogunniyi (2008). The difference is that this research utilized the amount of credit, meanwhile the other four studies used credor access variable using dummy variable. But it generated similar results that indicate credit can increase profit efficiency.

A farmer's formal education level is related to the ability of a farmer to manage his farm. Therefore, formal education level is predicted to affect profit efficiency. This research prooves that a farmer's education level has a significant effect and increases farming profit efficiency.

Other research also generated similar results, such as Nganga et al. (2010), Hyuha et al. (2007), Rahman (2003), Kolawole (2006), Ogunniyi (2011), and Abu and Asember (2011). Therefore, an effort to improve farmer education is a must. One way is to increase investment on education through allocating a larger budget for education.

The ability of a farmer to manage his farm not only depends on formal education level, but also on non-formal education. Non-formal education includes involvement in extension activities, communication with extension workers, training, and others. Those forms of non-formal education deliver practical and specific knowledge, and skills according to the farmer's needs. Therefore, farmers with non-formal education have higher managerial skills, so they manage their farms more efficiently. Previous research has also proved that non-formal education, with various terms, significantly increase profit efficiently (Hyuha et al. 2007; Kolawole, 2006; Karafillis and Papanagiotou, 2009; Ogunniyi, 2011; Abu and Asember, 2011).

Access to input markets tend to help farmers purchase input at the right quantity, time, and price. Purchasing input correctly leads to an increase in input utilization efficiency. Therefore, an access to input market is predicted to affect farming profit efficiency. This research prooves that access to input market has a significant effect on profit efficiency. Other studies support this conclusion, such as Wadud and Ar Rashid (2011).

Vegetable Farming Profit Loss

The low vegetable farming profit efficiency level indicates the existence of a relatively large profit loss. The indication of profit loss is also a chance to improveme by looking for the source of profit loss. Generally, profit loss is higher at a lower efficiency level (Table 6) and profit loss is also negatively related to farming actual profit.

Table 6. Profit loss according to profit efficiency level on vegetable farming in West Java, 2010/2011.

Efficiency Level	n	%	Actual Profit (Rp/Ha/Year)	Profit Loss (Rp/Ha/Year)
<0.1	7	3.65	10,973,365	146,635,834
0.1 - <0.2	18	9.38	25,666,096	146,641,626
0.2 - <0.3	14	7.29	40,138,364	113,035,468
0.3 - <0.4	21	10.94	51,589,350	91,588,715
0.4 - <0.5	21	10.94	62,476,794	74,449,413
0.5 - <0.6	22	11.46	80,698,188	68,860,682
0.6 - <0.7	31	16.15	126,079,224	67,795,358
0.7 - <0.8	39	20.31	144,485,179	47,553,307
0.8 - <0.9	19	9.90	249,426,292	45,654,842
Total	192	100.00		
Mean			101,843,578	78,509,945
Min			0	18,983
Max			523,747,619	455,246,803
Std. Dev.			95,983,249	62,246,926

The average vegetable farming profit loss is relatively high reaching up to 78.5 million rupiah per hectare annually. This shows that there is still a relatively high profit potential to be obtained by farmers if vegetable farming is conducted technically and allocated efficiently. The increase in infrastructure is one of the methods needed to increase profit efficiency. Therefore, an important implication of this research is the need for gradual and continuous infrastructure improvement.

CONCLUSION

Factors affecting vegetable farming profit are seed price, chemical fertilizer price, wage, and non-land capital accumulation. Wage has a positive effect on profit, indicating the importance of labor (labor intensive) and can be substituted with other input, including machinery. Vegetable farming has not reach efficient profit. Profit efficiency increases with increase in land area. The low level of vegetable farming profit efficiency (0.53) causes high profit loss. An increase in crop diversification, land conservation, seed technology adoption, credit, formal and non-formal education, and an access to input market are very effective in increasing vegetable farming profit efficiency.

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REDUCING THE DEPENDENCY ON RICE AS STAPLE FOOD IN INDONESIA – A BEHAVIOR INTERVENTION APPROACH

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ABSTRACT

A study was conducted to investigate factors influencing high consumption of rice in Indonesia and to conduct intervention strategies for reducing the high consumption of rice. In the first phase, 821 Indonesian participants were asked to fill in a questionnaire about knowledge and beliefs about rice as staple food. Most participants are unaware about the importance of reducing rice consumption. There were also several wrong beliefs found about consuming non rice as staple food. In the second phase of the study, 119 students, 44 housewives and 17 office-workers were involved in a campaign program to educate the participants about relevant knowledge concerning rice consumption. Knowledge about food and the awareness of reducing rice consumption of participants were increased after the campaign. In the third phase, 5 families (17 participants) were involved in a food provision program. For 21 consecutive days they were provided with various non-rice menus for their breakfast. Result shows that there was no intention of the participants to change their food choice after the food provision was over. We conclude that behavior intervention that is effective in reducing rice consumption in Indonesia is in the form of campaign; consist of importance of reducing rice consumption, food security that is alarming in Indonesia, and advantage of consuming non rice as staple food.

Key words: rice consumption**,** intervention, campaign, food provision

INTRODUCTION

As reported by FAO and the International Rice Research Institute (IRRI), Indonesia is recorded as a country that has high rice consumption per capita (*i.e.*, 139 kilograms per year in 2008; IRRI, 2008). The picture of Indonesian rice consumption has not changed for years, while other countries such as Malaysia and Japan have succeeded in reducing their rice consumption (*i.e.*, Malaysia has reduced its rice consumption to 80 kilograms per capita per year, and Japan consumes only 60 kilograms of rice per capita annually (IRRI, 2008). Ironically, as a rice producing country, Indonesia is also the biggest rice importer country in the world since 2009. If this condition continues, Indonesia will face a serious problem on food security. Food security is defined as "*a condition when all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preference for an active and healthy life*" (World Food Summit, 1996).

High dependency on rice as a staple food has several negative effects (Hariyadi, 2009). First, it could be a constraint for the development of local food resources which gave implications on less research investment into non-rice-based foods. Second, obtaining food security with one or two food items can be viewed as a vulnerable point of national security. Third, other kinds of food need to be promoted as staple food because rice supplies are likely to be decreasing from time to time. The poor condition of food security in Indonesia is becoming worse as Indonesia suffers from high population. The Indonesia Statistical Bureau reported that Indonesia has already more than 250 million people (Indonesia Statistical Bureau, 2010). With a population of more than 250 million people and still depending on imports to fulfill its need for staple food (*i.e.*, rice), food security in Indonesia is alarming.

To solve food security problem, besides attempting to increase domestic rice production, the Indonesian government is trying to implement a program to socialize the idea of food diversification program. Food diversification means having the presence of a broader food variety. It could also mean the enhancement of food availability, accessibility and stability (FAO, 2008). Considering the importance of food diversification, effort for food diversification has been invested for years in many countries such as Japan (Uehara, 2012). As a matter of fact, Indonesia has a big opportunity to reach its national food security by implementing food diversification. Almost every region in Indonesia has their own potential traditional staple food; some are even easier to grow than rice, such as corn in the islands of Maluku and cassava in Papua. Therefore, it is obvious that there is a huge possibility to reorient the regional food development to obtain food diversification in Indonesia.

However, several researchers have identified the cause of food diversification program failure in Indonesia. Handewi and Ariani (2008) underlined the importance of more comprehensive human resource development in the fields of food and nutrition science/technology through education and training. Cahyani (2010) noted that food security program in Central Java has not been going well because it is hampered by a culture which regards rice as the one and only main staple food. To be able to change this culture, Cahyani said that changing the mindset of the people plays a very important role. Arifin (2009) also pointed out that the public's virtual addiction to rice is effectively a cultural barrier to food diversification. There is a common belief that rice has to be eaten every day, even if alternative foods such as bread, corn, cassava or potatoes are readily available. Eating rice is also seen as a status symbol, while cassava is generally associated with poverty. Based on these reasons mentioned above, it could be hypothesized that the root problem of unsuccessful food diversification programs in Indonesia might have something to do with cultural and psychological barriers.

Food has for a long time been assumed to have a role in society beyond just filling empty stomachs – it has several meanings for an individual such as a statement of the self (*i.e.*, food provides information about the individual's identity) and social interaction (*i.e.*, food is a social symbol of social worth (Wolf, 1990). Food is also viewed as a common tool to communicate with the family and as cultural identity (Todhunter, 1973). The meaning of food can be seen from the choice of food made by people. Several decades ago, Davis (1928, 1939) proposed that food choices are influenced by cognitive factors (include attitudes, social norms and perceived controls), psycho-physiological factors (include neurochemical senses, chemical senses, food availability and mood, and stress) and developmental factors (include food exposure, social learning, and associative learning). In addition, Pike and Ryan (2004) include awareness, knowledge, or beliefs about food in cognitive aspects. However, cognitive approach to food choice has been criticized for its focus on individual variables, rather than other social variables (Ogden, 2010). Among psycho-physiological factors, big attention is given to food availability (*i.e.*, the physical presence of food when it is needed) as something that could highly influence the food choice. In relation with developmental factors, food exposure in particular, Birch and Marlin (1982) stated that exposure for more than 8 or 10 times during 6 weeks period could change the preference significantly. Furthermore, Williams et al. (2008) also mentioned that the impact of food exposure is accumulative. Related to developmental factor - social learning, Davis (1928) stated that social learning refers to the influence of observing other people's behavior on one's own behavior and also known as modeling or observational learning. It has to do with roles of peers, parents, and the media. Developmental factor - associative learning, refers to the impact of contingent factors on behavior such as food paired with rewards, food used as rewards, and food paired with the physiological consequences.

Food choice as well as eating behavior is evidently very difficult to alter because so many factors influence it. Buttriss et al. (2004) reviewed various methods to change food choice and eating behavior, and stated that intervention is one of the most common method used among any other methods. Intervention has four key issues to be addressed (Steg and Abrahamse, 2010), those are identification of the behavior to be changed, examination of the main factors underlying this behavior, application of interventions to change the relevant behavior and their determinant, and evaluation of intervention effects on the behavior itself. The choice of intervention strategies will be based on feasibility, cost-effectiveness, and availability of resources. Intervention could be in the form of persuasive communications, perhaps in the form of newspaper ads, flyers distributed in certain neighborhoods, or TV service messages. Other alternatives are face-to-face discussions, observational modeling, or any other applicable method.

This study sought to implement behavior intervention to reduce rice consumption in Indonesia. Then, the implemented behavior intervention is evaluated to choose the best intervention to be suggested to Indonesian government regarding rice consumption in Indonesia. The study was conducted in three consecutive phases. In the first phase, perception toward rice as staple food and the psychological barriers of reducing rice consumption among Indonesians were investigated using a questionnaire that was specially designed for the purpose of this research. The first phase of the study was started with hypotheses that there were wrong beliefs about rice as staple food that could be observed and intervened. The results of the first phase study were used as bases in designing and formulating an information campaign program for students, workers, and housewives (*i.e.*, the second phase of the study) and also as bases in implementing behavior intervention in the form of food provision (*i.e.*, the third phase of the study).

MATERIALS AND METHODS

The three consecutive phases of the study can be summarized as can be seen in Table 1.

Table 1. Three phases of the present study

	Survey	**Information Campaign**	**Behavior Intervention**
Participants composition	266 housewives 267office-workers 288 students	119 students 44 housewives 17 workers	17 family' members (from 5 different household)
Sampling method	Random sampling	Purposive sampling	Purposive sampling
Procedure	Questionnaire, interview	Information campaign	Food provision

Survey on perception of rice as staple food

The first phase of the study was aimed to investigate knowledge and belief toward rice and rice consumption as staple food. A survey was conducted to collect epidemiological data and information regarding the participants' eating habits, their knowledge on rice and non-rice foods, and their belief and attitudes toward consumption of non-rice foods.

Participants

Eight hundred and twenty one participants (mean age = 33.45, SD = 14.3, 574 female) –were participating voluntarily in this study. They were 266 housewives, 267 office-workers (144 female), and 288 students (166 female). Large number of participant is involved in this first phase to achieve representative data of baseline study. The reason for including students in this study, in particular student in junior high school and university students is because these students has already have power to make decision about type food they want to consume. For workers, we included this group as work place is an attractive setting for food choice interventions, as a wide target group can be reached and a supportive environment can be provided. Whereas reason for including family in particular for food provision was because food decision-making processes interact with family and community environments to shape families' thinking (*i.e.*, their constructed reality) about food, eating, health, and well-being as discussed by Gillespie and Gillespie (2007). Each category of participants was represented by three different social classes (*i.e.*, low, middle and high social classes, based on categorization of world bank as follows: low class spend less than US $ 2 per day, middle class spend US $ 2-20 per day, high class spend more than US $ 20 per day; The World Bank, 2010).

Procedures and Materials

A number of data collectors visited local communities of housewives, workplaces and schools from 3 different social classes in three regions of Java Island, with Kediri and Lamongan as representatives of East Java, Yogyakarta as a representative of Central Java, and Bandung and Garut as representatives of West Java. Java is selected as location of study due to the fact that most Indonesians live in Java and staple food in Java is rice. The sampling method used was purposive sampling and the participants were asked to sign an inform consent prior to the study begins. Following this, a set of questionnaires were given to be filled-in by the participants. For some low social class participants, the data collectors read the questions and wrote down the participants' answers (*i.e.*, it was more or less like a semi-structured interview).

The questionnaires were carefully designed by the researchers, especially to be able to capture the existing condition of the participants' demographic characteristics, eating habits, food choices during meal time, knowledge about the varieties of Indonesian staple foods and belief toward consumption of non-rice meal. A construct validity testing was performed to validate the questionnaires. A number of experts in the field of psychology were asked to discuss the questionnaire until reaching an agreement that the items used in the questionnaires could really measure the construct being studied.

Information Campaign

Based on the results of the study in the first phase, an intervention program in the form of a campaign was developed to change the knowledge and belief towards rice and the consumption of rice among students, housewives, and office-workers. The campaign also intended to promote the consumption of non-rice food as an alternative staple food.

Participants

A total of 180 participants were participated in the second phase. They were 119 students (mean age = 15.9, SD = 2.9, 48 female), 44 housewives (mean age = 51.6, SD = 7.3) and 17 workers (mean age = 39.2, SD = 10.6, 6 female). Number of participants in the second phase is limited compared to the first phase due to technical reason. The "pretest-posttest within subject" experimental design was used to measure the difference between the participants' knowledge and belief towards the consumption of non-rice food before and after the campaign. Purposive sampling was implemented in selecting the participants.

Procedure and Materials

The participants were gathered in a room. First, they were asked to fill out a pre-test questionnaire. The pre-test questionnaire measured the participants' knowledge and belief about rice consumption. Next, a presenter stood up in front of the room and presented a short lecture (about 30 minutes) using a set of power-point slides entitled "Reducing rice consumption". The short lecture contained about: fact about rice (*i.e.*, nutritional facts of rice, glycemic index of rice, diseases and several negative impact of rice over-consumption such as diabetes and obesity), Indonesian food security that is alarming, alternative staple foods available in Indonesia (e.g., potato, cassava, and corn) and incorrect beliefs about eating non-rice food (*i.e.,* feeling hungry, dizzy, weak, and have not eat yet if not consuming rice). In addition, the short lecture also encourages people to reduce frequency of rice consumption from three to two times a day, as well as reducing portion of rice in each meal. The content of the campaign was cautiously prepared and tested in various ways regarding its clarity, and delivered attractively with nice sense of humor by a psychologist who has his own experience in reducing rice consumption,

The participants were allowed to ask questions during and after the campaign presentation. This short lecture and question-answer session were meant to as an intervention to promote the participants knowledge and belief toward non-rice consumption. After the short lecture and question-answer session is over, the participants were asked to fill-in a post-test questionnaire, similar to the one they have filled-in before the presentation. At the end of the campaign program, participants were asked whether they have intention to eat rice twice a day for the next three months. This question is intended to measure changes of intention after intervention. In the question, "the next three months" is included to give time horizon to participant to avoid ambiguity of participants about duration of intention.

Behavior Intervention

Since food availability was hypothesized to play an important factor in food choice, food provision would be the third phase of the study. In this phase, the participants were provided with non-rice meals for their breakfast in 21 consecutive days.

Participants

Five families (17 participants in total) participated in this study, consisted of seven adult male (mean age = 31.43 year, SD = 15.63), five adult female (mean age = 49.80 year, SD = 7.16), and five teenage female (mean age = 18.2 year, SD = 8.7). Number of participants in the third phase is limited due to technical reason. The "pretest-posttest within subject" experimental design was used to measure the difference between the participants' knowledge and belief attitude towards non-rice consumption before and after food provision, as well as intention to consume non-rice as staple food. Purposive sampling was implemented in selecting participants.

Procedure and Materials

Before the food provision session begins, the participants were gathered in a room and an inform consent was signed. In the beginning of this phase, for a period of six days, they were asked to write down their daily food choice in a diary (provided by the researcher) and to rate (on a five-point scale) their feelings (*i.e.*, feel full, feel hungry, feel dizzy, and feel as if they have not eaten yet) toward the food they chose to eat. Starting from the seventh day, for 21 consecutive days, the participants were provided with one non-rice meal menu for breakfast. The non-rice food menus provided for the participants are as follows: macaroni soup + vegetables + milk for first day, sandwich + chicken fillet for second day, fried noodle + meat balls + egg + vegetables for third day, baked potato + cheese for fourth day, baked of mixed cassava, corn, cheese, and carrot for fifth day, fried potato + egg for sixth day, misoa for seventh day. The menus were repeated every 7 days. They were asked to consume the provided meal at their breakfast and were also asked to write down how they felt about the specific meal provided. The non-rice meal provided for the participants at their breakfast time was chosen based on their preferences (as found out in the first phase of the study). They were allowed to consume any meals they like (either rice or non-rice meal) for lunch and dinner. They were also asked to write down their choice of food and their feeling toward the chosen food in each lunch and dinner. In the end, after 21 days of food provision, the participants were asked again to write down their intention to consume non-rice as staple food, their food choice, for breakfast, lunch and dinner; and complete the diary with a note about how their feelings are toward those chosen food.

Statistical analysis

The data obtained in this study were analyzed by using SPSS (version 16.00). Data in the first phase were statistically analyzed by using descriptive analyses. Paired t-test was used to analyze differences between before and after campaign. Behavior intervention data was analyzed using non-parametric test Kruskall-Wallis.

RESULTS AND DISCUSSION

Survey of perception of rice as staple food

Knowledge and belief toward rice and rice consumption as staple food for students, workers, and housewives can be seen in Table 2.

Table 2. Knowledge and belief toward rice and rice consumption as staple food for students, workers, and housewives

	Student	**Housewives**	**Workers**
Frequency of eating rice 3 times a day	60%	56.8%	58.8%
Opinion about rice consumption level in Indonesia	very high (30%) high (11%) average (59%)	very high (54.6%) high (34.1%) average (11.3%)	very high (64.7%) high (17.6%) average (17.7%)
Awareness to decrease rice consumption	51.9% is unaware	45.5% is unaware	58.8% is unaware
Wrong beliefs about non-rice as a staple food	69 % feel still hungry 27% feel dizzy 61% feel they have not eaten if they did not eat rice.	60% feel still hungry 27% feel dizzy 59% feel they have not eaten if they did not eat rice.	51 % feel still hungry 25% feel dizzy 63% feel they have not eaten if they did not eat rice.

The main findings of the survey showed that students, housewives, and workers gave similar pictures. In general, they rely on rice as staple food. They consume rice for breakfast, lunch, and dinner. The main reason for choosing rice for the main menu is habit. Most participants have knowledge that rice consumption in Indonesia is on high or very high level, however, their awareness that rice consumption must be reduced is lacking.

Results of the first study shows that problem in reducing rice consumption in Indonesia is related to the awareness that rice consumption must be reduced and wrong beliefs about consuming non-rice as staple food. Therefore, attempts to increase the awareness to reduce rice consumption are playing an important role in reducing rice consumption in Indonesia.

Information Campaign

Differences between before and after campaign for each category (students, housewives, workers) can be seen in Table 3.

Table 3. Differences between before and after campaign for each category (students, housewives, workers)

	Students	Housewives	Workers
Food knowledge	$t(118) = -11.99$, $p < .001$*	$t(42) = -3.67$, $p = .001$*	$t(16) = -0.48$, $p > .01$
Awareness to reduce rice Consumption	$t(118) = 6.30$, $p < .001$*	$t(42) = 1.15$, $p > .01$	$t(16) = 0.12$, $p > .01$

*significant with α=0.05 based on paired t-test

Table 3 shows that for each group (*i.e.*, students, workers, and housewives), food knowledge was better after campaign. However, the increased awareness to reduce rice consumption was only found in student participants. The absence of increased awareness in workers could be influenced by the food pattern they possess. Workers eat only twice a day, because they skip lunch time in work hour (as lunch had to be paid by themselves) in order to save their money. As they have already eat rice twice a day, it is likely that the awareness to reduce rice consumption is absent. They have already aware to reduce rice consumption for different reason. The absence of increased awareness in housewives could be related to uncontrollable factors during campaign and the process of filling-in the questionnaire. Some of them had difficulties in reading and filling-in out the questionnaire. They were not prepared to do reading, writing, and did not bring their eyeglasses. This made them unable to answer the questionnaire properly and completely.

Behavior Intervention

Non-parametric test Kruskall-Wallis was applied in analyzing participants' feelings (*i.e.*, feel hungry, feel dizzy, feel as if have not eaten yet) after every breakfast, lunch, and dinner. As already been noted earlier, only at breakfast time participants were provided non-rice food. Result shows that among 17 participants of food provision, the only feeling that differs statistically significant among breakfast, lunch and dinner time was feel hungry ($p < 0.001$). Whereas feel dizzy and feel as if have not eaten yet does not differ statistically significant among the three meal times. Nonparametric Mann-Whitney test was conducted to analyze the difference between food choice before and after food provision. There was no significant difference on food choice before and after intervention.

The feeling of have not eaten yet and dizziness (that are common incorrect beliefs about eating non-rice food) was not shown for both rice eaters and non-rice eaters during food provision. This indicates wrong beliefs in Indonesians that eating non-rice staple makes them dizzy, give a feeling of have not eaten yet, and make someone weak. However the feeling of hunger was significantly different between rice consumption and non-rice consumption, in which most people feel hungrier when consume non rice than consume rice.

General discussion

In general, regarding intervention that is implemented in this present study, the importance of campaign to increase knowledge and awareness of Indonesian about reducing rice consumption are also realized by the Indonesian government. The Indonesian Minister of Agriculture, who supports such moves, was quoted as saying: "There's a saying in Indonesia that if you haven't eaten rice during the day, you haven't eaten at all. So we need to educate our population". Related with educating people in particular campaign in Indonesia, Taylor (2012) stated that material of campaign of reducing rice consumption is usually difficult to be understood. In the present study, campaign in the present study was prepared with cautions, tested in various ways regarding the clarity, and delivered attractively by a psychologist who has his own experience on reducing rice consumption, equipped with a nice sense of humor. The campaign material and ways of delivering the material plays an important role for a successful campaign.

Related to food provision, there was no significant difference on food pattern before and after food provision. This result indicates that food provision did not influence willingness to consume non rice as a staple food. This result could be explained based on duration of food provision. Lally *et al.* (2010) in their series of experiment found that the average time to create a habit was 66 days, but the range was from 18 to 254 days. They argued that only one literature related with this issue was found, that was Ronis et al. (1988), who argued that a behavior is habitual once it has been 'performed frequently (at least twice a month) and extensively (at least 10 times)' (p. 213). Lally et al. continued to argue that it is likely to take much longer than this for a repeated behavior to reach its maximum level of automaticity. Since the duration of food provision in this study is 21 consecutive days, it seems that duration plays an important role in this study. However, it should be underlined that 21 days is still in the range mentioned by Lally et al.. Other studies also used short range for food intervention, such as 25 days (Normand and Osborne, 2010), result in significant differences between before and after intervention.

Related with food availability and food preferences, as seen from the food provision that has not succeed in changing intention, availability of non-rice food was the only factor that influences willingness to consume in housewives. It could be understood as it is very common in Indonesia that housewives are the ones responsible for providing food to their family.

Based on literature study and questions has been asked in questionnaire of this study, other factors than availability of non-rice food that influence reducing rice consumption in Indonesia are culture and socio economic status. Although at the first time we hypothesized reducing rice consumption in Indonesia is hampered by culture (collective wrong belief that rice has to be eaten every day and rice is a symbol of status), this wrong belief can be minimized via campaign of reducing rice consumption. This fact can be found in all type of economic status (low, middle, and high income class).

Although such programs have been tried for decades in Indonesia, rice consumption continues to rise with the growing population and attempts to get people to cut back on it have never worked before. With regards to Indonesian government effort to reduce rice consumption in Indonesia, it should be underlined that the most important factor that influences rice consumption is awareness that rice consumption must be reduced due to food security and healthy reason. One day no rice (ODNR) campaigns might not be effective as it seems too difficult for Indonesians to spend one day without rice. This fact is supported by the Indonesian government whose admits that ODNR was not successful in reducing rice consumption in Indonesia (Hidayat, 2012). Based on the result of present study coupled with failure of Indonesian government in reducing rice consumption in Indonesia, it is likely that the most effective way in reducing rice consumption in Indonesia is by reducing the frequency of rice consumption a day (e.g., from three times to be twice a day) or reducing the portion of rice each time the Indonesians eat.

This study is the first study on behavior intervention for changing food preference or reducing rice consumption in a large society to address food security issues in Indonesia. Results of this study could be proposed to be as a model for other countries that also have the problem on reducing rice consumption and intend to obtain food security through reduction of rice consumption. Knowledge management related to reducing rice consumption in Indonesia will studied further in order to maintain the results of this present study.

It is expected that the results of this study could be implemented in a broader area in Indonesia, and finally, the love affair between Indonesian people and rice could be broken up, and the ultimate objective related to food security could be reached. Moreover, Indonesian people (especially in rural areas) are expected to be able to increase their income and poverty will be reduced.

This study has several limitations. First, the study is restricted to Java Island, whereas other main islands in Indonesia were not covered. However, as Java has the highest population density in Indonesia and major ethnic group lives in Java, we could assume that the results of the same study conducted in another island than Java might reveal almost similar results. Second, the group involved in this study was restricted to students, workers, and housewives. Considering other groups than the three groups would valuable for drawing further conclusions.

CONCLUSION

This study shows that behavior intervention is effective in reducing rice consumption in Indonesia in the form of information campaign; consist of importance of reducing rice consumption, food security that is alarming in Indonesia, and advantage of consuming non rice as staple food. Food provision gives no significant result compared with information campaign in reducing rice consumption.

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SOME PHYSIOLOGICAL CHARACTER RESPONSES OF RICE UNDER DROUGHT CONDITIONS IN A PADDY SYSTEM

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ABSTRACT

The most serious impact of climate change is the El Nino phenomenon that creates increased drought in paddy systems. Drought is the most important limiting factor for the sustainability of rice production. This research aimed to identify the physiological character of drought tolerant rice varieties in a paddy system under greenhouse conditions. The experimental design used was split plot design with three replications, with drought stress as the main plot and variety as sub-plot. The main plots consisted of a control (normal irrigation) and drought stress (drought imposed three weeks after transplant up to harvest). The sub-plots consisted of eight rice varieties: IR 64, Ciherang, IPB 3S, Way Apo Buru, Jatiluhur, Menthik Wangi, Silugonggo, and Rokan. Results showed that drought stress led to a decrease in grain yield per hill, chlorophyll a content and chlorophyll a/b ratio, and an increment of proline and total sugar accumulation. Tolerant varieties (Ciherang, Way Apo Buru and Jatiluhur) accumulated proline over a longer time and increased accumulation of total sugar at the stage of pre anthesis. Jatiluhur varieties showed less reduction in grain yield under drought stress (40.7%) than other varieties. Less reduction in grain yield under drought stress, accumulation of proline in a longer time, and an increased total sugar accumulation at anthesis phase during drought were physiological characters that played an important role in tolerance to drought stress in paddy systems.

Key words: chlorophyll**,** proline, starch, total sugar

INTRODUCTION

Drought is the most important limiting factor affecting rice production. This has become a problem for rice developing countries all over the world (Passioura, 2007). Currently, the situation has become more severe by climate change (Kawasaki and Herath, 2011; Prasad et al., 2012). Rice is a semi-aquatic plant that grows normally in flooded conditions. However, almost 50% of the paddy field system does not have sufficient water for irrigation. Therefore, a serious drought problem can affect rice production and quality.

The most serious impact of climate change is the El Nino phenomenon that results in an increased drought in paddy systems, which can occur when soil water content drops below saturation.

Rice has a variety of mechanisms by which it reacts to such conditions. Analysis of data on the impact of drought on paddy systems showed an increasing trend of total area affected by drought reaching 230.000 and 400.000 hectares in 2010 and 2011, respectively (Department of Agriculture, 2011).

Planting rice in the Asian region generally follows a bimodal rainfall pattern, thus drought stress during the growing season can be classified into 3 types, namely drought stress: early in the growing season (early stress), in the middle of the growing season (mild - intermittent stress), and in the late growing season (late stress) (Chang et al.,1979).

The response of rice plants to drought depends on the time and periods of drought associated to the growing phase (Fukai and Cooper, 1995). This suggests that drought stress at different growth stages of rice will show a different response. Rice plant growth include three main phases, namely vegetative, reproductive, and maturation (De Datta, 1981). Wopereis et al. (1996) described the effect of the early phase of drought stress on vegetative tiller growth and delayed flowering. In the reproductive phase, especially during flowering, it is known to be sensitive to drought, followed by gametogenesis (booting) and grain filling. Drought also affects the reproductive phase wherein there is an increase in percent empty grains and a decrease in grain weight causing a decrease in yield.

Rice sensitivity to drought increases when drought happens during the vegetative and flowering period. This leads to a decrease in seed production (O'Toole, 1982). Plant's response to drought stress can be analyzed through identification of characters that play an important role in drought tolerance. Analysis can be done at the morphological, physiological, cellular, biochemical, and molecular levels. Drought response at the cellular stage depends on the plant stage when drought occurs, duration of drought, and plant species (Prasad et al., 2012).

An important physiological response of plants to drought is its ability to maintain turgor pressure by reducing osmotic potential as a tolerant mechanism. The decrease in osmotic potential and the ability to accumulate soluble compounds help maintain turgor pressure. In the process of osmotic adjustment, the soluble compounds that are usually accumulated are sugar and amino acids, especially proline (Girousse et al*.,* 1996; Szabadoz and Savoure, 2009). Studies show that drought can accelerate senescence and remobilize assimilation in the stems to the seeds in cereal crops (Yang et al., 2001; Yang et al., 2003).

Tubur et al. (2012) reported that some varieties have a high tolerance to drought. Paddy rice and upland rice varieties are divided into three groups: tolerant varieties (Ciherang, Jatiluhur and Way Apo Buru), moderate (IPB 3S and Silugonggo), and susceptible varieties (IR 64, Menthik Wangi and Rokan) to drought.

The same varieties were also used by Supijatno et al. (2012) who reported that Jatiluhur variety was more efficient in water use than other varieties. Jatiluhur variety had a better yield and used less water per unit of yield. Further research is also needed to examine important physiological characteristics associated with drought stress tolerance. This research aimed to identify the physiological characters of drought tolerant rice in a paddy system under greenhouse conditions.

MATERIALS AND METHODS

This experiment was done in a plastic house at the Rice Research Bogor Agricultural University in 2012. Plant material used are IR 64, Ciherang, IPB 3S, Way Apo Buru, Jatiluhur, Menthik Wangi, Silugonggo, and Rokan rice varieties. Fertilizers used are 37.5 kg of N ha^{-1}, 36 kg of P_2O_5 ha^{-1}, and 60 kg of K_2O ha^{-1}, that were applied one week after planting. In addition, 37.5 kg of

N ha^{-1} was applied five and nine weeks after planting. Tools used for this research were a tensiometer (DIK-3151) and thermohygrometer (TL 8010).

The experiment was arranged in a split plot design with three replications. The main plots consisted of control (normal irrigation) and drought stress (drought imposed at three weeks after transplant up to harvest). The sub-plot consisted of eight rice varieties namely: IR 64, Ciherang, IPB 3S, Way Apo Buru, Jatiluhur, Menthik Wangi, Silugonggo, and Rokan.

Rice seeds were put in the oven for 72 hours in 43^0 C for uniformity of germination. After which, seeds were soaked in water for 5 hours and kept in a sealed and cool bag for 2 days. Seeds were planted in seedling trays until 12 days. Eight varieties were planted in every main plot. Thirty plants were planted in each sub-plot in 2 rows with a 20 cm x 20 cm spacing between each plant. Spacing between each variety was 25 cm. For the control, irrigation was given close to harvest, with water level kept 2.5 cm above ground. The water level was maintaned during the vegetative growth, pre-anthesis, grain filling to harvest for the control treatment, by making a canal inlet and outlet. For drought treatment, irrigation was stopped at three weeks after transplant up to harvest.

Laboratory analysis involving physiological character of proline was based from Bates et al. (1973). The anthrone method was used to determine carbohydrate using a spectrophotometer (UV-vis Shimadzu UV 1800) (Hodge and Hofreiter, 1962). Proline accumulation was measured when the plant was at 11 and 13 weeks after transplanting (stage of reproductive), while total sugar accumulation and starch was measured during anthesis and at harvest. Chlorophyll a, chorophyll b, and the chlorophyll a/b ratio were measured when the plants were 11 weeks after transplant (reproductive stage). Yoshida et al. (1976) method was used to determine chlorophyll content using a spectrophotometer (UV-vis Shimadzu 1201). Data were analyzed for significance by analysis of variance in the level of $\alpha = 0.05$ using LSD analysis.

RESULTS AND DISCUSSION

Physiological Character of Drought Tolerant Varieties

Chlorophyll content

Drought stress has a significant effect on chlorophyll a content of all varieties. Meanwhile, drought stress and variety show significant differences in decreasing chlorophyll a/b ratio (Table 1). Anjum et al. (2003) and Farooq et al. (2009) reported that drought in several plant species can cause a change in the chlorophyll a/b ratio and carotenoid content. A high chlorophyll a/b ratio was found in Silugonggo, followed by IPB 3S varieties. The value of the chlorophyll a/b ratio depends on the chlorophyll a and chlorophyll b content of each variety.

Table 1. Average chlorophyll-a and a/b content of eight varieties under drought stress

Treatment	Chlorophyll-a	Chlorophyll-a/b
Drought stress	------------- mg.g^{-1} FW	------------
Control	3.41 ^{a}	3.29 ^{a}
Drought stress	2.75 ^{b}	2.16 ^{b}
Variety		
IR 64	3.21 ^{a}	2.56 ^{b}
Ciherang	2.78 ^{a}	2.49 ^{b}

Treatment	Chlorophyll-a	Chlorophyll-a/b
IPB 3S	2.96 a	2.91 ab
Way Apo Buru	2.93 a	2.62 b
Jatiluhur	2.90 a	2.55 b
Menthik Wangi	2.81 a	2.50 b
Silugonggo	3.83 a	3.44 a
Rokan	3.28 a	2.74 b

Note: Values followed by the same letter in the same column are not significantly different according to LSD analysis at *P<5%*

Chlorophyll b content is affected by the interaction of drought stress with variety (Table 2). Drought stress causes an increase in chlorophyll b. Rokan, followed by Jatiluhur, and then IR 64 varieties contain higher chlorophyll b than other varieties. In more severe stress conditions, namely drought at three weeks after transplant until harvest led to a greater decrease in chlorophyll. This indicates that drought stress caused a strong loss of photosynthetic reaction centers. An increase in chlorophyll-b causes the chlorophyll-a/b ratio to decrease. Chlorophyll b serves as an antenna that collects light and transfers to the reaction center. Composed of a reaction center chlorophyll a. Light energy is converted into chemical energy in the reaction center which can then be used in the reduction process of photosynthesis (Taiz and Zeiger, 1991). The results showed IR 64 and Silugonggo varieties containing higher chlorophyll b than other varieties. The response of all varieties in the control was not significantly different. Result from the same research done in two lines of okra showed that drought can cause an increase in chlorophyll-b content (Jaleel et al., 2009). Other research results showed that chlorophyll-a and chlorophyll-b are susceptible to dehydration (Farooq et al., 2009).

Table 2. Effect drought stress and variety on chlorophyll b content

Variety	Control	Drought stress
	------- mg/g	-------------
IR 64	1.14 bc	1.47 a
Ciherang	1.12 bc	1.16 bc
IPB 3S	1.06 bc	0.99 c
Way Apo Buru	1.14 bc	1.10 bc
Jatiluhur	0.97 c	1.43 a
Menthik Wangi	1.00 c	1.30 ab
Silugonggo	1.00 c	1.33 ab
Rokan	0.97 c	1.51 a

Note: Values followed by the same letter in the same column are not significantly different according to LSD analysis at *P<5%*

Drought stress causes a decrease in chlorophyll content in all varieties, but the response between varieties showed an increase in chlorophyll b. The increase observed in the Rokan variety, followed by Jatiluhur, and then IR 64, indicates that an increase in chlorophyll b content is an adaptation to drought stress in order to increase photosynthetic capacity.

A decrease in chlorophyll a content has the ability to change the reaction energy of light radiation decreases such that photosynthesis is inhibited. Chlorophyll a and b play a role in the process of photosynthesis. Chlorophyll b acts as a photosynthetic antenna that collects light. Meanwhile, the decrease in chlorophyll was associated with a reduction in the flux of nitrogen into the tissue, as well as alteration in activity of enzyme systems, such as nitrate reductase (Taiz and Zeiger, 1991). Chlorophyll is the main component of the chloroplast which is involved in photosynthesis. A decrease in chlorophyll-a during drought is a sign of oxidative stress caused by photooxidated pigment, which degrades chlorophyll (Verma et al. 2004; Farooq et al. 2009).

Decrease in chlorophyll content and changes in chlorophyll level during drought have been reported in several plant species. This also depends on drought and the level. Chlorophyll plays an important part in the light harvesting process of photosynthesis and in reducing over energy (Anjum et al. 2011). Research conducted by Mannivannan et al. (2007) on sunflower showed a decrease in chlorophyll content upon drought stress. A reduced chlorophyll content is predicted to occur because the loss of the chloroplast membrane, excessive swelling in lamella vascular, and lipid peroxidation (Kaiser, 1987). Low photosynthesis pigment concentration can directly limit photosynthetic potential.

Proline content

Interaction between drought and variety has a significant effect on proline accumulation at the ages of 11 and 13 weeks after transplant (Table 3). Proline accumulation is an early response when a plant is experiencing a water deficit, in which it decreases cell damage (Anjum et al. 2011). Proline accumulation does not only happen in a tolerant variety, but also on susceptible varieties. However, drought-tolerant varieties can accumulate proline for a longer period of time than susceptible varieties (Saruhan et al. 2006). This was shown in Silugonggo, Rokan, and IR 64, that are categorized as susceptible varieties wherein at 11 weeks after transplant, it accumulated a higher proline concentration compared to other varieties. Even so, there was a decrease in proline concentration in Rokan, followed by Silugonggo, and the IR 64 variety during the 13 weeks after transplant (Table 4). The characters directly related to drought tolerance are the increased accumulation of proline and total sugar during drought stress. Yue et al. (2006) reported the mechanism of drought tolerance through osmotic adjustment as the increased accumulation of solutes, such as proline and total sugar. The results showed that proline levels at 11 and 13 weeks after transplant accumulate proline over a longer period time for IPB 3S followed by Way Apo Buru, Ciherang, and Jatiluhur varieties (tolerant varieties) (Table 4).

Table 3. Effect drought and variety on proline content at 11 and 13 weeks after transplant (reproductive stage)

Variety	Proline content (11 WAT)		Proline content (13 WAT)	
	Control	Drought stress	Control	Drought stress
	μmol.g^{-1}FW		μmol.g^{-1}FW	
IR 64	36.03 abc	41.90 a	21.92 b	21.04 b
Ciherang	32.16 cde	39.80 ab	18.66 bc	28.79 a
IPB 3S	21.56 g	23.63 fg	14.89 b	25.98 a
Way Apo Buru	27.56 d-g	24.50 fg	14.47 def	19.35 bc
Jatiluhur	24.13 fg	24.07 fg	14.20 def	17.04 cd
Menthik Wangi	34.80 a-d	24.33 fg	12.28 ef	12.34 ef
Silugonggo	29.03 c-g	35.63 a-c	14.08 def	14.25 def
Rokan	25.93 efg	33.96 bcd	12.13 f	16.16 cde

Note: Values followed by the same letter in the same column are not significantly different according to LSD analysis at *P<5%*

Proline plays an important role as an osmoprotectant, an energy sink to regulate redox potential, and as a radical hydroxyl scavenger (Sharma and Dietz, 2006). Furthermore, proline protects macromolecules from denaturization and also reduces acidity in the cell (Kishor et al. 2005) and acts as an antioxidant (Vendruscolo et al. 2007). According to Szabados and Savoure (2009), proline can act as a molecular signal to modulate mitochondrial function, affect cell proliferation or cell death, and initiate certain gene expression that is important role in protecting plants from stress.

Table 4. Relative decrease in proline accumulation of eight rice varieties during drought

Variety	Proline content 11 WAT (µmol.g^{-1} FW)	Proline content 13 WAT (µmol.g^{-1} FW)	Relative decrease (%)
IR 64	41.90	23.20	44.63
Ciherang	39.80	25.38	36.23
IPB 3S	23.63	22.08	6.55
Way Apo Buru	24.50	17.35	29.18
Jatiluhur	24.07	15.11	37.22
Menthik Wangi	24.33	12.34	49.28
Silugonggo	35.63	14.24	60.03
Rokan	33.96	14.24	52.41

Total sugar and starch content

Besides increasing proline accumulation, drought stress can also increase total sugar accumulation at the pre anthesis stage. Variety, drought stress, and interaction also have a significant effect. Tolerant varieties (Ciherang, Way Apo Buru, and Jatiluhur) have increased total sugar accumulation, reaching 2-4 times higher during drought than the control (Table 5).

Table 5. Effect drought stress and variety on total sugar at anthesis phase and harvest

Variety	Anthesis		Harvest	
	Control	Drought stress	Control	Drought stress
	mg gBK^{-1}		mg gBK^{-1}	
IR 64	34.54 ^{gh}	42.83 ^{fgh}	9.76 ^{d}	54.23 ^{b}
Ciherang	59.66 ^{f}	183.48 ^{c}	11.30 ^{d}	57.84 ^{b}
IPB 3S	43.75 ^{fgh}	139.90 ^{d}	14.80 ^{d}	85.14 ^{a}
Way Apo Buru	50.48 ^{fg}	131.59 ^{d}	12.70 ^{d}	46.99 ^{bc}
Jatiluhur	128.52 ^{d}	138.11 ^{d}	17.86 ^{d}	17.14 ^{d}
Menthik Wangi	135.83 ^{d}	230.53 ^{a}	8.71 ^{d}	73.75 ^{a}
Silugonggo	26.07 ^{h}	90.18 ^{e}	9.64 ^{d}	54.25 ^{b}
Rokan	58.23 ^{f}	289.38 ^{a}	7.58 ^{d}	34.20 ^{c}

Note: Values followed by the same letter in the same column are not significantly different according to LSD analysis at *P<5%*

Tolerant varieties accumulate total sugar in the stem and then translocate it to other organs for metabolism and growth. Meanwhile, susceptible varieties accumulate a high amount of total sugar in the stem during pre anthesis stage, however when drought occurs, there is some sugar translocation blockage to other parts of the plant, especially the seeds. This can be seen in the tolerant variety, Jatiluhur, which accumulates total sugar at the same concentration as the control and drought treatments. During the grain filling period of the control and drought treatment, total sugar re-translocation in Jatiluhur variety did not experience blockage to seeds. While it is a susceptible variety (Menthik Wangi), it experiences blockage of sugar re-translocation under drought conditions and has a high concentration of sugar at harvest.

Sugar accumulation in rice varieties is severely affected by drought. Total sugar accumulation is one mechanism for a tolerant plant in facing drought. Total sugar accumulation also plays a role in substrate hydrolysis in a biosynthetic process, producing energy and acts as a sensor and signal. It also functions as a typical osmoprotectant to maintain cell stability and maintain turgor pressure (Kishor et al. 2005). During drought stress, total sugar accumulation increases especially in the stem (Hu et al. 2006). Total sugar accumulation in the organ of a tolerant variety is more effective because of the high membrane stability and low water loss than susceptible varieties (Valentovic et al. 2006).

Varieties that are relatively tolerant to drought, especially Jatiluhur, clearly demonstrate that total sugar accumulation is significantly different in both the control and drought treatment during anthesis phase and harvesting stage. This due to most sugar and starch in the stem being actively relocated to seeds. Mc Dowell and Sevanto (2010) reported that drought can block carbohydrate transport, usage, and mobilization. If severe drought happens, then the plant will die if it reaches its critical point. Therefore, a starch content variable that was observed during the stage of anthesis and harvest in drought treatment can give information on how varieties experience blocked carbohydrate transport caused by water inefficiency in susceptible varieties.

Drought stress causes increased accumulation of solutes (proline and total sugar). Tolerant varieties (Jatiluhur, Ciherang, and Way Apo Buru) have a mechanism of tolerance through accumulation of proline over a longer time during drought stress and increasing total sugar reaching 2-3 times higher than the control. Increase in proline and total sugar accumulation when drought stress occurs is one of the indicators of plant tolerance to drought through osmotic adjustment. Yue et al. (2006) reported that the mechanism of tolerance through osmotic adjustment is an adaptive process which accumulates non-toxic "compatible solutes" in the cell and lowers the osmotic potential during water deficit.

Grain yield

Significant differences were observed in grain yield per hill in rice varieties under control and drought conditions. Drought stress reduced grain yield irrespective of rice varieties. The highest reduction in grain yield under drought stress was recorded in Rokan variety (95.22%), followed by Menthik Wangi (82.99%), and Silugonggo (73.94%), while less reduction was noted in Jatiluhur (40.72%) (Table 6). Rice is a crop that is very sensitive to water shortage in the reproductive phase, with water shortage leading to a higher reduction in grain yield. Decrease in grain yield is due to reduced panicle formation and high sterility. Liu et al. (2008) reported that water stress can abort pollination for up to 67 percent of total grain per panicle. When pollination occurs, the pollen reaches the ovule longer mikrofil in 1-8 days. Pollen cannot be on the surface of the flower because flowers fail to open due to drought. Grain yield is a multigenic factor, with susceptible varieties producing high grain yield under normal conditions, but it also shows a high percent reduction over control during drought. The yield stability in tolerant varieties was due to specific adaptive feature that make them able to produce stable grain yield even under stress (Van Heerden and Laurie, 2008; Liu et al. 2008).

Drought is a complex mechanism involving various plant adaptive features which produce a stable yield. Tolerant varieties (Jatiluhur) showed stable yield due to a better scavenging system, high accumulation of osmolytes during stress, and fast recovery after relief from stress.

Table 6. Effect drought stress and variety on grain yield per hill

	Drought stress	Control	Relative decrease (%)
		---g---	
IR 64	4.63 ^{l}	15.23 ^{cd}	69.60
Ciherang	6.35 ^{gh}	15.50 ^{cd}	59.03
IPB 3S	5.19 ^{h}	23.55 ^{a}	77.96
Way Apo Buru	5.06 ^{h}	13.95 ^{de}	63.73
Jatiluhur	13.48 ^{de}	22.74 ^{a}	40.72
Menthik Wangi	3.51 ^{jk}	20.64 ^{ab}	82.99
Silugonggo	3.32 ^{jk}	12.74 ^{fg}	73.94
Rokan	2.01 ^{k}	18.12 ^{b}	95.22

Note: Values followed by the same letter in the same column are not significantly different according to LSD analysis at *P<5%*

CONCLUSION

Physiological characters of rice varieties differed in their response to drought stress. However, drought reduced chlorophyll a, chlorophyll a/b ratio, and grain yield, but increased proline, total sugar, and chlorophyll b content. Tolerant rice varieties experiencing drought had better osmoregulation, in terms of proline and total sugar content. Meanwhile, tolerant varieties (Ciherang, Way Apo Buru, and Jatiluhur) tended to accumulate proline over a longer period time and had a higher total sugar accumulation. Jatiluhur varieties experiencing drought showed higher yield and stability than other varieties. Lesser reduction in grain yield during drought, accumulation of proline over a longer period of time, and an increase in total sugar accumulation at anthesis phase during drought were physiological characters that played an important role on tolerance against drought in paddy systems.

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ANALYSIS OF THE EFFECTS OF BEEF IMPORT RESTRICTIONS POLICY ON BEEF SELF-SUFFICIENCY IN INDONESIA

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ABSTRACT

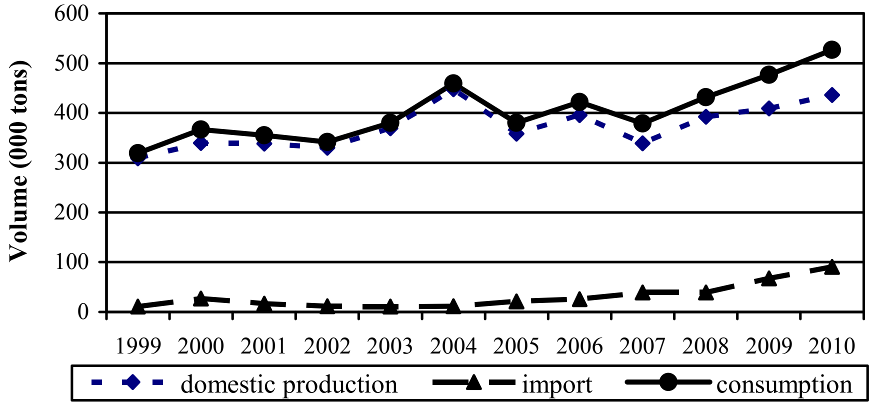
Beef consumption tends to increase over time, but the growth of domestic beef production is lower than the growth of consumption. This has led to the increase in import. In line with the launch of a beef self-sufficiency program, the government has attempted to reduce import quotas on beef and feeder cattle to encourage the growth of cattle and beef production. This study aims to analyze the impact of the restrictions of beef import on the performance of the beef cattle industry and livestock subsector and the forecast of beef self-sufficiency achievement in Indonesia. This study utilized time series data during the period 1990–2011. By using econometrics approach with simultaneous equatinons model, which is based on the Two Stages Least Squares method, the results of the analysis give some conclusions including: 1) restrictions on imports of feeder cattle and beef would increase domestic beef production and beef demand, but would reduce the population and production of cattle and livestock subsector performance; 2) reduction in imports of beef and feeder cattle followed by technology improvement will accelerate the achievement of beef self-sufficiency in Indonesia.

Key words: beef domestic production and consumption, import quota, estimated beef self-sufficiency level

INTRODUCTION

Livestock subsector plays an important role in food supply for the people, especially animal protein. As a source of animal protein, beef is needed to meet the nutritional needs of the people. Beef contains 10 kinds of amino acids and essential fatty acids especially conjungated linoleic acid which is beneficial for the growth of neurons in the brain that determines the level of human intelligence (Daryanto, 2009).

National beef demand has been met from three sources, namely local cows, imported cows, and imported beef (Hadi and Ilham, 2002). Along with population growth, rising incomes, and changing public tastes, consumption of beef in Indonesia tends to increase over time. During the 1999-2010 period beef consumption increased by 4.66 percent per year. On the other hand, the growth of domestic beef production is lower at 3.20 percent per year. As a result, beef import rose by 21.58 percent annually (Fig. 1). In this case, domestic beef production includes the slaughtered cattle from imported feeder cattle. Feeder cattle imports are also likely to increase. According to the Directorate General of Livestock Services (DGLS), imported beef and feeder cattle has accounted for approximately 30 per cent of the national beef demand (DGLS, 2011).



Source: Directorate General of Livestock Services, BPS-Statistics Indonesia (processed)

Fig.1. Trends in consumption, production, and import of beef in Indonesia, 1999-2010 (000 tons).

The low growth rate in the national cattle production encourages the rise in import of feeder cattle and beef. This condition will threaten national food security. Livestock industry, which has a high level of dependence on imports, has a big risk (Yusdja and Ilham, 2006). In the case of occurrence of import barriers, such as a sharp depreciation of rupiah, rising import tariffs, and impaired bilateral relationships, the volume of imports will decrease. This will lead to cut domestic cattle in a larger number to meet domestic consumption. As the growth of domestic cattle is relatively slow, this will deplete domestic resources that can lead to extinction (Ilham, 2006). Another risk is when there is an increase the volume of import, it will drain foreign exchange substantially.

To reduce the dependency of imported beef products, domestic beef production should be increased. The increase in domestic beef production will replace the import of beef supply. This is known as imports substitution strategy, which is also known as inward-looking policy (Bulmer-Thomas, 1982; Hess and Ross, 1997; Todaro and Smith, 2009). Efforts to encourage domestic production can be done through various policies such as tariffs and import quotas policy. If the imports quota is set smaller than the volume of imports on the free trade condition, then domestic price will increase and this will encourage domestic production (Houck, 1986; Pindyck and Rubinfeld, 1998b).

To encourage domestic beef production and reduce imports, the government has set the Self-Sufficiency Program on Beef and Buffalo policy in 2014 (PSDSK 2014). It is a revision of Beef Self-Sufficiency Program in 2005 and the Accelerating Beef Self-Sufficiency Program (P2SDS) in 2010, in which both programs failed to achieve (Syamsu, 2010). One operational step in the PSDSK 2014 is setting stock regulation on feeder cattle and beef through setting import quotas. This policy aims to reduce beef imports, in the form of either imported of feeder cattle or beef, with the hope of encouraging the growth of beef production and value-added of livestock subsector, creating job opportunities, and saving foreign exchange. Beef self-sufficiency can be achieved if domestic beef production is able to meet the minimum 90 percent of the total national consumption of beef. The program was implemented since 2010 and Indonesia has targeted to achieve beef self-sufficiency by 2014 (DGLS, 2011). Currently, there is no pre-determined import quota level on beef import, but the volume of beef import in a certain year is jointly determined by the Ministry of Agriculture and Ministry of Trade.

Based on the above explanation, this study sought to: 1) assess the impact of reducing import quota of feeder cattle and beef on the performance of beef cattle industry and livestock subsector in Indonesia; 2) evaluate the impact of reducing import quota policy of feeder cattle and beef on beef self-sufficiency in Indonesia.

PREVIOUS STUDIES ON THE BEEF SUPPLY AND DEMAND IN INDONESIA

Several studies on the supply and demand for beef in Indonesia have been done by Ilham (1998), Kariyasa (2004), Priyanto (2003), and Tseuoa et al. (2012). Ilham (1998) and Priyanto (2003) differentiated supply into supply from feedlot and smallholders. These studies examined factors that influence supply, demand, imports, and the price of beef in Indonesia. Tseuoa et al. (2012) emphasized their study on the impact of tariff reduction on the performance of beef cattle industry in Indonesia. The forecast of demand and supply of beef using various techniques was done by Ilham (2006), Kariyasa (2004), and Tseuoa et al. (2012). In these studies, the behavior of cattle production and beef cattle population has not been taken into account. Research on cattle production and beef cattle population was carried by Sukanata (2008) but for the Bali Province only.

METHODOLOGY

Data Type and Sources

This study utilized secondary time series data during the period 1990 – 2011. Data were taken from various sources including BPS-Statistics Indonesia, Central Bank of Indonesia (BI), Food and Agriculture Organization (FAO), Directorate General of Livestock and Animal Health Services (DGLS), and Directorate General of Customs and Excise. In addition to this, certain data and information were also taken from the study of the literature related to this study.

In this study, beef production from slaughtered imported feeder cattle was differentiated into beef imports and additional domestic beef production. Beef imports is the conversion of live weight imported feeder cattle. Additional beef production from fattening of imported feeder cattle was categorized as domestic production because it is the value added of the production process in Indonesia. To obtain beef production from the imported feeder cattle, a conversion factor adopted from BPS-Statistics (2002) was used. On average, the live weight of imported cattle slaughtered is 487.02 kg and produces 232.01 kg of carcass. The conversion factor of carcass to meat was found to be 0.8 (period 1990-2001) and 0.7493 (period 2002-2011). The averaged live weight of imported feeder cattle was 346.34 kg head^{-1}. So the extra weight during the fattening process was approximately 40.62 percent. This study is different from the study conducted by Tseuoa et al. (2012), where all beef production of imported feeder cattle were cocategorized as beef import. In addition, their study did not consider the fattening process as part of domestic production.

Model Constructions

By using econometric approach, the simultaneous equations model was used to answer the research objectives. The model consists of 2 blocks of equations, namely beef cattle industry and livestock subsector. The model was modified from Ilham (1998), Kariyasa (2004), Sukanata (2008), and Tseuoa et al. (2012). The overall model is described in the following equations:

1. Block of beef cattle industry

Equation of beef cattle production

$$QTS_t = a_0 + a_1POPT_{t-2} + a_2MSBT_{t-2} + a_3VIB_{t-1} + a_4CH_{t-1} + a_5RIR + U_1 \quad (1)$$

Hypothesis: $a_1, a_2, a_3, a_4, a_6 > 0$ and $a_5 < 0$

Equation of imported feeder cattle

$$MSBK_t = b_0 + b_1RHSBK_t + b_2RNTR_t + b_3WA_t + b_4QSDSL_t + b_5QDDS_t + b_6D1_t + b_7D2_t + U_2 \quad (2)$$

Hypothesis: $b_1, b_2, b_4, b_6, b_7 < 0$ and $b_3, b_5 > 0$

Equation of total imported beef cattle

$$MTS_t = (MSBT_t/1000) + MSBK_t \quad (3)$$

Equation of beef cattle population

$$POPT_t = c_0 + c_1QTS_t + c_2MTS_t + c_3QSD_t + c_4POPT_{t-1} + U_3 \quad (4)$$

Hypothesis: $c_3 < 0$; $c_1, c_2 > 0$; and $0 < c_4 < 1$

Equation of local beef production

$$QSDSL_t = d_0 + d_1RHDS_{t-1} + d_2QTS_{t-2} + d_3QSM_t + d_4D1_t + d_5QSDSL_{t-1} + U_4 \quad (5)$$

Equation of extra beef production from imported feeder cattle

$$QSDSM_t = 0.4062 * QBM_t \quad (6)$$

Equation of domestic beef production

$$QSDS_t = QSDSL_t + QSDSM_t \quad (7)$$

Hypothesis: $d_3 < 0$; $d_1, d_2, d_4 > 0$; and $0 < d_5 < 1$

Equation of beef import

$$QDM_t = e_0 + e_1RHSM_t + e_2RNTR_t + e_3QSDSL_t + e_4QDDS_t + e_5QDM_{t-1} + U_5 \quad (8)$$

Hypothesis: $e_1, e_2, e_3 < 0$; $e_4 > 0$; and $0 < e_5 < 1$

Equation of beef production from imported feeder cattle

$$QBM_t = k * MSBK_t \quad (9)$$

k = 0.3811 (1990 – 2001) and 0.3570 (2002 – 2011) (BPS-Statistics, 2002) (processed)

Equation of total beef imports

$$QSM_t = QDM_t + QBM_t \quad (10)$$

Equation of total beef productions

$$QSD_t = QSDS_t + QBM_t \quad (11)$$

Equation of national beef demand

$$QDDS_t = f_0 + f_1RHDS_t + f_2RHDAY_t + f_3GDP_t + f_4D1_t + f_5D2_t + U_6 \quad (12)$$

Hypothesis: $f_1, f_5 < 0$ and $f_2, f_3, f_4 > 0$

Equation of excess demand of beef

$$EQDS_t = QDDS_t - QSDS_t \quad (13)$$

Equation of domestic beef price

$$RHDS_t = g_0 + g_1RHDSJ_t + g_2RHSM_t + g_3RNTR_t + g_4QSDS_t + g_5QDDS_t + g_6T_t + g_7RHDS_{t-1} + U_7 \quad (14)$$

Hypothesis: $g_4 < 0$; $g_1, g_2, g_3, g_5, g_6 > 0$ and $0 < g_7 < 0$

2. Block of livestock subsector

Equation of GDP of beef cattle

$$GDPSP_t = h_0 + h_1QTS_t + h_2MSBK_t + h_3GDPSP_{t-1} + U_8 \quad (15)$$

Hypothesis: $h_1, h_2 > 0$ and $0 < h_3 < 0$

Equation of GDP of livestock subsector

$$GDPP_t = GDPSP_t + GDPNSP_t \quad (16)$$

Equation of employment in livestock subsector

$$DLP_t = i_0 + i_1RWP_t + i_2GDPP_t + i_3DLP_{t-1} + U_9 \quad (17)$$

Hypothesis: $i_1 < 0$; $i_2 > 0$; and $0 < i_3 < 1$

where:

QTS	:	beef cattle production (million heads)
MSBK	:	imported feeder cattle (000 tons)
POPT	:	beef cattle population (million heads)
QSDSL	:	local beef production (000 tons)
QDM	:	beef import (000 tons)
QDDS	:	national beef demand (000 tons)
RHDS	:	real domestic beef price (rupiahs kg^{-1})
GDPSP	:	GDP of beef cattle (trillion rupiahs)
DLP	:	employment in livestock subsector (000 workers)
MTS	:	total imported beef cattle (000 tons)
QSDSM	:	additional domestic beef production from imported feeder cattle (000 tons)
QBM	:	imported beef from conversion live weight imported feeder cattle (000 tons)
QSDS	:	domestic beef production (000 tons)
QSM	:	total beef imports (000 tons)
QSD	:	total beef production (000 tons)
EQDS	:	excess demand of beef (000 tons)
GDPP	:	GDP of livestock subsector (trillion rupiahs)
GDP	:	GDP without oil and gas (trillion rupiahs)
RHSM	:	real price of beef import (US$ ton^{-1}, cif)
MSBT	:	imported breeding cattle (tons)
VIB	:	Artificial Insemination technology doses (000 doses)
CH	:	number of rainfall (mm $year^{-1}$)
RIR	:	real interest rate (percent)
RHSBK	:	real price of imported feeder cattle (US$ ton^{-1}, cif)
RNTR	:	real exchange rate (rupiahs $US\$^{-1}$)
WA	:	number of foreign tourists (000 persons)
RHDAY	:	real chicken price (rupiahs kg^{-1})
RHDSJ	:	real beef price in Jakarta (rupiahs kg^{-1})
T	:	time trend
RWP	:	real wage in livestock subsector (000 rupiahs $month^{-1}$)
D1	:	dummy PSDSK 2014 policy (1990 – 2009 = 0; 2010 – 2011 = 1)
D2	:	dummy economic crisis (1998 – 1999 = 1; the others = 0)

Analysis Procedure and Policy Simulation

Based on the order condition criteria, it was found that the model is over identified. Therefore, the estimation of parameter was done by using the Two Stage Least Square (2SLS) method (Koutsoyiannis, 1977). To test whether the model experienced a serial correlation or not, Durbin Watson and Durbin-h statistics wer used. To test whether variables gave an influence simultaneously or not on the endogenous variable, statistical F-test was used. Finally, to test whether each variable gave a significant effect individually or not on the endogenous variable, statistical t-test was used (Pyndick and Rubinfeld, 1998a).

Before running the simulation for various selected policies, the model was validated using a statistical measure of Root Mean Square Percent Error (RMSPE) and Theil's Inequality (U-Theil). Theil U-statistic can be decomposed into components of bias, variance, and covariance. Bias portion (UM) indicated a systematic error, which measures the deviation of average values of estimation results with the actual data. Variance portion (US) measures the deviation of variance values of estimation results with the actual data. Covariance portion (UC) is the proportion of covariance and a residual bias from UM and US, and is often referred to as non-systematic errors (Pyndick and Rubinfeld, 1998a).

The simulation analysis aims to assess the impact of reducing the import of feeder cattle and the import of beef by 25 percent and 35 percent respectively, on cattle production, beef production, and beef consumption. In addition to this, the performance of the livestock subsector in Indonesia, which includes the GDP and employment creation, is also assessed. Finally, given the most appropriate policy simulation, the econometric model was used to forecast the demand and domestic production of beef.

RESULTS AND DISCUSSION

Factors Affecting the Performance of Beef Cattle Industry and Livestock Subsector

In general, the estimation results of the model are representative to explain the behavior of the endogenous variables with coefficient of determination (R^2) ranging from 0.7612 to 0.9961, except beef cattle production equation (QTS) which has a R^2 value of 0.6302. This suggests that the variation of the explanatory variables in each equation can explain variation in endogenous variables. Concerning statistical-F tests, the p-values <0.01 were observed for all equations. This indicates that in each equation, together, the explanatory variables have significant effect on each endogenous variable. Most of the estimated parameters signs were in line with expectations and in line with economic theory. The identification of factors affecting the performance of the beef cattle industry and livestock subsector are presented in Table 1. A discussion of the factors affecting the performance of beef cattle industry and livestock sector in Indonesia will be divided into two sub-sections, namely the performance of beef cattle industry that includes equation (1) to (7) and the performance of the livestock sector that includes equation (8) and (9).

Table 1. Results of parameter estimation, statistical tests, and elasticity of the model.

Variables	Parameter Estimation	Pr > |t|	Elasticity		Description of Variables
			Short run	Long run	
1. Beef cattle production (QTS)					
Intercept	-2.2274	0.1969			
$POPT_{t-2}$	0.1842	0.2179	0.8253	-	Lag2 of beef cattle population
$MSBT_{t-2}$	0.0002	0.0639	0.0921	-	Lag2 of imported breeding cattle
VIB_{t-1}	0.0004	0.0572	0.1974	-	Lag of Artifical Insemination (AI)
CH_{t-1}	0.0009	0.0018	0.7477	-	Lag of rainfall

Variables	Parameter Estimation	Pr > |t|	Elasticity		Description of Variables
			Short run	Long run	
RIR	-0.0040	0.2913	-0.0113	-	Real Interest rate
$R^2 = 0.6302$		$F_{stat} = 4.77^*$		DW = 2.99	
2. Imported beef cattle (MSBK)					
Intercept	21.4883	0.2046			
RHSBK	-0.0100	0.0524	-0.1217	-	Real price of imported feeder cattle
RNTR	-0.0033	0.0306	-0.2073	-	Real exchange rate
WA	0.0053	0.1263	0.2551	-	Number of foreign tourists
QSDSL	-1.2062	<.0001	-2.5477	-	Local beef production
QDDS	1.1979	<.0001	3.4200	-	Beef demand
D1	-50.4575	0.0002			Dummy PSDSK 2014 policy
D2	-8.1855	0.0975			Dummy economic crisis
$R^2 = 0.9925$		$F_{stat} = 226.15^*$		DW = 2.0373	
3. Beef cattle population (POPT)					
Intercept	-0.0982	0.3644			
QTS	1.0569	<.0001	0.2148	4.7211	Beef cattle production
MTS	0.0035	<.0001	0.0307	0.6749	Total imported cattle
QSD	-0.0073	<.0001	-0.1654	-3.6351	Total beef production
$POPT_{t-1}$	0.9545	<.0001			Lag of beef cattle population
$R^2 = 0.9961$		$F_{stat} = 945.43^*$		DW = 2.4595	Dh = -1.9338
4. Local beef production (QSDSL)					
Intercept	87.3049	0.1248			
$RHDS_{t-1}$	0.0044	0.0086	0.4504	0.4816	Lag of real domestic beef price
QTS_{t-2}	32.1121	0.0068	0.3271	0.3498	Lag2 beef cattle production
QSM	-0.8408	<.0001	-0.2482	-0.2654	Total beef imports
D1	70.8991	0.0005			Dummy PSDSK 2014 policy
$QSDSL_{t-1}$	0.0648	0.3687			Lag of local beef production
$R^2 = 0.7612$		$F_{stat} = 8.92^*$		DW = 1.7784	Dh = 0.5708
5. Beef import (QDM)					
Intercept	-7.2747	0.3668			
RHSM	0.0025	0.3253	0.1816	0.2997	Real price of beef import
RNTR	-0.0001	0.4628	-0.0340	-0.0561	Real exchange rate
QSDSL	-0.2987	<.0001	-2.4520	-4.0473	Local beef production
QDDS	0.2922	<.0001	3.2418	5.3509	Beef demand
QDM_{t-1}	0.3942	0.0016			Lag of beef import
$R^2 = 0.9675$		$F_{stat} = 83.33^*$		DW = 1.4897	Dh = 1.1505

Variables	Parameter Estimation	Pr > |t|	Elasticity		Description of Variables
			Short run	Long run	
6. National beef demand (QDDS)					
Intercept	-7.2747	<.0001			
RHDS	-0.0095	0.0385	-0.7511	-	Real domestic beef price
RHDAY	0.0092	0.0621	0.3817	-	Real chicken price
GDP	0.1408	0.0007	0.6844	-	Non-oil GDP
D1	62.1068	0.0058			Dummy PSDSK 2014 policy
D2	-38.5104	0.0661			Dummy economic crisis
R^2 = 0.8797		F_{stat}= 20.46*		DW = 2.5496	
7. Real domestic beef price (RHDS)					
Intercept	-8394.96	0.0383			
RHDSJ	0.755	<.0001	0.8571	0.9227	Real beef price in Jakarta
RHSM	2.124	0.0310	0.1781	0.1918	Real price of beef import
RNTR	0.314	0.1210	0.0868	0.0935	Real exchange rate
QSDS	-27.239	0.0051	-0.2727	-0.2936	Domestic beef production
QDDS	24.798	0.0189	0.3136	0.3376	Beef demand
T	226.560	0.0199			Trend
$RHDS_{t-1}$	0.071	0.2770			Lag of real domestic beef price
R^2 = 0.9675		F_{stat}= 53.30*		DW = 2.3842	Dh = -1.0076
8. GDP of beef cattle (GDPSP)					
Intercept	-0.2523	0.4312			
QTS	3.1117	<.0001	0.8407	0.8928	Beef cattle production
MSBK	0.0114	0.0189	0.1308	0.1389	Imported feeder cattle
$GDPSP_{t-1}$	0.0584	0.3711			Lag of GDP of beef cattle
R^2 = 0.7867		F_{stat}= 19.68*		DW = 2.2635	Dh = -0.9606
9. Employment in livestock subsector (DLP)					
Intercept	771.6793	0.1371			
RWP	-3.2432	0.0704	-0.3312	-0.9290	Real wage in livestock subsector
GDPP	47.8612	0.0144	0.4544	1.2747	GDP of livestock subsector
DLP_{t-1}	0.6435	0.0010			Lag of employment in livestock subsector
R^2 = 0.7849		F_{stat}= 19.46*		DW = 2.2542	Dh = -0.8977

Note : * indicates 1 percent level of significance

Performance of beef cattle industry

The performance of beef cattle industry includes supply and demand for beef. Beef supply in the domestic market comes from local production and imports. Local beef production is the result of slaughter cattle that are raised in the country.

Cattle production (QTS) is the number of animals born alive in one year. Technology improvements through increased doses of Artificial Insemination (AI), additional productive cows through imported breeding cattle, and the increase in the volume of rainfall that will increase the availability of forage will increase the cattle production. The increase in cattle population in year t-2 tends to have a positive impact on the increase in cattle production, while the rising interest rates tend to reduce the production of cows cattle. But the effect of these two variables is not significant ($p>0.2$). Only a small portion of farmers i.e., smallholders cattle raisers, access bank for credit. However, interest rate variable is included in the equation because there is an interest rate subsidy program from the Government to support 2014 PSDSK – beef self sufficiency – policy.

The response of cattle production to changes in the volume of imported breeding cattle, IB dose, and the amount of rainfall is inelastic in the short run. According to Marsh (1994), the response of the production of big livestock, such as beef cattle, to technological changes takes a long time due to biological factors.

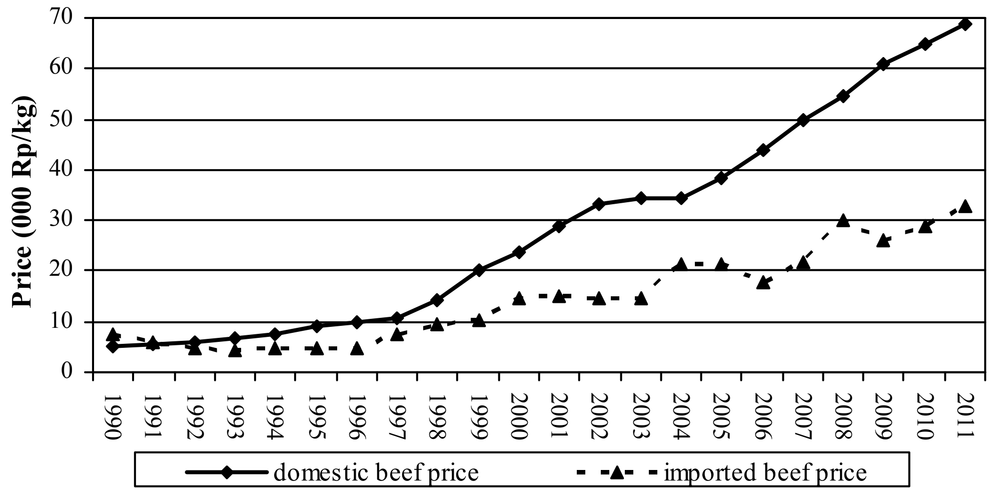
An increase in cattle production will encourage local beef production (QSDSL). Moreover, the increase in beef prices in the domestic market will also stimulate beef producers to increase their production. In contrast, the increase in the volume of imported beef will reduce local beef production. With the lower imported beef price, the local beef production could not compete with imported beef. The response of local beef production to changes in the domestic beef price, cattle production and beef imports is inelastic both in the short run and in the long run. PSDSK 2014 policy has positive effects to local beef production.

Cattle population (POPT) is affected by cattle production, total imported cattle, total beef production, and livestock population in the previous year. Increased cattle production and imported cattle will increase the cattle population, while the increase in beef production that reflects an increase in the number of the slaughtered cattle will reduce cattle population.

Indonesia's beef imports are in the form of feeder cattle and beef. The price of imported feeder cattle and the exchange rate negatively affect imported feeder cattle volumes (MSBK). The increase in price of imported feeder cattle followed by a depreciation of the rupiah as it happened during the economic crisis will lead to the increase in the price of feeder cattle in the domestic market and will decrease the volume of imported feeder cattle. Local beef production negatively affects the volume of imported feeder cattle. The increasing local beef production will reduce the excess demand for beef. This leads to the reduction of imported feeder cattle. In contrast, the increase in beef demand will increase the volume of imported feeder cattle. The increase in foreign tourists will increase the volume of imported feeder cattle. Most of the foreign tourists who come to Indonesia come from countries with higher beef per capita consumption than Indonesian (BPS, 2012). Thus, the increase of foreign tourists will increase the beef demand, especially from the hotel and restaurant business to support the tourism industry in Indonesia. With the lower growth rate of domestic cattle production, this will push the imported beef levels. The imported feeder cattle is one of the sources to meet the needs of domestic beef consumption. The PSDSK 2014 policy and economic crisis negatively affect the volume of imported feeder cattle. One operational step in this policy is setting stock feeder cattle through restrictions on imports to encourage domestic beef production.

The volume of beef imports (QDM) is affected by the local beef production, beef demand, and the volume of beef imports in the previous year. The increase in local beef production will reduce beef import volumes, while the increase in demand will increase the volume of beef imports. As a net importer country of beef, importing beef is a solution to close the gap between demand and domestic beef production. The response of beef imports to changes in local production and demand of beef in the short run and in the long run is elastic. The experience of imports in the previous year is used as a reference for the government to set import quotas for the next period.

Import price did not significantly affect the volume of beef imports. This condition indicates that import of beef in Indonesia is not only determined by the price of imported beef itself, but also by another factor i.e. a consumer demand to meet the needs resulting from the gap between supply and demand for beef in the country. Moreover, in the import process of beef there is a large government intervention in determining the import quota. Domestic prices are affected by supply and demand. Reduction in import quotas will encourage domestic production, thereby decreasing domestic prices. On the other hand, the increase in demand will increase domestic prices. On the other hand, the price of beef imports after being converted into rupiah was much lower than the price of local beef (Fig. 2). The greater the difference in price is an incentive for importers to import beef although the price goes up. This is because they have benefited from this activity. Thereby, beef imports tend to increase if additional import quota is approved by the government.



Source : BPS-Statistics (processed)

Fig. 2. Trend of Domestic Beef Price and Imported Beef Price in Indonesia, 1990 – 2011 (000 Rp/kg)

The national beef demand (QDDS) is influenced by domestic beef price, chicken meat price, non-oil GDP, PSDSK 2014 policy, and economic crisis. The increase in domestic beef prices will reduce beef demand. The economic crisis led to lower purchasing power, and this in turn will reduce beef demand. In contrast, the rise in chicken price will increase beef demand. This suggests that chicken is a substitute of beef. The increase in non-oil GDP will increase purchasing power, and this will increase beef demand. The response of beef demand to changes in the domestic beef price, chicken meat price, and non-oil GDP is inelastic in the short run. A study conducted by Hadi and Ilham (2002) also showed that beef demand is inelastic to own price changes. The PSDSK Policy 2014 is expected to encourage the production of local beef, decrease the domestic beef price, and increase income. These all together will increase beef demand.

The analysis result of domestic beef price (RHDS) shows that beef price in Jakarta, imported beef price, domestic beef demand, and the trend has a positive effect on the domestic beef price. Jakarta is the center of economic activity and the primary consumer of beef in Indonesia. Changes in beef prices in Jakarta will be transmitted to other regions in Indonesia, especially those with having a big influence on Indonesian beef prices. As a small country and a price taker, the rising prices of beef imports will be be transmitted to the domestic market, thereby increasing domestic beef price. The increase in beef demand as a result of an increase in income or in population will increase the excess demand for beef, so beef price in the domestic market will increase. And conversely, the increase in domestic beef production will reduce the excess demand for beef, so prices will tend to decline.

Performance of livestock subsector

The assessment of livestock subsector performance is based on GDP and employment indicators. The GDP of livestock subsector is the total of beef cattle GDP and non-cattle GDP. Cattle production and imports of feeder cattle have positive effect on GDP of beef cattle (GDPSP). The increase in cattle production will increase the value-added of this commodity. Meanwhile, the process of fattening imported cattle will also obtain a value-added in the form of extra weight cattle. The increase in GDP of beef cattle will increase the GDP livestock subsector.

The increase in the livestock sector GDP reflecting the rising scale of livestock sector will increase demand for inputs required in the production process, including labor. The value of parameter estimation of 47.86 implies that if the GDP of livestock subsector rose by Rp. 1 trillion, ceteris paribus, the demand for labor would increase by 47.86 thousand people.

The rising wages negatively affect the demand for labor (DLP). The increase in labor costs would increase the marginal cost of production. In this case, the rational producer will reduce the use of labor input to obtain the maximum profit. The response of labor demand to changes in the wage rate is inelastic in both the short run and the long run.

Impact of Beef Import-quota Reduction

1) Model validation

The results of model validation show that most of equations have RMSPE values below 25 percent. This indicates the predicted values follow the historical trend of the data well. Most of the equations have a U-Theil values close to zero. Based on it's components, it seems that bias portion (UM) and variance portion (US) are close to zero, and covariance portion (UC) approaches one. Therefore, it can be said that the model can follow the actual data and it is quite valid for simulation. Model validation results are presented in Table 2.

Table 2. Model validation results

Variable	Description of Variables	RMSPE	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	U
QTS	Beef cattle production	20.67	0.07	0.02	0.92	0.05	0.88	0.074
MSBK	Imported feeder cattle	111.40	0.05	0.36	0.59	0.08	0.87	0.230
QSDSL	Local beef production	18.77	0.04	0.56	0.40	0.03	0.93	0.106
QDM	Beef imports	105.90	0.02	0.17	0.80	0.03	0.94	0.177
POPT	Beef cattle population	8.99	0.46	0.32	0.22	0.20	0.34	0.045
QDDS	Beef demand	7.28	0.02	0.28	0.70	0.52	0.46	0.042
RHDS	Domestic beef price	5.01	0.03	0.02	0.95	0.07	0.90	0.020
GDPSP	GDP of beef cattle	23.37	0.10	0.04	0.86	0.01	0.89	0.080
DLP	Employment in livestock subsector	13.63	0.03	0.00	0.97	0.07	0.90	0.057
QSM	Total beef imports	104.50	0.04	0.31	0.64	0.09	0.87	0.202
QSDS	Domestic beef production	15.01	0.03	0.52	0.45	0.00	0.96	0.085
GDPP	GDP of livestock subsector	5.92	0.10	0.16	0.74	0.09	0.81	0.025

2) Simulation results

The import quota reduction policy is intended to reduce the proportion of imported beef in the form of both imported feeder cattle and beef imports. Policy simulations are based on the targets stated in the road map of PSDSK 2014. It is stated that the number of imported feeder cattle will be reduced gradually from 520 thousand heads in 2010 to 175.4 thousand heads in 2014, or by an average of 23.8 percent per year, while the amount of beef imports will be reduced gradually from 120 thousand tons in 2010 to 23.3 thousand tons in 2014, or by an average of 33.6 percent per year (Ministry of Agriculture, 2012). The result of policy simulation through reducing import-quotas of feeder cattle and beef by 25 percent and 35 percent respectively during the period 2012–2021 is presented in Table 3.

Table 3. Impact of reduction import-quotas on feeder cattle by 25 percent and beef imports by 35 percent on performance of beef cattle industry and livestock subsector in Indonesia, 2012 – 2021 .

Variables	Description of Variables	Unit	Base Value	Simulation Value	Changes	
					Unit	%
QTS	Beef cattle production	million heads	4.70	4.09	-0.61	-12.95
MSBK	Imported feeder cattle	000 tons	180.40	135.30	-45.10	-25.00
QSDSL	Local beef production	000 tons	265.70	358.80	93.10	35.04
QDM	Beef imports	000 tons	57.66	37.48	-20.18	-35.00
POPT	Beef cattle population	million heads	24.13	18.73	-5.39	-22.35
QDDS	Beef demand	000 tons	396.00	464.40	68.40	17.27
RHDS	Domestic beef price	Rp/kg	29,955.50	29,242.00	-713.50	-2.38
GDPSP	GDP of beef cattle	trillion Rp	17.41	14.89	-2.53	-14.51
DLP	Employment in livestock subsector	000 peoples	5,354.50	5,114.40	-240.10	-4.48
QBM	Beef imports from imported feeder cattle	000 tons	64.39	48.30	-16.10	-25.00
QSM	Total beef imports	000 tons	122.10	85.78	-36.32	-29.75
QSDSM	Additional domesic beef production from imported feeder cattle	000 tons	26.16	19.62	-6.54	-25.00
QSDS	Domestic beef production	000 tons	291.80	378.40	86.60	29.68
EQDS	Excess demand of beef	000 tons	104.20	85.96	-18.24	-17.50
GDPP	GDP of livestock subsector	trillion Rp	49.44	46.91	-2.53	-5.11

If the feeder cattle and beef import quotas are reduced by 25 percent and 35 percent respectively, the average volume of imports of feeder cattle and beef will decline respectively by 45.1 thousand tons and 20.2 thousand tons, bringing total reduction of imports to 36.3 thousand tons (29.75 percent) per annum. The decrease in the volume of beef imports encourage an increase in local beef production by 35.04 percent, equivalent to 93.1 thousand tons, to replace imports in order to meet domestic needs. The increase in local beef production and the decline in feeder cattle imports resulted in a decrease of 22.35 percent in cattle population. This led to the decrease in cattle production of 12.95 percent, equivalent to 0.61 million head per year.

On the other hand, the reduction of feeder cattle imports also reduced the beef production from the additional weight of imported feeder cattle amounting to 6.54 thousand tons. Therefore, the total domestic beef production increased by 86.6 thousand tons (29.68 percent) and this causes a decrease in the domestic beef price of 2.38 percent. As a result of the falling price, the national beef demand rose by 68.4 thousand tons (17.27 percent). As the increase in production was greater than that in domestic beef demand, the gap between demand and domestic production of beef decreased by 17.5 percent.

From the aspect of livestock subsector performance, the decrease in imported feeder cattle by 45.1 thousand tons and cattle production by 0.61 million head resulted in a decrease in the GDP of beef cattle by 14.51 percent or about Rp. 2.53 trillion. As a result, the value of livestock sub-sector GDP dropped 11 per cent, while employment in the livestock sub-sector fell by 4.48 percent, equivalent by 5 to 240.1 thousand people.

Projection of Production and Consumption of Beef

The projection of national demand and production of beef is obtained from econometric models that have been constructed previously. The projection is done to see the extent to which domestic beef production meets domestic consumption. The impact of reduction of imported feeder cattle and beef import on the demand and production of beef during the period 2012–2021 is presented in Table 4.

Table 4. Impact of reduction import-quotas on feeder cattle and beef on production and demand of beef in Indonesia, 2012 – 2021

Year	Beef Demand	Domestic Beef Production			
		Simulation A		Simulation B	
	(000 tons)	(000 tons)	%[1)]	(000 tons)	%[1)]
2012	441.29	337.24	76.42	337.24	76.42
2013	453.94	374.49	82.50	374.50	82.50
2014	457.07	353.55	77.35	362.12	79.23
2015	460.97	366.05	79.41	373.47	81.02
2016	463.91	366.86	79.08	375.35	80.91
2017	466.90	369.19	79.07	378.67	81.10
2018	473.45	388.23	82.00	398.63	84.20
2019	476.08	389.24	81.76	400.85	84.20
2020	484.10	413.84	85.49	426.80	88.16
2021	490.42	425.48	86.76	439.98	89.71

Note : [1)] = percent to beef demand
Simulation A : imported feeder cattle decrease by 25% and beef import decrease by 35%
Simulation B : imported feeder cattle decrease by 25%, beef import decrease by 35% and doses AI increase by 25%

In 2014, domestic beef production would not be able to meet the national demand. Beef consumption in 2014 is expected to reach about 457.07 thousand tons, while domestic beef production is estimated to be around 353.55 thousand tons. Thus, domestic production can only meet about 77.35 percent of the beef demand, so that the rest of 22.65 percent is expected to be met from imports. The government is targeting to achieve beef self-sufficiency in 2014, in which the national beef production is able to meet the minimum 90 percent of the national beef consumption.

The projection calculated until 2021 shows that the national beef production would not be able to meet the needs of national consumption. The beef consumption in 2021 is expected to reach around 490.42 thousand tons, while domestic production is predicted to be around 425.48 thousand tons. Therefore, domestic production would only meet about 86.76 percent of the domestic demand.

If the reduction in import-quotas is followed by technology improvements through increased doses of Artificial Insemination (AI) by 25 percent (Simulation B), then the domestic beef production will increase more. Domestic beef production reached 362.12 thousand tonnes (79.23 percent) in 2014 and 439.98 thousand tonnes (89.71 percent) in 2021. Improved technology will encourage the performance of beef cattle industry with increase of beef cattle production and beef cattle population, so it will increase the supply of cattle and local beef. In the long run, the import restriction policies followed by technology improvement will accelerate the achievement of beef self-sufficiency in Indonesia.

CONCLUSION AND POLICY IMPLICATION

Self-sufficiency policy implementation through reduction in import quota on feeder cattle and beef imports will encourage local beef production and reduce the domestic beef price. However, the increase in local beef production and the decrease in imports of feeder cattle could lead to the decrease in cattle population. This, in turn, could reduce the production of beef cattle. The decline in beef price would lead to the rising beef demand. The increase in domestic beef production is greater than the increase in beef demand so that the excess demand decreases. The decrease in the production of beef cattle and imported feeder cattle will reduce GDP of beef cattle and GDP of livestock subsector. As a result, employment in the livestock subsector will also decrease.

With the decline on imported feeder cattle by 25 percent and beef imports by 35 percent per year, Indonesia has not been able to achieve beef self-sufficiency in 2021. Import restriction policies followed by technology improvement will accelerate the achievement of beef self-sufficiency in Indonesia.

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DEVELOPMENT AND CHALLENGES OF AGRITOURISM IN MALAYSIA

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ABSTRACT

Agritourism started in 1991 in Malaysia as one of tourism diversity activity to improve country account balance. It was included in Sixth Malaysia Plan (1991-1995) where Malaysia's national tourism plan was formulated to increase tourist arrival into the country. This plan was successfully implemented and Malaysia has been in top 10 countries with highest number of international tourist arrival since 2006. At the beginning, most of agritourism places are usually in the form of introducing plants and animal, and its only known to local tourist and cater for the team-building and recreation activities. With the support from governments sectors in marketing and promoting the tourism package, there are many types of activities and packages has been developed and introduced to attract visitors which includes farm stay, pick you own, farm animals, fishing and homestay. The agritourism activities are runs by privates sectors and also local communities. As many of agritourism activities are relate to rural areas, the involvement of local village communities is important to ensure the success of a program and to get returns from the investment. One of such program is Homestay which has successful program to increase the farmers/fisherman income and at the same time introduced the local cultures to visitors. Although tourism has become the second source of income from foreign exchange in the country, the percentage of agritourism contribution is still low compared to other tourism sectors.

INTRODUCTION

Tourism is one of the most vibrant economic generators in the world. Agriculture played a significant role in country's development and economic contribution. The manufacturing industry was started in 1970's and since then GDP from agriculture sector has declined from 22.89% in 1980's to 8.49% in 2004 (Kamaruddin and Masron, 2010). In order to expand country's economy, tourism was developed in 1972 with establishment of Tourist Development Corporation Malaysia and the Ministry of Arts, Culture and Tourism (MOCAT) was only set up on 1987. Over the past decades tourism has become one of the largest and fastest growing economic sectors in the country and is the second largest contributor after manufacturing. Figure 1 shows in 2012, the industry is one of the main sectors contributed RM65.3 billion of income from 20.5 million tourist arrival, contributed 9.3% to GDP and provided 8.7% employment opportunity in the country (World Travel & Tourism Council, 2013). The government has acknowledged the tourism industry economic growth potential thus it was identified as one of the priorities areas under 10th Malaysia Plan (10MP) in June 2010 and to expand the tourism industry (Mohamed et al., 2013). Through 10MP, the tourism was included in of the 12 National Key Economic Areas under the Economic Transformation Program, which to in line with the Malaysia Tourism Transformation Plan to achieved the targeted 36 million tourism and RM168 billion in receipts by 2020 (EPU, 2013).

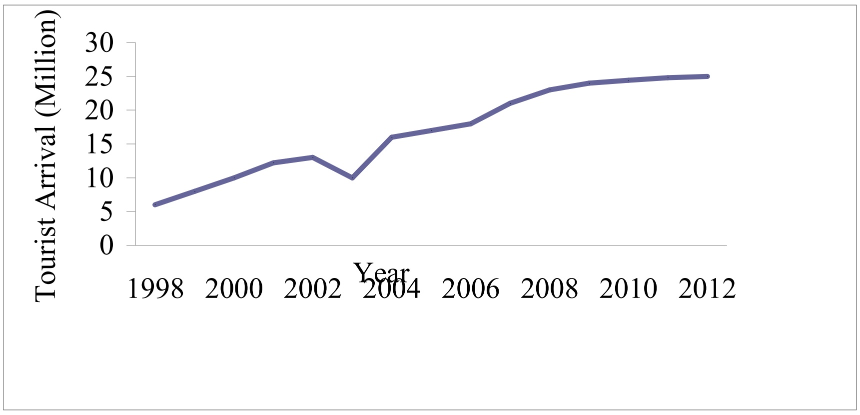

Fig. 1. Tourist arrival in Malaysia from 1998-2012.
Source: World Travel & Tourism Council, 2013

The tourism industry has diversified into new areas such as ecotourism, medical tourism, geotourism, culinary tourism, rural tourism and agritourism which are a subset of rural tourism. Agritourism is a tourist activity to visit a working farm or agri-entrepreneur area for learning or experience farms' life. The agritourism is a catalyst for initiation sustainable tourism activities and diversifying rural activities (Azimi et al., 2012). As agriculture is the fourth contributors to country's economic development, this sector has vast areas to offers visitors to experiences from farms and its resources. The Agritourism concept was first introduced in the country in 1991. It was then followed by International Conference on Agritourism industry held in Kuala Lumpur in 1992, with the objective to clarify the concept of agritourism, learn from other country experiences and to chart development strategy of agritourism in Malaysia (Mohamad, 1994). The tourist arrival to agritourism attraction areas in the country has increased from 0.5 mil in 2007 to 1.5 mil in 2010, which shows an increase of 1 mil within 3 years (Fig. 2).

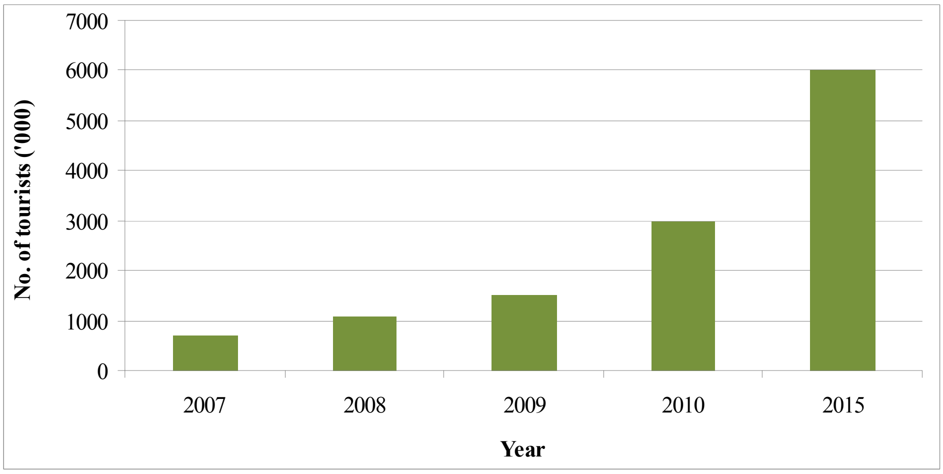

Fig. 2. Number of tourist visited agritourism areas. (2015 and 2020 is estimate number)
Source: Ministry of Agriculture and Agribased Industry, 2012.

It is expected in 2015, the income will be RM3 mil which will be contributed to RM115 billion from tourist received and also contributed to 2 million jobs opportunities in the country (Ministry of Agriculture, 2012). As revenue from agritourism increase, the national agritourism directions were introduced. The directions has marked agritourism as one of the foundation in national industry, community economy sources, as cultural transformation for agriculture community to become more commercialize, as environmental sustainable practice and as national identity on global stage (Ministry of Agriculture, 2012). The National agritourism Directions was introduced to give direction to support its development through strengthening of the agricultural community by encouraging and giving advices to agricultural communities. The economics of the farmers comes from the local agricultural activities, products and culture. Through agritourism, it could enhance and diversify farmers economic and at the same time, it also reduces the rural-urban migration of the young generation.

NATIONAL AGRITOURISM AUTHORITIES

In Malaysia, the tourism planning involves three-tier form of government administrative starting from federal to state and finally the local authorities. Various governmental agencies are responsible in development and promotion of agritourism industry. The Ministry of Agriculture and Agribased Industry (MOA) with its many departments such as Department of Agriculture (DOA), Department of Fisheries (DOF) and Department of Veterinary (DOV) located at many states are accountable to identifying the areas that could be developed into agritourism attractions. These departments' responsibilities also encompass in giving advices on agriculture technology and cultivation techniques to farmers. At national level, the overall tourism planning activities are carried out by Ministry of Tourism and Culture (MOTAC) while the Malaysia Tourism Promotion Board helps in terms of marketing and promotion (Ministry of Tourism Malaysia, 2011).

AGRITOURISM SECTORS

There are various agritourism attraction in the country manages by public and privates sectors. The public agritourism attractions are usually an establishment research centers and training centers open for public to visit (Fig. 3). Example of research center opened for public visits are Malaysia Agriculture Research and Developments (MARDI) station in Cameron Highlands. It showcasing agriculture technologies to promote high technology production system employed for planting fruits and flowers ex: soilless culture technology for strawberry and ornamental plants. MARDI station at Pulau Langkawi is showcasing technology in planting and cultivating of tropical fruits. Established training centers were also open for public visit, such as Melaka State's Departments of Agriculture, named Melaka Tropical Fruit Farm which surround with varieties of local's common and rare fruit trees, and farm animal; Tenom Agriculture Park managed by Department of Agriculture Sabah. It has various industrial plants such as cocoa and coffee, native orchids, pitchers plants, ornamental gardens, bee centre and museum. It is one of the attraction areas in Sabah. There are also agriculture parks purposely developed as a model farm and located near the cities areas, such as Agriculture Heritage Park and Botanical Garden in Putrajaya. These centers were opened to public with the objective to educate the public on the agriculture and also give a various fun activities to the new generation to recognize the crops.

A successful agriculture technologies adopted and practices by farmers was also introduced as an agritoursim attraction to visitor. The Department of Fishery Sabah had established *Tagal* System to the rural communities situated by the riverside Sabah. *Tagal* System means "fishing in rivers is prohibited by the concerned communities for a certain pre-agreed period of time" aims to restore the depleting fisheries resource, keep the rivers from pollution and generate income to the community. Under this system, the concerned communities are allowed to harvest fish from the rivers but in a sustainable manner (Wong et al., 2009). It is a community based fisheries resources management system, which is a stakeholder-driven system for rehabilitation, protection and conservation of river environment for sustainable development. Fishing is forbidden at this area, therefore the fishes are friendly and human are able to touches and stroke the fished. The friendliness of the fished has opened agritourism enterprise among the community living in *Tagal* areas by offering activities such as swimming with fish, fish SPA and fish feeding.

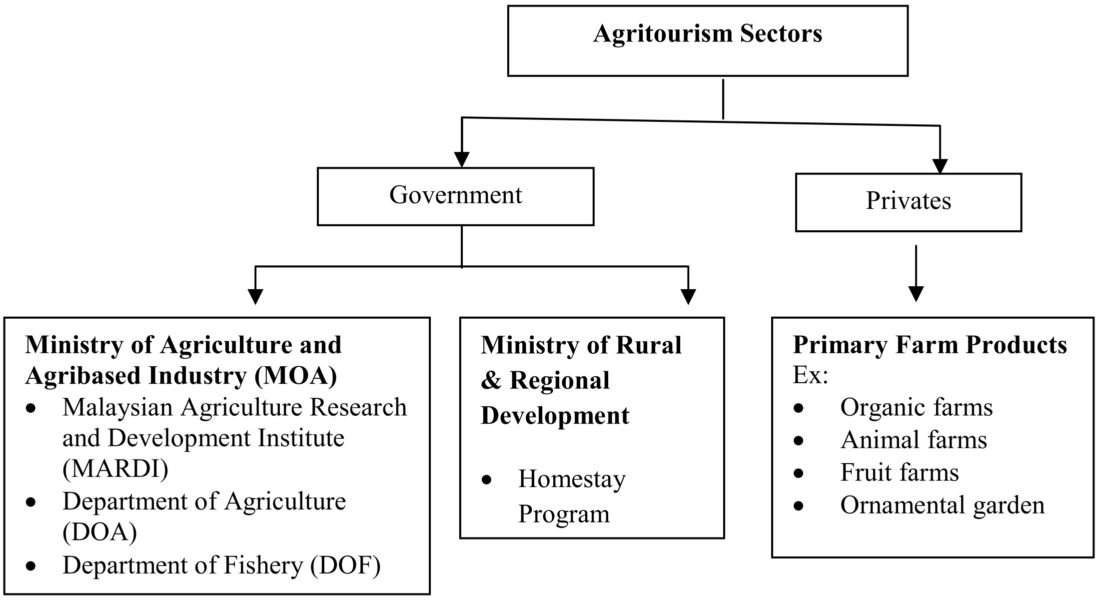

Fig. 3. Agencies involved in agritourism sectors in Malaysia.

The privates sector are usually has a primary farm products, where the farm are an established specialty commercial farm, such as organic farm, animal farms, flower garden etc. The farmer realized the advantages of diversification of income through agritourism, thus this has prompt them to developed facilities and activities in the farms to attract visitors. Many of these farms started as a commercial farms, the farms were opened to visitors, it was found the revenues has increase more than fifty percent or more. Example of private agritourism is farm animal. Farm animals are one of the main attractions to visitors either young or old. One of the most successful farm animal park is the UK Farm in Kluang Johor, which established 2003 for supplying goat's meat, goat's milk and commercialize toiletries product and started agritourism in 2008 (UK Farm, 2013). Since ventured to agritourism, the farm received 5000-7000 visitors monthly from local and international. The famous highland agritourism area in Malaysia is Cameron Highlands. It has boost many tea plantation, strawberries, flowers and honey bee farms to opened an area in their farm for agritourism purposed and in opened their farms to visitors thus attracted 56,700 visitors in 2011.

The Homestay program was formally introduced in 1995 after the launched of Rural Tourism Master Plan which the objective is to increase rural community in tourism industry and reduce rural urban migration. This program is collaboration between MOA, Ministry of Rural Development and MOTAC. These various agencies give supports to homestay operators by giving training, advice and promotion. Homestay is a form of tourism that has element of cross cultural exchange and it involves a community of rural areas. It offers a unique and relaxing lifestyle which is different compared to the other tourism sector. Peterson (2004) reported that the Malaysian homestay is different from countries concept, here the guest staying with operator family thus giving opportunities to interact with local communities and learn directly or indirectly from each other by exchanging culture, heritage and lifestyle. The homestay operator provides an alternative accommodation to tourist, thus the spaces, level of quality and security of homestay houses are very important element in Malaysia homestay.

Homestay provide job opportunities for local communities and improves qualities of life for local people (Bhuiyan et al., 2011). In Malaysia, homestay accommodation operates and organizes by *kampun*g (village) people where often located at rural area where the main economic is the agriculture (Clammer, 1996; Kennedy, 1993). Thus the activities always relate to culture, economic activities of the area, visit to cottage industry and nature. To attract the visitors, each homestay operators offered specific experiences to visitor. Many homestays located in Malaysia's granary areas offered activities related to traditional rice cultivation and harvesting. Homestays in Bagan Datoh, Perak which is country's coconut production area offered activities related to the coconut production and processing As cultural exchange is one of the component in homestay program, the traditional games such as batik drawing; kite making and flying; catch fish in mud (*mengagau-gagau ikan*), coconut bowling were also offered to visitor. A visit to *kampungs'* cottage industries is also a part of the homestay program, where the visitor could learnt the making of *kerepek* (crackers), *kuih* (local delicacies), handicrafts and purchased the products at lower prices.

Since introduction of National Plan for Rural Development Plan in 1995, the government through MOCAT had provided a specific fund to assist in the growth of expansion of Homestay program. The program has gained popularity among rural community, thus make them to open up and accepting tourist in their house (Pusiran and Xiao, 2013). This is proven by the increasing number of homestay operator form 286 in 1997 to 4463 in 2009 (Table 1). The program was also supported by the Ministry of Rural and Regional Development in developed the infrastructure of rural communities.

Table :1 Total number of homestay operators in Malaysia from 1997-2009.

Year	No of Homestay
1997	286
1998	321
2002	776
2004	948
2006	1563
2008	3034
2009	4463

Source: Ministry of Culture, Art and Tourism, Malaysia, 2012.

The Homestay Program has progressed well in generating income to community and country. This is reflected from MOCAT statistic which recorded that the total tourist arrival in 2010 and 2011 was 196,472 and 254,981, respectively which showed a 29.8% increment (Table 2). The homestay program have gained popularity especially among Japanese, Korean and Singapore tourist (Jamilah and Amran, 2007). On 15 November 2012, Malaysia received the Ulysses Award as recognition towards Malaysia's achievement in promoting Homestay Programme. The award was given by the UNWTO to Malaysia signifies the positive development in the homestay program in Malaysia and its ability to attract local and foreign tourists (Abdul Rahim Merican et al., 2014).

To ensure the quality of the accommodation and services offered to homestay visitor is at its best. Homestay operators need to register with MOTAC and attend the Homestay course. The officials from MOTAC will inspect the house to ensure it achieved the minimum requirement. Homestay operator also must meet criteria set by the Malaysian Homestay Association in order for them to get assistance and support from the government and relevant agencies.

Table 2. Comparison of homestay performance in 2010 and 2011.

Item	2010	2011	Increment (%)
Total Tourist Arrival:	196,472	254,981	29.8%
• Domestic	147,346	195,324	32.6%
• International	49,126	59,657	21.4%
Total Revenue (RM)	12.4 mil	15.7 mil	26.8%
Occupancy Rate	25.2%	33.1%	20.4%

Source: Ministry of Culture, Art and Tourism, Malaysia, 2012.

CHALLENGES IN AGRITOURISM

Although the agritourism has shown a good records in its development since is started, there are still improvement could be made to increase the revenue from this industry. It was reported, the overall income generated through tourism in Malaysia keep increasing, however only 25% were contributed from agricultural and agro-based product (Shuib, 2007). The agritourism in Malaysia still considered at young stage compared to other countries such as in European countries and United States. Thus need to go through obstacles to ensure the better route for this industry to develop further in the future. Lacking of maintenance and basic infrastructure is one of the problems facing by the agritourism operator. Visitors will only visit and re-visit to areas which are easily accessible, with proper basic utilities and well maintained farms. Many of the agritourism places located further to the rural areas, thus ggood transportation link is required to attract visitor to these places. Basic tourism amenities such as local transportation, comfortable accommodation and basic food service should be available for tourist. This would add market value to the product. A product would be difficult to market if they are not easily accessible by the public. The government agencies need to consider the location of tourism areas. For instances the access to the location being not too far away or difficult to go is important as most tourist spend a few days only for travelling purposes. As such the agritourism need to identify tourist attractions that are easily located within their vicinity such as natural attraction (waterfall, lakes, flora and fauna) (Pusiran and Xiao, 2013) to offers as activities for visitors.

There is a need to diversify agritourism products to differentiate individual package to attract more visitor. This could be achieved if the local community to be responsible and committed for development of tourism product on their sites. However, obtaining cooperation and commitment from every individual in the community is crucial (Yusnita et al., 2012). Community involvement is a very important factor in agritourism activities. There is needs for the authorities to improve the participation level in communities to ensure the success of projects. Lack of community participation may lead to failure of agritourism program closely related to community, such as the *Tagal* System and Homestay. The lack of good promotion and under-developed marketing strategies were also found to be a factor hindering the agritourism development. Internet is one the best tools for product promotion; however, searching for agritourism park through world wide web would only shown few of agritourism places in the country. The agritourism operator also lacking in networking with tourism industry players to helps them push for a more successful programme and marketing. Communication between the guide/host with the visitor is considered to be an important aspect in achieving good visitor satisfaction. The drawback in agritourism industry, especially at rural areas is the lack of communication skills or mastering the internationally accepted language especially English. (Pusiran and Xiao, 2013).

In the 10MP, the government has introduces six strategies to face these challenges). The first strategy is by diversification of agritourism based on products, such as farm produces, agricultural education, natural conservation and heritage, health, handicraft and culture. Second is to offer agritourism package specifically by country, this include preparation of suitable food and multilingual guide. The third strategies is to improve and upgrading of infrastructure, transportation and accommodation by given more incentive to agritourism operator and simplify loan application to encouraging them on upgrading their facilities and accommodations. The fourth strategy is to strengthen the agritourism quality and safety through introducing agritourism product rating and certification. The fifth is to prepare agritourism calendar and directories to simplify the agent to make booking and for tourist to plan their visit. The final strategy is to strengthen workforce with all stakeholders such as tour agencies and increase promotion (EPU, 2013). Through these strategies, the government is anticipating the agritourism could develop to higher level and achieve the targeted number of tourist arrival to agritourism area to 6 million.

CONCLUSION

The agritourism industry in Malaysia has plenty to offer to visitors due to plenty of resources available in the country. However, to be able to expand and further develop this industry, problems and challenges need to be overcome. Few problems faced in agritourism are the community participation and language barrier. The 10MP strategies planned to overcome various problems in agritourism, however, do not include community participation and language barrier, which is shown to be problems faced in agritourism products. The current 10MP related to promotion of agritourism product planning is until 2020. There are six more years to achieve the target set. It is imperative for the government to assess the execution of the current strategies to ensure the objective of the plan.

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NAPIER GRASS: A NOVEL ENERGY CROP DEVELOPMENT AND THE CURRENT STATUS IN THAILAND

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ABSTRACT

In recent years, there has been increasing an interest in the potential role of perennial C4 grasses, such as switch grass (*Panicum virgatum*) in the US and miscanthus (*Miscanthus* spp.) in Europe, as promising energy crops. Characteristics making perennial C4 grass attractive for biomass energy production are their high biomass yield potential, high lignocellulosic content, low input demand, and positive environmental impact. In Thailand, the Energy Regulatory Commission has established the Renewable and Alternative Energy Development Plan to reduce fossil fuel usage by 25% over 10 years (2012-2021). One of its targets is to increase alternative energy production to 13,927 MW by 2021 from the present 7,294 MW. To meet this goal, approximately 8,400 MW of electricity is needed, which could be sustainably supplied through 221,760,000 tons of harvestable biomass each year, exploiting current land resources. Of the 221,760,000 tons of available biomass, napier grass (*Pennisetum purpureum*) accounts for the majority. Napier grass originated from Africa where it is called Giant King Grass. This grass was introduced into Thailand over 30 years ago. After evaluating perennial grasses available in Thailand, 'Pakchong 1' napier grass has shown the greatest potential for biofuel production. In irrigated areas, napier grass provided up to 438-500 tons of fresh biomass ha^{-1} after harvesting 5-6 times per year. One ton of napier grass can produce 90 m^3 of biogas. The heating value for compressed biogas (CBG) produced from its biomass is 14-18 MJ kg^{-1}. The Royal Thai Government strengthened its support for renewable power generation from napier grass for two reasons: to generate electricity to feed the grid, and to produce CBG as an alternative for exhausting NGV and as a substitute LPG. However, since research on producing napier grass as a bioenergy source in Thailand is comparatively recent, there are still significant limitations for further development. The key challenges for napier grass production are the unavailability of a water supply source to allow high yield potential, need for the appropriate cultivars for given ecological conditions, and cost-effective management methods.

Key words: energy crop, biomass, renewable energy, perennial grass

INTRODUCTION

Thailand is a rapidly developing economy with not much indigenous energy resources. Thus, a national level of energy security is significant to Thailand in order to deal with increasing petroleum fuel price. In 2012, GDP growth at the rate of 6.4% has affected the increase in energy demand, which comes from (in decreasing order): the industrial (36.7%), transportation (35.6%), residential (15.1%), commercial (7.2%), and agricultural sectors (5.2%). Petroleum product consumption had the highest proportion (48.0%) of total energy consumption, followed by electricity (18.9%), traditional renewable energy (10.5%), coal and its products (7.9%), commercial renewable energy (7.7%), and lastly, natural gas (7.0%). This allowed a 16.7% increase in energy import value from the previous year to US$0.048 trillion (Alternative Energy and Efficiency Information Center, 2014). Although Thailand has some coal reserves (lignite and natural gas), natural gas is only available for 12.5 years while lignite for 100 years. To meet this high demand, Thailand imports oil, coal, gas, and electricity, which account for 46% of the total main energy consumption. Imported energy dependency has been growing at an average growth rate of 5.3% per year. Therefore, Thailand has been committed to improve energy security by promoting energy use efficiency and supporting the use of alternative renewable energy (GNESD, 2010).

In 2012, the Thai Department of Alternative Energy Development and Efficiency (DADE) introduced a 10-year Alternative Energy Development Plan (AEDP, 2012-2021) to accelerate renewable energy consumption up to 25% (13,927 MW) by 2021, from the present 9.9% (7,294 MW). The target 25% increase is excluded from the total energy consumption in 2021 as indicated in Table 1 (Alternative Energy and Efficiency Information Center, 2014).

Table 1. The renewable alternative energy development plan for 25% in 10 years (AEDP 2012-2021) in Thailand.

Types of Energy	Unit	New Target
Electricity		
Solar	MW	3000
Wind	MW	1800
Small Hydro Power	MW	324
Hydro Power and Pumped Storage	MW	-
Biomass	MW	4800
Biogas[1/]	MW	3600
MSW	MW	400
New Energy	MW	3
Total	MW	13,927
	ktoe	5,370
Heat		
Solar	Ktoe	100
Biomass	Ktoe	8500
Biogas	Ktoe	1000
MSW	Ktoe	200
Total	Ktoe	9800
Biofuels		
Ethanol	ml/day	9.00
Biodiesel	ml/day	7.20
New Energy Replacing Diesel	ml/day	3.00
Compressed Bio-methane Gas	tons	1200
Total	ml/day	1219.20
	ktoe	9464
Alternative Energy		25%

[1/] including napier grass 3,000 MW

As a result of AEDP (2012-2021), the use of domestic sources of alternative energy, such as solar, wind, hydro energy, biomass, biogas, MSW, and biofuel (ethanol and biodiesel) has increased by 14.3% from the previous year and comprised of 9.9% of total final energy consumption (Alternative Energy and Efficiency Information Center, 2014).

Most mandatory alternative energy targets are for sources of electricity, heat, and transportation (Table 1), with biomass, biogas, and compressed biogas (CBG) having the greatest contribution. By 2021, the electricity target of 4800 MW and the heat target of 8500 ktoe would be obtained from biomass. Biogas targets electricity, heat, and a CBG generation of about 3,600 MW, 1,000 ktoe, and 1,200 tons, respectively. To ensure that this renewable energy source obtains a share of 25% energy supply in Thailand by 2021, 221,760,000 tons of harvestable biomass exploiting current land resources are needed each year. Potential biomass feedstocks in Thailand are divided into four groups: agricultural wastes, agro-industrial residues from wood industries, furniture, and energy crops. Although the by-products and wastes mentioned above have high potential, they still face numerous problems, such as low biomass quality, insufficient quantity in some seasons, and technical and economic challenges. These feedstocks could only be supplied on a short-term due to their insufficient amounts. Thus, to maintain long-term production of renewable energy, the Thai Department of Energy has run projects promoting the cultivation of biomass crops, which can provide sustainable production of renewable energy (Department of Alternative Energy and Efficiency, 2012). A perennial grass, namely napier grass (*Pennisetum purpureum*) is considered as one of the most suitable energy crops with its potential yield, longetivity, ability to regrow after harvest and to grow in poor areas. Biomass feedstocks for biogas production of 3,000 MW have been estimated to come from this grass (DEDE, 2014).

The aims of this article are to review previous experiences involving the development of novel energy crops, such as napier grass in Thailand; to give an overview of the characteristics and requirements of napier grass; and to summarize the current status and main challenges of bioenergy production from napier grass.

PERRENNIAL GRASSES AS ENERGY CROPS

With the limitations of first generation bioenergy from food crops, a renewable energy source derived from lignocellulosic feedstocks have been considered as second generation bioenergy over decades (Naikl et al., 2010). Food crops (such as corn grain) cannot produce enough feedstock for biofuel production without threatening food supply and biodiversity. They also rely on subsidies and are not cost-competitive with existing fossil fuels. In addition, their management practices produce only limited savings of greenhouse gas emissions (Fargione et al., 2008, Searchinger et al., 2008). In contrast, second generation bioenergy has been evaluated if it could help solve such problems and supply a greater and sustainable energy supply. Moreover, lignocellulosic biomass is associated with low CO_2 emission and provides socio-economic benefits (Askew and Holmes, 2001). One of the high potential lignocellulosic feedstocks or non-food biomass typically includes a dedicated energy crop, i.e. perennial grass.

For the last centuries, perennial grass plays a key role as a forage crop contributing energy to farms using draft animal (Vogel, 1996). Currently, these perennial grasses may become a key lignocellulosic feedstock for bioenergy production through both biochemical and thermochemical conversion pathways. The characteristics making perennial C4 grasses attractive for biomass energy production are their high biomass yield potential, high lignocellulosic content, low input demand, and positive environmental impact. There has recently been increasing interest in the potential role of perennial C4 grass as promising energy crops in many countries. In Europe and the US, a number of candidate herbaceous grasses and short-rotation woody crops differ significantly in their yield potential. All high-yielding grass screened were potential candidates for biofuel production and lignocellulosic feedstocks. In Europe, the perennial grass receiving the most attention is Miscanthus (*Miscanthus spp*.), while in the US, switchgrass (*Panicum virgatum*) has been selected as the single 'model' energy crop species (Wright and Turhollow, 2010). Although their high yield potential is extremely important for selection, biomass yield must be balanced against input needs to contribute potential positive economic aspects for farmers. One of the key criteria is that these two grass species can grow on marginal land with limitations on conventional crop production. In addition, environmental factors were also considerably important. Both model energy crop species can provide a wide range of environmental benefits, including a relatively lower chemical fertilizer and pesticide requirement, a source of wildlife habitat, increased soil carbon storage with sequestering carbon belowground, and an improvement of soil erosion (McLaughlin and Kszoz, 2005, Wright and Turhollow, 2010). Based on these limitations, that is the reason why C4 perennial grasses, therefore, show the greatest potential as model energy crops in different parts of the world.

THE DEVELOPMENT OF 'MODEL' ENERGY GRASS IN THAILAND

Similar to the mandatory renewable energy development plan of different countries, the Thai Department of Energy has decided to focus on a "model" crop system and emphasize research and development of a single perennial grass to achieve the greatest possible outcome of its use as a model biomass crop (DEDE, 2014). Various perennial grass differ considerably in their potential productivity, chemical composition, environmental demands, and management practices (Wongwatanapaiboon et al., 2012). In order to identify those grasses that best fulfill the requirements for bioenergy production, research institutes in Thailand initially conducted research programs on bioenergy feedstock development, beginning with the screening of perennial grass species popularly grown in Thailand (ERDI, 2014; Wongwatanapaiboon et al., 2012). Previous research by Energy Research and Development Institute-Nakornping (ERDI, 2014) financially supported by Energy Policy and Planning Office (EPPO), demonstrated that the napier grass cultivar 'Pakchong 1' showed the greatest potential for bioenergy production among other introduced and local grass species (such as ruzi, purple guinea, bombaza, pangola, signal, atratum, setaria, bana, torpedo grass, paragrass, and greenpanic). Pakchong 1 can be harvested 5-6 times a year under irrigation and provides 437-500 tons biomass $year^{-1}$ ha^{-1}, which is 7 times greater than other species.

DESCRIPTION OF THE BACKGOUND OF NAPIERGRASS

A. Taxonomy and Morphology

Napier grass belongs to the tribe Paniceae in the subfamily Panicoideae of the Gramineae family (Bogdan, 1977). It is native to African regions, such as Kenya, Tanzania, Uganda, Ethiopia, and Zimbabwe. Some hybrids were developed in America (Cook et al., 2005). The 130 varieties of napier grass have been introduced into various subtropical and tropical areas (Tudsri, 2005). This species is naturalized throughout Southeast Asia (Mannetje, 1992). For Thailand, it has been introduced and grown as a forage crop since 1929 by Mr. R.P.Jones from Malaysia. Hybrid, King grass, and Mott dwarf were continuously introduced by the Department of Livestock Development from India and by the Thai Dairy Farming Promotion Organization from America (Tudsri, 2005).

Napier grass produces numerous tillers, providing 1 m or more width of plant base. The plant produces 20 or more internodes, ranging from 20 to 25 cm in length and up to 3 cm in diameter. With a cross-pollinated type, it sets little seed, but low seed set is partially because of self-incompatibility. A single genotype or clone can occupy a large area (Hanna and Monson, 1988). Because genotypes do not breed from seed due to high heterozygosity with sexual reproduction, napier grass is commonly vegetatively propagated (Stapf and Hubbard, 1934).

B. Ecological demands

Napier grass is a tall tropical perennial C4 grass with a high radiation use efficiency. In general, many C4 grasses are higher in nutrient use and have a water use efficiency about twice than that of C3 crops (Stanhill, 1986; Squire, 1990), but this is not the case in cool regions where photosynthesis is restricted. This grass can to be grown all year round with a water supply during dry season. It is well-adapted to a wide variety of soil types from sandy loam to clay soil (DLD, 2002; FAO, 2009) and can be grown in acidic or mildly saline soil. But it will grow well in deep, well-drained, and fertile soil with high rainfall (>1000 mm), but it cannot grow in soil waterlogged for long periods of time. At the same time, it can survive under drought conditions with its deep fibrous root system, but also responds well to irrigation (Skerman and Riveros, 1990).

There are large morphological variations, as well as natural cross-pollination and growth responses to different environments contributing to differences within species (Bogdan, 1977; Skerman and Riveros, 1990). Napier grass is a short-day plant, flowering when day length is 11 h or less. But an interaction between day length and temperature may affect flowering. The optimum temperature for this species is 30-35 ˚C (Ferris, 1978). When temperatures decrease below 10˚C, growth stops (Bogdan, 1977). Frost kills aboveground plant parts, and underground parts will regrow unless the soil freezes. It needs >100 days sunshine. Napier grass has a high stand persistence and better adaptation to marginal and erodible soils than conventional crops.

C. Biomass production

Napier grass is commonly used for forage and pasture in the tropics, with the potential to produce more dry matter per unit time than most other grasses (Hanna and Gupta, 1999). In Thailand, this species has been used for many years as a raw material for fodder and pasture (Tudsri, 2005; Ketkamalas, 2006). For recent studies, napier grass has been assessed as a lignocellulosic material feedstock, aside from animal feed. Kannika et al. (2012) reported that napier grass had outstanding agronomic characteristics and high potential as one of the dedicated energy crops in Thailand due to its higher yields and suitable chemical composition. Napier grass has been examined and developed as a promising bioenergy crop in other countries as well (Keffer et al., 2009).

Napier grass produces high dry matter yield when well-irrigated and fertilized, particularly with nitrogen (Skerman and Riveros, 1990). Biomass yield of napier grass reached 25.0 t $ha^{-1}yr^{-1}$ when grown in irrigated areas and dropped to 18.8 t $ha^{-1}yr^{-1}$ in non-irrigated areas (DLD, 2002). On the other hand, its productivity was highly correlated with rainfall pattern in Thailand. Kannika et al. (2013) also showed that biomass yields of 8 napier grass cultivars varied with season, with an overall pattern of highest yield in May and lowest yield in February (15.5 and 5.2 t DM ha^{-1}, respectively). A strategy for harvesting napier grass would be during seasons with enough soil moisture content for plant growth and not harvesting during dry season. Yet the economics and logistics of closing the processing plant for a long time must be considered. When compared with other 'model' energy grasses, napier grass has exhibited relatively great yield potential, providing between 27 and 58 t DM ha^{-1} yr^{-1}, probably the highest for biomass grasses (Table 2).

Table 2. Potential of perennial grasses grown or tested as 'model' energy crops.

Common name	Scientific name	Yield (t DM ha^{-1})	Citation
Switchgrass	*Panicum virgatum*	0.9-34.6	Pfeifer et al. (1990)
Miscanthus	*Miscanthus spp.*	5-44	Lewandowski et al. (2000)
Napier grass	*Pennisetum purpureum*	27-58	Kannika et al. (2013)

D. Biomass characteristics

Biomass quality is strongly correlated with its chemical content (Adler et al., 2006). Napier grass cultivars selected for fodders were high in leaf percentage, nitrogen and mineral content, and low crude fiber. Commonly, obtaining high nutritive values for forage grass is sacrificed with lower dry matter yield. In contrast to forage purposes, biomass characteristics are to obtain maximum biomass yield with desirable quality for bioenergy production via thermochemical or biochemical methods (Prochnow et al., 2009; Naik et al., 2010). A high lignocellose content is most desirable for bioethanol while low mineral contents (such as N, S, Cl, Si, and K etc.), ash, and high energy density (>14 MJ/kg) in biomass feedstock are mainly emphasized for the gasification process (Obernberger et al., 1997). Table 3 shows that the chemical composition of napier grass and other 'model' energy grasses are desirable for bioenergy production through both thermochemical and biochemical conversion methods. Chemical constitutuents for biomass (such as cellulose, hemicelluloses, lignin, ash and mineral contents) of napier grass have been examined to meet the required standards for biofuel production by Kannika et al. (2013). Their study also demonstrated that the key chemical elements varied with cutting season. Biomass quality of napier grass harvested during wet season provided higher quality for biofuel production than during dry season. However, better biochemical conversion efficiency from napier grass is still required by pretreating the raw material.

Table 3. Chemical compositions and heating values of 'model' energy grasses.

Common name	**Cellulose (%)**	**Hemicellulose (%)**	**Lignin (%)**	**N (%)**	**Ash (%)**	**Heating value (MJ kg^{-1})**	**Source**
Switchgrass	37	29	6	0.71-1.37	4.5-10.5	17	Christian et al. (1997); McLauglin et al., (1996); Sladden et al. (1991)
Miscanthus	31.3-54.8	24.8-37.7	6.4-13.3	0.19-0.67	1.6-4.0	9-17	Ma et al., (1999); Lewandowski et al., (2000); Kristensen, (1995)
Napier grass	35-47	19-26	4-12	1.2-2.0	8-16	14-16	Kannika et al. (2013)

E. Major cultivars

There are a number of napier grass cultivars available in Thailand. The are two subgroups of major cultivars of napier grass based on plant height, namely tall-, and dwarf to medium-tall types. Plant height of tall-type cultivars is approximately 2-6 m and 1-2 m for dwarf to medium-typed cultivars. All cultivars are propagated vegetatively. Because vegetative cuttings and seeds are easily hand-carried by scientists in the tropics and subtropics, it is difficult to investigate pedigrees and origins of these cultivars. As a result, there are different common names for a single cultivar in different countries and regions (Hana et al., 2004). From a previous study, six tall-typed cultivars (Merkeron, Pakchong 1, Taiwan A25, Wruck wona, Common, and King grass) provided higher annual biomass yields ranging 7.3-13.3 t ha^{-1} yr^{-1}, than seven dwarf to medium-typed cultivars (Small, Medium, Mott, Hybrid 1, Hybrid 2, Muaklek, and Tifton) producing 5.9-8.7 t ha^{-1} yr^{-1} when harvested three times per year (Ketkamalas, 2006). Kannika et al. (2013) also reported that biomass yields for tall-typed cultivars (Bana and Common) was 39.3-44.4 t DM ha^{-1} yr^{-1}, which is greater than that of medium tall-typed cultivars (Muaklek) providing 17.9 t DM ha^{-1} yr^{-1}.

CURRENT STATUS OF BIOENERGY DEVELOPMENT FROM NAPIERGRASS IN THAILAND

A. Costs and incomes

To increase biomass production and farmer profit, the government has offered price guarantees to farmers who grow napier grass at US$ 10 per ton based on a feed-in tariff (FIT) of US$ 0.15 per kWh (unit). The guaranteed price is higher than some economic crops and makes a higher gross income than rice and cassava (Table 4). In addition, growers will also earn US$ 625 ha^{-1} in the establishing year. The total production costs for napier grass is lower than for cassava and sugarcane, because it can be harvested many times a year. Thus, planting napier grass could generate a net income of US$ 743 per hectare a year, which is higher than rice, sugarcane, and cassava, which amount to US$ 488, 428, and 430 per hectare a year, respectively (Table 4).

Table 4. Total production cost, total gross income, net income, and total yield of major crops in Thailand.

Crops	Total production cost	Total gross income	Net income	Total yield	Source
	--------------------(US $/ha/yr)	-------------------		(t/ha)	
Rice	1,231	1,719 (US$ 366.6/t)	488	4.7	AFTC (2014)
Sugarcane	2,043	2,471 (US$ 35/t)	428	70.6	OCSB (2014)
Cassava	2,037	1,575 (US$ 73.3/t)	430	21.5	TDIT (2014)
Napier grass	1,444	2,188 (US$ 10/t)	743	218.7	OSSC (2014)

B. Biogas production from napier grass

According to AEDP (2012-2021), the Department of Alternative Energy Development and Efficiency (DEDE) has conducted renewable energy development projects promoting biogas as an alternative energy source of 3000 MW from napier grass. The goals of these projects are to use biogas for generating electricity, substitute LPG as cooking gas, and produce compressed biogas (CBG) for vehicles. It has supported studies, research, and prototype projects on green community energy from energy crops to produce biogas using 20% of the prototype budget (Alternative Energy and Efficiency Information Center, 2014).

Within this strategy, DEDE also promotes collaboration of farmers in the form of community enterprise or agricultural cooperatives (named Distributed Green Generation for Community Enterprises) to grow napier grass with farm contracts to sell their products to biogas plants. Moreover, the first 10-20 biogas plants chosen by the Ministry of Energy have also been awarded a subsidy of 20% of the investment cost or not more than US$ 0.66 million per project. The prototype projects on napier grass production have promoted growth in 3 different zoning areas dedicated as poor land, including dry land, wetland, and sub-standard rice cultivation areas in 10 communities around the nation. The project's goal is to promote as much as 1600 ha farm size to supply 10 MW to power plants (DEDE, 2014).

With its anaerobic digestion, napier grass 'Pakchong 1' can convert to biomethane at 0.62 m^3 $CH_4/kg/VS_{added}$, higher than other major feedstocks, including rice straw, cassava pulp, pineapple peel, cattle manure, chicken manure, water hyacinth, oil palm empty fruit bunch, and swine manure (Table 5) . One metric ton of napier grass cut at 60 days can be converted into biogas by 90 m^3

generating 170 kW day^{-1} electricity. Also, it is estimated that 'Pakchong 1' harvested 5 times per year can produce compressed biogas (CBG), with heating value of 14-18 MJ kg^{-1}, at 42875-49000 m^3 ha^{-1} yr^{-1}. The CBG would be able to replace the use of natural gas vehicle (NGV) in Thailand at 3118-3563 kg yr^{-1} (DEDE, 2014).

Table 5. Biomethane yield produced from different feedstocks in Thailand.

Biomass feedstocks	Digester	Biomethane yield (m^3 CH_4/kg/VS_{added})	Source
Rice staw	BMP batch	0.34	Nuntiya et al. (2009)
Cassava pulp	BMP batch	0.37	Nuntiya et al. (2009)
Pineapple peel	BMP batch	0.40	Nuntiya et al. (2009)
Water hyacinth	BMP batch	0.35	ERDI (2009)
Oil palm empty fruit bunch	BMP batch	0.37	ERDI (2009)
Swine manure	BMP batch	0.45	ERDI (2009)
Cattle manure	BMP batch	0.18	ERDI (2009)
Chicken manure	BMP batch	0.15	ERDI (2009)
Napier grass	ASBR	0.62	Patiroop et al. (2009)

For heat production from biomass, the Thai government has promoted a community-based approach on gasification of power plants and the gasification for industries with a total capacity of 5.4 MWe. With target of a 4,800 MW, the development focuses on promoting communities to collaborate in a broader production, namely "Distributed Green Generation (DGG)". The state utilities, i.e., EGAT and PEA (Provincial Electricity Authority) shall extend transmission and distribution lines to support the development of biomass power plant projects, especially in areas with a high potential for feed stocks (DEDE, 2010).

MAJOR CHALLENGES TO DEVELOPMENT OF BIOENERGY FROM NAPIER GRASS IN THAILAND

Promoting napier grass production with subsidy programs may lead to extending planting areas for current food crops. To meet the goal of 3000 MW, it has been implied that 1.6 million hectares would be planted with napier grass (DEDE, 2014). Because of high incentive levels available for renewable electricity, producers might divert existing conventional crops or croplands towards biofuels, which indirectly causes food security. The changes in land use trigger an increased food crop prices. For sustainable development, land use planning through zoning by the government would prevent prime agricultural areas from being converted to this grass. Moreover, abandoned or poor lands used for food crops could be used more for napier grass as well, without any impact on food supply.

Although napier grass efficiency in water use is higher than other conventional crops, water supply will always be a key factor for maximum biomass yield and seasonal yield distribution of an area. Zoning areas dedicated to plant napier grass are poor, and areas on dry and degraded lands under government policy would provide low productivity unless irrigated. Therefore, irrigation system management could sustain biomass production from napier grass in these areas.

Research work on napier grass as a bioenergy crop for Thailand has not yet matured. Most research in Thailand falls under the development of electricity and heat production technologies from napier grass, with focus on improving the production process and technologies involved in producing biogas, power, and heat from biomass. However, advanced research on breeding programs and crop management to improve biomass yield potential, the stability of yields over the years, and biomass quality under stress conditions is still limited and a necessity. Therefore, a serious mismatch between R&D investments and potential biobusiness opportunities for growing bioenergy production from napier grass is still a key challenge.

Increased interest in growing napier grass is due to incentive measures for investment projects, which are uncertain. The costs of biomass feedstocks from perennial grass are a function of stand establishment, management, and harvest of the biomass yield (Deimling et al., 2000) and are the most important factors for the success or failure of bioenergy production from napier grass. With a revised government policy, labor costs in Thailand shall almost double. Therefore, using farm machines to replace human labor could help decrease production costs and allow economic feasibility in the long run. However, further development of farming machines for napier grass production has only been recent.

In conclusion, because of its high lignocellulosic content, low input demand, and positive environmental impact, napier grass is selected as a ‘model’ energy grass for biomass production in Thailand. This grass will play a key role as a main biomass feedstock to meet electricity and heat production targets in an alternative energy development plan for 25% in 10 years. However, there are many challenges in the development of bioenergy from napier grass mentioned that must be addressed. Further research and development is necessary for sustainable development.

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Report from ISSAAS Secretariat

ISSAAS Board of Directors Meeting 2013

Date and Time: 11 November 2013; 20:30-22:00
Venue: Acacia Hotel Manila, Muntinlupa City, Philippines

AGENDA

(Presided by ISSAAS Acting President Dr. Fernando C. Sanchez. Jr.)

1. Greetings from ISSAAS Acting President: Dr. Fernando C. Sanchez. Jr.

2. Activities Report 2013 (Oct 2012-Sep 2013): Approved
   (1) International Congress 2012
   Dates: 14-16 November 2012
   Venue: St. Ellis Hotel and Bicol University, Bicol, Philippines

   (2) Board of Directors Meeting
   Date: 13 November 2012: 19:00-21:30
   Venue: St. Ellis Hotel, Legazpi City, Bicol, Philippines

   (3) Board of Directors Meeting
   Agenda: Resignation of ISSAAS President and Nomination of Acting President
   Date: 29 January 2013
   Venue: Email Conference

   (4) Board of Directors Meeting
   Agenda: Granting of ISSAAS MATSUDA AWARD
   Date: 24 July 2013
   Venue: Email Conference

   (5) Board of Directors Meeting
   Agenda: Amendment of the Bylaw of the ISSAAS AWARD
   Date: 6 August 2013
   Venue: Email Conference

   (6) Board of Directors Meeting
   Agenda: Granting of the ISSAAS SCIENTIFIC AWARD
   Date: 25 September 2013
   Venue: Email Conference

   (7) Publications of Journal
   Vol.18, No.2: Published in December 2012
   Vol.19, No.1: Published in June 2013

   (8) Others
   Co-sponsored the 12th -International Students Summit, held at Michigan State University, USA, 4-5 October 2012.

3. Financial Report 2013: Approved

4. Auditors' Report for 2013: Approved

5. Business Plan for 2014 (Oct 2013-Sep 2014): Approved

(1) International Congress 2013
Dates: 12-14 November 2013
Venue: Acacia Hotel Manila, Muntinlupa City, Philippines

(2) Board of Directors Meeting
Date: 11 November 2013
Venue: Acacia Hotel Manila, Muntinlupa City, Philippines

(3) Publications of Journal
Vol.19, No.2: To be published in December 2013
Vol.20, No.1: To be published in June 2014

(4) Others
Co-sponsored the 13th International Students Summit,
Tokyo University of Agriculture, Japan, 3-4 October 2013

6. Budget 2014: Approved

7. ISSAAS AWARDS

(1) THE MATSUDA AWARD: Dato' Sri Zakri A. Hamid, Malaysia
(2) THE SCIENTIFIC AWARD: Akimi Fujimoto, Japan
(3) THE SCIENTIFIC AWARD: Dewa Ngurah Suprapta, Indonesia

8. Letter of Appreciation
Dr. Roberto F. Ranola, Jr.,
Vice President of ISSAAS for the Philippines (2002-2011), and
President of ISSAAS (2012- January 29, 2013)

9. Donations from TUA and SAEDA

(1) Tokyo University of Agriculture: 300,000 Japanese Yen
(2) Society for Agricultural Education-Research
Development Abroad (SAEDA): 200,000 Japanese yen

10. Election of Officers: Jan 1, 2014 – Dec 31, 2015: Approved

<u>Headquarters</u>
President: Katsumi Takano (TUA, Japan)
Secretary General: Hironobu Shiwachi (TUA)
Auditors: Hiromitsu Negishi (TUA) and Hiroshi Okazawa (TUA)
Editor-in-Chief: Keishiro Itagaki (TUA)
Technical Editor: Susan May F. Calumpang (UPLB)
Chairperson, Award Screening Committee: Yusman Syaukat (IPB)

By Chapter

Indonesia

Vice President for Indonesia: Yusman Syaukat (IPB)
Directors: Alit Susanta (UNUD) and Abdjad Asih Nawangsih (IPB)
Regional Secretary: Dadang (IPB)
Advisors: Tineke Mandang (IPB) and Dewa Ngurah Suprapta (UNUD)

Japan

Vice President for Japan: Keiko Natsuaki (TUA)
Directors: Keishito Itagaki (TUA) and Machito Mihara (TUA)
Regional Secretary: Mami Irie (TUA)
Editors: Tadashi Baba (TUA) and Machito Mihara (TUA)
Advisors: Kanju Ohsawa (TUA)

Malaysia

Vice President for Malaysia: Abdul Shukor Juraimi (UPM)
Director: Halimi Mohd Saud (UPM)
Regional Secretary: Juwaidah Sharifuddin (UPM)

Philippines

Vice President for the Philippines: Fernando C. Sanchez, Jr. (UPLB)
Director: Evalour Aspuria (UPLB)
Regional Secretary: Simplicio Medina (UPLB)
Advisors: Priscilla Sanchez (UPLB), Roberto Ranola, Jr. (UPLB)

Thailand

Vice President for Thailand: Sombat Chinawong (KU)
Director: Seksom Attamangkune (KU)
Regional Secretary: Anamai Damnet (KU)

Vietnam

Vice President for Vietnam: Tran Duc Vien (HAU)
Regional Secretary: Nguyen Thi Bich Thuy (HAU)

11. Activities Report for 2013 by Each Chapter

Indonesia	Vice President Tineke Mandang
Japan	Vice President Kanju Ohsawa
Malaysia	Vice President Abdul Shukor Juraimi
Philippines	Vice President Fernando C. Sanchez, Jr.
Thailand	Vice President Sombat Chinawong
Vietnam	Vice President Tran Duc Vien

12. Plan for 2014 International Congress

Theme: *Agricultural Changes in Southeast Asia: Past, Present and Future*
Dates: November 8-10, 2014
Venue: NODAI Academia Center, Tokyo University of Agriculture, Tokyo, Japan
Schedule: November 7 (Fri): Arrival (Board Meeting in the Evening)
November 8 (Sat): Opening Ceremony, General Meeting and Symposium
November 9 (Sun): Individual Presentations, Closing Ceremony
November 10 (Mon): Congress Tour
November 11 (Tue): Departure

For more details: Visit http://www.nodai.ac.jp/issaas/issaas2014
Email issaas14@nodai.ac.jp

13. Other Matters

Review of payment mode for page charge of Journal of ISSAAS was raised based on current bank remittance issues (e.g. double bank charges, insufficient amount remitted). PAYPAL, Credit Card, and Payment collection by each chapter were some of the options given. While the Board has not approved a new payment scheme, all chapters have agreed to collect page charge payment on behalf of the Secretary General and/or Headquarters. The collection will be handed over to the Secretary General during the ISSAAS Congress.

ISSAAS General Meeting 2013

Date: 12 November 2013, 11:30-12:30
Venue: Grand Ballroom, Acacia Hotel Manila, Muntinlupa City, Philippines

AGENDA

1. Greetings from ISSAAS Acting President
   Dr. Fernando C. Sanchez. Jr., University of the Philippines at Los Banos

2. Activities Report 2013 (Oct 2012-Sep 2013)
   Presented by Dr. Keishiro Itagaki, representing Secretary General Akimi Fujimoto, and Approved

3. Financial Report 2013
   Presented by Dr. Keishiro Itagaki, representing Secretary General Akimi Fujimoto, and Approved

4. Auditors' Report for 2013
   Presented by Dr. Keishiro Itagaki, representing Auditor Hironobu Shiwachi, and Approved

5. Business Plan for 2014 (Oct 2013-Sep 2014)
   Presented by Dr. Keishiro Itagaki, representing Secretary General Akimi Fujimoto, and Approved

6. Budget 2014
   Presented by Dr. Keishiro Itagaki, representing Secretary General Akimi Fujimoto, and Approved

7. ISSAAS AWARDS: Given during the Opening Ceremony
   (1) THE MATSUDA AWARD: Dato' Sri Zakri A. Hamid, Malaysia
   (2) THE SCIENTIFIC AWARD: Akimi Fujimoto, Japan
   (3) THE SCIENTIFIC AWARD: Dewa Ngurah Suprapta, Indonesia

8. Letter of Appreciation: Given during the Fellowship Night
   Dr. Roberto F. Ranola, Jr., Vice President of ISSAAS for the Philippines (2002-2011), and President of ISSAAS (2012- January 29, 2013)

9. Donations from TUA and SAEDA: Received during the Opening Ceremony
   (1) Tokyo University of Agriculture: 300,000 Japanese Yen
   (2) Society for Agricultural Education-Research Development Abroad (SAEDA): 200,000 Japanese yen

10. Announcement of New Officers: January 1, 2014 – December 31, 2015
    Presented by Dr. Keishiro Itagaki, representing Secretary General Akimi Fujimoto

    President: Katsumi Takano (TUA)
    Secretary General: Hironobu Shiwachi (TUA)
    Auditors: Hiromitsu Negishi (TUA) and Hiroshi Okazawa (TUA)
    Editor-in-Chief: Keishiro Itagaki (TUA)
    Technical Editor: Susan May F. Calumpang (UPLB)
    Chairperson, Award Screening Committee: Yusman Syaukat (IPB)

    Vice President for Indonesia: Yusman Syaukat (IPB)
    Vice President for Japan: Keiko Natsuaki (TUA)
    Vice President for Malaysia: Abdul Shukor Juraimi (UPM)
    Vice President for the Philippines : Fernando C. Sanchez, Jr. (UPLB)
    Vice President for Thailand: Sombat Chinawong (KU)
    Vice President for Vietnam: Tran Duc Vien (HAU)

11. Activities Report for 2013 by Each Chapter

Indonesia	Presented by Vice President Tineke Mandang
Japan	Presented by Dr. Irie Mami, representing Vice President Kanju Ohsawa
Malaysia	Vice President Abdul Shukor Juraimi
Philippines	Vice President Fernando C. Sanchez, Jr.
Thailand	Presented by Dr. Thammasak Thongket, representing Vice President Sombat Chinawong
Vietnam	Presented by Nguyen Thi Bich Thuy, representing Vice President Tran Duc Vien

12. Plan for 2014 International Congress

    Theme: *Agricultural Changes in Southeast Asia: Past, Present and Future*
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13. Other Matters

The International Society for Southeast Asian Agricultural Sciences