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INPUT COMMERCIALIZATION, FARM YIELD AND INCOME OF POOR AND NON-POOR LYCHEE FARMERS IN LUC NGAN DISTRICT, BAC GIANG PROVINCE, VIETNAM

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ABSTRACT

The study analyzed the extent of input commercialization among poor and non-poor lychee farmers in Luc Ngan District, Bac Giang province, Vietnam in 2013. Primary data were gathered from a sample of 31 poor and 134 non-poor lychee farmers using structured questionnaires. Descriptive statistics were employed to compare the primary data collected and assess the degree of lychee input market participation of the two farmer groups. OLS regression analysis was used to analyze factors affecting degree of input commercialization among poor and non-poor farmers. Results showed that both poor and non-poor farmers participated in the input market. However, poor households have lower degree of input commercialization than non-poor households, with commercialization index of 25.4% and 46.4%, respectively. Farm size has positive influence on the degree of input commercialization whereas family labor has a negative effect. Non-poor farmers have higher crop yield than poor farmers, with 11,205 kg/ha and 9,352 kg/ha, respectively. Their farm profit is also higher than that of poor farmers. The study recommends that poor farmers should be assisted in term of credit services, extension services, and improved input distribution system.

Key words: OLS regression, market participation, smallholders

INTRODUCTION

World production of lychee is estimated at around 2.11 million metric tons (MT), with more than 95% of the area and production contributed by Asia. Lychee is widely distributed throughout the world's sub-tropical and tropical regions. Major centers of production are China, India, Taiwan, Vietnam, Thailand, Madagascar, Nepal, Bangladesh, and South Africa. Small production centers include Australia, South Africa, Israel, Mexico, Brazil and USA (Evans et al., 2004). China is the leading country in terms of production volume followed by India, Taiwan, Thailand, and Vietnam with volume of 1,000,000 MT, 430,000 MT, 110,000 MT, 85,000 MT and 40,000 MT, respectively (FAO, 2002).

Fruit production is an important part of Vietnam's agriculture. The Ministry of Agriculture and Rural Development (MARD) reported that fruit production in 2005 is close to 6.5 million MT. Lychee has contributed significantly to rural and agricultural development. With production approaching 156,000 MT, Vietnam is the third largest lychee producer in the world (Institute of

Agricultural Science for Southern Vietnam, 2014). Lychee is considered a high value commodity and is mainly grown in the northern part of Vietnam. According to Vu and Nguyen (2002), Bac Giang province has the biggest lychee-planted area and volume of production in Vietnam with shares to national area and production of 57% and 40%, respectively. Luc Ngan, on the other hand, is considered the largest lychee producing district of the province as well as nationwide. Its lychee production contributed up to 55% of the provincial production with 72,000 MT in 2013 (Department of Industry and Trade Bac Giang, 2013).

In Vietnam, majority of the poor live in rural and mountainous areas, where conditions are very difficult to improve their income. Bac Giang province is one such region located in the north of Vietnam with 19.6% of total households considered poor and 8.8% classified as near poor in 2010 (Vietnam's Minister of Labour, 2011). According to Decision No. 9/2011/QD-TTg released by Vietnam's Prime Minister, the poverty line applicable for the period 2011- 2015, for farmers who live in mountainous, rural areas, lowlands and islands, income is below 4,800,000 VND per year (or 231.24 USD) (Vietnam's Prime Minister, 2011).

Agricultural sector in general and fruit production in particular has a big role to increase farmers' income and contribute to poverty reduction. There is a strong correlation relationship between high agricultural productivity and poverty reduction (Minten and Barrett, 2008). The use of inputs such as fertilizer, pesticide and labor is seen as an important way to improve agricultural output and productivity and therefore incomes of rural households, especially the poor. "Greater dependence of the producers on the input market as the source of production inputs has been associated with increased productivity" (Okoboi, 2011). The contribution of fertilizer to increased yield is perhaps the greatest among the purchased inputs (Couston and Aspiras, 1979). Similarly, Okoboi (2011) indicated that expenditure on fertilizer, fungicides, herbicides and hired labor is significantly associated with an increase in maize yield. Do (2003) also found that an increase in amount of labor and fertilizer could lead to an increase in lychee yield.

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Besides increase in crop production, the use of inputs can ensure a higher quality of crop. Fertilizer is one component of producing a crop with higher quality. However, applying more fertilizer than is recommended or needed by the crop entails additional costs and may reduce fruit and vegetable quality (Kessel, 2012). Pesticides are very important as they improve the quality and yield of agricultural produce (Markets and Markets, 2013). Pesticides allow consumers to consume high-quality product that is free of insect blemishes and insect contamination (CropLifeAmerica).

Although the use of inputs in production is desirable, the input market participation of poor farmers in Luc Ngan district, Bac Giang province may still be limited compared to middle-income and rich farmers. In general, poor farmers in developing countries are constrained by many problems including inadequate market information, lack of extension service, poor access to credit, limited infrastructure, and difficult access to technology. The farmers' limited knowledge of input markets and access to technology and other facilities are reflected in low productivity which in turn results in lower income. In all these studies cited, however, none appears to have simultaneously considered the relationship of input commercialization**,** farm yield and income of poor and non-poor farmers.

Therefore, this paper discusses (1) the extent of input commercialization among poor and non-poor lychee farmers in Luc Ngan district, Bac Giang province, Vietnam; (2) the factors affecting degree of input commercialization among poor and non-poor lychee farmers; and (3) the yield and income performance of poor and non-poor lychee farmers in the study area.

METHODOLOGY

Conceptual Framework

Three groups of factors are hypothesized to be affecting the degree of input commercialization between poor and non-poor farmers. These include farmer's characteristics, farm's characteristic and other factors (Figure 1).

Farmer's characteristics refer to individual characteristics of farmers such as age, sex, experience and educational level of household head. Farm characteristics consist of farm size, number of lychee trees, and distance between farm and input market. Access to credit, extension services, market information, input prices, and source of input are categorized as other factors.

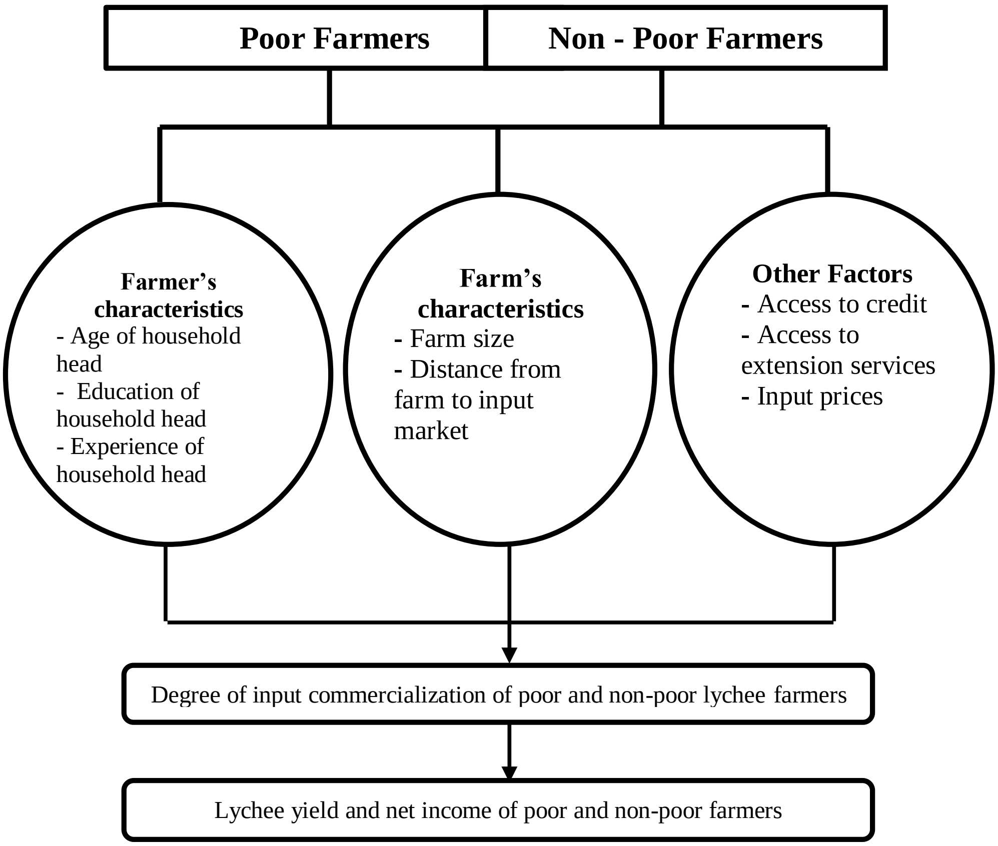


Fig. 1. A conceptual framework of input commercialization among poor and non-poor lychee farmers

Analytical Methods

Study area and data collection

This study was conducted in Luc Ngan district. Luc Ngan is bounded on the northwest and northeast by districts of Lang Son province, on the southwest by Luc Nam district and on the southeast by Son Dong district (Figure 2). Topography of Luc Ngan is divided into two zones. The first zone is a high mountainous terrain, making up nearly 60 % of the natural area of the district. It includes 12 communes. This area is largely sloping with more than 25^0 and average elevation of 300 - 400 meters (m) above sea level. Land in this area has potential in developing forest plantation, raising livestock and planting fruit trees. The second zone is low hilly terrain including 17 communes and 1 town. This area accounts for over 40% of the total area of the district. It has lower slope and average altitude of 80-120 m above sea level. Land in this area is suitable for the cultivation of fruit trees especially lychee.

Source: bacgiang.gov.vn

Fig. 2. Map of Bac Giang district showing the study area (Luc Ngan district, Bac Giang province, Vietnam)

Thirty-one randomly selected poor lychee farmers and 134 non-poor lychee farmers from the three communes (My An, Quy Son and Tan Lap) in Luc Ngan district, Bac Giang province served as respondents for this study. The farmer-respondents were personally interviewed using structured questionnaires. The study sites represent the highest volume of lychee production in the district and have lychee farmers who are considered poor.

The poor lychee farmers were determined by local officials based on the poverty line of Vietnam. Based on the total number of lychee households of each commune, the number of respondent-farmers of each commune was determined. The numbers of households engaged in lychee farming in My An, Quy Son and Tan Lap commune were 1,525, 4,215 and 1,806 households, respectively. With total of 165 selected farmers, there were 34, 92 and 39 respondents from My An, Quy Son and Tan Lap commune, respectively.

Lychee poor farmers were selected based on the poverty rate of each commune. The rates of poverty in My An, Quy Son and Tan Lap were 8.9%, 5.2% and 44%, respectively. Therefore, the number of lychee poor farmers selected from each commune was 4, 6 and 21, respectively.

Degree of input commercialization

Input commercialization index of households is commonly determined as the proportion of the value of purchased inputs to total value of crop production. On the other hand, household participation in input market is determined as the ratio of value of purchased crop inputs to the total value of crop inputs used (Gebremedhin and Jaleta, 2010). In this study, lychee input market participation (LIMP) index is given as:

$$\boldsymbol{LIMP_k} = \frac{\sum_{n=1}^{N} \overline{P_i} X_{kn}^{p}}{\sum_{n=1}^{N} \overline{P_i} X_{kn}^{T}} \quad \text{(Eqn 1)}$$

Where:

$\boldsymbol{X_{kn}^{p}}$ is the amount of input n purchased by the poor or non-poor farmer k.
$\overline{\boldsymbol{P_i}}$ is average actual price paid by poor or non-poor farmer for inputs.
$\boldsymbol{X_{kn}^{T}}$ is the total amount of input n used in the lychee production.

The value is zero if the farmer does not buy any input in the market and one if the farmer buys all inputs in the market (Gebremedhin and Jaleta, 2010). In the empritical analysis for this study, LIMP is referred to as lychee input commercialization index or LICI. If the index is multiplied by 100, then the value ranges from zero to 100%.

OLS model

The OLS regression model was employed to determine the factors affecting the degree of input commercialization among poor and non-poor lychee farmers in the study area. The empirical model is expressed as:

$\boldsymbol{Y_i} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}$ Age + $\boldsymbol{\beta_2}$ Sex + $\boldsymbol{\beta_3}$ Lab + $\boldsymbol{\beta_4}$ Educ + $\boldsymbol{\beta_5}$ Exp + $\boldsymbol{\beta_6}$ Fsize + $\boldsymbol{\beta_7}$ Credit + $\boldsymbol{\beta_8}$ Ext + $\boldsymbol{\beta_9}$ cfp + $\boldsymbol{\beta_{10}}$ Idismkt + $\boldsymbol{u_i}$ (Eqn. 2)

Separate analyses were done for the poor and non-poor farmer groups. A combined analysis of two farmer groups was also estimated using OLS regression model. The specific OLS regression model for analyzing the determinants of lychee commercialization of 165 farmers in the input market is stated as follows:

$\boldsymbol{Y_i} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1}$ Age + $\boldsymbol{\alpha_2}$ Sex + $\boldsymbol{\alpha_3}$ Lab + $\boldsymbol{\alpha_4}$ Educ + $\boldsymbol{\alpha_5}$ Exp + $\boldsymbol{\alpha_6}$ Fsize + $\boldsymbol{\alpha_7}$ Credit + $\boldsymbol{\alpha_8}$ Ext + $\boldsymbol{\alpha_9}$ Cfp + $\boldsymbol{\alpha_{10}}$ Idismkt + $\boldsymbol{\alpha_{11}}$ HHtype + $\boldsymbol{u_i}$ (Eqn. 3)

Where:

i represents the number of respondents, i = 1, 2,..., n.
Y_i represents the dependent variable "degree of commercialization" of farmer i measured as LICI.
β_0, $\boldsymbol{\alpha_0}$ is intercept of the model.
$\boldsymbol{\beta_j}$ (j = 1 to 10) and $\boldsymbol{\alpha_j}$ (j=1 to 11) are coefficients of independent variables in the OLS model.
$\boldsymbol{u_i}$ is the error term of the model.

Coefficients of the OLS model were estimated using the STATA 10 software. Table 1 shows a description of independent variables of the empirical OLS model. Chemical fertilizer included nitrogen, phosphorous and potassium in Table 1. The average price of chemical fertilizer paid by farmers is calculated by weighted average method.

T-test was conducted to determine and compare whether there is a significant difference between poor and non-poor farmers in terms of the socio – economic, farm and other characteristics as well as farm yield and profit.

Table 1. Description of the explanatory variables and expected signs in the input commercialization model

Variable	Description	Measurement	Expected sign
Age (Age)	Age of household head	Years	+
Sex (Sex)	Sex of household head	D = 1 if male; 0 = otherwise	+
Family labor (Lab)	Labor of household members employed in lychee farming	Number of mandays contributed by family members	-
Education (Educ)	Number of years of formal education of household head	Years	+
Experience (Exp)	Farming experience of household head	Years	+
Farm size (Fsize)	Size of area cultivated for lychee	Hectares	+
Credit access (Credit)	Lychee farmer has access to credit	D =1 if yes; 0 = otherwise	+
Extension access (Ext)	Lychee farmer has access to extension services	D =1 if yes; 0 = otherwise	+
Chemical fertilizer price (Cfp)	Average price of chemical fertilizer paid by farmers	Thousand VND per kilogram	-
Input market distance (Idismkt)	Distance between the residence of household and the nearest input market	Kilometer (Km)	-
Household type (Hhtype)	Type of household	D =1 if household type is non-poor; 0 = otherwise	+

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Majority of the household heads of poor (58%) and (94%) non-poor farmers were male. The gender of household head captures the differences in market orientation between male and female. Males are expected to have a higher propensity to participate in markets than females (Martey et al., 2012).

Access to credit will provide more financial support for farmers to enable them to participate in input market. The proportion of poor farmers with access to credit was about 55% which is higher than that of non-poor farmers (47%). In general, poor farmers are constrained by many problems. One big problem is inadequate capital to buy inputs. Therefore, access to credit will help them to participate in input market.

Access to extension services will provide new methods to increase the yield of lychee and in turn, increase marketable surplus. However, only 29% and 77% of poor and non-poor respondents, respectively, participated in lychee training that were organized in the last three or four years in Luc Ngan.

Table 2. Characteristics of poor and non-poor lychee farmers, (categorical variables), Luc Ngan district, Bac Giang province, Vietnam, 2013.

Variable	Item	Poor farmers		Non-poor farmers		Total	
		n	%	n	%	N	%
Number of respondents		31	18.79	134	81.21	165	100.00
Sex	Female	13	41.94	8	5.97	21	12.73
	Male	18	58.06	126	94.03	144	87.27
Credit access	Yes	17	54.84	10	7.46	27	16.36
	No	14	45.16	124	92.54	138	83.64
Extension access	Yes	9	29.03	103	76.87	112	67.88
	No	22	70.97	31	23.13	53	32.12

Source: Survey result, 2014

Table 3 shows that poor farmers have mean age of 49 years, while non-poor farmers were about 46 years old. The difference in ages between the two groups was significant at 5% probability level. The youngest farmer was 21 years old to oldest was 72 years old. The age of household head is a proxy measure of experience and availability of resources. It is possible that older and more experienced heads are able to make better production decisions, such as adoption of new agricultural technologies and using improved inputs (Enete and Igbokwe (2009) as cited by Martey 2012).

Results show that 16 % of the poor farmers reported they did not attend formal schooling, while only 1% of non-poor farmers did not spend time in school. The mean years of education shows that the non-poor farmers spent 2.4 more years in school than poor farmers. Education allows the farmer to improve his knowledge, make independent decision, and increase the ability to use farm resources efficiently. Moreover, it will endow farmers with better production and managerial skills (Martey, 2012). They are not only able to complete operations in a timely manner, organize production processes, choose the technology best suited for a particular situation but they also possess marketing and financial management skills (Boehlje el at, 2001).

The differences in the average number of family labor engaged in lychee-related activities, farm size, and farm experience between poor and non-poor household groups are significant at 1% and 5% probability level. Among poor farmers, the mean distance to input market was about 2.39 km, which is higher than that of non-poor farmers (1.61 km), which is not statistically significant. Nevertheless, according to Woldesenbet (2013), the closer the market to the farm, the lesser would be the transportation charges. Data show that all input supply agents are located in the village. Thus, farmers and producers do not have to spend much time and cost on transportation and purchase of production inputs.

Table 3. Characteristics of poor and non-poor lychee farmers, (continuous variables), Luc Ngan district, Bac Giang province, Vietnam, 2013.

Variable	Poor farmers (a)	Non-poor farmers (b)	All	Difference (a-b)
Number of respondents	31	134	165	-
Age of household head (years)	49.74	46.34	48.04	3.4^{**}
Experience of household head (years)	28.00	25.99	27.00	2.01^{**}
Education of household head (years)	4.84	7.23	6.03	-2.39^{***}
Family labor in lychee farming (persons)	2.29	3.16	2.73	-0.87^{***}
Farm size (hectares)	0.35	0.85	0.58	-0.5^{***}
Input market distance (km)	2.39	1.61	2.00	0.78^{NS}

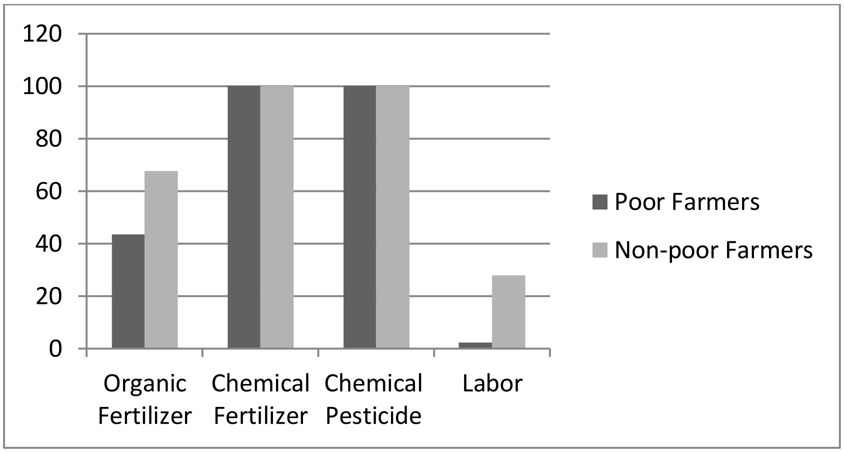
Note: *** and ** are statistically significant at 1% and 5% probability level, respectively. T-test.
NS is not significant at 10% probability level.
Source: Survey result, 2014

Extent of input commercialization among poor and non – poor lychee farmers

The input distribution network in this district does not operate effectively. All of the lychee farmers had transactions in the input market for fertilizers, pesticides and labor, although the degree of commercialization varied between the poor and non-poor farmers. Figure 3 shows that both farmer groups purchased all the chemical fertilizers and pesticides used, that is, 100% commercialization. Most of inputs (chemical fertilizers and pesticides) for lychee production are distributed by private enterprise systems. Therefore, counterfeits and poor quality of chemical fertilizers and pesticides are still sold to farmers at a high price (Do and Cong, 2015). Farmers could not distinguish between poor and good quality fertilizer, thus affecting their lychee yield and profit.

The participation of poor and non-poor farmers in labor market is low, at 2.3% and 27.92%, respectively. This indicates that family labor was still the main resource in lychee farming operations, especially among the poor farmers. The degree of organic fertilizer commercialization of non-poor farmers is 67.7% which is higher than that of poor lychee farmers (43.6%). The difference is due to the higher value of homemade organic fertilizer for non-poor farmers.

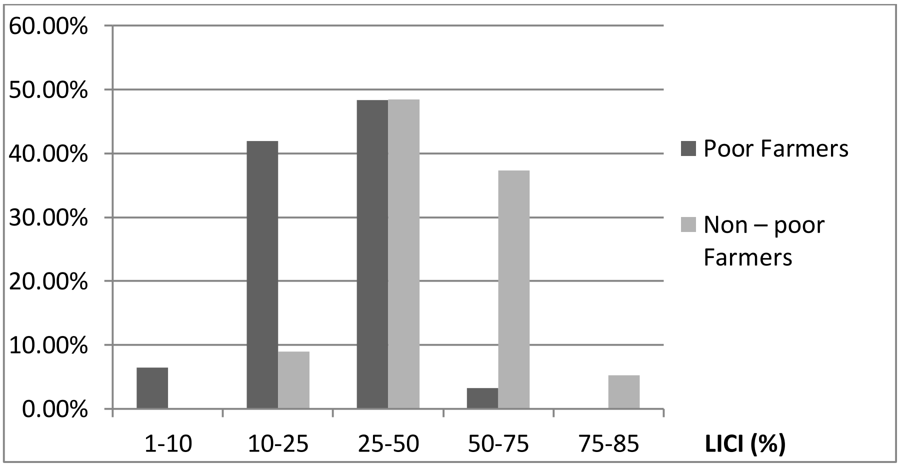
Overall, the degree of input commercialization of the non-poor farmers as measured by LICI was 46.4% while that of the poor farmers was only 25.4%. These ratios indicate that input commercialization among the non-poor farmers is higher than among the poor farmers in the study area, with a significant difference at 1% probability level.



Source: Survey results 2014

Fig. 3. Proportion (%) of commercialization among poor and non-poor farmers by type of input

The distribution of the extent of lychee input commercialization among the poor and non – poor lychee farmers in the study area is presented in Figure 4. The result shows that among all farmers surveyed, none attained a ratio above 85%. The highest lychee input commercialization index (LICI) was 75% - 85%. However, this was only among non-poor farmers comprising 5.2% of total respondents. The lowest was 6.4% which was among poor farmers only.



Source: Survey results, 2014

Fig. 4. Proportion (%) of farmers by input commercialization index, poor and non – poor lychee farmers, Luc Ngan district, Bac Giang province, Vietnam, 2013.

The findings also indicated that a higher proportion (37.31%) of non-poor farmers in the study area participated in the input market at 50-75% input commercialization index compared to only 3.23% among poor farmers. Non-poor farmers bought a larger proportion of inputs they used than poor farmers. This is attributed to their advantages in capital and knowledge in lychee cultivation.

Factors affecting extent of input commercialization among poor and non – poor lychee farmers

OLS regression models were used to identify factors affecting degree of lychee input commercialization among the poor and non-poor farmers. The STATA 10 program was used to estimate coefficients of OLS models. The results of OLS regression models are presented in Table 5.

The adjusted R^2 value was 0.6784 and 0.5616 for OLS regression of poor and non-poor farmers, respectively. These values indicate that 67.84% and 56.16% of total variation in input commercialization index can be explained by the variables included in the model (Table 5). Among the explanatory variables considered, gender of household head, farm size, and credit access have positive influence on the degree of input lychee commercialization among the poor farmers. On the other hand, price of chemical fertilizer (Cfp) and family labor have negative effect. For non-poor farmers, age of household head, education attainment, farming experience, farm size, and access to extension services have positive and significant influence on the degree of lychee input commercialization. Family labor has negative significant influence (Table 5).

Table 5. OLS regression results for determinants of degree of lychee input commercialization among poor and non-poor farmers in Luc Ngan district, Bac Giang province, Vietnam, 2013.

Variable	**Poor farmers (n = 31)**			**Non-poor farmers (n =134)**			**All farmers (n=165)**		
	Coefficient	Std. Error	T-value	Coefficient	Std. Error	T-value	Coefficient	Std. Error	T-value
Intercept	27.5124 ^{NS}	22.4040	1.23	8.5302 ^{NS}	10.8214	0.79	-23.0947***	7.9486	-2.91
Age	0.2135 ^{NS}	0.3599	0.59	0.8691***	0.1183	7.34	0.9056***	0.1038	8.73
Sex	6.4815**	3.0840	2.10	1.5807 ^{NS}	2.2492	0.70	3.6268**	1.8278	1.98
Labor	-3.0909**	1.3876	-2.23	-3.8637***	0.9712	-3.98	-2.6923***	0.6557	-4.11
Education	0.7342 ^{NS}	0.5317	1.38	0.7107***	0.2642	2.69	0.8765***	0.2265	3.87
Experience	0.0823 ^{NS}	0.3235	0.25	0.2878*	0.1497	1.92	0.3472***	0.1324	2.62
Farm size	21.7416*	11.5265	1.89	3.2972**	1.5989	2.06	4.1249 ***	1.6496	2.50
Credit	6.8240*	3.8967	1.75	-2.0022^{NS}	1.8428	-1.09	0.7417^{NS}	1.6370	0.45
Extension services	0.3576^{NS}	3.8112	0.09	3.6592***	1.3754	2.66	3.0904***	1.2721	2.43
Cfp	-4.0311*	2.3259	-1.73	-1.3662 ^{NS}	0.8333	-1.64	-1.1654 ^{NS}	0.7659	-1.52
Idismkt	0.3294^{NS}	0.4974	0.66	-0.0942^{NS}	0.2966	-0.32	0.0318^{NS}	0.2532	0.13
HH type							19.4577***	2.2293	8.73
R^2		0.7856		R^2		0.5945	R^2		0.7368
Adjusted R^2		0.6784		Adjusted R^2		0.5616	Adjusted R^2		0.7179
F (10, 20)		7.33		F (10, 123)		18.04	F (11, 153)		38.94
Prob > F		0.0001		Prob > F		0.0000	Prob > F		0.0000

Note: ***, ** and * are significant at 1%, 5% and 10% probability level, respectively.
NS is not significant at 10% probability level.

The gender of the head of poor households was found to have a positive and significant influence at 5% probability level on the degree of input commercialization. Poor farmers are more likely to participate in the input market if he is male household head. The higher probability of poor male household head participating in the lychee input market than female household head may be related to economic status, level of information and extension access. In Vietnam, the female usually stays at home while the male makes important decisions on farm production, which in this case is the respondent's main source of income. However, the effect of sex of non-poor household head on the input commercialization was negligible. It could be due to that fact that there was little variation in sex data of non-poor farmers with 94% of them being male. In addition, both of male and female household heads of non-poor group spent more years in school and have access to extension services. Therefore, there was not difference in decision to participate in the inputs market between male and female household heads of non-poor group.

Family labor has a negative significant influence on input commercialization of poor and non-poor farmers. This indicates that households who had more family labor are less likely to hire labor for lychee production as well as participate in the input (labor) market. With highly available family labor, they do not need to hire more labor in farming operations (Table 5).

Price of chemical fertilizer also has significant and negative effect on the level of input commercialization of poor farmers. It means that the poor farmers are less likely to increase degree of input commercialization if price of chemical fertilizer is high. They have less capital resource, which limits their participation in the input market. On the contrary, non-poor farmers have more financial resources, thus, their level of input commercialization is not likely to be much influenced by the price of chemical fertilizer.

Farm size has positive significant influence on input commercialization of the poor and non-poor farmers. The poor farmers who have bigger farms are likely to buy more inputs for producing the crop. It is because larger size of area cultivated with lychee will require farmers to add more inputs such as labor, fertilizer and chemical pesticide.

Access to credit of the poor farmers has a positive and significant effect on input commercialization. This suggests that poor farmers who have access to credit were more likely to increase the level of input commercialization. Access to credit will provide more financing for the farmer to purchase the inputs, thereby increasing lychee production. However, the effect of credit access of non-poor farmers on the input commercialization was negligible and not clear. It could be noted that a high proportion of non-poor farmers (92.5%) indicated they had enough capital for lychee production, hence, they did not have to access to credit.

Age and farming experience of non-poor household head have positive and significant influence on the degree of input commercialization. Older household heads are more likely to increase participation in the input market. For farming experience, if the number of years of household head experience increased by one year, then the proportion of lychee input commercialization could increase by 0.28%.

Consistently, the educational level and access to extension services of non-poor households have a positive and significant impact on the degree of input commercialization at 1% probability significant level. Households who have access to extension services and are literate are more likely to participate in the input market. This is because access to extension services will provide new farming methods to increase the yield of lychee. Thus, farmers may need to buy more inputs. In addition, higher educational level corresponds to better technology adoption and participation in the input market. However, the effect of these factors on the degree of input commercialization of the poor farmers is not significant as most of them have similar educational attainment and did not have access to extension services.

A combined analysis of two farmer groups was also estimated using OLS regression model. The results for determinants of degree of lychee input commercialization for all farmers in Luc Ngan district are also presented in Table 5.

Based on the results of the multiple regression analysis involving 165 sample grower-respondents in Luc Ngan, about 72% of the total variation in input commercialization could be explained by the 11 explanatory variables included in the model. This model was significant at 1% probability level. The extent of input commercialization is significantly influenced by age of household head, sex of household head, family labor, education attainment, farming experience, size of area cultivated with lychee, extension services access, and type of household. The greater number of significant variables could be due to a bigger sample size when all farmers were considered in the model.

For the type of household (HH type), the positive and significant coefficient at 1% probability level suggests that degree of input commercialization of the non-poor lychee farmers was greater than that of the poor lychee farmers. This could be attributed to the difference in farm investments between the two farmer groups. The value of coefficient of household type was 19.4577 which means that the degree of input commercialization among non-poor households is higher by 19.4% than among poor households.

Yield performance of poor and non-poor lychee farmers

Results of this study show that non-poor farmers who have higher degree of input commercialization obtained higher lychee yields than the poor farmers. The yield difference between the two farmer groups is statistically significant at 1% probability level on per hectare basis and at 5% probability level on per tree basis. The difference in yields between the groups could be attributed to difference in the level of input application. Use of inputs which include hired labor, fertilizer and chemical pesticide was higher among non-poor farmers than poor farmers as shown earlier. Moreover, non-poor farmers have higher educational level and have more access to updated extension services and information

Table 6. Yield performance of poor and non-poor lychee farmers, Luc Ngan district, Bac Giang province, Vietnam, 2013.

Item	Production (kg/farm)	Area planted (ha/farm)	Number of bearing (trees/farm)	Yield	
				kg/ha	kg/tree
Poor farmers	3,273	0.35	98	9,352	33.31
Non-poor farmers	9,524	0.85	246	11,205	38.74
Difference	6,251***	0.50***	148***	1,853***	5.43**

Note: *** and ** are statistically significant at 1% and 5% probability level, T-test.
Source: Survey result, 2014

Profit performance of poor and non-poor lychee farmers

Profit is computed as the difference between the total revenue and total cost expended on producing the crop. Therefore, profit is determined by farm yield, price of lychee and total cost in this study. If farmers have good quality of lychee, they will be able to sell their product at higher price.

Non-poor farmers participated more in input market compared to poor farmers. They also got greater yield of lychee. Therefore, their net income or profit is bigger than poor farmers' profit even though they incurred higher total cost (Table 7).

The profit per ha and per farm of the non-poor farmers was also higher than that of the poor lychee farmers. The difference in profit between the groups is about 41,086 thousand VND on per hectare basis and 63,707 thousand VND on per farm basis. This is significant at 1% probability level.

Table 7. Profit performance of poor and non-poor lychee farmers, Luc Ngan district, Bac Giang province, Vietnam, 2013.

Item	**Poor Farmers (n=31)**		**Non – poor farmers (n=134)**		**Difference**	
	1000 VND/ha (a)	1000 VND/farm (b)	1000 VND/ha (c)	1000 VND/farm (d)	(a-c)	(b-d)
Minimum	7,875	2,707	19,113	11,596	-	-
Maximum	107,144	46,435	152,599	226,678	-	-
Average	47,991	14,134	89,077	77,841	41,086***	63,707***

Note: *** is statistically significant at 1% probability level. T-test.
Source: Survey result, 2014

CONCLUSION AND RECOMMENDATIONS

Poor households have lower degree of input commercialization than non-poor households, with commercialization index of 25.42% and 46.39%, respectively. The degree of input commercialization of poor farmers was influenced by sex of household head, family labor, farm size, credit access, and price of chemical fertilizer. Non-poor farmers have higher crop yield than poor farmers, with 11,205 kg/ha and 9,352 kg/ha, respectively. Their farm profit is also higher than that of poor farmers.

The following are the recommendations to increase the poor farmers' participation in input market. Firstly, to improve credit access has a positive and significant influence on the degree of poor farmers' input commercialization. However, for most small farmers, access to credit amount is limited and the bank procedures are complicated. To meet their capital requirement for lychee production, the government as well as credit agencies should consider improving the support given to poor farmers. A more simplified approach of accessing credit and bigger credit amount could allow farmers to purchase more inputs. Secondly, poor farmers have limited access to extension services. Many of the poor farmers did not know and participate in lychee training courses. Therefore, the Provincial and District Centers for Agriculture Extension should provide extensive training courses for farmers, especially the poor. And lastly, the government should improve the input distribution network to ensure that farmers are able to use quality inputs at lower prices. The input distribution system in Bac Giang is still not adequate (Le, 2012). Prices of inputs such as fertilizers, pesticide, and chemicals are still high. In addition, the farmers are not sure about the quality of inputs.

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IMPACT OF INVESTMENT INCENTIVES ON AGRIBUSINESS AND MACROECONOMY OF INDONESIA: A COMPUTABLE GENERAL EQUILIBRIUM MODEL

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ABSTRACT

To create a strong agriculture development, the agribusiness approach needs to be applied holistically. Agroindustry is believed to be the leading sector which can run the agribusiness system well. Therefore, the agroindustry, particularly food agroindustry, need to be given the priority in the agricultural development through the giving of investment incentive like the lessening of added value tax and the increasing of subsidy. This study aims to analyze the impact of the investment incentives on agribusiness and macroeconomy of Indonesia. The analysis is done by using the Computable General Equilibrium model with the main data of Social Accounting Matrix Indonesia in 2005, which is classified in 37 sectors, 8 household groups, government institution and company. The findings of this study show that: the higher government spending in the electronic and gas sectors has the biggest impact on investment absorption. Tax deduction can be used as instrument to achieve such objective. The national output is influenced mainly by increasing subsidy in the the fertilizer industry, the electricity and gas, and the agricultural infrastructure simultaneously. Some sectors such as rice commodity, vegetable and processed fruit industries and flour industry are significantly affected by increasing infrastructure subsidy and tax deduction. This study recommends government to implement some policies related to increasing spending and tax incentives. Some analysis need to be carried out to see the possibilities of dispute with international rules.

Key words: output of economy, economic model, CGE, SAM, agribusiness, agroindustry

INTRODUCTION

The change of sectoral output based on the current price shows that the agricultural sectors (agriculture, forestry and fishery) still play an important role in the Indonesian economy, i.e. more than 20% of GDP in 1985, but the share of the agricultural sector tends to decline from time to time. On the other hand, the share of the industrial sector is always constant (about 10 %). In 1975, the mining sector increased until 19 %, but this increase was caused by the increase in oil price in 1974. According to the GDP of constant price in 1973, the contribution of the mining sector was only 11% in 1975, while the share of the industrial sector increased by 7% between 1970 and 1980. In reality, the industrial sector is to be prioritized in the Indonesian economy. Based on GDP constant price in 1983, the share of the industrial sector is 18% in 1988, exceeds the mining sector (16%). However the agricultural sector still dominated Indonesian economy during this period (Mackie and Sjahrir 1989).

The structural adjustment is based on the share of sectoral export and import (Akita 1991). Based on the export share, the contribution of mining sector is still dominant, i.e. more than 60% from the total export in 1985. The export ratio of mining sector reached its peak in 1975 (of 81 %) and decreased to become 53% in 1985. In 1980, there was a direction shift from the dependence on the export of primary product to the export of industrial product, so the export of forestry product is decreasing. The export of log wood is replaced with the export of sawn wood and plywood. The export ratio of forestry is decreasing from 45% in 1980 to 5% in 1985, at the same time the sawn wood and plywood industries are succeeded to increase the export ratio from 27% to 44%. The government introduces the new form of log wood export in the beginning of 1980-s and develops the industry of plywood and sawn wood. The beginning of 1980-s showed a symptom of export substitution from the primary product export to the industrial export. Beside the log processing industry, the export of textile industry also experiences the increase.

From the import aspect, the capital goods and the intermediate goods like: machinery, chemical products and metal products dominate heavy industry; it records around 60% from the total import. However, the import ratio tend to decline, 45% of the domestic demand for the heavy industry in 1985 were import products. The industrial strategy of import substitution for end products caused the segment of light industry like food processing and textile to decrease gradually from 18% in 1971 to less than 5% in 1985. The import ratio of the light industry segment was around 3% in 1985.

Since 1980, there was a significant change in production structure and trade in Indonesia, because of the decrease of oil price. The Indonesian economy shifted from the inward looking structure based on the oil export to become the outward looking structure based on the industrial export (Akita 1991; Dumairy 1996; Saleh *et al*., 2000). The import-substitution industrialization strategy (ISI) is applied in order to eliminate the dependence on imported product and even to export them.

In the period of 1987-1996, the four important sectors in the Indonesian GDP were agriculture, mining, processing industry and trade, hotel and restaurant. However, in 1996 there was a significant change in the GDP: first is the processing industry, followed by the trade, agriculture and mining due to continuous economic growth, which at the time reached 8%, and low inflation (Bappenas 1997).

During the economic crisis of 1997/1998, the Indonesian economy collapsed and experienced a negative growth of 12.9. According to Basalim *et al.* (2000), the contraction of the economy mainly came from the subsector of non oil and gas. The worsening of performance of the non oil and gas processing industry was the result of the internal and external weaknesses of this subsector. In the internal side, there was a strong dependence of the industry on the import raw material as well as the financial dependence on the banking loan. In the external side, the problem came from the weakness of the exchange value of *rupiah* and the market demand.

The agricultural sector was the "buffer" sector of economy from the deeper negative impact due to the economic crisis. Based on Statistical Agency of Indonesia data (BPS, 1998; BPS, 2001), in 1993 the agricultural sector could absorb the employment of 50.6% and the industrial sector absorbed of 15.7%. The share of employment absorption by the agricultural sector declined in 1997 to 40.7% and in the industrial sector declined to 12.9%. On the other hand, the contribution of the agricultural sector to employment showed an increase from 40.7% to 45.1%, from 1997 to 2000. Meanwhile, the contribution of the industrial sector showed a small increase from 12.9% in 1997 to 12.9% in 2000.

The difference between agriculture and other sectors of the economy in most countries around the world is the significant degree of policy interventions. In many developed countries, policy interventions in agriculture are common practice and have yielded levels of farm subsidies among the highest in the world (OECD, 2002; Brook 2010). In contrast, trade policies and overvalued exchange rates in many developing countries have resulted in a taxation of agriculture, and during the 1970s and 1980s agriculture was often effectively discriminated (Wiebelt *et al.*, 1992). However, more recent analyses of this so-called agricultural policy bias in 15 developing countries indicate that such generalizations today are difficult; country specific circumstances affect the relative impact of trade policies on agriculture and the rural economy (Jensen *et al*., 2002).

In Indonesia, the micro, small and medium enterprises are generally dominated by the industry with agricultural base (agro-industry). The growth increase of agro-industry is one priorities of development direction of Indonesia in the future (Deperindag 2002). This should be done because the agricultural sector, specially the activity of agro-industry, plays an important role in maintaining the economic stability in Indonesia. Development of agro-industry needs a lot of investment such as building, machines, water sanitation etc. To accelerate the growth target, it is necessary to have the investment incentive in the sector of agro-industry in the form of tax lessening and subsidy. In order to attract agro-industrial investment in the country, the government of Indonesia has given the investment incentive such as Government Rule No. 1, 2007 and Government Rule No. 7, 2007. Will such policy bring a siginificant impact on the national economy? This paper will investigate the impact of investment incentive in the agro-industrial sector on the economy (output) in Indonesia.

RESEARCH METHODOLOGY

Data and source of data

This paper employed secondary data of Indonesia consisting of the *Sistem Neraca Sosial Ekonomi* (SNSE) – Social Accounting Matrix (SAM) - of Indonesia in 2005, the Input-Output Table of Indonesia in 2005, SUSENAS in 2005, Armington elasticity, the elasticity of export demand (CET), the elasticity of primary input substitution, the elasticity of employment substitution, and the elasticity of household expenditure. SNSE data in 2005 and Input-Output Table in 2005 were compiled from the Statistical Agency of Indonesia (BPS), while the elasticity data were obtained from various previous studies (Oktaviani 2000; Oktaviani and Drynan 2000; Sitepu *et al*., 2007; Haryono 2008).

Computable General Equilibrium Model

The study used computable general equilibrium (CGE) model. CGE Model of Comparative Static is one of the economic models which can analyze the economic macro and micro toward the change of policy/economy on macro level and micro level (De Janvry and Sadoulet 1986). The general equilibrium model saw the economy as one system. In this model, there are interrelatedness among the economic actors, i.e. between industry, household, investor, government, importer and exporter, and between the different commodity markets. The entire markets are in equilibrium and have specific structures to reach the equilibrium Dixon *et al*, (1992).

Similar with other common CGE models, the model used in this study assumes that all industries operate under the competitive markets either in the output markets or in the input markets. This implies that no sector or household can govern the markets. Hence, all economic sectors are price-takers. At the output level, the price paid by consumers equals marginal cost of producing goods. Similarly, wages received by labor are equal to their marginal productivity of labor. In addition, demand and supply equations for private agents are derived from optimization procedures.

The structure of production in a given industry, as an example is depicted in Figure 1. In the production process, each industry can produce several commodities. Industries use both intermediate and factor inputs. Each intermediate input can be source domestically or imported. Factor inputs for each industry are labor, capital and land. Key simplifying assumptions made in this production model include input-output separability and the multi-stage. The hierarchical structure in the model is based on constant elasticity of substitution (transformation) production functions except for the combining of intermediate goods and aggregate primary factors, a stage which uses the Leontief or fixed proportions technology.

The production function can be defined as: F(input,output) = 0

and can be written as G(input)= **X1TOT** =H(outputs)

where **X1TOT** is an index or the level of industry activity. The assumption of input-output separability in the transformation function means the production of a combination of products by an industry is not directly linked to the particular combination of inputs used, but only through the intermediary of the index of activity in that industry (Blackorby *et al*., 1978). Similarly, product prices have no effect on input combinations except through their effect on the level of activity in the industry. This represents a substantial empirical simplification.

While the H(outputs) transformation function is assumed to have only a single stage, the G(inputs) function is hierarchically nested with up to three stages. This implies further separability and further simplifies the demand functions. In particular, the demand for inputs at any given level can be expressed as a function of the prices of inputs at that level and need not be expressed as functions of prices of inputs at lower levels in the hierarchy.

The study adopts the Standard CGE model which was built by Lofgren *et al.* (2002) for the International Food Policy Research Institute (IFRI). The Model of Investment Incentive and Trade Liberalization in the Food Agro-Industry Sector in Indonesia was analyzed using GAMS program for windows.

The sector classification analyzed in the model of capital investment incentive covers 37 sectors, i.e.: *First*, the activity of primary food crop agriculture, i.e.: rice, corn, all kinds of tubers, other food crops, and vegetable and fruit. *Second*, the activity of agro-industry in creating the added value covers rice processing industry, wheat flour industry, and other flour, bread and cracker, noodle, sugar, cattle food, processed soybean, and other food types. *Third*, the subsystem of agricultural input and infrastructure such as fertilizer, pesticide, water supplying, agricultural infrastructure. *Fourth*, the supporting subsystem, i.e. transportation and banking services. The four classifications have represented the comprehensive agribusiness subsystem from the upstream to downstream levels and other sectors.

The institution classification is divided into government institution, company and household. Household is classified into 8 groups, i.e.: (1) farm labor household, (2) farm entrepreneur household (having land), (3) village household with the category of low group free entrepreneur, administrative staff, traveling salesman, free worker of transportation sector, individual service, manual laborer, (4) village household with the category of non work force and not clear group, (5) village household with the category of top group free entrepreneur, non agricultural entrepreneur, manager, military, professional, technician, teacher, administrative worker and top group, (6) city household with the category of low group free entrepreneur, administrative staff, traveling salesman, free worker of transportation sector, individual service, manual laborer, (7) city household with the category of non work force and not clear group, and (8) city household with the category of top group free entrepreneur, non agricultural entrepreneur, manager, military, professional, technician, teacher, administrative worker and top group.

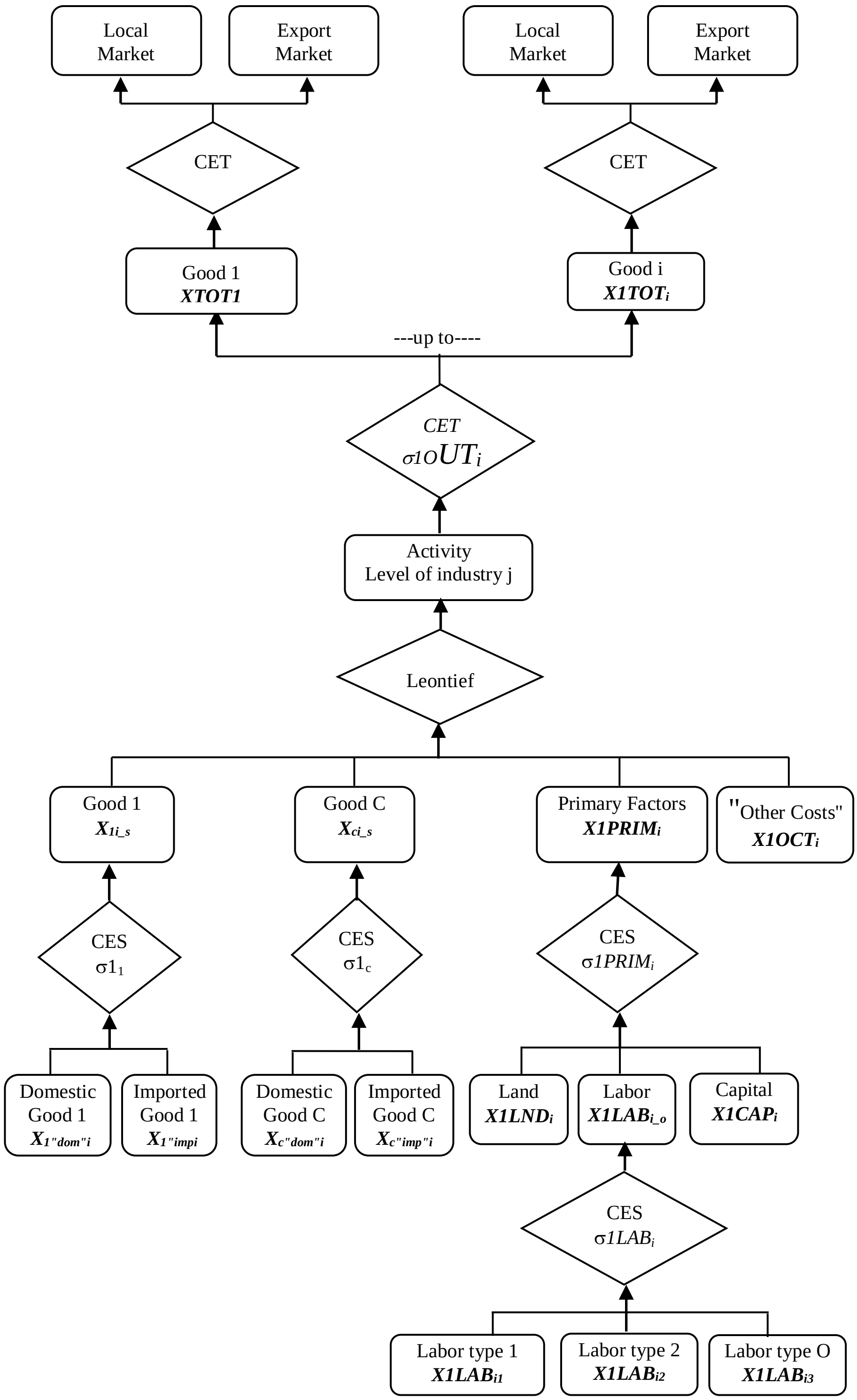

Fig. 1. Production structure

The policy simulation is carried out by increasing 10 % of the investment incentive (tax) covering incentive of added value tax, subsidy incentive and incentive of export tax. The scenario of policy simulation of the investment incentive (tax) and incentive of export tax in form of the decline of investment incentive (tax) or export tax together or partially in the industry of animal husbandry and fishery and their products, the processing industry and the fruit and vegetable preserving, industry of animal oil and vegetable oil, the industry of rice milling and rice hulling, the industry of wheat flour, the industry of other flour, bread industry, cracker and other, noodle industry, macaroni and its kinds, sugar industry, the industry of processed cereals, the industry of soybean processing, other food industry, and cattle food industry. Besides that, there are also policy simulation of subsidy to fertilizer industry, electricity and gas, and agricultural infrastructure.

RESULTS AND DISCUSSION

Agricultural development with the approach of agribusiness system will strengthen the foundation of national economic development (Saragih *et al.* 1998). From the five subsystems in the agribusiness system, the agro-industry subsystem is declared as the activator of economic development. This is based on the fact that the agro-industry has the multiplier effects to the upstream and downstream sectors of agriculture. The multiplier effect in form of long backward linkages indicates that the agro-industry can generate growth in the upstream of the sectors. While forward linkages indicate that the agro-industry can generate growth in the downstream of the sectors.

One of the government policies in accelerating the economic progress through the development of agro-industrial sector is by making the policy instrument which can attract the investors, both domestic and foreign countries, to invest their capital in the country. The policy instrument meant amongst all is giving the tax incentive. However, for the developing country the incentive (particularly tax) for investment should be selective because it is very expensive and can create the distortion in the tax system, decrease the tax revenue and restrain the budget. Therefore, the entire investment incentive, including tax, should be conducted effectively.

Impact of investment incentive in food agro-industry sector on the share of investment absorption

The result of CGE model by using the basic data of *Sistem Neraca Sosial Ekonomi* (SNSE) – Social Accounting Matrix (SAM) - of Indonesia in 2005 showed that the segment of investment absorption in Indonesia of 21.7%. The simulation of 10% tax reduction in the agro-industry sector (animal husbandry and fishery industry and their products, processing and preserving industry of fruit and vegetable, animal oil and vegetable oil industry, rice milling and rice hulling industry, wheat flour industry, other flour industry, bread industry, cracker and others, noodle industry, macaroni and its kind, sugar industry, processed cereals industry, soybean processing industry, other food industry, and cattle food industry) will increase the share of investment absorption in Indonesia (Table 1). Likewise the simulation of 10 % tax reduction for each agro-industry sector will increase the segment of investment absorption, except the simulation of tax decline in the processing and preserving fruit and vegetable industry, other flour industry, and cattle food industry.

The simulation of tax reduction in some agro-industry sector have positive impacts to the share of investment absorption, especially incentive of tax reduction in the industry of animal oil and vegetable oil, i.e. 0.01047%. This indicates that if the government wishes to increase the share of investment absorption through the tax incentive, so tax reduction in the food agro-industry sector such as animal oil and vegetable oil industry should be prioritized. Crude Palm Oil (CPO) and Palm Kernel Oil (PKO) are the raw material for vegetable oil, particularly cooking palm oil industry. The investment incentive in form of tax reduction for this industry will theoretically push the development of cooking palm oil industry in Indonesia.

Table 1. Impact of 10 % tax reduction in agro-industry sector on the share of investment absorption

Simulation Scenario	Change (%)
Basic Value (%)	**21.70047**
Agro-industry sector	0.00839
Industry of Livestock, Fish and the Results	0.00237
Industry of processing and preserving of fruit and vegetable	-0.00596
Industry of Animal Oil and Vegetable Oil	0.01047
Milled Rice and Process of Hulling Rice Industry	0.00077
Wheat Flour Industry	0.00019
Other Flour Industry	-0.00050
Industry of Bread, Biscuits and the Like	0.00039
Industry of Noodles, Macaroni and the Like	0.00202
Sugar Industry	0.00033
Processed Grains Industry	0.00027
Soybean Processing Industry	0.00018
Other Food Industry	0.00066
Cattle Feed Industry	-0.00041

The simulation of 10% subsidy in the fertilizer industry, electricity and gas, and agricultural infrastructure together will increase the share of investment absorption in Indonesia, except for the subsidy on the agricultural infrastructure (Table 2). The subsidy on the electricity and gas sector gives the highest positive impact in compare to the subsidy on the fertilizer industry. The electricity and gas are the main source of energy in the production process of the agro-industrial companies beside oil fuel and coal. With the subsidy of electricity and gas, it will reduce the production cost of agro-industry and increase the production in order to obtain the higher profit. The expectation of higher profit will push both the domestic and foreign investor to invest in the field of agro-industry. The subsidized fertilizer is intended for the small farmers who are food crop farmers, such as rice, corn and cassava. The agro-industry for these commodities is generally small scale industry. So, the positive impact of the fertilizer subsidy is relatively small to the share of the investment absorption in the agro-industrial sector as a whole.

Table 2. Impact of 10 % subsidy on the share of investment absorption

Simulation Scenario	Change (%)
Basic Value (%)	**21.70047**
Fertilizer, electricity and gas, and agricultural infrastructure	0.01680
Fertilizer	0.19068
Electricity and gas	0.36585
Agricultural infrastructure	-0.51653

Based on the above results, the impact of the investment incentive on the share of investment absorption through two policy instruments suggest that the incentive through the subsidy instrument gives the highest impact, particularly the subsidy on the electricity and gas sectors. However, the incentive of tax reduction also can be done, particularly the tax incentive in the sector of animal oil and vegetable oil industry.

Impact of investment incentives in food agro-industry sector on the national economy

The simulation of 10% reduction of the value added tax in the agro-industry sectors has the highest positive impact on the output of vegetable and processed fruit industry sector, followed by sugar industry, with increase of 4.57584% (Rp 0.108192 trillion) and 0.08064% (Rp 0.00496 trillion), respectively. On the other hand, the noodle industry and macaroni have the highest decrease of -2.55314% or Rp 0.03599 trillion (Table 3).

Table 3. Impact of tax reduction of agroindustry sector on the national economy

Sector	Basic Value (Trillion Rupiah)	Change			
		SIMALL (%)	SIMVAT2 (%)	SIMVAT6 (%)	SIMVAT8 (%)
Paddy	66.30770	0.00298	-0.00099	0.00012	0.00012
Corn	16.29657	-0.00309	-0.00029	0.00309	-0.00023
Tubers	21.06792	0.00057	0.00102	0.00072	0.00004
Soybean	2.58200	0.00397	-0.00198	-0.00017	0.00011
Other Food Crops	1.88972	-0.02229	-0.00233	0.00458	-0.02379
Vegetables and Fruits	59.12292	0.00967	0.01034	-0.00007	0.00016
Cane	5.64762	0.04089	0.00540	-0.00013	0.00000
CPO	14.30216	-0.07162	0.01702	0.00158	-0.00551
Other Plantation and Forestry	89.39150	0.00061	0.00224	-0.00008	0.00003
Livestock and Fishery	86.56227	-0.00005	-0.00253	-0.00027	0.00020
Mineral	379.02700	0.00860	-0.01509	-0.00124	0.00398
Industry of Livestock, Fish & Results	77.93571	-0.00291	-0.00018	-0.00003	-0.00024
Processed Vegetable and Fruit Industry	2.36442	4.57584	4.46925	-0.00709	0.02530
Industry of Animal and Vegetable Oil	150.26015	-0.08889	0.02194	0.00203	-0.00702
Milled Rice and Process of Hulling Rice Industry	79.18253	0.00703	0.00018	0.00043	-0.00023
Wheat Flour Industry	2.48977	-0.10019	0.00152	0.00001	-0.11757
Other Flour Industry	1.40775	0.00764	-0.00696	0.59082	0.00464
Industry of Bread, Biscuits and the Like	2.09855	-0.10567	0.00161	-0.00002	-0.00123

Sector	Basic Value (Trillion Rupiah)	Change			
		SIMALL (%)	SIMVAT2 (%)	SIMVAT6 (%)	SIMVAT8 (%)
Industry of Noodles, Macaroni and the Like	1.40977	-2.55314	0.02540	0.00451	-2.36821
Sugar Industry	6.14775	0.08064	0.01236	-0.00013	-0.00014
Processed Grains Industry	36.12387	0.01740	-0.00155	-0.00024	-0.00007
Soybean Processing Industry	5.33719	0.03363	-0.00003	-0.00020	-0.00039
Other Food Industry	22.78214	-0.00916	-0.00105	-0.00013	-0.00561
Cattle Feed Industry	14.42555	0.01170	-0.00165	-0.00029	0.00019
Fertilizer Industry	46.58777	-0.00239	0.00329	0.00029	-0.00088
Pesticide Industry	0.78971	-0.02117	0.02912	0.00258	-0.00932
Other Industries	2467.68415	0.00092	-0.00325	-0.00025	0.00078
Electricity and Gas	116.25573	-0.00363	0.00195	0.00022	-0.00066
Clean Water	14.35682	-0.00477	0.00073	0.00014	-0.00044
Building	311.28640	-0.00128	0.00049	0.00006	-0.00019
Agricultural Infrastructure	15.36838	-0.00023	0.00008	0.00001	-0.00002
Other Infrastructures	48.18106	-0.00003	-0.00018	-0.00001	0.00005
Trading, Hotel and Restaurant	790.54585	-0.00153	-0.00110	0.00029	0.00018
Transportation Services	351.54949	-0.00120	-0.00015	0.00018	0.00011
Financial Services	250.99239	-0.00289	0.00020	0.00003	-0.00006
Government Services	74.87523	-0.00083	-0.00046	-0.00002	0.00003
Other Services	515.03725	-0.00378	0.00032	0.00009	-0.00043

Notes:
SIMALL : Tax of agroindustry sector, declining of 10%
SIMVAT2 : Tax of Industry of processing and preserving of fruit and vegetable, declining of 10%
SIMVAT6 : Tax of Other Flour Industry, declining of 10%
SIMVAT8 : Tax of Industry of Noodles, Macaroni and the like, declining of 10%

The simulation of 10% tax reduction in vegetable and processed fruit industry (SIMVAT2) has the impact on the output increase in the sector itself of 4.46925% (Rp 0.105672 trillion), followed by the simulation of tax reduction in other flour industry sector (SIMVAT6) which result in an increase of 0.59082% increase of the sector itself or Rp 0.008317 trillion**.** Meanwhile, the simulation of tax reduction on the noodle industry and macaroni (SIMVAT8) has a negative impact with -2.36821% decrease or Rp 0.03339 trillion. The simulation of the 10% subsidy to fertilizer industry, electricity and gas, and agricultural infrastructure all together will increase the output in the industrial sector of fertilizer, electricity and gas, and vegetable and processed fruit industries (Table 4).

Table 4. Impact of subsidy on the sectoral output

Sector	Basic Value (Trillion Rupiah)	Change			
		SIM-INFALL (%)	SIM-PUK (%)	SIM-LIGAS (%)	SIM-PPERT (%)
Paddy	66.30770	0.08417	0.11200	-0.03754	0.01043
Corn	16.29657	-0.01067	0.05014	-0.06497	-0.00181
Tubers	21.06792	0.00768	0.03314	-0.02331	-0.00040
Soybean	2.58200	0.09314	0.10296	-0.00563	-0.00092
Other Food Crops	1.88972	0.06437	0.05671	0.01284	-0.00147
Vegetables and Fruits	59.12292	0.00513	0.05751	-0.04863	-0.00068
Cane	5.64762	0.01633	0.07009	-0.05051	-0.00085
CPO	14.30216	-1.39361	-0.50650	-1.06087	-0.02436
Other Plantation and Forestry	89.39150	-0.14024	-0.04031	-0.11050	0.00460
Livestock and Fishery	86.56227	-0.06579	-0.00345	-0.05501	-0.00225
Mineral	379.02700	0.80071	0.23662	0.61583	0.00905
Industry of Livestock, Fish and Results	77.93571	-0.14739	-0.02834	-0.11903	-0.00114
Processed Vegetable and Fruit Industry	2.36442	4.57802	2.20987	3.13761	0.05807
Industry of Animal Oil &Vegetable Oil	150.26015	-1.79868	-0.67595	-1.32880	-0.04374
Milled Rice & Process of Hulling Rice Industry	79.18253	-0.09164	0.02556	-0.12475	0.00408
Wheat Flour Industry	2.48977	-0.16486	-0.04676	-0.12423	-0.00186
Other Flour Industry	1.40775	0.58152	0.21368	0.39621	0.00387
Industry of Bread, Biscuits & the Like	2.09855	-0.12816	-0.03785	-0.09217	-0.00209
Industry of Noodle Macaroni& the like	1.40977	-1.78276	-0.64817	-1.25467	-0.01475
Sugar Industry	6.14775	-0.05466	0.01643	-0.06843	-0.00066
Processed Grains Industry	36.12387	-0.09907	0.00268	-0.10530	0.00375
Soybean Processing Industry	5.33719	-0.04226	0.00063	-0.03960	-0.00087
Other Food Industry	22.78214	-0.14951	-0.02730	-0.12930	0.00079
Cattle Feed Industry	14.42555	-0.02172	0.00741	-0.02343	-0.00089
Fertilizer Industry	46.58777	0.99309	1.11402	-0.13292	-0.00163
Pesticide Industry	0.78971	-1.15098	-0.20935	-0.93322	-0.03256
Other Industry	2467.68415	-0.06764	-0.03703	-0.02416	0.00121

Sector	Basic Value (Trillion Rupiah)	Change			
		SIM-INFALL (%)	SIM-PUK (%)	SIM-LIGAS (%)	SIM-PPERT (%)
Electricity and Gas	116.25573	2.11672	-0.05825	2.16836	-0.00227
Clean Water	14.35682	0.11008	-0.02640	0.13058	-0.00227
Building	311.28640	-0.05682	-0.01012	-0.04877	-0.00062
Agricultural Infrastructure	15.36838	-0.00602	-0.00159	-0.00523	0.00003
Other Infrastructures	48.18106	0.01259	0.00165	0.01131	0.00008
Trading, Hotel and Restaurant	790.54585	-0.17113	-0.02520	-0.15118	-0.00162
Transportation Services	351.54949	-0.13448	-0.02640	-0.11218	-0.00113
Financial Services	250.99239	-0.10265	-0.02238	-0.08389	-0.00141
Government Services	74.87523	0.00684	0.00705	-0.00242	0.00276
Other Services	515.03725	-0.14818	-0.02843	-0.12279	-0.00163

Notes:

SIMINFALL : Subsidy for fertilizer, electricity and gas, and agricultural infrastructure of 10%
SIMPUK : Subsidy for fertilizer of 10%
SIMLIGAS : Subsidy for electricity and gas of 10%
SIMPPERT : Subsidy for agricultural infrastructure of 10%

The simulation of the subsidy in the three sectors together gives the highest impact on the industrial output of vegetable and processed fruit, followed by the output of electricity and gas sectors, and the output of fertilizer industry, i.e. increase of 4.57802% (Rp 0.10824 trillion), 2.11672% (Rp 2.46081 trillion) and 0.99309% (Rp 0.46266 trillion), respectively.

The simulation of 10% subsidy to fertilizer (SIMPUK) has the biggest impact on the increasing output of vegetable and processed fruit industries (2.20987% or Rp 0.05225 trillion), followed by the increasing output of fertilizer industry (1.11402% or increase of Rp 0.51900 trillion). Moreover, the simulation of the subsidy to electricity and gas of 10% (SIMLIGAS) gives the highest impact on the increasing output of vegetable and processed fruit industries (3.13761% or increase of Rp 0.07419 trillion), followed by the increasing output of electricity and gas sectors (2.16836% or increase of Rp 2.52084 trillion). Then, the simulation of 10 % subsidy to agricultural infrastructure (SIMPPERT) also gives the highest impact on the increasing output of vegetable and processed fruit industries (0.05807% or increase of Rp 0.00137 trillion), followed by the increasing output of rice sector (0.01043% or Rp 0.00692 trillion).

The above simulation noted that the policy of incentive through the subsidy to fertilizer industry, electricity and gas as well as agriculture infrastructure gives higher impact on the economy compared to the incentive of added value tax reduction, particularly in the sector of vegetable and processed fruit industries. In order to make this study easy to be used by decision makers, a web based prototype information system has been developed for use by decision makers when planning the resource allocation based on economic sector analysis (Suroso 2012).

CONCLUSION AND POLICY RECOMMENDATIONS

The agricultural development through the approach of agribusiness system with the main priority in the subsystem of agro-industry will have multiplier effect through the backward and forward linkages in the agribusiness sector. In order to accelerate investment in the agro-industrial sector, this paper carried out simulations concerning some possible incentives. The incentive through subsidy gives the biggest positive impact on the share of investment absorption, especially in the sector of electricity and gas. Moreover, tax incentive in the food agro-industry sector can also be done, especially in the industrial sector of animal oil and vegetable oil.

The subsidy in the fertilizer, electricity and gas, and agricultural infrastructure industries simultaneously and partially also give an impact on the economy, with the highest positive impact on the output of its industry and in the industry of vegetable and processed fruit. The simulation of subsidy in the agricultural infrastructure also gives a quite significant impact on the output of rice commodity. The investment incentive in form of tax reduction in the sector of agro-industry simultaneously and partially will give the highest impact on the increasing output of industrial sector of vegetable and processed fruit as well as other flour industry sector.

Based on above results of the study, it suggested that the government of Indonesia has to consider a higher government expenditure policy in forms of subsidy and tax deductions to push the development of the agro-industry in Indonesia. The subsidy can be implemented in the form of inputs, outputs and infrastructure development. However the government needs to analyze further such mechanisms in order to avoid dispute with international rules. For further study, a user-friendly information system is required to assist decision makers when planning the resource allocation based on economic sector analysis.

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SCREENING METHOD FOR IRON TOLERANT RICE SUITED FOR TIDAL SWAMP AREA

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ABSTRACT

Previous research conducted in the greenhouse at the Cikabayan University Farm, Bogor Agricultural University, Indonesia from July to September 2010, using cultivar IR 64 and Margasari found that Fe concentration in solution that causing low Fe toxicity symptoms was ≤ 52 ppm Fe, moderate toxicity was 143 ppm Fe, and severe toxicity ≥ 325 ppm Fe. This research aims at: 1) To observe the effects of two levels of Fe concentrations on growth of rice; 2) to find out rice genotypes that tolerant or semi tolerant to iron toxicity; 3) to verify toxicity levels in the green house and in the field. The green house experiment was conducted at the Cikabayan University Farm, Bogor Agricultural University from July to September 2010 using Yoshida's nutrient solution with Fe added according to the treatment levels. This research used factorial design with two factors, which are: Fe concentrations (143 and 325 ppm Fe) and 20 paddy genotypes. The field experiment was done in two tidal swamp areas, in Belandean and Danda Jaya, Barito Kuala District, South Kalimantan Province, Indonesia, consisting of four genotypes chosen in the green house experiment and IR64 as a control. Results showed that increasing in Fe concentration from 143 to 325 ppm and period of Fe stress increase Fe toxic symptoms in rice. Four paddy genotypes that had been selected in the green house (Inpara-1, Inpara-2, Inpara-4, dan TOX4136 line) showed lower Fe toxic symptom after planted in the tidal swamp area. Inpara-1 and Inpara-4 genotypes indicated as tolerant genotypes to iron toxicity and perform higher yield than the other genotypes in both of field experimental locations in the tidal swamp area. Fe concentration at 325 ppm in Yoshida's solution can be used for screening of rice tolerant genotypes to iron toxicity.

Key words: iron toxicity, rice geonotypes, green house, field

INTRODUCTION

Iron toxicity is one limiting factor of rice production in the paddy field; it reportedly occurs in Asian countries such as China, India, Indonesia, Thailand, Malaysia, and Philipines (Asch *et al.* 2005). Specific visual symptoms related to iron toxicity, are primarily associated with accumulation of oxidation products of polyphenols which is called bronzing or yellowing in rice (Yamauchi and

Yoshida, 1981). Iron toxicity in paddy results in poor growth, limited tillering and as a consequence, low yield or a failed harvest (Audebert and Sahrawat, 2000). Many researches show iron toxicity could decrease yield by around 12-100% (Sahrawat , 2004; Sahrawat, 2010).

Iron toxicity causes physiological stress in rice, and it is common in ultisol, oxisol, and sulfic acid tidal swamp land with high iron concentration (Sahrawat 2004). Tidal swamp area in Indonesia is 20.1 million ha, and about 6.7 million ha is sulfic acid soils (Alihamsyah, 2004), with high pyrites and soluble Fe content that potentially cause iron toxicity in paddy. Iron toxicity is not only caused by higher absorption of Fe^{+2} in paddy tissues, which is enhanced by Fe concentration in the soil, but also relates with other factors such as nutrient imbalance and reductive environment condition with poor drainage (Sahrawat , 2004). Iron toxicity also relates with sensitive rice cultivar such as IR64 that causes low productivity (Suhartini, 2004; Suhartini and Makarim, 2009). A sensitive cultivar (IR64) performed lower yield (58%) compared to a tolerant cultivar (Margasari) in tidal swamp land in South Kalimantan, in which soil Fe concentration was 719 ppm and pH 3.84(Noor *et al*. 2005). Using tolerant genotype against iron toxicity is the cheaper and easier way for farmers to solve iron toxicity problems. In order to get higher productivity, it is necessary to perform early selection for paddy genotypes that can tolerate high iron levels with potentially higher yield.

One of the problems in the evaluation for rice genotypes that tolerant to iron toxicity is if the number of genotypes to be evaluated is large, and the other problem is variation in Fe concentrations in the soils. As a consequence, results of selection for tolerant genotypes may not be consistent (Audebert and Sahrawat, 2000). In order to eliminate environmental variation in the field, selection for tolerant genotypes can be done under the controlled environment in the green house, using nutrient solution culture or hydroponics (Asch *et al*. 2005). An appropriate selection method with a short process period in the green house is important in order to get tolerant rice genotype for production in the field. A screening method in the green house having a high correlation with performance and productivity in the field is necessary in order to identify tolerant rice genotype in a fast, cheap and precise way. Previous researches showed that there are differences in rice selection methods using nutrient solution in the green house, primarily Fe concentrations in nutrient solution, solution pH, seedling age and period of Fe stress (Asch *et al*. 2005; Dorlodot *et al*. 2005; Aung, 2006; Kpongor, 2003). This research therefore sought to observe the effects of two levels of Fe concentrations on the growth of rice; to select rice genotypes that are tolerant or semi tolerant to iron toxicity and to verify the iron toxicity levels in the green house and in the field in order to develop a better method for screening.

MATERIALS AND METHODS

Experiments were done in a green house at the Cikabayan University Farm, Bogor Agricultural University from July to September 2010, and in two locations in a tidal swamp area in Barito Kuala, South Kalimantan from Fabruary to July 2011.

Soil analysis

Soil analysis was done in the Swamp Land Agricultural Research Agency in Banjarbaru, South Kalimantan. Soil pH was measured in a 1:1.5 (w/v) water solution using a pH meter. Clay minerals were identified by X-ray diffraction analysis (Rigaku RAD-2RS Diffractometer). The content of organic carbon (C) in soil was measured with a NC analyzer (Sumigraph NC analyzer NC-800-13 N, Sumika Chem. Anal. Service). Available P content was obtained by the Bray 1 method (Bray and Kurtz 1945), while the absorbance at 693 nm was determined using a UV-VIS spectrophotometer (UV-1200, Shimadzu Corporation, Japan). Cation exchange capacity (CEC) was obtained by extraction with 1 mol L^{-1} NH_4OAc pH 7.0 and the contents of exchangeable bases (calcium and magnesium) were determined by atomic absorption spectrophotometry (AA-640-12, Shimadzu Corporation, Japan) while those of exchangeable potassium and sodium were determined by flame emission spectrophotometry (AA-640-12, Shimadzu Corporation, Japan). Base saturation was defined as the ratio of total exchangeable bases to CEC, expressed as a percentage. Exchangeable Al was extracted with 1 mol L^{-1} KCl. Exchangeable Al was extracted with 1 mol L^{-1} KCl and measured with acid-base titration. Iron (Fe) was exracted with 1 mol L^{-1} NH_4 OAc (ammonium acetate) and then Fe in solution was determined by atomic absorption spectrophotometry. Pyrite was determined by oxidizing pyrite with hydrogen peroxide and soluble sulphate, which was equivalent with pyrite, was measured by turbidimetry.

Green house experiments

Rice genotypes tolerant to iron toxicitywere evaluated under two environmental stress conditions which caused moderate and severe iron toxicity symptoms. Previous research demonstrated that ≤ 52 ppm Fe concentration in solution caused low Fe toxicity symptoms with a score of ≤ 3 in IR64. Moderate toxicity with score = 5 was observed in 143 ppm Fe, and severe toxicity with score ≥ 9 was observed in ≥ 325 ppm Fe (Noor *et al*. 2012). In the experiment, a factorial in randomized block design was used with two factors, namely (1) Fe concentrations: 143 ppm, moderate Fe toxicity symptom and 325 ppm, severe Fe toxicity symptom) and (2) Genotypes: 20 genotypes that could be divided into three groups:

a) Genotypes that have been released as irrigated paddy rice (4 genotypes)
b) Genotypes that have been released as swamp or tidal swamp rice (4 genotypes)
c) Genotypes as promotion tidal swamp rice (8 genotypes) (Table 1).

Table 1. Rice genotypes used in this study

No.	Rice Genotype	Remarks
1	IR 64	Lowland /Rain Pad Rice
2	Ciherang	Lowland /Rain Pad Rice
3	Inpari-1	Lowland /Rain Pad Rice
4	Inpari-6	Lowland /Rain Pad Rice
5	Margasari	Swamp /Tidal Swamp Rice
6	Indragiri	Swamp /Tidal Swamp Rice
7	Dendang	Swamp /Tidal Swamp Rice
8	Inpara-1	Swamp /Tidal Swamp Rice
9	Inpara-2	Swamp /Tidal Swamp Rice
10	Inpara-3	Swamp /Tidal Swamp Rice
11	Inpara-4	Swamp/Flooding Tolerant Rice
12	Inpara-5	Swamp/Flooding Tolerant Rice
13	BP1031F-PN-25-2-4-KN-2	Tidal Swamp Promoted Line
14	B11586F-MR-11-2-2-2	Tidal Swamp Promoted Line
15	BP-1027F-PN-1-2-1-KN-MR-3-3	Tidal Swamp Promoted Line
16	B10891B-MR-3-KN-4-1-1-MR-1	Tidal Swamp Promoted Line
17	IR72049-B-R-22-3-1-1	Tidal Swamp Promoted Line
18	BP367E-MR-42-4-PN-3-KN-MR-4	Tidal Swamp Promoted Line
19	B10387F-MR-7-6-KN-3-KY-2	Tidal Swamp Promoted Line
20	TOX4136-5-1-1-KY-3	Tidal Swamp Promoted Line

Every experimental unit was replicated three times. Rice was transplanted into a plastic box with sand as a medium, where half concentration of Yoshida's nutrient solution at pH 5.0 was added. After 14 days, single seedlings were transferred into a PVC plastic pot (1200 ml capacity; 7.5 cm x 23 cm, diam. x length) with half concentration of Yoshida's nutrient solution (1000 ml) (Yoshida *et al*. 1976) at pH 4.5, and acclimated for 7 days. After acclimatisation, it was treated using $FeSO_4$ for two levels of Fe concentrations at pH 4.0 (Fig. 1). The top of the plastic pot was covered with a plastic liner to minimize oxygen loss and solution media evaporation. The solution with Fe was added everyday to replace the solution that was lost by absorption and evapotranspiration and nutrient culture was replaced once a week.

Fig. 1. Research activities in the green house: (a) Rice seedling in sand box, (b) Rice seedling at 14 days age transferred to a plastic pot (PVC) and acclimated for 7 days. (c) Rice that had been treated with Fe and grown for 4 weeks.

Observations conducted consisted of Fe toxicity levels on rice for a period of 1 to 4 weeks after transplanting, tiller numbers, root length, shoot weight and root weigt at 4 weeks after transplanting. The toxicity levels were indicated by leaf damage starting from the tip leaf that became brown and then black, and the scoring of iron toxicity symptoms referred to IRRI-INGER (1996), modification by Asch *et al*. (2005) and Aung (2006) (Table 2). Four genotypes were chosen for the field trial according to its tolerance to Fe toxicity (scoring) and plant growth.

Table 2. Fe toxicity symptom scores in rice

Fe Score	Fe Toxicity in Leaf (%)	Tolerancy Levels
1	0	Highly tolerant
2	1-9	Tolerant
3	10-29	Tolerant
5	30-49	Moderately tolerant
7	50-69	Sensitive
9	70-89	Very sensitive
10	90-100	Very sensitive

Sources : IRRI-INGER (1996), modification by Asch *et al*. (2005) and Aung (2006)

Verification of Iron Toxicity Symptoms in the Field

Verification of tolerant rice genotypes in the green house was done in field at two locations that potentially have different levels of iron toxicity stress. The field experiment was done in a B type of tidal swamp area in Belandean and Danda Jaya, Barito Kuala District, South Kalimantan Province. The B type of tidal swamp is characterized by temporary flooding by a big tide (sea or river) which occurs periodically. Rice genotypes used for the experiment were four genotypes chosen from the green house experiment. IR 64 was used as a sensitive control. Four genotypes TOX4136, Inpara-1, Inpara-2, and Inpara-4 which have been selected based on the concentration of 325 ppm Fe at 4 week stress with Fe toxicity symptom score 5.0 (moderate) and one sensitive variety IR 64 (score Fe 7.7) based on the results of the previous experiment (Noor *et al.*, 2012). The treatments were replicated three times and the 21 day olds seedlings were transplanted into (4 x 5) m^2 of plot at 20 x 20 cm^2 spacing with two seedlings per hole. Half of nitrogen and all of P and K fertilizer were applied at 7 days after transplanting, and the other half of N was given four weeks after first application. Observations on iron toxicity symptom were done at 4 and 8 weeks after transplanting.

Statistical analysis

Data analysis was done using analysis of variance, and the Least Significant Difference at 95% confidence level used for advance analysis.

RESULTS AND DISCUSSION

Green House Experiments

Iron toxicity symptom on rice in green house

Generally, iron toxicity symptoms in irrigated paddy (4 genotypes), swamp rice (8 genotypes), and promoted lines (8 genotypes) increased with increasing in iron toxicity, and period of observation and iron concentration in nutrient solution (Fig. 2).

In 143 ppm Fe condition, iron toxicity symptoms in the three genotype groups were almost similar, except in the week 4th iron toxicity symptom scores in paddy rice were higher than the other groups. Under 325 ppm Fe condition, paddy rice showed toxicity symptom scores higher than the other groups for all of observation periods. Average different iron toxicity symptom scores between 143 ppm Fe and 325 ppm Fe conditions at 1, 2, 3, and 4 weeks observation were 0.20, 1.88, 2.20 and 3.00 (Fig. 2).

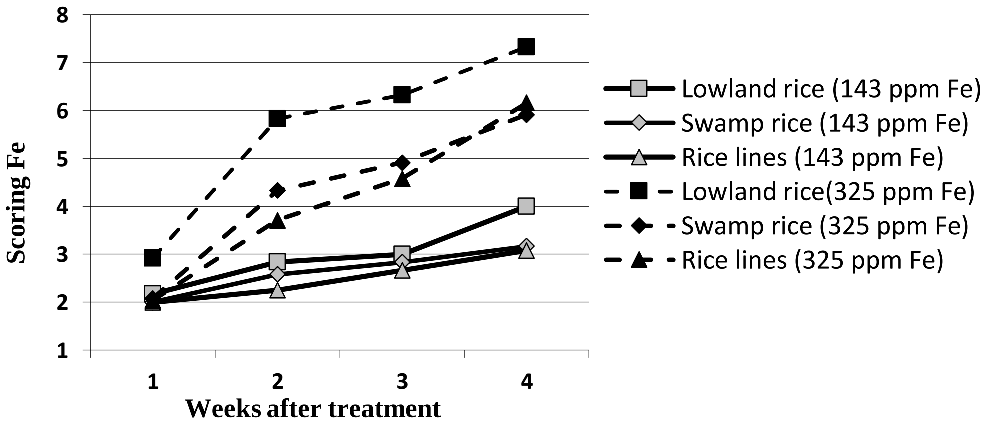

Fig. 2. Change of Fe toxicity average score of irrigated, swamp and promoted line rices in two levels of Fe concentrations for 4 weeks.

In the second week of observation, iron toxicity symptom scores significantly different among treatments, especially for 325 ppm Fe (2.3 – 6.3), Iron toxicity symptom in the second week at 143 and 325 ppm Fe treatments were different only for genotypes such as IR64 Ciherang, Inpari-1, Inpari-6, Indragiri, Dendang, and Inpara-1 (Table 3).

Table 3. Interaction between genotype and Fe concentrations for Fe toxicity symptoms at 2 and 4 weeks after treatment.

No.	**Rice genotype**	**2 Weeks**		**4 Weeks**	
		143 ppm Fe	**325 ppm Fe**	**143 ppm Fe**	**325 ppm Fe**
1	IR 64	2.7 a B	6.3 a A	5.0 a B	7.7 ab A
2	Ciherang	3.0 a B	5.7 ab A	4.3 ab B	6.3 bcd A
3	Inpari-1	2.7 a B	5.0 abc A	3.7 ab B	7.0 abc A
4	Inpari-6	3.0 a B	5.7 ab A	3.7 ab B	8.3 a A
5	Margasari	3.0 a B	5.0 abc A	3.0 b B	5.7 cde A
6	Indragiri	2.7 a A	4.3 bcd A	3.0 b B	6.3 bcd A
7	Dendang	2.7 a A	4.3 bcd A	3.0 b B	6.3 bcd A
8	Inpara-1	2.7 a A	4.3 bcd A	3.0 b B	5.0 def A
9	Inpara-2	3.0 a A	3.7 cde A	3.0 b B	5.0 def A
10	Inpara-3	2.7 a B	5.0 abc A	3.7 ab B	6.3 bcd A
11	Inpara-4	2.0 a A	3.0 de A	3.0 b B	5.0 def A
12	Inpara-5	2.0 a B	5.0 abc A	4.3 ab B	7.0 abc A
13	BP1031F-PN-25-2-4-KN-2	2.3 a A	3.7 cde A	3.0 b B	5.0 def A
14	B11586F-MR-11-2-2-2	2.0 a B	5.0 abc A	3.7 ab B	7.0 abc A
15	BP-1027F-PN-1-2-1-KN-MR-3-3	2.0 a A	3.0 de A	3.0 b B	7.0 abc A
16	B10891B-MR-3-KN-4-1-1-MR-1	2.0 a B	4.3 bcd A	3.7 ab B	7.0 abc A
17	IR72049-B-R-22-3-1-1	3.0 a B	4.3 bcd A	3.0 b B	5.7 cde A
18	BP367E-MR-42-4-PN-3-KN-MR-4	2.7 a A	4.3 bcd A	3.7 ab B	7.0 abc A
19	B10387F-MR-7-6-KN-3-KY-2	2.0 a A	2.7 de A	3.0 b B	5.7 cde A
20	TOX4136-5-1-1-KY-3	2.0 a A	2.3 e A	3.0 b B	5.0 def A

Values within columns having the same lowercase letters are not significantly different (P<0.05) using LSD test. (critical value of t test for 2 weeks = 1.9 and 4 weeks = 2.0)

Based on iron toxicity score observation at 4 weeks in the 325 ppm treatment, paddy field genotypes (IR64, Ciherang, Inpari-1, Inpari-6) showed high toxicity symptomp scores that were 6.3-8.3 (average 7.33). Iron toxicity symptom score in swamp paddy genotypes were between 5.0-7.0 (average 5.83) whereas iron toxicity in tidal paddy genotypes were between 5.0-7.0 (average 6.18) . Iron toxicity scores at 4 weeks for all paddy genotypes at 325 ppm treatment were higher than those of 143 ppm treatment (Table 3). Based on the score of iron toxicity symptoms at 4 weeks at 143 ppm treatment, 17 genotypes were classified as tolerant (3.0-3.7). There were 11 genotypes had the lowest score (3.0) from the 17 tolerant genotypes. Many selected genotypes were classified as tolerant, based on iron toxicity score at 143 ppm treatment, making it less effective as a basis for selection.

Based on the scores of iron toxicity symptoms at 4 weeks at 325 ppm Fe stress treatment, 11 genotypes performed moderately tolerant (score 5.0-5.7), with five genotypes with the lowest score (score of 5.0). Five genotypes considered to be moderately tolerant to iron toxicity were Inpara-1, Inpara-4, TOX4136-5-1-1-KY-3 line, Inpara-2, and BP1031F-PN-25-2-4 -KN-2 liner. The research results showed that Fe concentrations that causes Fe toxication in plants is very diverse. The Fe levels in solution which causes toxicity vary widely ranged between 10-500 ppm Fe (Bode *et al*., 1995; Asch *et al*., 2005; Fageria and Rabelo, 1987). The concentrations of Fe nutrient in solution of 250-500 ppm with pH 4.5-6.0 significantly boosted the levels of Fe in plant tissue and showed symptoms of Fe toxicity on sensitive plants (Majerus *et al*. 2007; Mehraban *et al*. 2008).

Verification of iron toxicity symptoms in the field

To verify the tolerance of varieties tested under greenhouse conditions, five varieties were tested in a field trial in the tidal swamp in Belandean and Danda Jaya, South Kalimantan Province.

Soil characteristics

Soil analysis showed that the soil was very acidic, with a pH of 3.8 and 4.1 in Belandean and Danda Jaya, respectively. Levels of toxic elements, such as exchangeable-Al (9.70 me/100g) and Fe concentration (631 ppm), in Belandean were higher than in Danda Jaya which had exchangeable-Al at 6.37 me/100 g and 425 ppm Fe. The depth of the layer of pyrites ($FeS_2 \geq$ 2%) in Belandean was more shallow ($\geq$ 40 cm) than in Danda Jaya ($\geq$ 54 cm), while pyrite content in Belandean was also higher (4.37%) than in Danda Jaya (2.48%).(Table 4). Belandean possesses higher level of stress than the Danda Jaya location based on the depth of the more superficial layers of pyrites and pyrites content, exchangeable-Al, higher Fe and the lower soil pH, higher soil Fe content and lower pH. Levels of pyrites was high and pyrites layer depth was more shallow at Belandean, and as a consequences, iron toxicity stress were more severe than in Danda Jaya (Table 4). The shallow pyrites layer in the soil has greater potential to cause iron toxicity in rice, because shallow layer is easy to be affected by oxidation. When the pyrite layer is oxydized, it would decrease soil pH, increase Al and Fe toxicity and lower nutrient content. Under reductive environment, excessive iron in the form of ferrous ions (Fe^{2+}) will appear in acid sulfate soils and may become toxic for rice (Dent, 1986).

The oxydation of pyrates produce ferric ions (Fe^{+3}) and H^+ that cause soil to become very acidic, based on the chemical reaction below (Dent, 1986) :

$$FeS_2 + 15/4\, O_2 + 7/2\, H_2O \rightarrow Fe(OH)_3 + 2\, SO_4^{2-} + 4\, H^+$$

Under flooded reductive conditions, ferric ions (Fe^{+3}) will reduce to ferrous ions (Fe^{+2}) which can be absorbed in larger amounts resulting in phytotoxicity. The reduction of ferricc to ferrous ions is commonly associated with iron reduction bacteria, and the reaction is as follows (Dent, 1986) :

$$Fe(OH)_3 + 3H^+ + e^- \Leftrightarrow Fe^{2+} + 3H_2O$$

Table 4. Soil characteristics of the field in tidal swamp area, KP. Blandean and Danda Jaya, Barito Kuala District, South Kalimantan

Soil Characteristic	KP. Blandean		Danda Jaya	
	Value	Criteria*	Value	Criteria*
pH (H_2O)	3.80	Very Acid	4.10	Very Acid
C. Organic (%)	5.01	High	4.16	High
N total (%)	0,25	Medium	0.27	Medium
P Bray I (ppm P_2O_5)	12.80	Medium	15.20	Medium
P total (mg/100g P_2O_5)	84.00	High	112	High
K total (mg/100 g K_2O)	8.00	Low	8.00	Low
Excngeable Base (me/100g) :				
Ca	1.50	Low	1.10	Low
Mg	1.37	Low	1.30	Low
K	0.09	Very low	0.09	Very Low
Na	0.62	Medium	0.62	Medium
KTK (me/100 g)	15.75	Medium	12.65	Medium
Al-dd (me/100 g)	9.70	High	6.37	High
Fe (ppm)	631	-	425	-
Texture (%):				
Clay	69	Silty Clay	63	Silty Clay
Silt	31		36	
Sand	0		1	

*Soepraptohardjo (1983)

Iron toxicity symptoms and rice yield

The level of iron toxicity symptoms in the field showed that more stress was found in Belandean than in Danda Jaya location, either in the 4th or 8th week of observation, especially for sensitive varieties such as IR 64. Higher toxicity in Belandean resulted in lower yield compared to that in Danda Jaya. Iron toxicity symptom scores of Inpara-1 and Inpara-4 varieties were lower and these varieties produced higher yield than the others in both locations. For both locations, IR 64 as a sensitive control variety showed higher iron toxicity symptom score and produced lower yield than the others (Table 5). Observations were done in the 4th or 8th week after transplanting because these refered to the results in the greenhouse experiments. Iron toxicity symptom scores at 8 weeks showed that green house tolerant varieties had lower level of symptom scores (3.0 – 4.3) than the control variety IR 64 (7.0) in Belandean and in Danda Jaya locations. Tolerant varieties also had lower level of symptom scores (2.0 – 3.7) than sensitive control variety IR 64 (5.7). Yield of Inpara-1, Inpara-2 and Inpara-4 performed were 3.85, 3.32 and 4.01 ton ha^{-1}, respectively in Belandean which were higher than that of IR 64 (2.1 ton ha^{-1}). In Danda Jaya location, Inpara-1, Inpara-2 and Inpara-4 performed yield of 4.51, 4.12 and 5.46 ton ha^{-1} respectively which were higher than yield of IR 64 as a sensitive control variety (2.33 ton ha^{-1}). The yield of TOX4136 line had no significant difference with the yield of IR 64 in both locations. The facts above showed that the results in the green house were confirmed by the results in the field.

Concentrations of Fe in the soil at 300-400 ppm cause iron toxicity in rice plant (Breemen and Moormann 1978). The critical border of Fe concentration (extraction by 1N NH_4OAC, pH 4.8) in the soil of tidal swamp land that can cause iron toxicity is 260 ppm Fe (Sulaiman *et al.* 1997). Initial soil analysis in the two locations were 425 ppm Fe with pH 4.1 (Danda Jaya) and 631 ppm with pH 3.8 (Belandean) were higher than the concentration that stated by Breemen and Moormann (1978) and

Sulaiman *et al.* (1997). Those conditions potentially cause toxicity for sensitive variety such as IR 64. Belandean, with lower pH and higher soil Fe concentration, has the potential to cause more severe iron toxicityon rice than Danda Jaya location.

Table 5. Fe toxicity symptom scores at 4 and 8 weeks after transplanting and rice yield in tidal swamp land in Blandean and Danda Jaya in the first planting season, 2011.

Rice Genotype	**Belandean**			**Danda Jaya**		
	Iron toxixity score (4 weeks)	**Iron toxixity score (8 weeks)**	**Rice Yield (t/ha)**	**Iron toxixity score (4 weeks)**	**Iron toxixity score (8 weeks)**	**Rice Yield (t/ha)**
TOX4136	3.0 c	4.3 b	2.46 b	3.0 b	3.7 b	3.33 ab
Inpara-1	3.0 c	3.0 b	3.85 a	2.0 b	2.0 b	4.51 ab
Inpara-2	4.3 b	4.3 b	3.32 a	3.3 b	3.7 b	4.12 ab
Inpara-4	3.0 c	3.0 b	4.01 a	2.7 b	2.0 b	5.46 a
IR 64	6.3 a	7.0 a	2.10 b	5.7 a	5.7 a	2.33 b
Average	3.92	4.32	3.15	3.34	3.42	3.95
Least significant difference of t-test	1.19	1.46	0.82	1.87	1.68	2.20

Values within columns having the same lowercase letters are not significantly different ($P<0.05$) using LSD test.

Trials conducted by other researchers in the tidal swamp land showed that the yield of rice was affected by the level of iron toxicity. Iron toxicity symptoms could appear at different growth stages and could influence vegetative as well as the reproductive growth. Iron poisoning at the vegetative stage can decrease plant height and dry matter production, and can affect tillering formation and number (Fageria, 1988). Ferrous ions that are absorbed by the plant causes leaf discoloration, decreases tiller number and significantly decreases yield. Decreasing rice yield by iron toxicity is also caused by disturbing in the metabolic processes in the plant that can change the physiology or agronomic characters of the rice plant. The scoring system for iron toxicity symptoms was demonstrated to correlate with rice yield, where increasing 1 point will reduce rice yield by 0.426 ton ha^{-1} (Audebert 2006). The condition without iron toxicity (score=1) gave a yield of 4,14 ton ha^{-1}, and increasing the iron toxicity score to 3, 5 and 7 decreased rice yield to 2.86, 2.01 and 1.16 ton ha^{-1}. Suhartini and Makarim (2009) also showed that the iron toxicity symptom score affected rice yield. Iron toxicity score < 3.5 supported rice yield > 4.3 ton ha^{-1} or was not so affected by iron toxicity. In contrast, by increasing iron toxity score > 4.5, the rice yield obtained was reduced to ≤ 2.01 ton ha^{-1}.

Iron toxicity symptom scores in green house and field

The longer the period of stress, the higher the iron toxicity levels in the green house as well as in the field, especially for sensitive or rather tolerant varieties in Belandean (Fig. 3). Iron toxicity scores of 5 genotypes at 4 weeks after transplanting (ATP) in the green house showed higher iron toxicity scores than in the two locations in the field at 4 or 8 weeks ATP. Inpara-1 and Inpara-4 showed lower toxicity symptom scores than the other genotypes in both locations in the field. Iron toxicity scores at 2 weeks ATP of TOX4136 genotype and Inpara-2 were lower than that in the field, while Inpara-1 and Inpara-4 genotypes in the green house had higher or similar iron toxicity scores than that in the field. IR 64 genotype showed iron toxicity symptom that was similar in the green house and in the field at 4 and 8 weeks ATP, and consistenly higher than the other genotypes.

Iron toxicity symptom scores of 4 genotypes that was chosen from green house showed lower scores (2.0-4.3) in the field experiment than that of the green house score (5.0) especially for Inpara-1 and Inpara-4 genotypes. These results indicate that selection of tolerant rice genotypes at Fe concentration of 325 ppm (Yoshidas'nutrient solution) in the green house for 4 weeks can be used as the criteria for selection, because it has verified that the symptom scores in the field were lower than those in the green house. Sensitive variety IR 64 constantly showed similar iron toxicity scores in both conditions, the green house (score 7.7) and in the field (score 7.0). The chosen genotypes from green house Inpara-1, Inpara-2 and Inpara-4 showed lower symptom scores and performed higher yield than that IR 64 (Table 4). Experimental results showed differences in iron toxicity level of the tested rice genotypes under green house conditions compared to field conditions. Inpara-1 and Inpara-4 in the green house was classified as rather tolerant varieties (Fe toxicity score = 5.0), and these changed to the tolerant genotypes class (score = 2.0-2.7) in the two field locations. TOX4136 line and Inpara-2 variety were classified as rather tolerant genotypes in the green house (5.0), and in Blandean (4.3), yet changed to the tolerant genotypes (3.7) when they were planted in Danda Jaya.

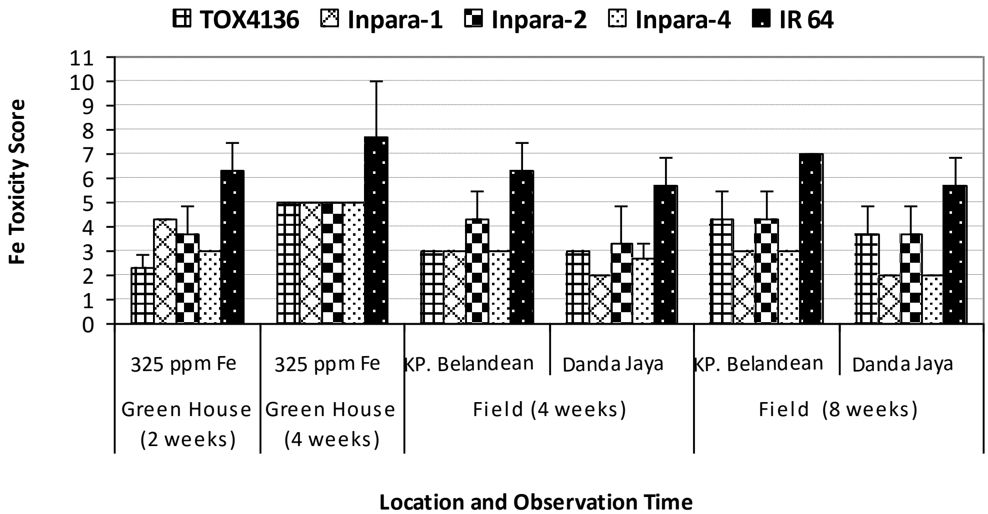

Fig. 3. Iron toxicity symptom of five rice genotypes in the green house (325 ppm Fe) and in the tidal swamp land (Blandean and Danda Jaya) in the first planting season, 2011.

The facts above indicate that Fe concentration of 325 ppm at pH 4.0 in Yoshida nutrient solution provide clearer Fe toxicity symptoms compared to soil in Blandean location (631 ppm Fe, pH 3.8) and soil of Danda Jaya location (425 ppm Fe, pH 4.1). These results indicate that Fe in solution in lower quantities can produce Fe toxicity faster than Fe in the soil. There is a variation of iron toxity in the soil according to the pH in the soil solution (Sahrawat, 2004). At pH below 5.0, the plant is susceptible to iron toxicity (Dobermann, and Fairhurst 2000). The critical limit of iron concentrations that causes iron toxicity are 100 ppm at pH 3.7 and 300 ppm or more at pH 5.0 (Sahrawat *et al.* 1996). The concentration of 250 ppm Fe or more in the Yoshidas' solution could be used to differentiate rice tolerance, because it showed clearly Fe toxicity symptom (*bronzing*), growth reduction and plant tolerance during the 4 weeks period of stress. Iron concentration at 250 ppm could be used to compare tolerance of various varieties in solution culture (Dorlodot *et al*. 2005). Iron concentration at 2000 ppm in Yoshidas' solution culture with 3 days period of stress could be used to differentiate sensitive and tolerant cultivars in nutrient + seaweed solution (Kpongor 2003). Clear iron toxicity symptoms were demonstrated after 8 days of Fe stress at a concentration of Fe > 300-500 ppm Fe (Bode *et al*. 1995).

CONCLUSIONS

A screening method in the green house for rice tolerant genotype that related with the level of Fe toxicity symptom and rice productivity in the field is needed in order to select tolerant genotypes in shorter time, cheaper cost, and better accuracy than a direct selection in the field. Based on the score of iron toxicity symptoms at 4 weeks after treatment, 17 genotypes were classified as tolerant using 143 ppm Fe, and 11 genotypes performed moderately tolerant using 325 ppm Fe. Inpara-1 and Inpara-4 indicated as the tolerant genotypes to Fe toxicity, and performed higher yields in the two field research locations. Rice genotypes that were selected in the green house showed lower Fe toxicity symptoms in the tidal land than those in the green house. Fe concentarion at 325 ppm under Yoshida' nutrient solution at pH 4.0 in the four weeks period of stress can be used for screening of rice tolerant genotypes to Fe toxicity.

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INFLUENCE OF RICE STRAW MULCH ON SALINE SOIL : FORAGE PRODUCTION, FEED QUALITY AND FEED INTAKE BY SHEEP

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ABSTRACT

The utilization of saline soils requires appropriate management including planting of tolerant plants such as *Panicum maximum* and *Sesbania grandiflora.* The research was conducted to evaluate the effect of rice straw mulch in saline soil on forage production, feed quality and feed intake by sheep. This study was conducted during the dry season (April – September 2013) in saline soil in Kaliori sub-district area, Rembang Regency, Central Java Province, Indonesia. The experimental treatments were *P. maximum* monoculture without mulch (M1); *P. maximum* monoculture + 3 ton/ha mulch (M2); *P. maximum* monoculture + 6 ton/ha mulch (M3); *S. grandiflora* monoculture without mulch (M4); *S. grandiflora* monoculture + 3 ton/ha mulch (M5); *S. grandiflora* monoculture + 6 ton/ha mulch (M6); mixed cropping of *P. maximum* and *S. grandiflora* without mulch (M7); mixed cropping of *P. maximum* and *S. grandiflora* +3 ton/ha mulch (M8); mixed cropping of *P. maximum* and *S. grandiflora* +6 ton/ha mulch (M9). Rice straw mulch application in saline soil increased dry matter production and crude protein content of *P. maximum* and *S. grandiflora.* Application of 3 - 6 ton/ha mulch in saline soil sufficiently increased forage production and feed quality of *P. maximum* and *S. grandiflora.* Dry matter (DM) intake of *P. maximum* and *S. grandiflora* in this study was at the range of DM requirement of fattened sheep.

Key words : Dry matter intake, mixed cropping, *Panicum maximum, Sesbania grandiflora*

INTRODUCTION

Saline soil is characterized as the presence of excess salt on the soil surface and in the root zone (Abrol et al.1988). The effect of saline stress includes both ionic (chemical) and osmotic stresses (Xiong et al. 2002). Ionic stress occurs when excessive amount of salt enters the plant reaching toxic levels in the older transpiring leaves causing premature senescence. The reduced ability to take up water is an osmotic stress to plants in saline conditions (Munns 2002). The effect of ionic and osmotic stress will reduce plant growth.

Plants have varying tolerance to soil salinity conditions. Kusmiyati and co-workers (2012) tested five forage grasses (*Panicum maximum, Setaria sphacelata, Euchlaena mexicana, Brachiaria brizantha* and *Cynodon plectostachyus*) in saline soil with electrical conductivity (EC) of 11 dS/m. Among the five forage grasses tested, *Panicum maximum* (guinea grass) was the most tolerant plant based on mineral concentration. Qadir et al. (2008) reported that *Sesbania* has shown promise for biomass production on moderately saline sodic soil among the forage species. Salt tolerant plants could be grown in different cropping systems as pure stand/monoculture or mixed cropping.

Panicum maximum is a perennial bunch grass that is reasonably palatable for cattle (Fig. 1). This grass is well suited for cut and carry, a practice in which grass is cut and brought to ruminants in stalls. It has been used succesfully for making silage and hay. The leaves of this grass contain good levels of crude protein (Aganga and Tshwenyane 2004). *Panicum maximum* is a shade tolerant grass that makes it suited to coexisting with trees in agroforestry (Paez et al. 1997). *Sesbania grandiflora* is a small legume tree in the genus *Sesbania* (Fig. 2). The leaves of this legume is valued as a fodder for ruminant particularly during dry season throughout Indonesia (Van Eys et al. 1983b)

Fig. 1. *Panicum maximum*

Fig. 2. *Sesbania grandiflora*

Utilization of saline soils requires appropriate management. Water management that reduce evaporation from soil surface in saline soil will help to control root zone salinity. Mulch is one way to reduce evaporation. Salinity was found to be higher in the treatment without mulch than with different mulch materials (Rahaman et al. 2004). The beneficial effect of mulch on crop growth include reducing evaporation (Taban and Naeini 2006), conserving soil moisture content (Athy et al. 2006; Duppong et al. 2004), reducing soil temperature (Duppong et al. 2004), and increasing plant nitrogen and potassium content (Wang et al. 2008).

Little information is available on the effect of mulching in saline soil on forage production, feed quality and feed intake by sheep. The present study therefore sought to evaluate the effects of rice straw mulch in saline soil on *Panicum maximum* and *Sesbania grandiflora* forage production, feed quality and feed intake by sheep.

MATERIALS AND METHODS

Study area

This study was conducted during the dry season (April–September 2013) in saline soil in the Kaliori sub-district area, Rembang Regency, Central Java Province, Indonesia. Rembang regency is located on the northeast coast of Central Java Province where annual rainfall is 1140 mm year^{-1}. The soil type is alluvial with silt loam texture with a soil pH of7.89 (alkaline) and electrical conductivity (EC) of 8.7 dS/m. Organic matter content, total nitrogen, available phosphorus and potassium levels were 0.26%, 0.01%, 44.47 mg/kg and 1.21 Cmol/kg, respectively. Exchangeable potassium and sodium content were 1.21 Cmol/kg and 13.31 Cmol/kg, respectively, while cation exchange capacity was 22.99 Cmol/kg.

Stand establishment

The experiment was laid out in a randomized complete block design (RCBD) with three blocks. The experimental treatments were *P. maximum* monoculture without mulch (M1); *P. maximum* monoculture + 3 ton/ha mulch (M2); *P. maximum* monoculture + 6 ton/ha mulch (M3); *S. grandiflora* monoculture without mulch (M4); *S. grandiflora* monoculture + 3 ton/ha mulch (M5); *S. grandiflora* monoculture + 6 ton/ha mulch (M6); mixed cropping of *P. maximum* and *S. grandiflora* without mulch (M7); mixed cropping of *P. maximum* and *S. grandiflora* + 3 ton/ha mulch (M8); mixed cropping of *P. maximum* and *S. grandiflora* +6 ton/ha mulch (M9).

Soil tillage was done before planting. Each experimental plot was 4 m long and 4.5 m wide. *P. maximum* was planted at 100 cm x 75 cm in monoculture and in mixed cropping. *S. grandiflora* was planted at 100 cm x 75 cm in monoculture, while in mixed cropping, *S. grandiflora* was planted between *P. maximum* rows. Rice straw as mulch was applied on the soil surface of each plot according to the treatment. The organic fertilizer (cow dung) was added to the soil at 115 tons/ha. The recommended levels of nitrogen (60 kg N/ha/cutting), phosporus (150 kg P_2O_5/ha) and potassium (100 kg K_2O/ha) were applied using urea, SP-36 and potassium chloride (KCl), respectively.

P. maximum and *S. grandiflora* were planted at the same time. Two vegetative planting material (tillers) of *P. maximum* were planted per hole. Three seeds of *S. grandiflora* were buried at approximately 0.5 depth. Two weeks after planting, only one vigorous plant of *S. grandiflora* was allowed to grow. *P. maximum* was cut to a suitable height of 15 cm at four weeks after planting. During the first cut, the growth and production of grass were not recorded. The second cut of grass was done six weeks after the first cut and the third cut was done six weeks after the second cut. *S. grandiflora* was cut at 16 weeks after planting or at the same time with the third cut of grass.

Fresh forage yield was determined from plants within an area of 3 m^2 from the center of each plot, cut at 10 and 30 cm above soil, for *P. maximum* and *S. grandiflora*, respectively. One hundred grams of fresh forage yield was dried at 105ºC until the weight of sample was constant to measure dry matter percentage.

Data collection

Parameters measured were dry matter (DM) production, crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) and feed intake by sheep. Dry matter production was calculated by multiplying dry matter percentage and fresh yield. Dry matter production of *P. maximum* was the sum of DM production at second cut and third cut. Crude protein, ADF and NDF of *P. maximum* were measured at third cut. Crude protein was determined using the procedure of the Association of Official Analytical Chemists (AOAC 1984). Acid detergent fibre and neutral detergent fibre were determined according to the method developed by Van Soest and co-workers (1991).

Land equivalent ratio (LER) was used to evaluate mixed cropping efficiencies with respect to monoculture/sole crops. It was expressed as LER = $M_a/S_a + M_b/S_b$, where M and S refer to mixed cropping and monoculture crop yield, respectively and the subscripts *a* and *b* indicate the component crops in the mixture.

P. maximum and *S. grandiflora* from saline soil were tested on four thin tailed sheep, weighing an average 21.77 $\pm$ 0.93 kg, 4.5 – 5 months old, and kept in individual pens. Water was provided *ad libitum.* Freshly chopped feed was given twice daily at 0700 hours and 1700 hour for seven days. Each sheep was fed with a fresh mixture of the two forages, i.e. *P. maximum* and *S. grandiflora* (3 kg for each). During the measurement period, refusals were collected once daily and weighed. Dry matter intake was calculated as the difference between the offered and the refused quantity on a dry matter basis.

Statistical analysis

Analyzed data of dry matter (DM) production, crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) were done using analysis of variance, followed by Tukey's range analysis to compare the difference between treatments according to Steel and Torrie (1991).

RESULTS AND DISCUSSION

Forage production

Rice straw mulch on saline soil affected significantly dry matter production of *P. maximum* and *S. grandiflora* (Table 1). Dry matter production was significantly lower without mulch. Dry matter production of *P. maximum* or *S. grandiflora* at 3 tons and 6 tons per ha mulch were not significantly different. Maximum dry matter production of *P. maximum* or *S. grandiflora* were observed in monoculture with 6 ton/ha mulch. Minimum dry matter production of *P. maximum* or *S. grandiflora* were observed in mixed cropping without mulch. The increased dry matter production is due to the higher soil moisture content in the mulch treatment. Soil moisture content in treatments without and with mulch were 2.6 % and 7.2 %, respectively.

Higher soil moisture content, nutrient content and cation exchange capacity of the soil in the mulch treatment can boost growth and crop production. Pervaiz (2009) determined that mulching increased soil water content. The use of mulches improves the availability of potasium (K) in the soil (Adeniyan et al. 2008) while accumulation of nitrate in the soil was higher in mulch treatments (Coppens et al. 2006). The use of mulch also increases soil organic matter and cation exchange capacity (Athy et al. 2006).

Table 1. Dry matter production of *P. maximum* and *S. grandiflora.*

Treatments	*P. maximum*	*S. grandiflora*
	..................(g/m^2)..................	
P. maximum monoculture without mulch	207.5± 56.4[bc]	-
P. maximum monoculture + 3 ton/ha mulch	386.3± 63.4[a]	-
P. maximum monoculture + 6 ton/ha mulch	429.9±71.6[a]	-
S. grandiflora monoculture without mulch	-	107.8±39.1 [cd]
S. grandiflora monoculture + 3 ton/ha mulch	-	241.5±32.8 [ab]
S. grandiflora monoculture + 6 ton/ha mulch	-	263.5±42.2 [a]
Mixed cropping without mulch	194.7±72.3[c]	49.5±16.4 [d]
Mixed cropping + 3 ton/ha mulch	342.1±76.2[ab]	160.2±11.0 [bc]
Mixed cropping + 6 ton/ha mulch	394.9±66.3[a]	197.1±38.7 [abc]

Values within columns having the same superscript are not significantly different (P<0.05) using Tukey's range test.

Land equivalent ratio (LER) was higher than one in all of the mixtures indicating a yield advantage over monocrop (Table 2). The highest LER (1.7) for dry matter production was obtained in mixed cropping of *P. maximum* and *S. grandiflora* at 6 ton/ha mulch. Land equivalent ratio without mulch and 3 ton/ha mulch were 1.4 and 1.6, respectively. Land equivalent ratio ranged from 1.4 to 1.7 thus, 40% to 70% more land should be used in monoculture in order to obtain the same yield in mixed cropping. The mixed cropping *P. maximum* and *S. grandiflora* out-yielded the monoculture (LER>1). Mixed cropping uses environmental resources better than monoculture and competition between mixed cropping components is not high. LER greater than one was due primarily to the increase in water and nutrient availability for plants. Soil moisture content at *P. maximum* monoculture and *S. grandiflora* monoculture were 2.4 % and 3.8 %, respectively, while soil moisture content in mixed cropped *P. maximum* and *S. grandiflora* was 8.2 %.

Table 2. Land equivalent ratio (LER) values of different mulch treatments

Treatments		DM production of mixed cropping	DM production of monoculture	LER
		.... (g/m^2)	....	
Without mulch	*P. maximum*	194.7±72.3	207.5±56.4	1.4±0.1
	S. grandiflora	49.5±16.4	107.8±39.1	
3 ton/ha mulch	*P. maximum*	342.1±76.2	386.3±63.4	1.6±0.5
	S. grandiflora	160.2±11.0	241.5±32.8	
6 ton/ha mulch	*P. maximum*	394.9±66.3	429.9±71.6	1.7±0.3
	S. grandiflora	197.1±38.7	263.5±42.2	

Forage Quality

Crude protein, ADF and NDF content of *P. maximum* that was grown on saline soil were 7.8 – 12.1%, 30.1 – 35.0%, and 60.2 – 64.1%, respectively (Table 3). Forage quality of *P. maximum* obtained in this research was much higher than those reported by Babayemi and Barnikole (2006). It was reported that crude protein and NDF content of *P. maximum* in Nigeria, which has a tropical climate, were 7.35% and 69%, respectively. *P. maximum* in this research was cut before it was blooming and was done six weeks after the second cut (sixteen weeks after planting). While Babayemi and Barnikole (2006) analysed *P. maximum* samples that were collected from 1 and 2 years established plots.

Table 3. Crude Protein (CP), Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) (%) content of *P. maximum* and *S. grandiflora.*

Treatments	***P. maximum***			***S. grandiflora***		
	CP	**ADF**	**NDF**	**CP**	**ADF**	**NDF**
P. maximum monoculture without mulch	7.8 ± 0.4^{b}	35.0 ± 0.7^{a}	62.0 ± 1.0^{a}	-	-	-
P. maximum monoculture + 3 ton/ha mulch	10.3 ± 0.8^{ab}	30.3 ± 0.8^{b}	63.6 ± 1.4^{a}	-	-	-
P. maximum monoculture + 6 ton/ha mulch	12.1 ± 1.9^{a}	30.1 ± 1.6^{b}	64.1 ± 1.5^{a}	-	-	-
S.grandiflora monoculture without mulch	-	-	-	20.8 ± 0.7^{b}	20.0 ± 1.6^{a}	30.3 ± 1.7^{a}
S. grandiflora monoculture + 3 ton/ha mulch	-	-	-	24.6 ± 0.4^{a}	20.3 ± 0.9^{a}	30.2 ± 1.5^{a}
S. grandiflora monoculture + 6 ton/ha mulch	-	-	-	23.4 ± 1.3^{ab}	20.6 ± 0.9^{a}	29.7 ± 0.3^{a}
Mixed cropping without mulch	8.0 ± 0.5^{b}	34.7 ± 0.9^{a}	61.8 ± 2.5^{a}	21.4 ± 0.3^{ab}	20.4 ± 1.4^{a}	30.5 ± 0.7^{a}
Mixed cropping + 3 ton/ha mulch	9.8 ± 0.6^{ab}	32.1 ± 1.9^{ab}	60.2 ± 2.4^{a}	22.1 ± 0.9^{ab}	20.5 ± 1.0^{a}	30.5 ± 0.6^{a}
Mixed cropping + 6 ton/ha mulch	9.9 ± 0.8^{ab}	32.2 ± 1.9^{ab}	60.4 ± 0.7^{a}	22.8 ± 2.2^{ab}	20.2 ± 0.2^{a}	30.1 ± 1.5^{a}

Values within columns having the same superscript are not significantly different ($P<0.05$) using Tukey's range test.

Crude protein content values between 20.8 – 24.6% of *S. grandiflora* planted in saline soil, as found in this research, were lower than the value of 33.78% reported by Nag and Matai (2000) for fresh leaf of *S. grandiflora* from Calcutta. On the other hand, ADF and NDF content of *S. grandiflora* obtained by this research in saline soil were 20.0% - 20.6% and 29.7% - 30.5%, respectively. These values were higher than 19.1% ADF and 23.2% NDF of *S. grandiflora* in Kenya, as reported by Wandera and co-workers (1991). The treatments affected significantly crude protein of *P. maximum* and *S. grandiflora*. Crude protein content of *P. maximum* monoculture without mulch treatment was significantly lower than with mulch treatments. Crude protein content of *P. maximum* or *S. grandiflora* were not significantly different for 3 ton/ha mulch and 6 ton/ha mulch (Table 3).

The effect of saline stress includes both ionic (chemical) and osmotic stresses (Xiong *et al.*, 2002). Ionic stress occurs when excessive amount of salt enters the plant to toxic levels in the older transpiring leaves causing premature senescence. The reduced ability to take up water is osmotic stress of plants in saline conditions (Munns 2002). Moisture content in saline soil without mulch application was lower, so plants grow under water stress. Costa *et al.* (2008) reported the plants subjected to water stress suffered, with corresponding decrease in the amounts of total protein caused by the decrease in their synthesis, and a fall in nitrate reduction activity caused by the low nitrate flux.

The other important characteristics for forage quality are the content of ADF and NDF. In general, digestible energy decreases as ADF increases. ADF content of *P. maximum* was significantly higher at no mulch treatment both at monoculture and mixed cropping, while ADF content of *S. grandiflora* was not affected by treatments (Table 3). Water stress of plants without mulch will encourage the generative phase of plant. Cell wall development increased at the time of flowering so, ADF content of grass will be higher at no mulch treatment.

Treatments did not affect NDF content of *P. maximum* and *S. grandiflora.* This result is in accordance with Suyama *et al.* (2007) who reported NDF content of wheatgrass, Paspalum, wildrye, bermuda grass and alfalfa were not significantly different among non- saline, moderately saline and highly saline irrigation water. Generally, high crude protein and low NDF are indicators of high forage quality. NDF is an esimate of the structural cell wall components of plants excepts pectins and consists of the slowest digesting fraction such as cellulose, hemicellulose, lignin and cutin. NDF content of forage was negatively correlated with dry matter intake of ruminants.

Feed Intake

Dry matter (DM) daily intake was 645.1 g/day and 230.6 g/day for *P. maximum* and *S. grandiflora*, respectively. Hence, total dry matter intake was 875.7 g/day. The intake of dry matter as percent of body weight was 4% (Table 4). Dry matter intake of *P. maximum* and *S. grandiflora* of fattened sheep in this study was within the range of DM requirement for fattened sheep as suggested by Ranjhan (1981), which is about 3–5%.

Table 4. Daily feed intake of sheep fed with *P. maximum* and *S. grandiflora*

Parameters	*P. maximum*	*S. grandiflora*	Total
	.... (g/kg $BW^{0.75}$)		
Dry matter intake	64.01±1.2	22.90±0.6	86.91±1.3
Crude protein intake	6.18±0.1	5.16±0.1	11.34±0.2
Acid Detergent Fibre intake	20.75±0.4	4.65±0.1	25.40±0.4
Neutral Detergent Fibre intake	39.71±0.8	6.92±0.2	46.63±0.7

Dry matter intake of *P. maximum* and *S. grandiflora* were 64.01 g/kg BW (body weight)$^{0.75}$ and 22.90 g/kg BW$^{0.75}$, respectively. Hence, total dry matter intake was 86.91 g/kg BW$^{0.75}$. Total dry matter intake of fattened sheep in this study was higher than that reported by Van Eys *et al*. (1983a). Total dry matter intake of sheep fed only *P. maximum* was 39.4 g/kg BW$^{0.75}$ (Van Eys *et al*. 1983a). The addition of *S. grandiflora* in this study increased dry matter intake. Dry matter intake in sheep was earlier demonstrated to increase with increasing amount of legumes (Rangkuti *et al*. 1983).

Crude protein intake was 11.34 g/kg BW$^{0.75}$. Crude protein intake for basic living of growing sheep was demonstrated to be 4.74 g/kg BW$^{0.75}$ (Kearl 1982). In this study, there is excess crude protein intake of 6.60 g/kg BW$^{0.75}$ which can be used for production purposes in the form of daily live weight gain. Factors affecting protein intake were feeding level and the protein content in the feed. High crude protein intake was expected to increase the amount of protein in the body retention of livestock to meet basic living and production requirements (Ranjhan 1981).

Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) intake by sheep in this study were 25.40 g/kg BW$^{0.75}$ and 46.63 g/kg BW$^{0.75}$, respectively. The NDF content affected the ability of ruminants to consume feed (Van Soest 1994). NDF content greater than 50% would reduce the level of dry matter intake. NDF content of *P. maximum* in this study was high (62.0%), while the NDF content of *S. grandiflora* was 30.2%. The low NDF content of *S. grandiflora* will compensate the high NDF of *P. maximum.*

CONCLUSION

Rice straw mulch increased dry matter production and crude protein of *P. maximum* and *S. grandiflora* in saline soil. The application of 3-6 ton/ha mulch sufficiently increased forage production and feed quality of *P. maximum* and *S. grandiflora* planted in saline soil. Dry matter intake of *P. maximum* and *S. grandiflora* in this study was at the range of dry matter requirement of fattened sheep.

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MORPHO-PHYSIOLOGICAL RESPONSE OF RICE GENOTYPES GROWN UNDER SALINE CONDITIONS

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ABSTRACT

Salt accumulation in irrigated soil is one of the main factors limiting rice productivity. A greenhouse experiment was conducted at Cimanggu Experiment Station, Bogor, Indonesia from May to September 2014 using a completely randomized design in a factorial arrangement with three replications. Four salt tolerant and two salt sensitive genotypes of rice were used in this experiment. The treatments were five concentrations of NaCl (0, 20, 40, 60 and 80 mM) applied on 21 day-old seedlings and maintained until harvest time. The study sought to evaluate the response of several rice genotypes to various NaCl concentrations through observation of morphological and physiological characters. The study showed that the increase of NaCl concentrations in soil significantly reduced plant height, number of panicles plant^{-1}, panicle length, leaf length, 1000 grain weight, and grain yield. On physiological characters, salinity increased [Na^+], decreased [K^+] and [Ca^{2+}] concentrations, and reduced K^+/Na^+ and Ca^{2+}/Na^+ ratios in the leaf tissue. The addition of 40 mM NaCl can distinguish tolerant and sensitive genotypes. The grain yield of sensitive genotypes decreased 90-100% at 40 mM NaCl, while the tolerant genotypes showed <70% in grain yield reduction.

Key words: morpho-physiological characters, NaCl, salt tolerance, saline soil

INTRODUCTION

Salinity is one of the main obstacles to increase rice (*Oryza sativa* L.) production in the world (Hosseini *et al.*, 2012; Abbas *et al.*, 2013; Ali *et al.*, 2014). Salinity affects one-third of all irrigated land in the world, impairs normal growth and limits the realization of yield potential of modern cultivars. Salt accumulation in irrigated land affects physiology, morphology and biochemistry in rice plants (Sankar *et al.*, 2011). Rice yield loss on land conditions with low salinity (2-6 dS m^{-1}) reached 40%, moderate salinity (6-10 dS m^{-1}) reached 75%, and high salinity levels (> 10 dS m^{-1}) reached 100% (Zeng and Shannon, 2000). Sankar *et al.* (2011) reported that the sensitivity of the rice plant to salinity ranges from 0 dS m^{-1} to 8 dS m^{-1}. Rice is classified as sensitive to salinity, but rice is one of the recommended crops to be grown in saline soil, because rice has the ability to grow in waterlogged soil (Sankar *et al.*, 2011; Aref and Rad, 2012). Availability of water in irrigated rice systems enables the salt molecules to dissolve and transport these as run-off and leaching such that salt levels can be reduced (Asch and Wopereis, 2001).

Rice plant response to salinity varies according to the growth stage. In the vast majority of rice cultivars, plants at the early seedling phase are most sensitive to salinity (Zeng and Shannon, 2000; Zeng *et al*., 2001; Haq *et al.,* 2009). According to Zeng *et al*. (2001), salinity stress during seedling phase can reduce plant dry weight by two-fold compared to when stress occurs in the ripening phase. In the irrigated rice planting in coastal areas, salinity may occur at any stage of plant growth. Therefore, it is important to determine the response to salinity in rice plants throughout the growth stage.

The screening and breeding of rice varieties for tolerance to salinity have been carried out for over three decades and various methodologies have been used to screen tolerant varieties (Flower 2004; Egdane *et al*. 2007; Rao *et a*l. 2008). This study sought to evaluate the response of several rice genotypes at various NaCl concentrations through observation of morphological and physiological characters in saline soil. The differences in response will be useful index when salinity screening of rice genotypes is carried out in saline soil under greenhouse conditions to select suitable genotypes or useful breeding materials.

MATERIALS AND METHODS

Six rice genotypes with different levels of tolerance to salinity were used in this study. These genotypes were selected based on screening using nutrient solution at seedling phase containing 120 mM NaCl. Four genotypes were tolerant, namely IR77674-3B-8-2-2-14-4-AJY2, IR81493-B-B-B-6-B-2-1-2, Dendang and Pokkali, while the other two were sensitive, namely Inpara 4 and IR 29. The greenhouse experiments were conducted at the Cimanggu Experimental Station, Bogor, Indonesia from May until September, 2014 using completely randomized design in factorial arrangement with three replications. The treatment in this study was application of four concentrations of NaCl (20, 40, 60 and 80 mM). These NaCl concentrations were equivalent to EC (electrical conductivity) of 4.8 dS m^{-1}, 6.2 dS m^{-1}, 8.8 dS m^{-1} and 12.3 dS m^{-1}, respectively. In this experiment, the rice plants did not survive at 1-2 weeks after 80 mM NaCl treatment, so that only four NaCl concentrations remained in this experiment.

Rice seeds were sown in a box filled with soil under non-saline conditions (without the addition of NaCl, equivalent to EC of 1.2 dS m^{-1}) until 21 days. The seedlings were then transplanted into pots containing soil and water with ratio of 7:3, one seedling for each pot. NaCl was previously added into the soil according to treatments. The water condition was maintained in the same level of volume throughout the experimental period. The plant growth was observed until harvest time. The variables observed were morphological and physiological characters, i.e. days to flower, plant height, panicle number $plant^{-1}$, flag leaf length, panicle length, 1000 grain weight, grain yield $plant^{-1}$, Na^+, K^+, and Ca^{2+} contents in the leaf tissue. The morphological and physiological characters were observed at the reproductive stage, i.e. at mature grain phase and dough grain phase, respectively. The rice leaves were oven-dried at 70 ^{0}C for three days. About 0.5 g of each dried powdered sample was digested with 5 mL of nitric acid at 300^{0}C, 0.5 mL of perchloric acid at 200^{0}C and 20 mL of 6 M hydrochloric acid. The ion concentrations were analyzed using atomic absorption spectroscopy (Perkin Elmer 1100 B).

Data Analysis

All data were analyzed using SAS 9.1 for the analysis of variance (ANOVA). Significance of differences of treatment means were analyzed by F-test at 95% probability level and Duncan's Multiple Range Test (DMRT) at 95% probability level.

RESULTS AND DISCUSSION

Effect of salinity on plant growth

Rice plant is relatively sensitive to soil salinity (Jamil *et al*., 2012). The accumulation of a lot of salt in the soil generates a blockage for normal growth and development of plants (Ali et al., 2014). Salinity screening in greenhouses is usually done during the seedling phase. Salinity tolerance of the rice plant from vegetative to reproductive phases is important to be known. Salinity screening under greenhouse conditions using soil media is still performed rarely because it is relatively difficult in implementation. In this study, through an analysis of selected morphological and physiological variables, the salt tolerance of six rice genotypes in saline soil has been determined. An understanding of plant response under varied level of salt stress is important to determine the critical NaCl concentration that could be used for screening the rice genotypes for salinity tolerance in saline soil, especially under green house conditions. None of the genotypes survived at 80 mM NaCl concentration, therefore the results are not presented. Inpara 4 and IR29 did not survive at more than 20 mM NaCl. The plants died at 1-4 weeks after transplanting. The variances of plant growth and yield variables were analyzed and the results are presented in Table 1. The overall effects of NaCl concentrations (S), genotypes (G) and NaCl*genotype (S*G) interaction were highly significant ($P<0.01$) for all variables observed.

Table 1. Mean square for growth and yield parameters at different genotypes and NaCl concentrations.

Source of Variation	df	Means Square						
		Days to flower	Plant Height	Panicle (plant^{-1})	Leaf length	Panicle length	A 1000 grain weight	Yield (plant^{-1})
Genotype (G)	5	1060.62**	2550.40**	5.30**	741.23**	40.23**	111.04**	39.66**
NaCl (S)	3	71.29**	902.87**	122.15**	350.04**	66.59**	61.03**	1340.12**
S * G	12	31.10**	224.97**	4.19**	54.87**	11.17**	12.56**	50.03
Error	42	7.68	51.65	0.96	1.89	1.32	0.38	1.95
CV (%)		3.32	7.53	11.40	4.26	5.01	2.85	10.65

** Significant at $p< 0.01$ in *F*-test.

Salinity prolonged the number of days to flower (Fig. 1), changed morphological trait such as reduction in plant height (Fig. 2), panicle number plant^{-1} (Fig. 3), leaf length (Fig. 4), panicle length (Fig. 5), and in reduction of yield component such as a 1000 grain weight (Fig.6), and grain weight plant^{-1} (Fig. 7). The decreased in osmotic potential was the first effect of NaCl addition to the growth medium. It disrupted the absorption of water and nutrient by plants. The accumulation of toxic ions such as Na^+ is harmful to the plant, so that the plant spends a lot of energy to compartmentalize them in specific plant tissues which leads to the reduction of plant growth (Nemati *et al*., 2008).

Salinity increased the number of days to flower of the genotypes, compared to control (Fig. 1). The exception of this variable was shown by Pokkali. The reduction of the number of days to flower was demonstrated by Pokkali at 40 mM NaCl concentration (63 days), while at 20 mM NaCl concentration the days to flower of Pokkali was equal to control (66 days). The highest increase of this variable was shown by IR81493 where it took 102 days to flower at 60 mM NaCl concentration, while control took only 87 days.

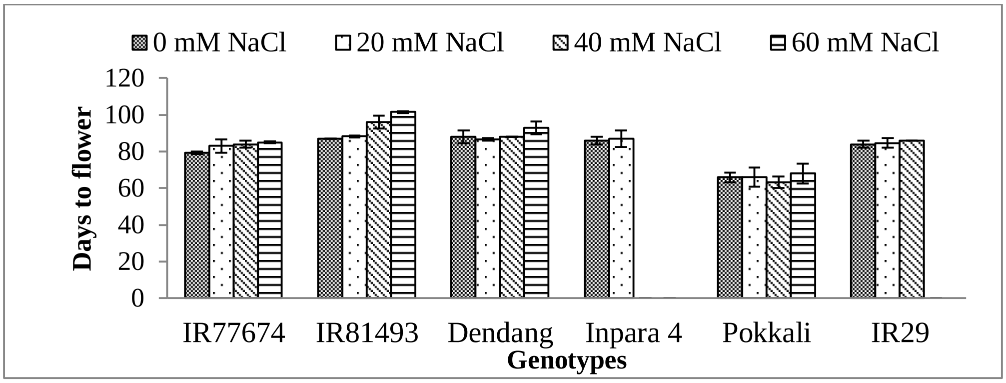

Fig. 1. Effect of varied levels of salinity on number of days to flower of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

Salinity caused significant reduction in plant height of the genotypes starting at 40 mM NaCl concentration (Fig. 2). This was observed in all of the genotypes except for Pokkali and IR81493. The plant height of Pokkali and IR81493 at 40 mM NaCl concentration were not significantly different from control. Plant height reduction was earlier demonstrated to be caused by the reduction in cell division and cell elongation (Yaghubi *et al.*, 2013). NaCl damages plants through ion toxicity and osmotic stress. The osmotic phase rapidly inhibits growth of young immature leaves by decreasing cell proliferation and delaying cell elongation, while the ionic phase gradually induces cellular senescence of mature leaves (Urano *et al.*, 2014).

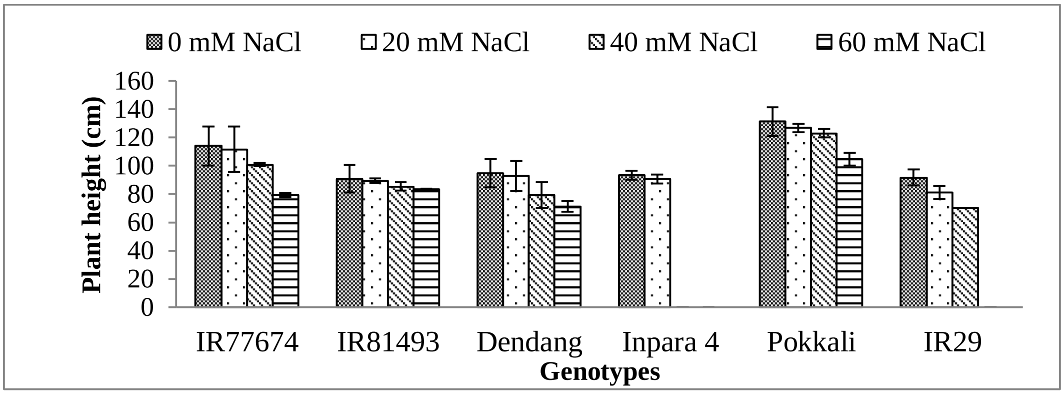

Fig. 2. Effect of varied levels of salinity on plant height of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

The number of panicles is related to tillering ability of the plant. In this experiment, salinity caused significant reduction in number of panicles compared to control. However, the tolerant genotypes, Pokkali and Dendang, showed lower reduction in number of panicles than other tested genotypes (Fig. 3). The inhibition of tillering ability was the main cause of yield loss under salt stress (Zeng *et al.* 2003; Haq *et al.* 2009). The reduction in tillering capacity might be due to the toxic effect of salt on plant growth and development.

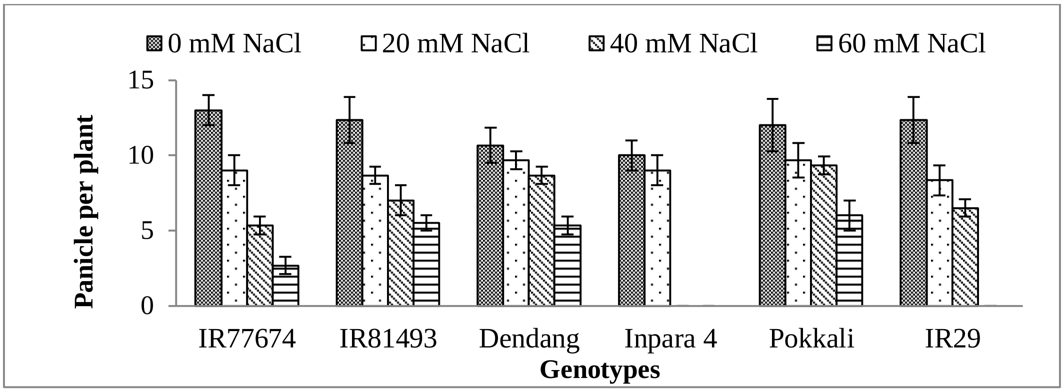

Fig. 3. Effect of varied levels of salinity on panicle number plant^{-1} of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

The leaf length of the genotypes was reduced by the increase of NaCl concentration, except for IR81493 at 40 mM NaCl concentration (Fig.4). The lowest reduction was observed in Dendang at 60 mM NaCl concentration (19.1 cm) compared to control (24.9 cm). In this experiment, the high significant reduction can be shown to start at 40 mM NaCl. Under saline conditions, the leaves tend to be smaller and thicker which observed adaptive mechanism of plants to reduce water loss by reducing their evaporation surface. Therefore, leaf elongation in rice declined after exposure to salinity (Yaghubi *et al.,* 2013).

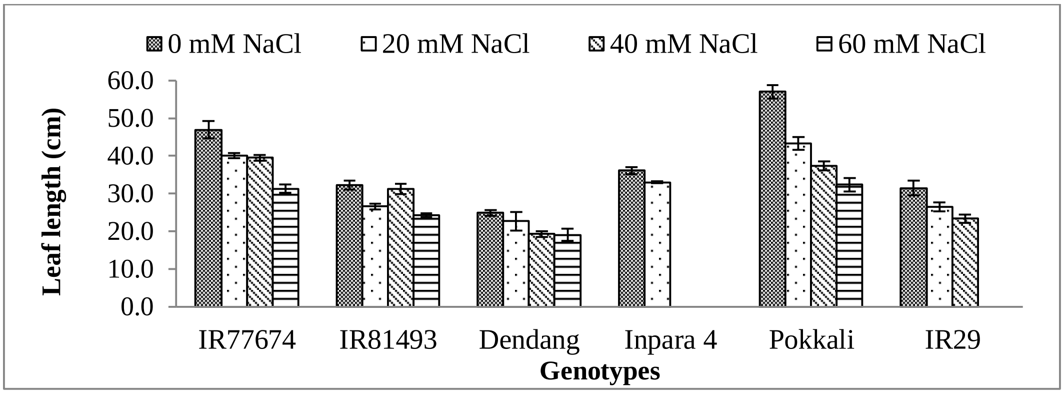

Fig. 4. Effect of varied level of salinity on leaf length of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

The panicle length is one of the important yield components under salinity because it determines the grain bearing panicles. In this experiment, salinity caused significant reduction in panicle length compared to control starting at 40 mM NaCl concentration (Fig. 5). The panicle length of the sensitive genotype (IR29) was reduced significantly from 22.5 cm to 18.1 cm, whereas the reduction of tolerant genotype (Pokkali) from 25.8 cm to 23.2 cm which was not significant. The panicle length of IR77674 and IR81493 was not reduced significantly as the NaCl concentration was increased from 0 mM to 40 mM, whereas the panicle length reduction of Dendang and Inpara 4 was significant. Zeng *et al*. (2001) observed that salinity influenced panicle initiation of rice by inducing reduction of primary and secondary rachis-branches and flower primordial, so that salinity also reduced the number of spikelets on the panicle.

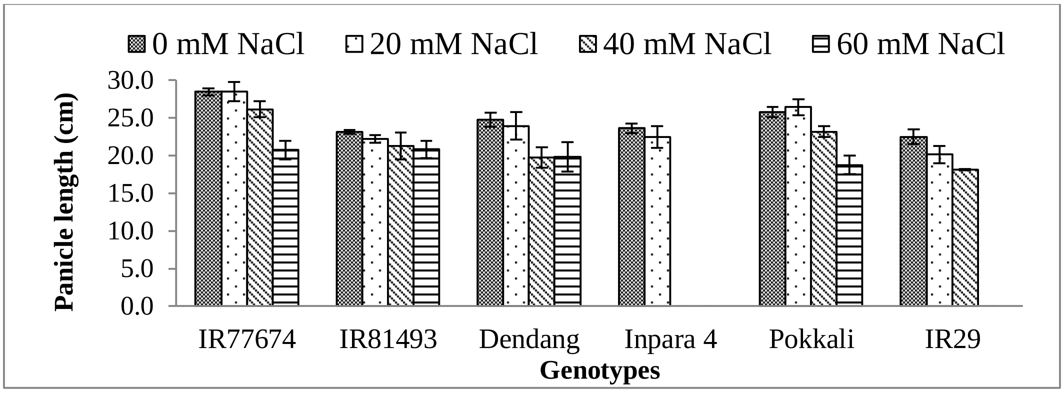

Fig. 5. Effect of varied levels of salinity on panicle length of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

Salt stress reduced a 1000 grain weight in all genotypes (Fig. 6). The significant reduction was observed starting at 40 mM NaCl concentration compared to control in IR81493, Dendang and IR29. The reduction of a 1000 grain weight was not significant for IR77674 and Pokkali. Rao *et al.* (2008) reported that a 1000 grain weight was reduced significantly under salinity condition, indicating that salinity reduced the size of the rice grains.

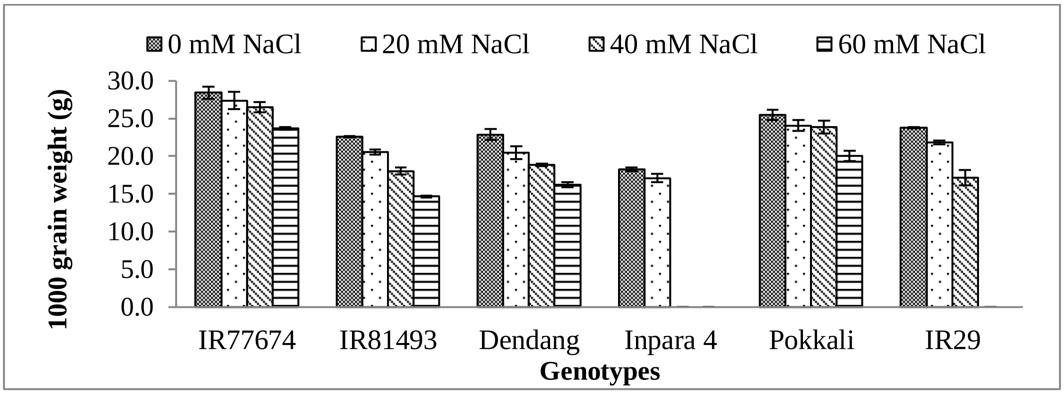

Fig. 6. Effect of varied levels of salinity on 1000 grain weight of six rice genotypes. Inpara 4 and IR29 did not survive at 40 mM and 60 NaCl, respectively.

Rice yield is highly dependent upon the number of fertile tiller plant^{-1} and filled grain panicle^{-1} (Zeng *et al.*, 2003). In this experiment, the reduction in grain yield, i.e. grain weight plant^{-1} was observed when plants were stressed at 20 mM NaCl, except in Dendang. All of genotypes showed significant reduction in grain yield at 40 mM NaCl concentration compared to that of control. The grain yield reduction at 20 mM to 40 mM NaCl concentrations was observed in all genotypes except in Pokkali (Table 2).

Table 2. Means of grain yield plant^{-1} of six rice genotypes of rice under varied salinity levels.

NaCl	Grain Yield (g plant^{-1})					
	IR77674	IR81493	Dendang	Inpara 4	Pokkali	IR29
0 mM	27.11±4.07 a	23.27±3.32 a	22.50±4.97 a	21.78±2.68 a	26.58±4.58 a	23.05±5.47 a
20 mM	18.71±3.12 b	14.71±4.04 b	19.67±2.51 a	11.02±2.37 b	16.46±0.54 b	8.19±2.97 b
40 mM	9.54±2.31 c	9.87±1.43 c	7.16±1.91 b	0.00±0.00 c	14.30±3.87 b	2.10±0.05 c
60 mM	1.34±0.52 d	2.10±0.23 d	2.62±1.33 c	0.00±0.00 c	6.72±1.77 c	0.00±0.00 d

Means within columns followed by the same letter are not different at P = 0.05 according to Duncan's Multiple Range Test (DMRT).

The reduction in percentage of yield of the genotypes by the increase in salt concentration is shown in Fig. 7. The reduction in grain yield at 20 mM NaCl concentration relative to control was less than 40% for all rice tolerant genotypes (IR77674, IR81493, Dendang and Pokkali), while in sensitive genotypes (IR29 and Inpara 4), the yield reduction were 64.4% and 49.4%, respectively. The reduction in grain yield of sensitive genotypes at 40 mM salt level was 100% for Inpara 4 and 90.1% for IR29, while in Pokkali as the most tolerant genotype compared to other tested genotypes, the reduction was 46.2 %. The grain yield of IR77674, IR81493 and Dendang was reduced by 64.8%, 57.6%, and 68.2%, respectively, at 40 mM salt level compared to control. The grain yield reduction was most pronounced when plants were stressed at 40 mM NaCl. The reduction in grain yield was 90-100% for sensitive genotypes (IR29 and Inpara 4) and less than 70% for tolerant genotypes.

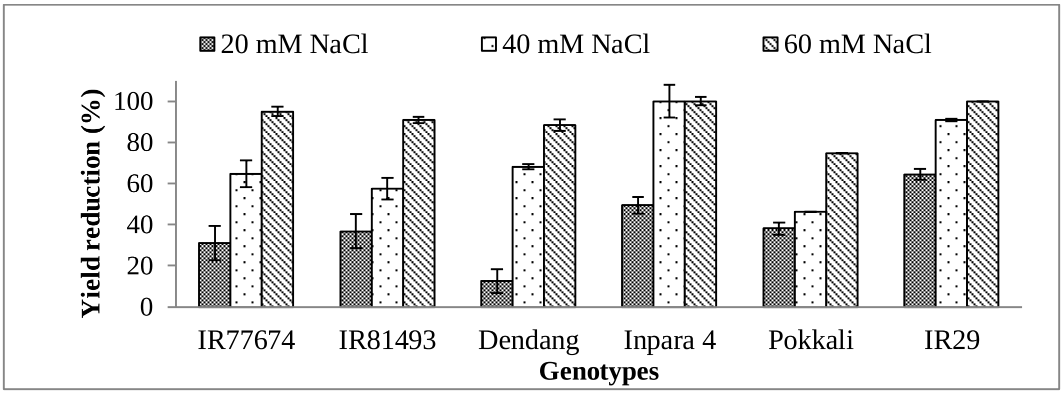

Fig. 7. Grain yield reduction (%) of rice genotypes under varied salinity levels relative to control (0 mM NaCl)

Effect of salinity on physiological characters

The influences of salinity on plant growth by ionic and osmotic ways sometimes differ between one and another and sometimes overlap (Hariadi *et al*., 2015). Analysis of variance revealed that NaCl concentration and genotype factors were highly significant ($P<0.01$), whereas NaCl*genotype interaction was significant ($P\leq0.05$) on K^+ concentration (Table 3). In response to applied salinity there was reduction in all genotypes on K^+ concentration in leaves compared to control. The maximum K^+ concentration was observed in IR77674 (2.87%) followed by Pokkali (2.85%) in the control treatment, while at 40 mM salt level, it was recorded in Dendang (2.65%) followed by IR77674 (2.57%). The most sensitive genotype in this experiment, Inpara 4, had the lowest leaf K^+ concentration at 20 mM salt level (2.24%) compared to other genotypes, while IR29 which known to be used as standard sensitive control, had the lowest K^+ concentration at 40 mM NaCl concentration (1.86%). The K^+ reduction in tolerant genotypes, at 40 mM NaCl, was less than 10%, while it was more than 25% for the sensitive genotypes (Fig. 8).

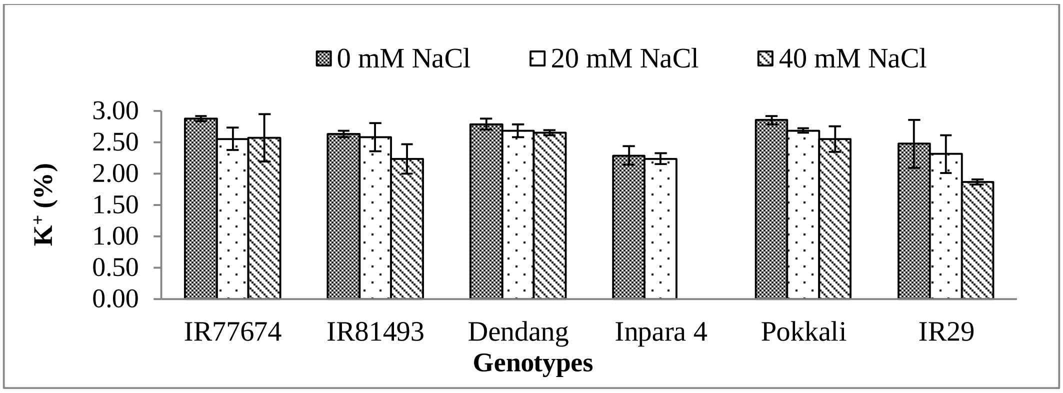

Fig. 8. Effect of varied levels of salinity on K^+ concentration in leaf of six rice genotypes. Inpara 4 did not survive at application of 40 mM NaCl.

Fig. 9 showed that the genotype differences in leaf Na^+ concentration under saline and non-saline conditions. For Na^+ concentration, the analysis of variance showed that the effect of genotype, salt levels and NaCl*genotype interaction were highly significant (Table 3). Salinity caused the increase of leaf Na^+ concentration in the genotypes. IR77674 and IR81493 had the lowest leaf Na^+ concentration compared to the other genotypes. The highest increase of leaf Na^+ concentration was shown in sensitive genotype IR29, i.e. 0.06%, 0.11% and 0.13% under control, 20 mM and 40 mM NaCl concentrations, respectively.

Table 3. Mean square for physiological parameters at different genotypes and NaCl concentrations.

Source of variation	df	Means Square				
		K	**Na**	**Ca**	**K/Na**	**Ca/Na**
Genotype (G)	5	0.654**	0.009**	0.085**	17726.667**	922.948**
NaCl (S)	2	0.687**	0.006**	0.146**	7912.777**	707.751**
S * G	10	0.048*	0.001**	0.021**	620.880*	38.950**
Error	36	0.023	0.000	0.004	223.036	13.429
CV		6.070	15.893	8.440	23.977	20.435

*, ** Significant at $p<0.05$ and 0.01 in *F*-test, respectively.

Salinity exhibited significant effects on physiological traits such as ion concentrations of rice plants (Jamil *et al.*, 2012). Increased soil salt concentrations decrease the ability of a plant to take up water and Na^+ and Cl^- are taken up in large amounts by roots, both Na^+ and Cl^- negatively affect growth by impairing metabolic processes and decreasing photosynthetic efficiency (Deinlein *et al.*, 2014). The result of the experiment showed that sodium (Na^+) in leaf increased under salinity stress in all rice genotypes (Fig. 9). In contrast, leaf potassium (K^+) content in salt-stressed plants was significantly reduced (Fig. 8). The diminution of K^+ concentration in leaf tissue may be due to direct competition between K^+ and Na^+ at plasma membrane, inhibition of Na^+ on K^+ transport process and/or Na^+ induced K^+ efflux from the root (Jamil *et al.*, 2012). In this study, the highest increase of leaf Na^+ concentration was recorded by IR29 which is sensitive genotype. Pokkali and Dendang had a lower leaf Na^+ concentration than IR29 at 40 mM NaCl concentration, although it was still high if it was compared to the other tolerant genotypes. It means that Pokkali and Dendang could maintain growth even when leaf Na^+ concentration was high. In this experiment, IR77674 and IR81493 were categorized as salt tolerant due to less accumulation of Na^+ and high accumulation of K^+ in leaves under salt stress.

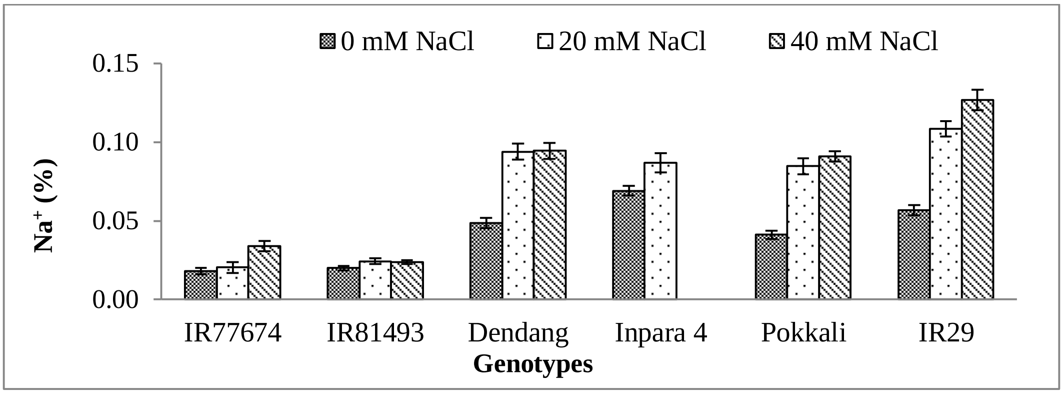

Fig. 9. Effect of varied levels of salinity on Na^+ concentration in leaf of six rice genotypes. Inpara 4 did not survive at application of 40 mM NaCl.

Table 3 showed that the NaCl concentrations, genotypes and NaCl*genotype interaction were highly significant ($P<0.01$) on Ca^{2+} concentration. The leaf Ca^{2+} concentration of different rice genotypes, under control and salinity is presented in Fig. 10. The Ca^{2+} concentration was prone to reduce by the increase of salt levels in all genotypes, except in IR77674 and IR81493. Among genotypes, Pokkali showed the highest level of leaf Ca^{2+} concentration under saline condition.

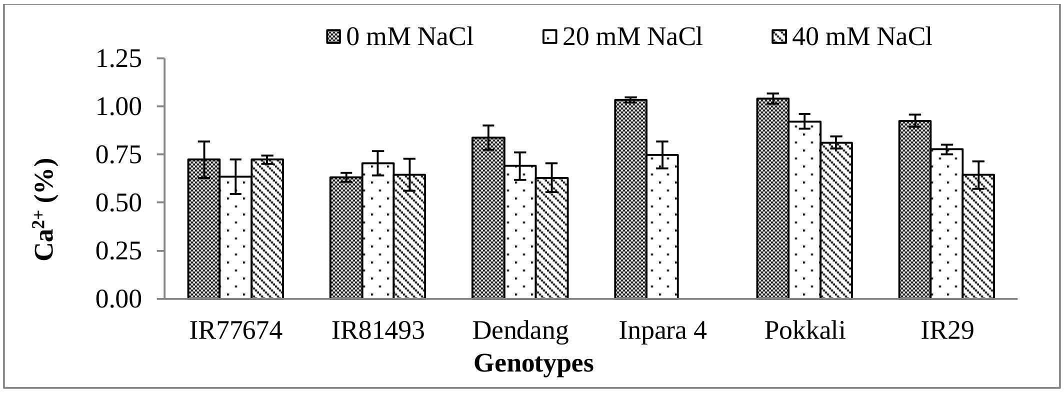

Fig. 10. Effect of varied levels of salinity on Ca^{2+} concentration in leaf of six rice genotypes. Inpara 4 did not survive at application of 40 mM NaCl.

Analysis of variance showed that the effect of NaCl concentration and genotypes was highly significant ($P<0.01$), while the NaCl*genotype interaction was significant ($P\leq 0.05$) on K^+/Na^+ ratio (Table 3). There was significant reduction in K^+/Na^+ ratio in all genotypes under salt stress compared to control. The lowest K^+/Na^+ ratio under salt stress was achieved by IR29, i.e. 21 and 15 at 20 mM and 40 mM salt levels, respectively. IR77674 and IR81493 showed the high K^+/Na^+ ratio under salt stress conditions (Fig. 11).

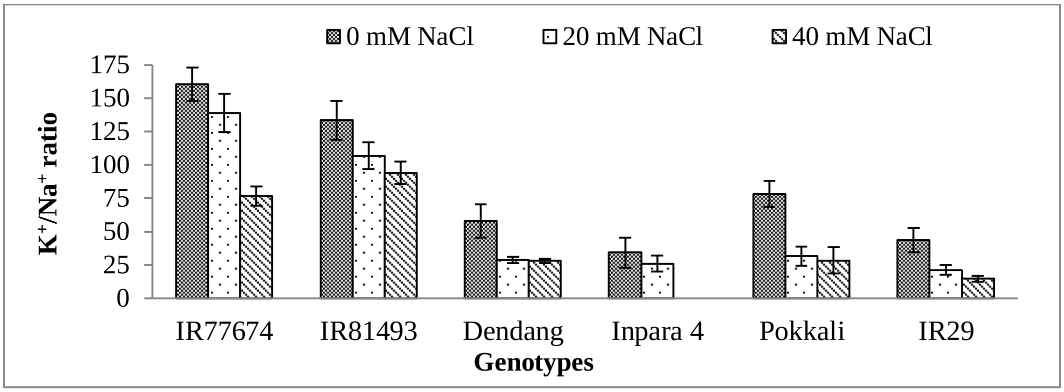

Fig. 11. Effect of varied levels of salinity on K^+/Na^+ ratio in leaf of six rice genotypes. Inpara 4 did not survive at application of 40 mM NaCl.

Data regarding Ca^{2+}/Na^+ ratio in leaf of six rice genotypes under saline and non-saline condition are shown in Fig.12. Analysis of variance revealed that salt level, genotypes and NaCl*genotype interaction were highly significant ($P<0.01$) on Ca^{2+}/Na^+ ratio (Table 3). In response to applied salinity, there was reduction on Ca^{2+}/Na^+ ratio in all genotypes along with the increase of NaCl concentration. The lowest reduction was observed in IR81493 (29 and 27 at 20 mM and 40 mM salt level, respectively) compared to control (32). The lowest Ca^{2+}/Na^+ ratio (5) was observed in IR29 at 40 mM NaCl concentration.

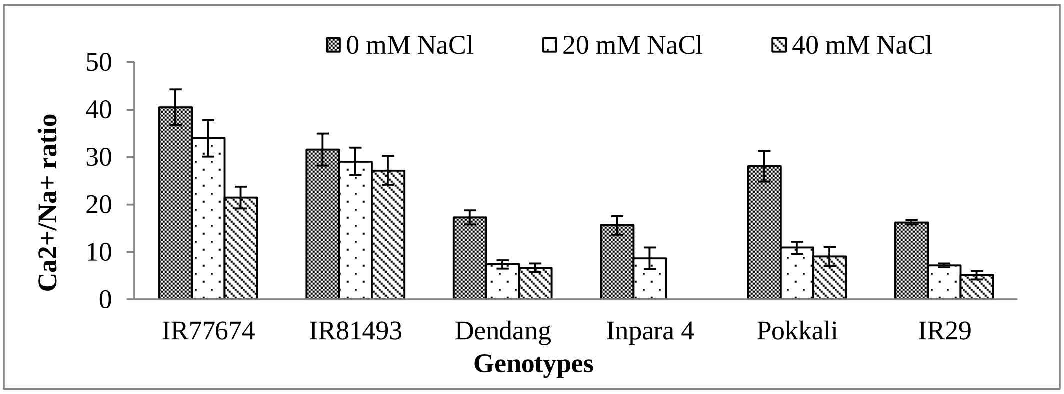

Fig. 12. Effect of varied levels of salinity on Ca^{2+}/Na^+ ratio in leaf of six rice genotypes. Inpara 4 did not survive at application of 40 mM NaCl.

A good supply of K^+ to plants can minimize injurious effects of high Na^+ under salinity. Influx of Na^+ in shoot tissue is often accompanied by the decrease in leaf K^+ concentration, leading to a decrease in K^+/Na^+ ratios. The decrease in K^+ contents occurred in plants grown in medium with excessive Na^+ (Haq *et al.*, 2009). One of the key features of salt tolerant plants is the ability of plant cells to maintain optimal K^+/Na^+ ratio in the cytosol when exposed to salt stress (Tester and Davenport, 2003; Haq *et al.*, 2009). The decreased in K^+/Na^+ ratios may relate directly to a decrease in yield in some conditions (Asch *et al.*, 2000). From this study, the tolerant genotypes, Pokkali and Dendang, showed the highest reduction of K^+/Na^+ ratio under salt stress, but could maintain growth with the result that the grain yield was not reduced excessively. Similarly, other tolerant genotypes, IR77674 and IR82493, showed high K^+/Na^+ ratio. These tolerant genotypes could maintain the grain yield under salt stress up to 40 mM NaCl, even better than the sensitive genotypes, IR29 and Inpara 4, which showed the low leaf K^+/Na^+ ratio.

K^+ and Ca^{2+} have been reported to be the major contributors to osmotic adjustment under stress conditions in several plant species (Jamil *et al*., 2012). Ca^{2+} is known to play a crucial role in maintaining the structural and functional integrity of plant membranes in addition to its considerable roles in cell wall stabilization, regulation of ion transport and selectivity and activation of cell wall enzymes (Ashraf, 2004). The maintenance of calcium acquisition and transport under salt stress is an important determinant of salinity tolerance. In this study it was shown that the NaCl*genotype interaction was significant. By increasing salt level treatments, the Ca^{2+} concentration and Ca^{2+}/Na^+ ratio in leaf tissue of the genotypes tend to decrease. Thus, enhancement of salinity affects the concentration of Ca^{2+} in the leaf tissues of the tested genotypes.

CONCLUSIONS

Salinity inhibited growth of the six rice genotypes from vegetative to reproductive stages, as shown by reduction of plant height, panicle number plant^{-1}, panicle length, leaf length, 1000 grain weight and grain yield. The growth reduction was caused by the increase of leaf Na^+, the reduction of leaf K^+ and leaf Ca^{2+} concentrations, and the reduction of leaf K^+/Na^+ and leaf Ca^{2+}/Na^+ ratios. The high Na^+ concentration in the soil solution reduces the absorption of K^+ and Ca^{2+} ions. The tolerant and sensitive genotypes can be distinguished at 40 mM NaCl (7-8 dS m^{-1}), showing that the addition of 40 mM NaCl to growth medium can be used as a useful tool to select tolerant and sensitive genotypes under greenhouse conditions. The relative grain yield reduction at 40 mM NaCl of tolerant genotypes was less than 70% and while it was more than 90% for sensitive genotypes.

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LITCHI FARMERS' PREFERENCE FOR THE ADOPTION OF VIETNAMESE GOOD AGRICULTURAL PRACTICES IN LUC NGAN DISTRICT, VIETNAM

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ABSTRACT

Vietnam has great potential for litchi production and exportation, however, food safety standard is a significant challenge. In an effort to overcome this challenge, the Vietnamese government introduced the Vietnamese Good Agricultural Practices (VietGAP) for litchi farmers and considered it as a significantbreakthrough for market accessibility and exportation of Vietnamese litchi. This study sought to explore farmers' attitude toward VietGAP, and the influence of VietGAP standard on adoption decision of litchi farmers in Luc Ngan district - the largest and most well-known litchi production region in Vietnam. A questionnaire-guided interview survey was conducted of 300 households covering those who adopted VietGAP and non-adopting farm households. The study revealedthat most litchi farmers have a positive attitude toward different aspects of VietGAP litchi production and 88.7% of respondentsperceived that VietGAP adoption is a sustainable practice for litchi production in the future. However, a significant number of non-adopters still expressed hesitation and doubts on the application of VietGAP. Choice experiments showed that requirements for pre-harvest fruit wrapping and monocropping, and price premium affected significantly farmers' adoption behavior while animal raising and pesticide standard were not a constraint for adoption. In addition, litchi farmers require a premium of between 16-60%of conventional litchi price for VietGAP adoption.

Key words: Choice experiment, farmer's attitude, food safety

INTRODUCTION

Recent reports and studies show that demand for litchi has increased in the high-end markets such as Canada, Saudi Arabia, United Arab Emirates, United States, and Europe Union (Commonwealth Secretariat, 2001; Evans et al., 2005; Ghosh, 2001). Although Vietnam was listed among the top five litchi producing countries in the world (Evans et al., 2005; FAO, 2002), it has failed to penetrate these developed nations due to challenges in meeting quality standards. Consequently, 95% of the exported volume from Vietnam was to China over the recent decade with a low price(Vietnam Trade Promotion Agency, 2014b). In this context, Vietnam Ministry of Agriculture and Rural Development (MARD) introduced Vietnamese Good Agricultural Practices (VietGAP) litchi in 2008 in Luc Ngan district, Bac Giang province, which was considered as a significant breakthrough for growers to fulfill high-end consumers' expectation about high quality litchi. Luc Ngan district has been best known as the predominant litchi production region of Vietnam with high annual outputs. Moreover, Luc Ngan litchi has been recognized as a traditional specialty and protected geographical indication(Vietnam Trade Promotion Agency, 2014b). In fact, VietGAP litchi in Luc Ngan was developed based on Global Good Agricultural Practices (GlobalGAP) including a set of criteria which aimed to produce clean and safe litchi.Apparently, VietGAP introduction enabled litchi exportation of Vietnam recently. After the implementation, VietGAP litchi has been accepted by several foreign markets such as South Korea, ASEAN, Russia, and especially Japan, as Japanese customers strongly prefer the taste and color of Luc Ngan VietGAP litchi (Ministry of Science and Technology, 2014). Litchi export value increased rapidly from under US$1 million in 2008 to nearly US$20 million 2014 as VietGAP production increased (Department of Industry and Trade Bac Giang, 2014; Vietnam Trade Promotion Agency, 2014a).

Although VietGAP litchi in Luc Ngan has gradually acquired significant recognition by many foreign trade partners, the adoption rate was negligible. In 2014, there were 243 out of about 40,000 households holding valid VietGAP certification; whereas many others still follow conventional practices by applying chemical pesticides and fertilizers, or even untreated organic fertilizers. Questions arise as to why the adoption rate is modest. Which GAP criteria prevented farmers' adoption? This study therefore sought to investigate farmers' attitude to different aspects of VietGAP, and explore the main VietGAP criteria that serve as a barrier for farmer adoption of VietGAP. Several studies explored the determinant of GAP or sustainable agricultural practice adoption. Those studies emphasized the influence of farmer characteristics, farm characteristics, or exogenous factors such as national policy on adoption decision (Athipanyakul *et al*., 2012; D'Souza *et al*., 1993; Loan *et al*., 2016; Pongvinyoo *et al*., 2014; Teklewold *et al*., 2013; Van Thanh *et al.*, 2015). This study focused on analyzing the influence of VietGAP criteria itself on farmers' adoption decision.

METHODS

Choice experiment method

For exploring the determinants of VietGAP criteria itself on farmers' adoption decision, the choice experiment (CE) model was used mainly in this study. The CE model relies on two pillars: Lancaster's characteristic theory and Random utility theory by McFadden. Lancaster's characteristic theory of value says that good is featured by set of characteristics so demand for good is described as demand for specific characteristics instead of the whole good itself (Lancaster 1966). The random utility theory derived by McFadden describes a model of individual choice and represent individual's preference by observed part and random part (McFadden 1973).

An individual *i*'srandom utility *U* for alternative *j* is assumed to be: $U_{ij} = V_{ij} + \varepsilon_{ij}$ (1)

Where U_{ij} is person *i*'s utility of choosing alternative *j*; V_{ij} is the deterministic component of utility which is observable by researchers; ε_{ij} is unobserved element or error terms.

Let *J* is the set of all possible options. If an individual chooses option *j* it means that choice *j* is the most preferred option in the choice set *J*. The choice made of option *j*is modeled as the probability that *j* is chosen $P_i(j|J)$:

$$P_i(j|J) = Prob\ \{U_{ij} > U_{il}\ ;\ \forall j \neq l,\ l \in J\} \quad (2)$$
$$P_i(j|J) = Prob\ \{\ V_{ij} + \varepsilon_{ij} > V_{il} + \varepsilon_{il}\ ;\ \forall j \neq l,\ l \in J\}$$
$$P_i(j|J) = Prob\ \{\ V_{ij} - V_{il} > \varepsilon_{il} - \varepsilon_{ij};\ \forall j \neq l,\ l \in J\}$$

In other words, rational people always choose the option with highest attained utility. From expression (1), assuming that error terms ε_{ij} are independently and identically distributed (IID) with an extreme value distribution, the probability of choosing alternative j in expression (2) was estimated as:

$$P_i(j|J) = \frac{e^{V_{ij}}}{\sum_{l=1}^{J} e^{V_{il}}} \qquad (3)$$

Assuming that individual preferences are heterogonous; the deterministic component of utility can be expressed as vector β random parameter varying among individual, and Z_{ij} is vector of attribute: $V_{ij}=\beta Z_{ij}$

Then the probability that individual*I*will choose alternative j is therefore

$$Pi(j|J) = \int \frac{e^{\beta Z_{ij}}}{\sum_{l=1}^{J} e^{\beta Z_{il}}} f(\beta) d\beta \qquad (4)$$

The specification (4) is the mixed logit choice probability, where $f(\beta)$ is density function specifying distribution of β.

In this study, a litchi farmer's random utility can be written as: $U_{ij} = V_{ij} + \varepsilon_{ij}$

Generally V_{ij} is assumed to be linear function of vector of farming practices Z and vector of coefficient βso a litchi farmer's utility function becomes:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \sum_{k=1}^{K} \beta_k Z_{jk} + \gamma P_j + \varepsilon_{ij}$$

Where Z_{jk} represents growing practice k of alternative j; coefficient β_k is the coefficient associated with practice k; γ is marginal utility of money; P_j is price premium to follow practices in alternative j.

For simplicity, the subscript i and j which represented individual i and alternative j are removed.

Our objective turns to estimate the vector of coefficient β and γ

$$V = \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \ldots + \beta_K Z_K + \gamma P \qquad (5)$$

When farmers have to follow a practice, they need an amount of money to trade off the cost and difficulties incurred. The value that farmers attach to a practice is the implicit price or marginal willingness to accept (WTA) for a change in a single attribute level as specified below.

$$\textit{Implicit price for practice } Z_k = -1(\beta_k/\gamma) \qquad (6)$$

Selection of study site

Litchi is planted mainly in 18 communes (out of a total of 30 communes) in Luc Ngan district and VietGAP procedure has been introduced in 5 litchi growing communes including Hong Giang, Quy Son, Thanh Hai, Phuong Son, and Tan Quang since 2009. However, there are many litchi farm households that have not adopted VietGAP in these 5 communes. Farm management involves the use of synthetic chemical inputs such as pesticides and fertilizers. Therefore, six communes including 5 VietGAP adoption communes above and one non-VietGAP commune (Giap Son commune) were drawn as the representative study site.

Data collection

Secondary data on litchi production including the litchi area, yield and produce as well as number of litchi households in Luc Ngan district and selected communes were gathered from statistical yearbooks of the district and from related studies. The information on VietGAP introduction and adoption in the district were collected from the report of Department of Agriculture and Rural Development (DARD) at the district level and also from the annual reports on agricultural production in each selected commune.

Household survey: a total of 300 households were selected for direct interviews including 45 VietGAP adopted households, and 255 non-adopted households. The number of litchi farm households in each commune was proportionally taken from selected communes, survey households were randomly selected with regards to VietGAP adoption and non-VietGAP adoption aspect based on the household list provided by Commune Farmer Association. The details of selected households in each communes is presented in Table 1.

Table 1. The number of survey households in study sites.

Sample Communes	No. of litchi households	No. of survey households	No. of adopting households	No. of Non-adopting households	YearVietGAP introduced
Quy Son	4,267	76	9	4,258	2009
Hong Giang	2,160	38	120	2,040	2009
Thanh Hai	3,565	63	46	3,519	2013
Tan Quang	2,140	38	28	2,112	2013
Phuong Son	2,789	50	40	2,749	2013
Giap Son	1,960	35	-	1,960	-
Total	**16,881**	**300**	**243**	**16,638**	

Source: Statistical Yearbook of Luc Ngan district, 2014; VietGAP (2014)

The direct interviews with the litchi households were conducted during the fall of 2015 using a standard questionnaire. The first part of the questionnaire focused on collecting socioeconomic and farm characteristics of Luc Ngan litchi farmers.The second part was to gather their attitude toward GAP litchi using Likert five-scale question. The third part was choice experiment design to investigate litchi farmers' preference for different attribute of GAP. There are four main steps in designing choice experiment. *Firstly*, the relevant attributes are identified during focus group discussion with litchi farmers and the head of Farmers Association. Five main concerned criteria of litchi growers during farming practices are premium price, pesticide use, intercrop, animal control, and pre-harvest fruit wrapping requirement. For conventional farming, farmers should follow reference dose on pesticide label and the quarantine periods to comply with normal requirement of Maximum Residue Limit (MRL) of Vietnam Ministry of Health.For VietGAP practice, farmers need to comply with Codex MRLs. For GlobalGAP practices, US and EU have their own MRLs regulated by the US Environmental Protection Agency and EU Food Safety Authority. According to US-EU standard, the pre-harvest interval is normally longer and the maximum application rate is lesser than Codex Alimentarius. These criteria are rationally considered by litchi farmers; therefore they are selected as attributes in choice experiment design of study. *Secondly*, all levels associated with different attributes are identified as shown in Table 2. *Thirdly*, all levels associated with GAP characteristics were combined and 3x2x2x2x4=96 combinations of attribute levels were obtained. After that, orthogonal fractional factorial design was used to obtain 16 manageable possible profiles. *Finally*, these profiles were then paired in 8 cards, status quo was included in each card and provided to each respondent with clear explanation. By selecting one among three choices, farmers would reveal their preference.

Table 2. Assigned attributes and levels

Attributes	Assigned levels
Pesticide use	1. Normal requirement of MRL (Status quo)
	2. Follow Codex MRL (VietGAP)
	3. Follow US, EU standard MRL (Global GAP)
Monocropping Cultivation	1. Permit intercropping (Status quo)
	2. Prohibit intercropping (VietGAP and Global GAP)
Animal raising	1. Permit animal raising (Status quo)
	2. Prohibit animal raising (VietGAP and Global GAP)
Wrapping requirement	1. Leave litchi fruit unwrapped (Status quo and VietGAP)
	2. Wrap litchi fruit with special nylon bag (Global GAP)
Price premium	1. 0%
	2. 30% higher than average market price
	3. 50% higher than average market price
	4. 100% higher than average market price

Analysis procedure

The empirical analyses of this study relied on three main procedures. Firstly, descriptive statistics method was used to describe the litchi production situation in the districts. Next, comparative analyses was used to identify the differences between the farm groups. Choice experiment model was employed to identify the determinants of GAP criteria on farmers' adoption.Data collected from the choice experiments was the input for mixed logit regression to provide estimated indirect utility function of Luc Ngan litchi growersas in expression(7) which is derived from expression (5) above. After that, Stata software was used to give Delta analysis and statistical analysis (Stata, 1999). The variables in expression (7) is explained in Table 3.

$$V_{ij}= \beta_1\, pu_1 + \beta_2\, pu_2 + \beta_3\, cul + \beta_4\, ar + \beta_5\, ph + \gamma\, pp \qquad (7)$$

Table 3. Variables and description

Variables	Denote	Description
Pesticide use	pu_1	1 = Pesticide use under Codex MRL standard; 0=other
	pu_2	1 = Pesticide use under US/EU MRL standard; 0=other
Monocroppingcultivation	*cul*	1 = Monocropping litchi; 0 = Intercropping
Animal raising	*ar*	1 = Prohibition of animal raising in litchi orchard
		0 = Raising animals in litchi orchard
Wrapping requirement	*wr*	1 = Wrap litchi fruits with nylon bag before harvest
		0 = Leave fruits unwrapped before harvest
Price premium	*pp*	Percentage higher than average price

RESULTS AND DISCUSSION

Overviews of litchi production in Luc Ngan district

Litchi production in Luc Ngan district started in the 1960s and increasingly expanded during the 1990s. The well-suited natural weather conditions in Luc Ngan district influenced greatly litchi special taste and appearance so that Luc Ngan litchi was certified as the protected trademark by the National Office of Intellectual Property of Vietnam, and received protection certification in Japan, the Republic of Korea, Cambodia, Laos, and China (Department of Industry and Trade Bac Giang 2012). To date, the production area is about 18,000 ha, and production fluctuates between 60,000 and 130,000 tons depending on weather conditions. In 2014, litchi production in Luc Ngan district reached to 130,000 tons due mainly to favorable weather (Table 4).

Table 4. Litchi growing area and yield of Luc Ngan district 2010-2014.

	2010	**2011**	**2012**	**2013**	**2014**
Area (ha)	18,000	18,000	18,000	17,000	18,000
Production (ton)	60,000	90,000	80,000	72,000	130,000

Source: Department of Industry and Trade Bac Giang (2014)

In 2014, Luc Ngan was by far the largest litchi growing region of Vietnam. Its litchi production area was approximated 28% of country's production area, which contributed nearly 35% of the whole country production, as shown in Table 5.

Table 5. Litchi production area and yield, 2014.

	Yield (thousand ton)	**%**	**Area (thousand ha)**	**%**
Luc Ngan District	130	35.43	18	28.40
Others	236.89	64.57	45.39	71.60
Whole Vietnam	**366.89**	**100.00**	**63.39**	**100.00**

Source: Department of Industry and Trade Bac Giang (2014)

VietGAP litchi production in Luc Ngan district and farmers' adoption

VietGAP was developed based on GlobalGAP with a lower criteria to harmonize with national conditions. VietGAP provides guidelines for the application of production methods covering food safety, environmental management, worker health, safety, and product quality. There are 12 sections in the standard namely: (1) Site assessment and selection; (2) Planting material; (3) Soil and substrate management; (4) Fertilizers and soil additives; (5) Water and irrigation; (6) Crop protection and use of chemicals; (7) Harvesting and handling; (8) Waste management and treatment; (9) Worker health and welfare; (10) Record keeping, recall, and traceability; (11) Internal audit; and (12) Complaints and resolve complaints. Farmers are subject to mandatory training and guideline production practices to receive VietGAP certification which is valid for two years (Ministry of Agriculture and Rural Development 2008)

The VietGAP pilot project was introduced to local farmers in Quy Son commune in 2008 under the financial support and technical guidance of Canadian International Development Agency. The overall objectives of this program were to enhance responsibility of litchi growers in production, improve the quality safety and marketability of litchi, and enhance economic efficiency for litchi farmers. Accordingly, litchi farmers were provided free training courses, free production site assessment, and free product inspection.After the success of first production model, VietGAP was implemented in Hong Giang and Quy Son commune. In 2013, Phuong Son, Thanh Hai, and Tan Quang embarked on the expansion. In 2014, there were 12 production groups in five communes having valid certification of VietGAP on the area of 132 ha (VietGAP 2014)

As the result, VietGAP litchi programing Luc Ngan district has achieved remarkable success by enhancing the litchi exportation of Vietnam. As in Fig. 1, from 2008 to 2009, VietGAP project was at starting point and litchi export value stood at around US$1 million. In 2010, VietGAP production of Luc Ngan was 16 thousand tons; however litchi export value was still negligible since VietGAP litchi was not recognized by foreign customers. From then on, litchi export value increased rapidly as VietGAP litchi has gained increasing acceptance by foreign markets. For instance, litchi export value was US$15 million in 2012, which was up around 200% compared to that of 2011 (Fig. 1).

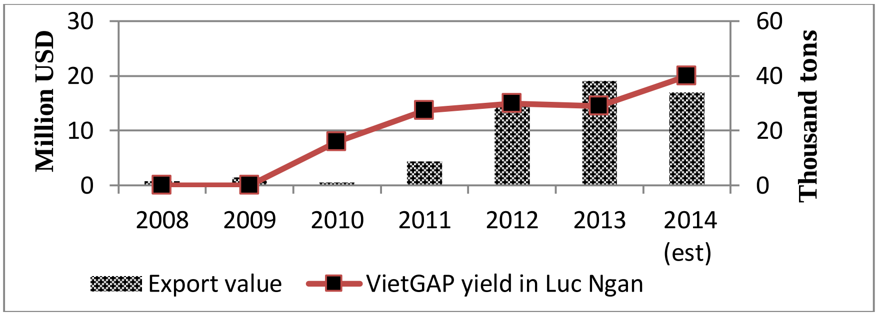

Fig. 1. Vietnam litchi export value and yield in Luc Ngan 2008-2014.
Source: Department of Industry and Trade Bac Giang, 2014; Vietnam Trade Promotion Agency, 2014a

Sample description

Our sample included 45 adopted households with valid VietGAP certification; and 255 non-adopted households.The sample description is indicated in Table 6.

Table 6. Socio-economic characteristics of litchi farmers in Luc Ngan.

(Average for one survey household)

Characteristics	Unit	Adopter group (n=45)		Non-adopter group(n=255)		Total (n=300)
		Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	
1. Farmer's characteristics						
a. Household size	people	5.09	0.9250	4.96	1.0379	4.98
b. Age	year	46.16	8.7255	43.28	10.1134	43.71
c. Education	year	8.27	3.3737	7.56	2.7743	7.66
2. Farm characteristics						
a. Agricultural land	ha	0.62	0.1749	0.60	0.3698	0.60
b. Litchi land	ha	0.53	0.1629	0.48	0.3391	0.48
c. Annual income	mil. VND	129.67	57.6340	108.58	57.1752	111.74
d. Litchi income	mil. VND	111.80	37.2703	75.02	50.2004	80.54

***Source**: Household survey 2015*

Among the 300 household respondents, there are 256 male and 44 female household heads. Two thirds are over 40 years old and the average household size is around 5 persons. The average agricultural land is 0.60 ha per household, of which litchi production occupies about 0.48 ha, on the average. Litchi production appeared to be the major crop and major income source of our sample households. On the average, litchi orchards make up 80% of the agricultural land of sample families. The mean litchi income is 80.54 million VND (US$3,661)[1] per year, which accounts for 72%of total household income. Additional sources of income are from salary and other activities like trading or transportation service. Income from livestock is negligible because raising is mainly for family consumption purposes.

Farmers' attitude toward GAP

Table 7 presents the proportion of farmers who attended the training course about VietGAP and GlobalGAP for litchi with respect to group of farmers. It can be seen that famers know more about VietGAP than GlobalGAP. About 67% of total respondents stated that they know about VietGAP. Specifically, VietGAP comprises a set of practice regulated by government to produce clean and safe litchi. There was 40% of respondents attending VietGAP training courses by local authority. Of two groups, all the adopters attended official VietGAP training program; whereas, only 29% of non-adopters joined the training class.

Besides, 30% of total respondents knew about GlobalGAP litchi, andsmall proportion (7%) was provided official training about GlobalGAP. Of two groups, VietGAP farmers seemed more interested in GlobalGAP litchi since 42% of this group attended GlobalGAP litchi class; whereas most of non-VietGAP farmers (99.22%) ignored GlobalGAP litchi training programs.

Table 7. Distribution of respondents with knowledge and attendance in training course about GAP.

		% of total adopters (N=45)	**% of total non-adopters (N=255)**	**% of total farmers (N=300)**
1. Knowledge about	yes	100	61.2	67
VietGAP litchi	no	0	38.8	33
2. Attended VietGAP	yes	100	29.4	40
litchi training	no	0	70.6	60
3. Knowledge about	yes	84.4	20.4	30
GlobalGAP litchi	no	15.6	79.6	70
4. Attended GlobalGAP	yes	42.2	0.8	7
litchi training	no	57.8	99.2	93

Source: Household survey 2015

A majority of litchi producer participants expressed positive attitude toward different aspects of VietGAP litchi production. About 95% of respondents asserted that VietGAP helps to reduce pollution, farmers' exposure to health hazards, and pest infestation (Table 8). According to the advice of the Agricultural Extension Board, GAP households in the same area should spray pesticides for litchi together at the recommended time. Some adopters said that the frequency of spraying is reduced in half compared to conventional practice since pests were effectively managed after the first spraying. As a result, adverse effects of pesticide are cut down. All of the adopters affirmed that farmers were less exposed to hazard from pesticide use while following VietGAP litchi practices. Most non-adopters (94.1%) also supported this statement.

[1] 1USD=22,000VND

In addition, high proportion of respondents (88.7%) perceived that VietGAP for litchi is sustainable practice for the future. Farmers added that, so far the trade of litchi has been dependent upon the biggest Chinese importer but now they feel very vulnerable due to the political issue between two countries. A small proportion of non-adopters showed disagreement against statement; however, majority of people had a full agreement. This implies that VietGAP practice is promising for majority litchi growers to shift into more stable markets. In addition, 76% of interviewees decisively indicated that VietGAP would offers nice appearance and better quality litchi compared to conventional practices, and also admitted the necessary and important role of recording practice. However a significant number of non-adopter householders expressed hesitation and disagreement against statement.

Finally, 42.4% of interviewees agreed that VietGAP litchi practice would help to reduce input cost of production. Some VietGAP respondents noted thatalthough pesticide prices are more expensive, pesticide expenditure was reduced by about ten percent compared to conventional practice since the frequency of sprayingis reduced; other costs appeared to remain the same. However, a large proportion of sample (85.4%) showed uncertainty and disagreement about VietGAP practice being able to increase income. Farmers specified their fundamental concerns on no contract farming while current output price of VietGAP litchi was not enough to compensate for their practice; this registered a neutral and negative attitude. Although farmers showed especially positive attitude toward GAP, there was hesitance to adopt due to the feeling of uncertainty

Table 8. Percentage of farmers' attitude toward GAP for litchi.

Statement	Percentage (N=300)				
	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
1. VietGAP litchi is sustainable practice for future	46.3	42.3	9.1	2.3	0.0
2. VietGAP litchi has nicer apprearance and better quality compared to conventional litchi	28.0	48.0	18.0	6.0	0.0
3. VietGAP practice is time-consuming	53.0	37.3	4.7	5.0	0.0
4. Recording practice is necessary & important	20.7	49.3	21.3	8.7	0.0
5. VietGAP litchi reduces all forms of pollution	47.0	47.0	6.0	0.0	0.0
6. VietGAP litchi reduces input cost of production	2.7	39.7	49.7	5.7	2.2
7. VietGAP litchi increases farmers' income	1.3	13.3	60.7	22.0	2.7
8. VietGAP litchi reduces farmers' exposure to health hazards	49.0	46.0	2.3	2.7	0.0
9. VietGAP litchi is efficient in reducing pest & disease infestation	45.0	49.7	4.7	0.6	0.0

Source: Household survey 2015

The influence of main GAP criteria on GAP adoption likelihood

The empirical results of mixed logit model (Table 9) indicates that cultivation, pre-harvest fruit wrapping requirement, pesticide standard, and price premium significantly impact on farmers' adoption decision.

Firstly, monocropping cultivation is negatively related to the growers' utility as expected. It clearly demonstrates that prohibition of intercrop non-litchi fruit in litchi orchard will reduce the utility of litchi farmers.Similarly, pre-harvest fruit wrapping requirement has a negative coefficient which implies that the requirement of covering fruit by nylon bag 21 days before harvesting would reduce farmer' utility. Additionally, price premium is found to be strongly positive desirably.

Another specific result of the model is pesticide use variables. Pesticide use following Codex standard and following US or EU standard are both positive and statistically significant at 1% level. In this context, farmer's utility would increase if pesticide use followed international standard. Actually the usage of high standard pesticide is not the main difficulty for litchi growers since they are aware that it would help to lower their health risk. This also agrees with the findings of Tran Huynh Bao Chau et al. (2015) that VietGAP program reduced heath problems caused by pesticide exposure.

Finally, the study revealed that animal raising is statistically insignificant factor. In fact the existence of animal raising is not the constraint of VietGAP adoption. Although two thirds of sample households have raised animals, the range is limited; hence animals can be easily be moved elsewhere away from VietGAP practice area.

Table 9. Estimated coefficients of mixed logit model for GAP litchi preference

	Estimated Coefficients	
Variables	**Coeff.**	**Std. Err**
Mean		
Monocropping cultivation	-0.43886***	0.1510903
Wrapping requirement	-1.65971***	0.1722495
Animal raising	0.03568	0.1276922
Price premium	0.27206***	0.0314727
Pesticide use_US	0.55126***	0.1591618
Pesticide use_Codex	0.62467***	0.1897499
SD		
Monocroppingcultivation	1.19085***	0.2094027
Wrapping requirement	1.75394***	0.2069804
Animal raising	0.04108	0.5770746
Price premium	0.11461***	0.0395126
Pesticide use_US	0.04688	0.2857956
Pesticide use_Codex	0.35449	0.5635703
Number of observation	3600	
Log likelihood	-1087.607	
Chi^2	100.43	

Note: $^{1/}$*, **, *** denote significance at 10%, 5% and 1% levels, respectively
$^{2/}$Mixed logit model was used because it extends conditional logit model by allowing the parameters in the model to be randomly distributed such as *culphpp*

We estimate the implicit price for each GAP practice as in Table 10. Litchi farmers would require price premium of 6,100 VND per kilogram higher than conventional litchi price (10,000VND per kilogram) for wrapping fruit using nylon bag at 21 days before harvest. This is a challenging task for farmers since it is laborious to bag each bunch of fruit. Besides, a price premium of 1,613 VND per kilogram compared to price of conventional litchi would be enough for farmers to switch from intercropping to monocropping.

Pesticide variables are not the barriers of GAP adoption since our litchi farmers prefer the application of pesticide under Codex criteria (VietGAP) and EU/US criteria (GlobalGAP). It is important to highlight that litchi farmers truly illustrate positive attitude toward pesticide under Codex standard (VietGAP) or US/EU standard (GlobalGAP) because most of the respondents agree that “VietGAP litchi practice reduces farmers' exposure to health hazards”. Non-GAP farms should practice according to the advice of Extension Board, which means they have a choice whether to follow or not. However, GAP-farms have to follow the advice of Extension Board. For example, Extension Board informs the spraying schedule, adopted farmers have to spray according to schedule. If they are busy, they have to hire labor to do that. In case of non-GAP farms, if they are busy, they normally delay the spraying schedule. Moreover, several adopter households admitted that “the frequency of spraying is reduced by half compared to conventional practice”, or “application of pesticides according to VietGAP litchi, pesticide cost is reduced by about ten percent since the frequency of spraying is reduced”. Obviously, it would be much more efficient when all households in the same neighborhood spray pesticidesat the same time. Moreover, farmers are aware that the use of high standard pesticide in accordance with VietGAP requirement would be much safer for pesticide applicators, hence the farmers do not ask for price premium for pesticide use requirement and implicit price is negative (Table 10).

Table 10. Estimated implicit price to follow single practice

Attribute	Variables Denote	Implicit price (VND)	P_value	95% Confidence Interval	
Wrapping requirement	*wr*	6,100	0.000	-7.55580	-4.64496
Monocropping cultivation	*cul*	1,613	0.001	-2.59320	-0.63289
Pesticide use_US	*pu_us*	-2,026	0.004	0.64714	3.40528
Pesticide use_Codex	*pu_codex*	-2,296	0.001	0.88665	3.70543

Note:The significant level was tested by Delta method.

CONCLUSION

Luc Ngan district has been best known as predominantly a litchi production region of Vietnam and VietGAP has been introduced to litchi farm households in the district since 2008 in order to meet food safety standards for exportation. However, the adoption rate for VietGAP in the district is still low. The study results show that majority of litchi farmers expressed positive attitude toward different aspects of VietGAP litchi production. The study also focused on analyzing 5 VietGAP criteria that affect the adoption decision of litchi farmers in the district and reveal that wrapping requirement, monocrop cultivation, and price premium are significant factors for farmers’ choice of adoption. Farmers require price premium of 6,100 VND per kilogram (equivalent to 60% of current price of conventional litchi) to comply with pre-harvest wrapping requirement, and price premium 1,613 VND per kilogram (equivalent to 16% of current price of conventional litchi) to monocrop litchi.

This is the first study investigating the impact of GAP criteria on the likelihood of adoption using choice experiments; hence the findings would fill in the literature gap about application of CE in studying GAP adoption determinants. Moreover, this study would be the useful reference for policy makers to design effective policies for improving the application of GAP litchi in Luc Ngan district. Local authority should attempt to provide litchi farmers more extension service, training courses, and technical assistance, especially for wrapping fruits, to tackle the biggest challenge of farmers against

GlobalGAP adoption. The study also revealed that if farms in same neighboring area are organized as production group and spray pesticides simultaneously per advice of Extension Board, the cost of pesticide and frequency of spraying will be reduced considerably. In fact, MARD only assigns VietGAP certification for production groups instead of individual households. Many farms do not adopt VietGAP due to non-adoption of VietGAPby their neighborhood. Therefore, organizing litchi farmers as production groups would help to address problems of spraying pesticides and form the necessary base for VietGAP compliance**.**

ACKNOWLEDGEMENT

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PERFORMANCE TEST OF SUGARCANE PLANTER WITH MINIMUM TILLAGE AT DIFFERENT DENSITIES OF SUGARCANE LEAF RESIDUES

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ABSTRACT

This paper attempts to demonstratethe performance of a sugarcane planter at the Agricultural Machinery Center, Kasetsart University Research from April 2014 to March 2015 with minimum tillage resulting from a slippery sliding rate (slip %), drawbar pull, drawbar power and PTO power as varied by the different densities of residues at 0, 2, 4, and 6 ton/ha and 2 depth levels of soil at 10 cm and 20 cm. The test was done over one and two rounds in the crop field, after the final sugarcane harvesting, with a moisture content of 22.115% (bulk density) and 19.202 % (bulk density) . It was discovered that the fuel consumption rate of the sugarcane planter was at125 m/l at a tractor velocity of 3.2616 km/hr, the slippery sliding rate at 4.44 %, the draft (pulling) of lower link and top link at 8.30 kW, PTO power at 16.56 kW .The performance and total power of the sugarcane planter with minimum tillage resulted from the depth level of the soil opener and the different densities of the sugar cane leaf residues at 0 2 4 and 6 ton/ha and depth level of the soil to affect performance of the sugarcane planter. Therefore, the angle of subsoil opener should be reduced to less than 31 degrees to reduce the effect of soil resistance.

Key words: drawbar (pulling) power, green technology, sustainable, deep placement fertilizer

INTRODUCTION

Padilla-Fernandez and Nuthall (2009) noted the important resource-use inefficiencies in sugar cane production in Central Negros, Philippines. Output could be increased by 22% through better use of available inputs by rationalizing the use of NPK, especially N-fertilizer, and seed inputs. A soil test should be conducted to determine fertilizer requirements of the soil in Central Negros. Under a specification of variable returns to scale, the mean technical, scale and overall technical efficiency indices were estimated to be 0.7580, 0.9884 and 0.7298. Input use differences between the technically efficient and inefficient farms are highly significant in terms of area, seeds and labor inputs. There was no significant difference in the use of fertilizer and power inputs.

The cubic dimensions of a prototype sugarcane planter were determined to 198 cm x 298 cm x 230 cm, weighing 1,270 kg with a capacity of at least 600 kg of sugarcane sticks. It operates in the crop field at the rate of 3.22 rai/hr with an efficient percentage of 48.16 and a break even area of 12.04 rai. It could plant new sugarcane sticks between the rows of the old sugarcane and could be filled with fertilizer (Tangwongkit et al. 2000). Krueaharncharnpong (2003) demonstrated that the use of power take-off (PTO) affected the average size of a clod of earth. Thus, at an increasing-forward speed, the average size of a clod of earth was bigger when PTO was not used. Hoki et al. (1988) experimented using PTO as a power generator and compared when driven or not driven by human force. Their findings revealed that it was better to use PTO as a power generator, thoroughly penetrating the soil disturbance. Moreover, in wet or soft soil conditions, it was better not to use PTO as a power generator. The need for power of this kind results from the speed of PTO, the speed of the tractor and the depth of tillage; thus the higher the PTO speed, the deeper the tillage.

Takanori et al. (2011) examined the need to vary power at different depth levels to add the fertilizer. It was determined that the measurement of PTO torque and the revolution speed (rpm) of the model/prototype (soil layer for tillage and adjustment of tillage types, potential of tillage, adding fertilizer at the same time, and determining the power need) can be ascertained from the values from the power origin. However, when the experiment was conducted in the actual paddy field, it was found that the PTO torque increased from 77% to 129%. As for the factor of the different angles of the plowing discs, a 30- degree angle of the plowing discs resulted in a bigger clod of earth than when engaging a 25- degree angle of the plowing discs, at an increasing-forwarding speed. Moreover Chaorakam et al. (2012) discovered that after using V-shaped, VR_A, VR_B and Bubble Coulter plowing discs and collecting soil samples from each furrow to bake at a temperature of 110 °C for 24 hours, the amount of soil particles in the furrow dug by a V-shaped plowing disc was significantly less than that in the other furrows dug by other plowing discs. Outputs by C-shaped-European-rotating-plow blade and prototype rotating-plow blade are as follows: the average size of a clod of earth was from 10.22 to 20.56 mm and from 12.17 to 24.80 mm, respectively. The percentage of the slippery sliding rate was from 4.60% to 7.85% and from 3.60% to7.69 %. Moreover, installation of the C shaped-European-rotating-plow blade required less special power than the installation of the prototype rotating-plow blade (Mongkol et al. 2008).

Prasertkarn (2009) reported that the tractor's speed affected the drawbar power as well as the total power, whereas the vibration and the width of vibratory range also affected the drawbar power and the area of soil distribution. Al-Janobi and Al-Suhaibani (1998) conducted an experiment to measure the draw pull of plowing discs in sandy loam soil. Their study revealed that the factors affecting the draw pull were the speed of the tractor and the depth of tillage. In this study, the plowing discs used in the experiment were those with a diameter of 660 mm and the working widths were at 1 and 115 mm. In this experiment, the pig-head-shaped plow, the chisel plow and the set of Offset Disk Harrow were compared. It was discovered that the plowing disc and the pig-head-shaped plow yielded a higher horizontal draft than the set for the Offset Disk Harrow at the same depth of tillage and forwarding speed. Manian et al. (2000) examined black clay loam and sand in artificial soil trays at disk angles of 40, 44 and 48 degrees, tilt angles of 16, 20 and 24 degrees, diameters of 51, 56 and 61 cm and at the forwarding speeds of 4, 7 and 10 km/ hr. It was demonstrated that the draw pull and the horizontal force in the black clay loam were rather high. Meanwhile, the vertical action force decreased when the moisture content in the 2 soil types increased.

Although tillage does not directly affect the growth of a plant, indirectly it does. Thus, such indirect advantages as greater soil porosity, better ventilation in soil, increased vaporization are helpful in the eradication of weeds and therefore good for the growth of the plant. Although tillage is good for plant growing, it can damage the agricultural system, particularly in changing the soil's physical and chemical properties. The disadvantages of tillage include increasing the density and stress from water. Using a mid-sized tractor can increase density and water stress in the soil at a 60-cm depth. Taking these problems into account, therefore, the opinion to grow sugarcane using a planter with minimum tillage in order to better the conditions of soil is growing in acceptance.

This study, therefore, sought to determine the performance of a sugarcane planter for an unprepared-soil area, and using the drawbar power to analytically determine the total power requirement for the planter installation via a tractor. This would test the performance of the sugarcane planter without PTO power tillage usage.

MATERIALS AND METHODS

This research was conducted in the Agricultural Machinery Center, Kasetsart University Thailand from 2014 to 2015. In order to measure the drawbar pull, the strain gauges, Wheatstone bridge type, were installed on the lower link and top link pin together with PTO-torque transducer (No. 3 in Fig. 1). Meanwhile, in order to measure the torque of PTO power; a potentiometer was installed (No.1) to measure the leaning angle between the plane and the core top link. Moreover, the PTO torque transducer (ONOSOKKIT), type HM-640, was also installed to measure the number of revolutions. All the electric signals from these devices will be sent to a dynamic recorder, Kyowa-EXD-100A, and analyzed using the program DCS-100A according to Fig. 1.

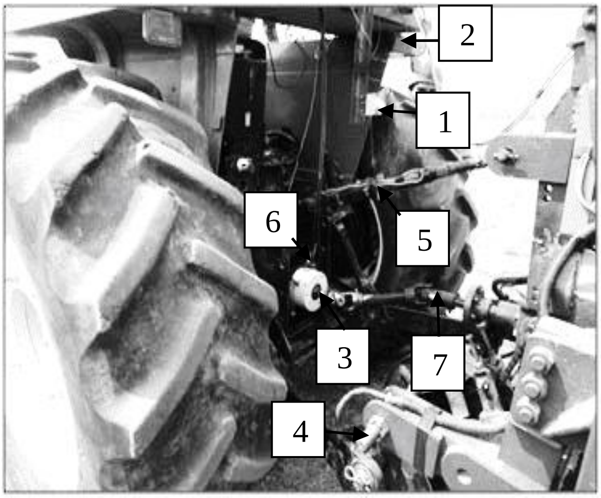

Fig. 1. Installation of measuring device for performance test of sugarcane planter
1) Potentiometer 2) Recorder EDX-100A 3) PTO - Torque transducer.
4) Lower link 5) Top link 6) PTO power Speed transducer 7) Driven shaft

EXPERIMENTAL CONDITIONS

Performance evaluation of sugar cane planter

The study was conducted in the Agricultural Machinery Center, Kasetsart University to determine the power need of the sugar cane planter at varying soil depths. The experimental field to test the performance of the sugarcane planter was designed with an area of 20 x 100 m^2 according to the terms in the factorial were 4 as: density of residue, depth of soil, moisture content and PTO power. The tested factors included the densities of the residues at 0, 2, 4, and 6 ton/ha; the depth of soil at 0-15 cm and 0-21 cm; the moisture content of the residue and soils at 22.115% bulk density and 19.202 % bulk density and PTO power at 16.56 kw.

Four furrows of sugarcane were specified and each furrow was tested with 4 replications. The sugarcane planter (Fig. 2) was installed attached to the tri-pod on a tractor to open the soil into a furrow for each sugarcane line. The driven force in a multifactor experiment type was used. The factors of interest were the following: the PTO power used in the experiment, the effects of the residues, the speed of the tractor: 0.906 m/s or 3.261 km/hr at 2,200 rpm, and low gear was used in 4 rounds of plowing. The depth and moisture contents were also measured and collected for further calculations to determine various factors affecting the performance of the sugarcane planter such as the pulling power, the PTO power and other power usages in the multifactor experiment.

Fig. 2. Sugarcane planter prototype

THEORETICAL CALCULATIONS

The horizontal drawbar pull was calculated from the lower link pins transducer and the top link transducer to determine the drawbar power formulae as follow.

$$\text{Drawbar power} = F \times V \qquad \text{[Equation 1]}$$

Where the drawbar measures the pulling force (kw), F measures the horizontal drawbar pull (kN) and V measures the velocity (m/s) formulae as follows:

$$\text{PTO power} = \frac{2\pi NT}{60{,}000} \qquad \text{[Equation 2]}$$

Where:

PTO is the power of the supporting axle (kw),
N is the revolution speed of the supporting axle (rpm)
T is the torque of the supporting axle (N-m)

This can be determined by the calculation of the Data Rocker-EDX-100A formulae as follow.

$$\text{Total power} = \text{Drawbar power} + \text{PTO power} \qquad \text{[Equation 3]}$$

Where:

Total power are all the whole power (kw),
PTO power is the power take-off (kW)
Drawbar power is the pulling power (kw)

RESULTS AND DISCUSSION

A comparison was made on the effects of the different densities of sugarcane leaf residue on the performance of a sugarcane planter with minimum tillage in terms of the depth of the soil, the slip present or slippery sliding rate, drawbar power, PTO power and total power. The experiment was conducted at the speed of 3.2616 km/hr and an engine revolution of 2200 rpm. Fig. 3 shows the relationship of PTO power compared with the depths of soil resulting from soil opening by sub-soil. Both the depths of the soil and the density of sugarcane leaf residue at 6 t/ha, could affect the tendency to use the maximum PTO power of 15.027 kw at 16.5 cm soil depth.

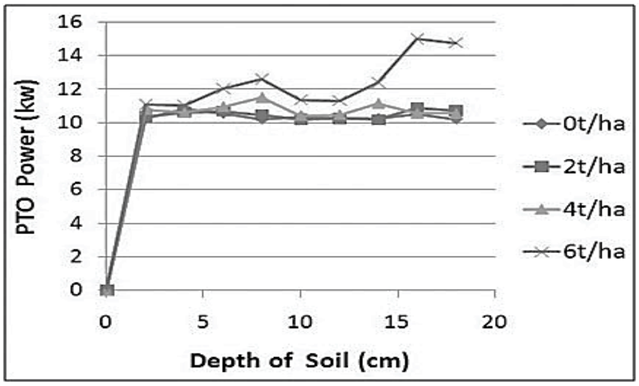

Fig. 3. Relationship between PTO Power and depth of soil

The graph shows the relationship between the depth of soil and the drawbar power varied according to the different density of residue seen in (Fig. 4). It could affect the tendency to use the maximum draft 8000 N at a soil depth of 20 cm. The drawbar power is likely to be higher when the depth of soil and the density of residue increase. It was, therefore, draft of 7162.99 N at velocity of 2.536 km/hr, according to Fig. 5.

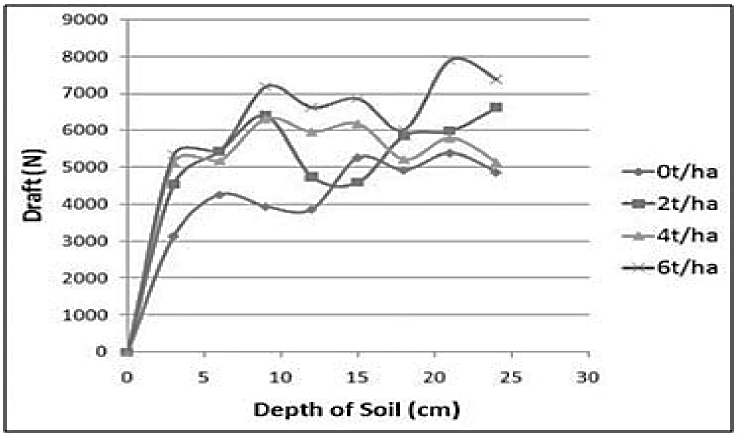

Fig. 4. Relationship between draft and depth of soil

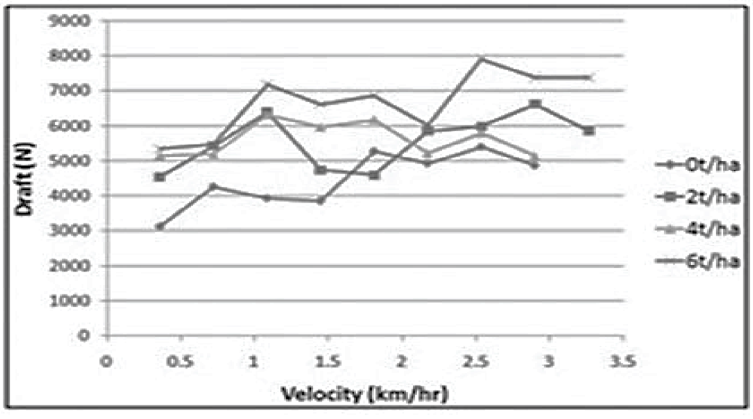

Fig. 5. Relationship between draft and velocity

The depth of soil is affected by drawbar power, it could affect the tendency to use the maximum draft 7100 N at depth of soil 20.8 cm (Fig. 6). The drawbar power is likely to be higher when the depth of soil and the density of residue are greater. Thus, drawbar power of 7162.99 w at velocity of 2.536 km/hr, according to Fig. 7.

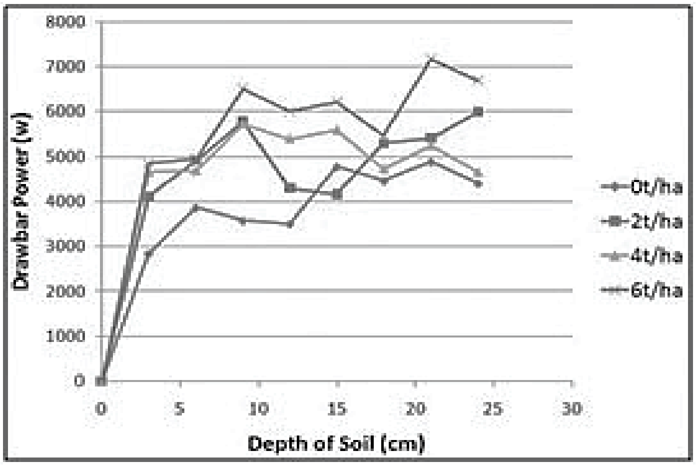

Fig. 6. Relationship between drawbar power and depth of soil

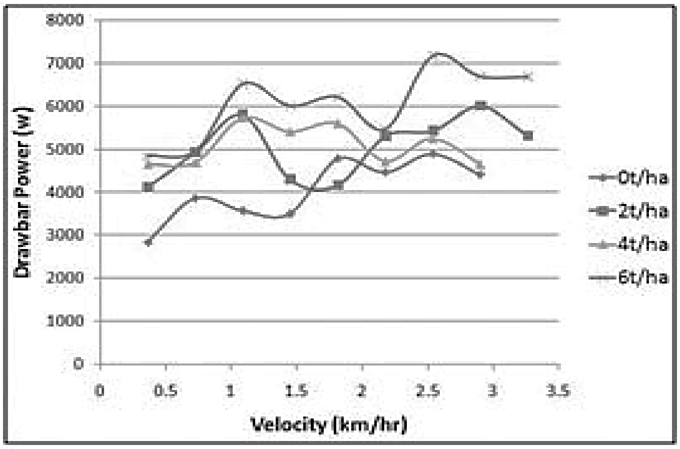

Fig. 7. Relationship between drawbar power and velocity

CONCLUSIONS

The field experiment findings demonstrate that the prototype sugarcane planter is suitable to be installed on a 33.337 hp tractor. The horizontal drawbar pull was taken from the lower link and top link pins transducer at 8.30 kw. Thus, the use of agricultural machinery as a power origin together with an agricultural tool can affect the performance and efficiency of the agricultural tool. Specifically, the power requirement of tractor is not appropriate to use with an agricultural tool because the end result will be an over-fuel consumption rate, pollution and damage to the rear connecting devices of the tractor. The different densities of the residues at 0, 2, 4 and 6 ton/ha and depth level of the soil affected the performance of the sugarcane planter.

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AGROBACTERIUM-MEDIATED TRANSFORMATION AND EXPRESSION OF *BT* GENE IN TRANSGENIC SUGARCANE

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ABSTRACT

Sugarcane borers are the major biotic pests of sugarcane. For the development of insect resistance in sugarcane an insect resistant gene *Cry1A*(*b*), also known as *Bt* gene was transferred to sugarcane through *Agrobacterium*-mediated transformation at the Center for Agricultural Biotechnology, Kasetsart University, Kamphaeng Saen Campus, Thailand in 2015. The bacterium carries the binary vector pCAMBIA1302-Ab possessing *hygromycin phosphotransferase* (*hpt*) and *Cry1A*(*b*). Both genes are under the control of 35SCAMV promoter. For transformation, calli were induced from the most inner leaf whorl of 5-6 m onths old sugarcane shoot, of cultivar LK 92-11. The calli were submerged in *A. tumefaciens* suspension for 10 min and co-cultivated for 3 days in the dark on MS medium containing 100 µM acetosyringone. The calli were transferred onto callus induction medium containing 30 mg/L hygromycin. After six weeks 20 calli were alive and 20 plants were regenerated. Out of 20 plants, 16 plants showed a PCR positive band of *hpt* gene at the size of 800 bp and 7 out of 16 plants showed PCR positive band of *Cry1A*(*b*) gene at the size of 2500 bp. Southern blot analysis revealed that three transgenic plants had two copies of *Cry1A*(*b*) gene and one transgenic plant had one copy of the transgene integrated in the genome. Expression analysis of the transgenic sugarcane plants was done by using real-time PCR. The four transgenic plants of three months old showed transcriptional expression of *Cry1A*(*b*) gene. The transgenic sugarcane possessing a single copy of *Cry1A*(*b*) showed about 6-19 times higher expression level compared to the two copies transgenic plants.

Key words: callus, real-time PCR, Southern blot, genetic transformation

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is very important to the agro-based industry and largely grown in tropical and sub-tropical region of the world. Sugarcane germplasms have a complex polyploidy level, with chromosome number varying from 80-120 (Joyce *et al*. 2010). Insect pests are a major problem for sugarcane yield loss all over the world. One of the significant pests of sugarcane is Lepidopterous stem borers (Weng *et al.* 2011). The major Lepidopteran insect pests of sugarcane are stem borer (*Diatraea saccharalis*) (Rossato *et al.* 2010), root borer (*Emmalocera depressalis*), sugarcane top borer (*Chilo terrenellus*) (Goebel and Way 2003), pink borer (*Sesamia inferens*) and Maxican rice borer *(Eoreuma loftini).* These borers cause yield losses of nearly 25-30 percent (Kalunke *et al.* 2009), but insect resistant germplasm is not available in the collections all over the world.

Bacillus thuringiensis (*Bt*) is a gram-positive, spore-forming, soil bacterium. During the sporulation time *Bt* produces insecticidal proteins that paralyze the larvae of some harmful insects, including borers, all of which are common plant pests whose infestations produce considerable negative effects on important crops. The insecticidal toxins (*Cry* toxins) of *Bt*, is also known as δ-endotoxins. The *Cry* gene family code for this toxin. *Cry* genes express during the stationary phase of growth. *Cry* proteins constitute 20–30% of the cell dry weight which is usually accumulate in the mother cell. It starts in stage III of sporulation and continuing to stage VII. *Cry* toxin is a simple toxin and it is defined as a monomer or oligomer of a toxic simple protein on the basis of its mode of action (Ibrahim *et al.* 2010). Insect resistance has developed in many crops through the introduction of *B. thuringiensis* crystal protein (*Cry*) gene (Estruch *et al.* 1997). *Bt* gene is now used to develop transgenic insect resistance in many plant crops including brinjal or eggplant (Kumar *et al.* 1998), rice (Ye *et al.* 2003), cotton (Stewart *et al.* 2001), sugarcane (Braga *et al.* 2003), potato (Meiyalaghan *et al.* 2006), chickpea (Sanyal *et al.* 2005), white cabbage (Deng *et al.* 2011), mat rush (Ling *et al.* 2009), and pigeon pea (Sharma *et al.* 2006). Development of insect resistant crop varieties with resistance against insect pests is a very important advantage of genetic engineering in agriculture. The insect resistant crop plants with high productivity are also environmentally safe. For fully acceptance and adaption, insect resistant crops face so many challenges. But insect resistant crops can be commercialized by following biosafety guidelines. There are no strong evidences for any hazards of genetically modified crop plants. By using proper regulatory mechanism transgenic crops can be commercialize and improved (Bakhsh *et al.* 2015). Though there are so many restrictions to commercialize *Bt* transgenic crops, it is increasing rapidly and cultivated in more than 32 million hectares in all over the world. Some countries adopted genetically modified (GM) crops for insect resistance and many other countries are trying to introduce it in the future (Kumar *et al.* 2008). In 1996, transgenic *Bt* maize (corn) were first commercialized in North America (Shelton *et al.* 2002). It was developed to manage both corn borers and corn rootworms and created much interest for corn growers. At present, transgenic cotton and potatoes are available in USA and some other crops including rice, soybeans, broccoli, lettuce, walnuts, apples and alfalfa are being developed. A large number of *Bt* cotton areas were also found in India and China.

Sugarcane is a polyploid crop with a complex genetic make-up. Due to its genetic complexity and long breeding cycle, transgenic technology could be the best method to develop borer resistance in sugarcane. Genetic transformation using *Bt* genes is regarded as an effective method to develop insect-resistant transgenic plants (Valderrama *et al.* 2007; Weng *et al.* 2011). For transformation of the *Bt* gene, the *Agrobacterium*-mediated transformation method was used in this study. Plant transformation by the soil-borne plant pathogen, *Agrobacterium tumefaciens*, has become the most commonly used method for plant transformation (Tripathi 2005). *Agrobacterium* – mediated transgenic plants are generally fertile and the foreign genes are often transmitted to the progeny in a Mendelian manner (Rhodora and Thomas 1996). The development of transgenic crops that produce *Bt* Cry proteins has been a major breakthrough in the substitution of costly and laborious spraying of chemical insecticides with environmental friendly alternatives (Bravo *et al.* 2007).

The present work was carried out through the transfer of an insect resistant *Bt* or *Cry1A*(*b*) gene into a commercial sugarcane cultivar to develop transgenic sugarcane plants using the *Agrobacterium*-mediated transformation method. To determine and compare the expression level of the transgene in each transgenic sugarcane plants, real-time PCR technique was used. This will be important data for green house bio-assay in the future.

MATERIALS AND METHODS

Callus induction and determination of hygromycin concentration for selection

The experiment was conducted in 2015 at the Center for Agricultural Biotechnology, Kasetsart University, Kamphaeng Saen Campus, Thailand.

Unexpanded shoot apices of 5-6 months old sugarcane cultivar LK 92-11 were used as the explants for callus induction (Fig. 1A). The explants were surface sterilized by using 15% commercial bleach for 15 minutes. These were washed with sterile water three times and the most inner young leaves were cut to approximately 0.5 cm each (Fig. 1B) and cultured on MS medium supplemented with 20 g/L sucrose, 7 g/L agar, 3 mg/L 2,4-D and 10% (V/V) coconut water (CW), at 26 ± 1^{o}C in the dark. Calli were sub-cultured at 30 day intervals onto the same medium. After 60 days, embryogenic calli were transferred onto the same medium containing different concentrations of hygromycin (0, 10, 20 and 30 mg/L) to find out the appropriate concentration for the selection of the resistant calli. The calli were sub-cultured on the new selective medium every two weeks. After six weeks of cultivation the appropriate concentration of hygromycin was selected.

Agrobacterim-mediated transformation

Before transformation all big calli were divided into small pieces and cultured on callus induction medium for five days. Each big callus was divided into 6-7 pieces and a total of 100 small pieces of calli were precultured for transformation.

Agrobacterium culture

Agrobacterium tumefaciens strain EHA105 carries the binary vector pCAMBIA1302-Ab possesses *hygromycin phosphotransferase* (*hpt*) and *Cry1A*(*b*) kindly provided by Dr. S. Chanprame was used for transformation. This *Cry1A*(*b*) was isolated and modified from native bacterium found in Thailand. Both genes are under the control of 35SCAMV promoter. The bacterium was cultured in 20 mL liquid LB medium containing 50 mg/L kanamycin (Thai Meiji Pharmaceuticals Ltd., Bangkok, Thailand) at 28^{o} C and shaken overnight at 180 rpm. From this culture again 2 mL of suspension was transferred to 20 mL liquid LB medium containing 50 mg/L kanamycin and 100 µM acetosyringone (SIGMA-ALDRICH, USA) and shaken overnight at 200 rpm.

Infection

After overnight culture, 20 mL of *Agrobacterium* suspension was centrifuged at 6000 rpm for 5 min and the supernatant was discarded. The pellet was re-suspended (by gently pipetting) in 5 mL liquid callus induction medium. Five mL of suspension were transferred into a bottle containing 15 mL liquid callus induction medium (MS+ 20 g/L sucrose, 3 mg/L 2,4-D + 10% (V/V) coconut water (CW) and 100 µM acetosyringone). The precultured calli were immerged in the bacterial suspension and shaken at 120 rpm for 15 min at 26^{o} C. The calli were placed on tissue paper to remove the excess medium and later placed on co-cultivation medium.

Co- cultivation and selection

The infected calli were transferred onto co-cultivation medium (MS+20 g/L sucrose, 7 g/L agar, 3 mg/L 2,4-D, 10% (V/V) CW + 100 µM acetosyringone, pH: 5.7) and kept in the dark for three days. After three days, the calli were washed with liquid MS callus induction medium + 200 mg/L cefotaxime three times to remove most of the bacteria. Then the calli were placed on sterile tissue paper and placed in selective medium (MS+20 g/L sucrose, 7 g/L agar, 3 mg/L 2,4-D, 10% (V/V) CW + 30 mg/L hygromycin, 200 mg/L cefotaxime (Siam Pharmaceuticals Co. Ltd., Bangkok, Thailand), pH: 5.7). Every two weeks, the calli were washed one time with liquid MS+300mg/L cefotaxime and subcultured on the same medium. Then, after six weeks of selection the live calli were transferred onto regeneration medium.

Plant regeneration

The putative transformed calli were transferred to regeneration medium (MS+20 g/L sucrose, 7 g/L agar + 30 mg/L hygromycin, 200 mg/L cefotaxime, pH: 5.7) until the shoots were visible. After 60 days of sub-culturing the putative transgenic shoots were transferred to the rooting medium (MS+20 g/L sucrose, 7 g/L agar, 5 mg/L NAA+ 30 mg/L hygromycin, 200 mg/L cefotaxime, pH: 5.7). After 60 days of growth in the culture medium, the plants were transferred into pots with a soil-pertile mixture (1:1 ratio).

Confirmation of the existence of the transgenes by PCR technique

Transgenic plants were confirmed by using the **p**olymerase chain reaction (PCR). Phire Plant Direct PCR Master Mix (Thermo Scientific, Lithuania) was used as the PCR master mixture. This master mix is designed to perform PCR directly from different plant material without prior DNA purification. A small piece of three months old putative transgenic sugarcane leaf (approximately 2 mm in size) was taken and placed in 20 µL of dilution buffer (supplied by manufacturer), the leaf sample was crushed with a pipette tip, by pressing briefly. The plant material was centrifuged and used 0.5 µL of the supernatant as a template. In a 20 µL PCR reaction mixture containing 10 µL 2X Phire Plant Direct PCR Mix, 0.2 µl (10 µM) of each *hpt* (*hygromycin phosphotransferase*) forward primer (5'-CCTGAACTCACCGCGACG-3') and reverse primer (5'-AAGACCAATGCGGAGCATA TA -3'), 0.5 µL of template and 9.1 µL distilled water. The same master mix was also made with 10 µM *Cry1A*(*b*) for both forward (5'-CATGGACAACAACCCAAACATCAACG-3') and reverse primer (5'-GTCACCTTGCTACCGAAAGTCCTCGTT-3'). For both sets, primer PCR conditions were one cycle of initial denaturation at 98^o C for 5 min, followed by 40 cycles of denaturation at 98^o C for 5 sec, annealing at 62^o C for 5 sec and an extension at 72^o C for 20 sec, followed by a final extension at 72^o C for 1 min. This analysis was conducted by using BIO-RAD T100™ Thermal Cycler, USA. After that the PCR amplified products were electrophoresis on 1% agarose gel at 50 V for 60 min.

Southern blot analysis

Genomic DNA was extracted from young leaves of transgenic and untransformed control sugarcane plants by using the modified DNA extraction methods described by Aljanabi *et al.* (1999). Then genomic DNA (50 µg per reaction) from each plant was digested with *Nco*1 restriction enzyme for 16 hr. Next the DNA was transferred, by capillary transfer (Sambrook and Russell, 2001) onto a positively charged membrane (Amersham Hybond™ -N$^+$, GE Healthcare, UK). The PCR amplified gene probe (900 bp) of *Cry1A*(*b*) labeled with DIG-dUTP (Roche Diagnostics, Germany) was used in the hybridization. Pre-hybridization and hybridization was done by using the standard protocol (Sambrook and Russell, 2001). After 16 hr of hybridization the membrane was washed with different concentrations of saline sodium citrate (SSC) buffer (2x, 1x and 0.5x SSC). The membrane was transferred into a plastic bag containing 15 ml blocking solution (10x blocking reagent:maleic acid buffer=1:9) with 1 µL (0.75U/µL) of anti Digoxigenin-AP Fab fragments (Roche Diagnostics, Germany), sealed and shaken for 30 min. Then the membrane was washed twice with washing buffer (1x maleic acid and 0.3% tween 20) for 30 min. After washing the membrane was exposed to X-ray film (Kodak medical X-ray film, USA) for 15 min. The film was transferred to a box containing developing solution for 1-2 min. When the DNA band was visible the film was immediately transferred to a box containing fixing solution for 1-2 min and air dry the film for 10-15 min at room temperature.

Determination of expression levels of *Cry1A*(*b*) in transgenic sugarcane

Total RNA was extracted from young leaves (0.1 g) of 3 months old sugarcane by using the method described by Laksana and Chanprame (2015). The concentration of total RNA was measured by using Nanodrop™ and adjusted to 1500 ng/µL. The extracted total RNA was used for synthesis of 1st strand cDNA. The reaction mixture contained 1 µg of total RNA, 2 µg Oligo (dT) primer (IDT, Singapore), 0.8 mM dNTP (Thermo Scientific, Lithuania). RNase free water was added to make the volume 12.5 µL and mixed gently. The reaction was incubated at 65º C for 5 min and then cooled at 4º C for at least 2 min. Then 1x reaction buffer, 0.5 unit RiboRock RNase inhibitor (Fermentas, Lithuania), 1mM dNTP and 1µL Revert Aid M-Mul VRT (Fermentas, Lithuania) was added to the reaction mixture tube and mixed gently, incubated at 42º C for 1 h and the reaction was stopped at 70º C for 10 min, then cooled at 4ºC for at least 5 min. RNaseH (0.2 µL) was added for removal of the remaining total RNA. The specific primers for *Cry1A*(*b*) gene (AY742219.1) were designed by using the primer3 program (http:// simgene.com/Primer3) (Table 1). The product size was about 200 bp. For real-time PCR, in 20 µL reaction mixture containing 100 ng of cDNA, 10 µL 2X SensiFAST SYBR No-ROX mix buffer (Bioline Reagent Ltd. USA) and 0.8 µL of 10 µM forward and reverse primers specific to *Cry1A*(*b*) and *Actin* genes (Table 1). The amplification of both genes was performed by using the following condition: preliminary denaturation at 95º C for 2 min, 45 cycles of denaturing at 94º C for 15 sec, annealing at 58º C for 15 sec and an extension at 72º C for 20 sec. This analysis was conducted by using Mastercycler® ep realplex4 (Eppendorf). The expressions of *Cry1A*(*b*) in transgenic sugarcane were compared with the control sugarcane (non-transgenic). *Actin* was used as a reference gene. Three replications of each sample were used in this experiment.

Table 1. Primers for amplifying *Cry1A*(*b*) gene and *Actin*

Remarks	Primers	Sequence
For amplifying partial	Partial *Cry1A*(*b*) F	5'-CTCCACAACAACGCATCGTC-3'
Cry1A(*b*)	Partial *Cry1A*(*b*)R	5'-GTAGGCGAACTCAGTGCCAT-3'
For amplifying *Actin*	*Actin*F	5'-GAGAGGGGTTACTCCTTC-3'
	ActinR	5' - CTCTTTTCAACTGAGGAGCT-3'

RESULTS AND DISCUSSION

Plant transformation and regeneration

In this study, sugarcane callus was used as transformation material for the *Agrobacterium*-mediated transformation (Fig. 1C). Prior to transformation, the calli were subjected to different concentrations (0, 10, 20 and 30 mg/L) of hygromycin (Fig. 2A). At 30 mg/L of hygromycin all the non-transformed sugarcane calli died within 6 weeks and this concentration of hygromycin was selected and added in the growth medium (Fig. 2B). Dongting *et al.* (2007) used 30 mg/L hygromycin in the selection media during *Agrobacterium*-mediated transformation in sugarcane. Arencibia *et al.* (1998) used 25 mg/L hygromycin as the selection pressure in sugarcane transformation. Subramanyam *et al.* (2011) used a 30 mg/L hygromycin in banana, as well as in oil palm (Surrerat and Sompong 2012).

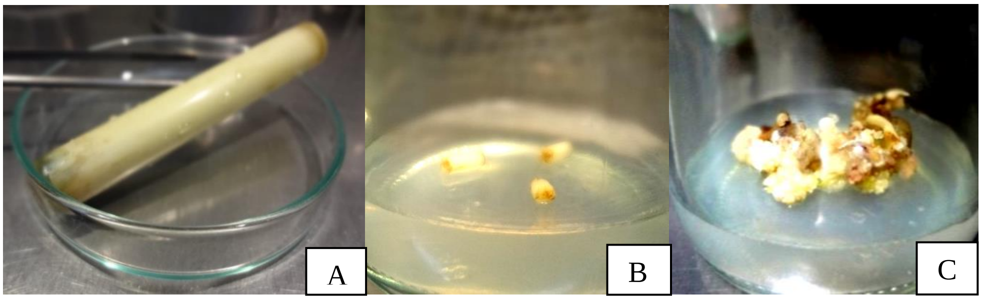

Fig. 1. Callus induction from sugarcane leaf. A) A section of unexpanded young leaf B) Pieces of inner most leaf C) Callus initiated from a piece of inner most leaf

During infection, 100 µM acetosyringone was added to the infection medium, because it increases the transformation efficiency. *Agrobacterium* culture supplemented with an appropriate concentration of antibiotic and 100 µM acetosyringone increased the transformation efficiency in monocot (Southgate *et al.* 1996).

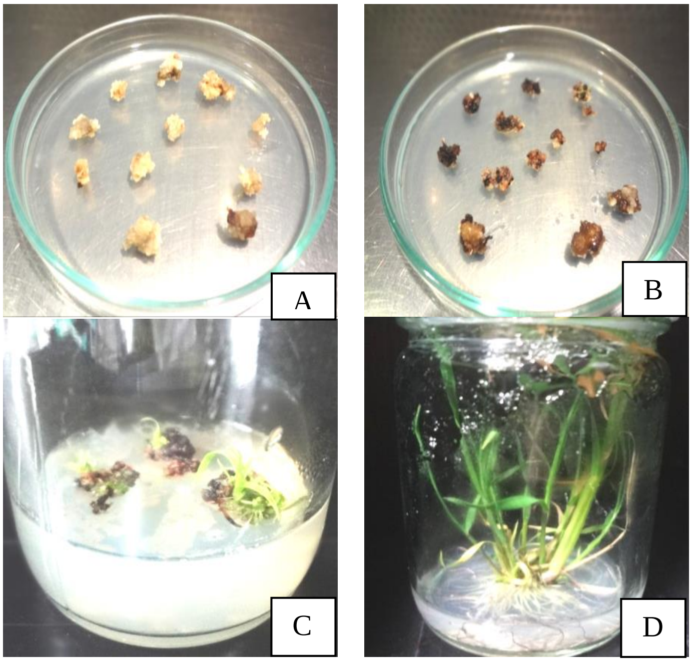

Fig. 2. Selection of putative transgenic sugarcane. A) Sugarcane calli on selective medium, B) After six weeks of selection, C) Putative transformed calli and shoots on shooting medium, D) Regenerated plants on rooting medium.

After transformation, regeneration efficiency was good in sugarcane. All of the selected calli developed shoots after 60 days on shoot induction medium (Fig. 2C). The plantlets were transferred to rooting medium and within 30 days these produced roots (Fig. 2D). Twenty plants were regenerated from 20 transformed calli giving a 100% regeneration. Among these, 16 plantlets showed PCR positive for *hpt*. The transformation efficiency for *hpt* was 80%. Seven out of 16 plantlets showed PCR positive for both *hpt* and *Cry1A*(*b*) gene, with a co-transformation efficiency of both genes of about 43%. These were transferred to soil and finally four plants survived (Fig. 3).

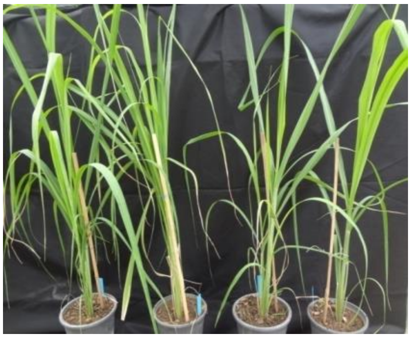

Fig. 3. The 3 months old transgenic sugarcane plants in pot

PCR for confirmation of transgenic plants

Putative transgenic sugarcanes were confirmed by using polymerase chain reaction (PCR). The 0.5 µL of Thermo Scientific Phire Plant Direct PCR Master Mix containing crude extract of sugarcane leaves was used as the template for determination of *Cry1A*(*b*) gene. The expected size of the positive PCR product is 2500 bp. It was found that all plants showed 2500 bp of *Cry1A*(*b*) gene (Fig. 4). Wang *et al.* (2005) reported that the efficiency of *Agrobacterium*-mediated transformation to produce PPT-resistant sugarcane was 30% as detected by PCR.

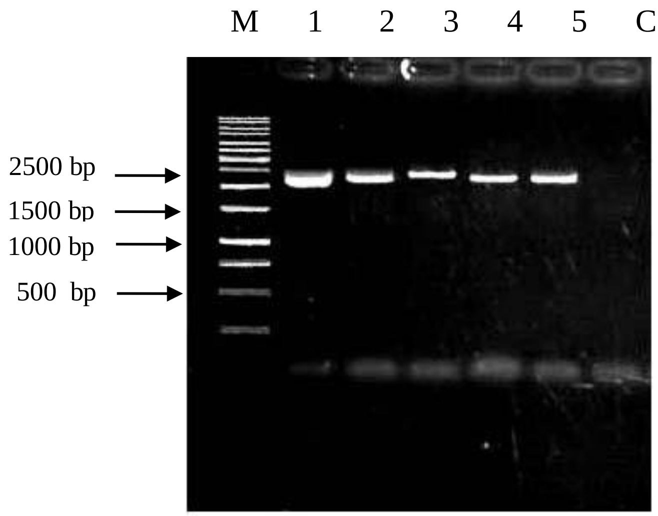

Fig. 4. PCR analysis of putative transgenic sugarcane plants. Lane M: GeneRular™ 1 Kb DNA ladder (Fermentas), lane 1: positive control, pCAMBIA1302-Ab, lane 2-5: *Cry1A*(*b*) gene from 4 independent transgenic sugarcane plants and lane c: non-transgenic sugarcane plants.

Southern blot analysis

Southern blot analysis was done in 4 *Cry1A*(*b*) PCR positive plants. The genomic DNA (50 μg) of 4 PCR positive plants, untransformed control plant and pCAMBIA1302-Ab were digested with *Nco* 1 restriction enzyme. A *Cry1A*(*b*) probe (900 bp) was used for detection of the transgene. It was found that three transgenic plants (lane 1-3) showed two copies of the gene integration and one transgenic plant (lane 4) showed a single copy of gene integration (Fig. 5).

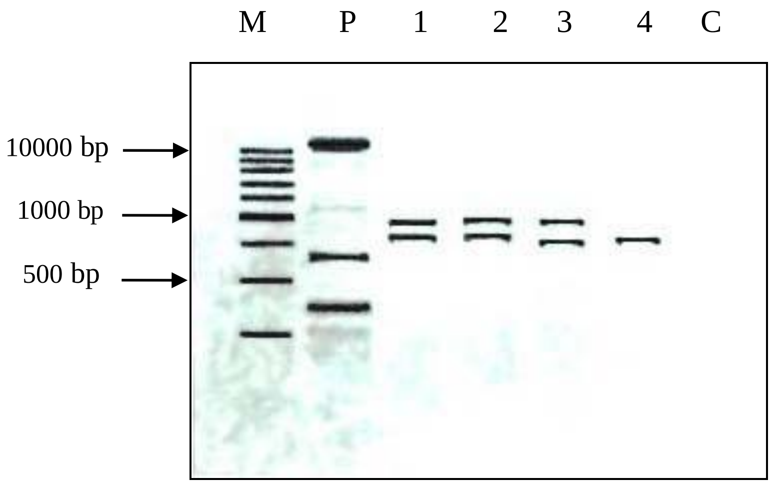

Fig. 5. Southern blot analysis of transgenic sugarcane plants. Lane M: GeneRular™ 1 Kb DNA ladder (Fermentas), lane P: positive control (pCAMBIA1302-Ab), lane 1-4: 4 independent transgenic sugarcane plants, lane C: Untransformed plants.

The bands indicate the integration of *Cry1A*(*b*) gene into the genome of the transformed sugarcane plants, whereas the untransformed plant did not showed any integration of the transgene. In sugarcane, using the *Agrobacterium*-mediated transformation method one to three copies of transgene integration were described by Kalunke *et al.* (2009).

Cry1A(*b*) expression analysis in transgenic sugarcane plants

The transcriptional expression levels of *Cry1A*(*b*) gene in four transgenic sugarcane plants were determined by using real-time PCR. It was found that the transcriptional levels of the transgene were higher in all transgenic plants compared to the control sugarcane plant (non-transgenic) (Fig. 6). Real-time PCR is a high-throughput method for quantifying transgene expression in transformed plants as Toplak *et al.* (2004) who reported that some transgenic lines of potato and tobacco showed high transgene expression in real-time PCR analysis.

Among the 4 transgenic plants, plant no. 4 showed 6-19 times higher *Cry1A*(*b*) gene expression compared with the others. The expression of th e gene in this plant was about 160 times higher than the untransformed plant. In Southern blot analysis, this plant showed a single gene insertion. Gene expression level is negatively correlated with copy number of the inserted gene. More than one copy of gene insertion creates co-suppression during gene expression. In tobacco, gene expression reduced with the increment of copy number of the integrated gene (Allen *et al.*, 1996; Gang *et al*., 2002). Rao *et al.* (2013) also studied the copy number of transgene in transgenic tobacco and its impact on expression level. Expression in line QCC11 having two copies of transgenes was high while the least expression was seen in lines QCC10 showing three copies of gene. The *Agrobacterium*-mediated transformation process is suitable for sugarcane. *Agrobacterium* transformation of plants has a high frequency of single gene insertion. The insertion of fewer gene copies targeted into transcriptionally active regions in the plant genome and with fewer truncated gene introductions currently makes *Agrobacterium*-mediated gene transfer a promising method for introducing agronomic genes into sugarcane (Grevelding *et al.* 1993).

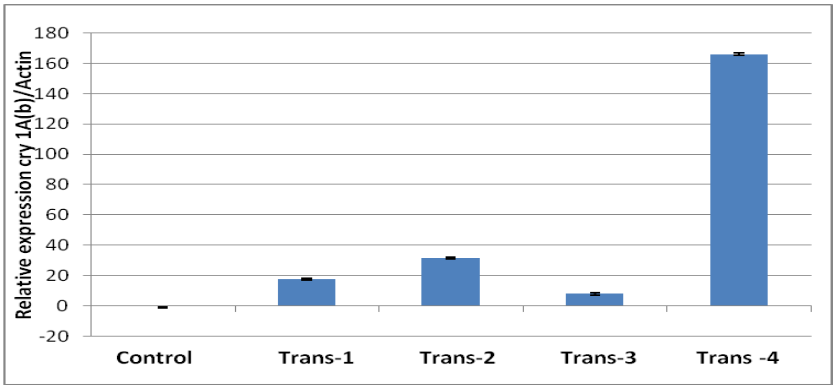

Fig. 6. Expression levels of *Cry1A*(*b*) gene in 4 transgenic sugarcane plants (3 months old) compared with control (untransformed) sugarcane plant.

CONCLUSION

Sugarcane is a very important economic crop in tropical and subtropical regions of the world. The transformation of the *Cry1A*(*b*) gene will be one of the efficient approaches to control the stem borer infestation. *Agrobacterium*–mediated transformation method was found suitable for sugarcane cultivar LK 92-11. During transformation 100 µM acetosyringone was used. As a selection pressure 30 mg/L hygromycin was used. This concentration may be used as suitable selection pressure for further transformation of sugarcane. We found 80% transformation efficiency of the *hpt* gene and 43% for co-transformation of *hpt* and *Cry1A*(*b*) gene. The transformed plants also showed a high expression of the transgene compared to the control, in real-time PCR analysis. Southern blot analysis showed one to two copies of gene integration in the selected transgenic plants. The method described here could be used as an efficient approach for gene transformation in sugarcane. Due to the *Cry1A*(*b*) gene was isolated from native bacterium, this will make *Cry1A*(*b*) gene is more specific to insect pest of sugarcane in Thailand. This data will be important for bio-safety procedure in greenhouse bio-assay in the future.

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STRATEGY PRIORITIZATION FOR SUSTAINABLE TOURISM IN BALI, INDONESIA: FOCUSING ON LOCAL AGRICULTURAL PRODUCTS ANALYTICAL HIERARCHY PROCESS (AHP) APPROACH

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ABSTRACT

The role of local agricultural products to support sustainable tourism in Bali is really important. This study was undertaken to ascertain the priority strategy that need to be implemented based on the criteria of sustainable tourism through optimizing the use of local agricultural products to reduce tourism leakage in order to be able to support sustainable tourism in Bali. Analytical Hierarchy Process (AHP) was undertaken which is a method to solve a complex situation which is not structured into several components in a hierarchical arrangement, by giving the subjective value of the relative importance of each variable, and specify which variable has the highest priority in order to affect the outcome of the situation. The study was conducted to analyze the priority strategy based on eight experts' opinion which was conducted in Bali Province during the period of July up to October 2014. Seven criteria were constructed based on the basic concept of sustainable tourism namely economically viable, socially and culturally acceptable and environmentally friendly and eight alternative strategies were formed. The results show that the most important strategy was to develop agriculture, livestock, fisheries and handicrafts. The following recommended strategy was to optimize the potential of local product, and to empower the community.

Key words: leakage, linkage, community

INTRODUCTION

Tourism is one of the fastest growing industries in the world in terms of generating incomes, foreign exchange earnings and creating job opportunities. It has been predicted by the World Tourism Organization that 1.6 billion people will be travelling internationally by the year 2020 and spending more than US$ 2 trillion annually or US$ 5 billion everyday (Theobald 2005). This potential growth result in rapidly expanding development of destinations. As more governments recognize the important role of tourism, governments rapidly develop their tourism potential to meet demand of tourists. Tourism in the rural areas of developing countries is also rapidly expanding and is often a primary means of income in these areas. However, high levels of leakage dramatically reduce the economic impact of tourism (Lacher and Nepal 2010). In general, tourism leakage is the part of tourist expenditure which occurs when the industry imports both products and services for support. It occurs when tourists demand standards of equipment, food, and other products that cannot be supplied by the host country (UNEP 2010).

This condition has also happened in the development of tourism in Bali. Even though tourism has brought about development for Bali's economy for many years, the economic impacts of tourism development have not been fully beneficial for the Balinese community. Tourism leakage limits the positive impact of tourist expenditure on a destination (Bull 1991; Lundberg et al. 1991). The import leakage from tourism in Bali was estimated to be about 40% for international standard hotels, based on the Nusa Dua Project in 1977 (Rodenburg 1980).

Tourism leakage occurred on four types of accommodation in Bali. The results by micro analysis (industrial level) were as follows: (i) leakage of 4,5 star-rated chain hotels was 51.0%, (ii) leakage of 4,5 star-rated non-chain hotels was 22.7%, (iii) leakage of 1,2,3 star-rated hotels was 12.0%, and (iv) leakage of non star-rated hotels was 8.8%. Meanwhile, calculation of tourism leakage based on macro analysis by using Social Accounting Matrix (SAM) shows that: (i) leakage of 4 and 5 star-rated chain hotels was 55.3% (ii) leakage of 4 and 5 star-rated non-chain hotels was 7.1%, (iii) leakage of 1,2and3 star-rated hotels was 15.7%, (iv) leakage of non-star rated hotels was 2.0%, and (v) average leakage of all types of hotels was 19.5% (Suryawardani, 2014). The main sources of tourism leakage on accommodation in Bali are imported beverages and foods, online booking fees, management fees and profit transfer to overseas (Suryawardani 2014). Wiranatha and Suryawardani (2014) proposed some strategies to minimize tourism leakage in Bali, namely: (i) optimization of the potential of local products; (ii) development of agriculture, livestock, fisheries and handicraft industry; (iii) empower communities; (iv) reduce the use of imported products for tourists; (v) urge government to develop and implement supporting policies in order to minimize leakage; (vi) establishment of international trade policy that reduces import and increases export of local products; (vii) establishment of policy on restriction of foreign investment on accommodation sector in Bali; and (viii) facilitation of public-private partnership on investment in tourism. However, among these strategies, the identification of the priority strategy that needs to be implemented, has not been undertaken so far.

This study was therefore undertaken to ascertain the priority strategy that needs to be implemented based on the criteria of sustainable tourism - economically viable, socially and culturally acceptable and environmentally friendly - through optimizing the use of local agricultural products to reduce tourism leakage in order to be able to support sustainable tourism in Bali.

LITERATURE REVIEW

Sustainable tourism approach in tourism development

Sustainable tourism includes three main aspects, namely: sustainability, education and local participation. The aspect of sustainability should cover four dimensions, namely economically viable, environmentally friendly, socially responsible and culturally acceptable. Economical viability refers to a level of economic gain from the activity sufficient either to cover the cost any special measures taken to cater for the tourist and to mitigate the effects of tourist's presence or to offer an income appropriate to the inconvenience caused to the local community visited-without violating any other conditions-or both. Environmentally friendly measures avoid or minimize the enviromental impact of tourist activities. Social responsibility is the ability of the community to absorb input, such as extra people, for short or long periods of time, and to continue functioning either without the creation of social disharmony as a result of these inputs or by adapting its functions and relationships, so that the disharmony created can be alleviated or mitigated. Cultural acceptability is the ability of people to retain or adapt elements of their culture which distinguish them from other people. Cultural impacts are easily seen over the long term and are therefore more difficult to measure, although the cultural subversion of many local communities are well documented (Moffat 1993 in Wiranatha, 2001).

In regards with tourism development, all of those dimensions should be coherent each other, to ensure quality, continuity and balance between the needs of tourism, protection of the environment and prosperity for the local community. The economic benefits of tourism should be beneficial not only for the companies concerned but also for the local communities as the host. The business entity coordinates stakeholders' interests, instead of maximizing shareholder (owner) profit, in order to achieve quality, continuity and balance. Good qualityinvolves providing a quality experience for the visitor, while improving the quality of life of the host communities and protecting the environment. Continuity ensures the supply of the natural resources and the continuity of the culture of the host community with satisfying experiences for visitors. Sustainable tourism balances the needs of tourism industry, the natural environment and the local communities. Sustainable tourism emphasizes mutual goals and cooperation among visitors, host communities and destination, in contrast to more traditional approaches to tourism which emphasize their diverse and conflicting needs (UNWTO, 2010).

Challenges of local agricultural products in sustainable tourism

The tourism industry involves linkages between stakeholders within destinations. The expansion of local linkages represents the increase of usage of other sectors at the destination which stimulates the economy as a whole and creates synergy effects between different sectors of the economy. The concept of local linkages has been defined generally as the mechanisms through businesses built with residents in their local economy (Pattullo 1996). The linkage between tourism and the local agricultural sector benefits from each other's activities (Ashley *et al.* 2002). In many destinations, local linkages failed due to numerous challenges that confront the tourism industry, such aspoor infrastructure, product development and management, marketing, linkages within local economy, institutional and technical capabilities, and skilled personnel (Mitchell 2006). Hotel-generated importations in many resorts were due to the lack of ability of the local economy to meet, among others, the hotel demands (Driscoll 2005; Momsen 1973; Meyer 2007).

Demand for local foodstuffs can be influenced by characteristics of hotels, maturity of the tourism industry, types of tourists, promotion of local foods, food safety, training and nationality of chefs, seasonality of tourism, informal nature of smallholder suppliers (Torres and Skillicorn, 2004). Large size and high class hotels owned and/or managed by foreigners are less likely to source their food items locally; compared to the smaller and lower class hotels owned by locals (Belisle 1983). (Meyer 2010; McBain 2007). Similarly, mass tourism requires bulk supplies of foods which are more likely to be sourced through imports. Moreover, enclave tourism has the least contribution to local economy as compared to the rest of travel modes as most establishments offering the former kind of tours tend to import more (Anderson et al. 2009); Anderson 2010). Some tourists are conservative with the types of foods that they are familiar with (Pattullo 1996; Torres and Skillicorn 2004). In order to create linkages between tourism and local suppliers of local agricultural products, foods must be produced in a safe, sanitary and healthy environment that ensures high quality food product. This adds to the barriers that constrain the creation of linkages between the tourism industry's demand for foods and local agricultural production (Ashley et al. 2006; Pattullo 1996). On the other hand, in ecotourism, culture and community tourism, the tourists are more likely to use locally produced food stuffs as part of their experience (McBain 2007). Tourist's food consumption and preference do not necessarily represent a significant obstacle to promote linkages between the local agricultural sector and the tourism industry (Torres 2002). The more tourism industry matures with a high number of tourism arrivals, the more likely to import food. This viewpoint is more applicable in small islands that lack adequate land resources and capacity to feed both locals and visitors.

Tourism leakage tends to be highest when the local destination economy is weak and lack quantity and quality of inputs for the tourism industry (Hemmati and Koehler 2008; Meyer 2007; Torres 2003). A prevailing trend in many developing countries depends heavily on imports. Hence, optimizing the use of local agricultural products gives more benefits for local people (Bull 1991).

Although it is argued that the tourism industry is well positioned to create high direct, indirect and induced economic impact, several authors have reported that multiplier effects of tourism are often considerably less than expected due to high investment costs and leads to a high dependency on foreign capital, skill, and management personnel, as well as import (Pavaskar 1987). Import content and the size of the tourism multipliers were inversely related, countries with high leakage rate tend to end up with small multipliers and relatively insignificant effects from tourist spending (Karagiannis 2004). First, small economies, in particular small island developing states, tend to rely strongly on imports, because they do not have the capacity to produce the goods and services that are required to meet the demands of the industry. Larger states, on the other hand, that do not often face these resource constraints can develop stronger inter-sector linkages between tourism and the rest of the domestic economy. Second, many developing countries do not have well-developed domestic industries and need to develop stronger inter-sector linkages within the economy.

Leaks out of the destination economy depend in large part on how the tourist receipts are re-spent within the economy (Lundberg *et al.*, 1991). The more receipts re-spent within the local economy, so that the smaller the leakage and the higher the multiplier. Rapid tourism development in developing country is often accompanied by a drastic rise in leakage (Unluonen et al. 2011). This can be minimized through promotion of local ownership, encouraging greater joint ownership between local and international investors and strengthening inter-sector linkages as it would play a key strategic role in reducing economic leakage since increase in linkages could reduce import content by substituting foreign imports of goods and services with locally-produced supplies (Torres 2003).Prospects for strengthening linkages by reducing tourism leakages, will depend on the capacity to overcome a number of structural challenges namely low total factor productivity, high tariff dispersion and trade costs, weak investment locally, weak public institutions and inefficient governance structures (Hemmati and Koehler, 2008). This results in relatively higher production costs, and creates a disincentive to use locally produced goods and services in national tourism sectors. High tariff dispersion and trade costs affects the supply of goods and services. All of these factors have operated to limit growth or cause decline of agricultural, manufacturing and financial services sectors. At the same time, these factors have not encouraged the development of service sectors of great potential such as the creative industries, performing arts and crafts. On the assumption that such structural challenges can be addressed, the issues of leakages and linkages could be resolved by the development of a tourism-based full-service economy. Improved linkages can be realized through strategies for strengthening the current tourism value chain, as well as through the addition of new services, technologies, and public-private partnerships and investments (Pattullo 1996).

Expanding the competitiveness services sector beyond tourism is a way to draw in the strengths of tourism industry while creating more sustainable economic growth (Andriotis 2002). Promotion of agro-tourism linkages is one of the potential strategies. Tourism-specialized agriculture must be able to produce quality highly-valued commodities (Cai et al. 2006) as well as regional handicraft producers and artisans. An appropriate environment to promote private sector participation, through public sector investment in infrastructure and human resources and an effective and efficient regulatory policy framework is critical to achieve these benefits

Analytical Hierarchy Process (AHP)

AHP is a method to solve a complex situation which is not structured into several components in a hierarchical arrangement, by giving the subjective value of the relative importance of each variable, and specify which variable has the highest priority in order to affect the outcome of the situation (Saaty 2005). AHP aims to analyze all alternatives in an effective decision making process by selecting the best alternative which have been undertaken through structuring of problems, determination of alternatives and values, requirement of preferences with respect to time, and specifications for the risk. It seeks to have a functional hierarchy with the main input of human perception, thus complex and unstructured problems can be solved into groups and is constructed to form a hierarchy (Saaty 2005; Eriyatno 2012; Eriyatno and Larasati 2013). In this research, AHP is undertaken to choose the priority of strategies to optimize the use of local agricultural products to minimize tourism leakage in order to support sustainable tourism in Bali. Expert choices are used to systematically analyze and as a consideration in evaluating a complex decision in order to organize estimation and intuition into a logic form.

Basic Principles of AHP

To make a decision in an organised way to generate priorities, Saaty (2008) suggests to decompose the decision into the following steps:

a. Define the problem and determine the kind of knowledge sought.
b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
d. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained (Saaty 2008).

METHODOLOGY

Respondents

A survey was undertaken in Bali Province from July to October 2014. Information used in this method was gained from respondents' opinion, as the main purpose of AHP is to have a functional hierarchy with the main input of human perception. Respondents in this research were experts who understood linkages between tourism and agriculture. There was no requirement regarding the number of experts involved in this model (Hendry 2013; Saaty 2005) as long as they have knowledge and in-depth understanding. Eight respondents were chosen as they were experts, namely: government official (1), tourism stakeholder (1), community leader (1), and academia (5). To limit bias as the expert size was too small, some efforts were undertaken, *ie*., (1) Respondents were chosen carefully for their good understanding of the topic of the research, (2) Comprehensive and structured questionnaires were designed carefully, (3) Respondents were assisted by giving clear explanation for every question to contol consistency of the answer and (4) in-depth interview was undertaken to get knowledge and experience of the experts.

Data analysis

AHP computer program was undertaken to choose the priority of strategy to optimize the use of local agricultural products in order to support sustainable tourism in Bali.

Structural Hierarchy

In AHP analysis, a structural hierarchy was constructed based on criteria and alternative strategies. The criteria was based on the concept of sustainable tourism (Table 1). Alternative strategies were developed based on the work of Wiranatha and Suryawardani (2014) (Table 2). The structural hierarchy is shown in Figure 1.

Table 1. Criteria of model of selection of priority strategy on the role of local agricultural products to support sustainable tourism in Bali

Criteria	Remarks
A	Community Based Tourism
B	Increase Provincial Income
C	Import Substitution
D	Foreign Tourist Interests
E	Availability (quantity, quality and continuity).
F	Socially and culturally acceptable
G	Environmentally friendly

Table 2. Alternative strategies for model of selection of priority strategy on the role of local agricultural products to support sustainable tourism in Bali

Alternative	Remarks
A	To optimize the potential of local products
B	To develop agriculture, livestock, fisheries and handicraft
C	To empower the community
D	To empower the community leaders
E	To empower the community organizations
F	To develop policy in reducing import and increase export of local products
G	To restrict new accommodation development in order to prevent agricultural land use change.
H	To facilitate public-private partnership investment

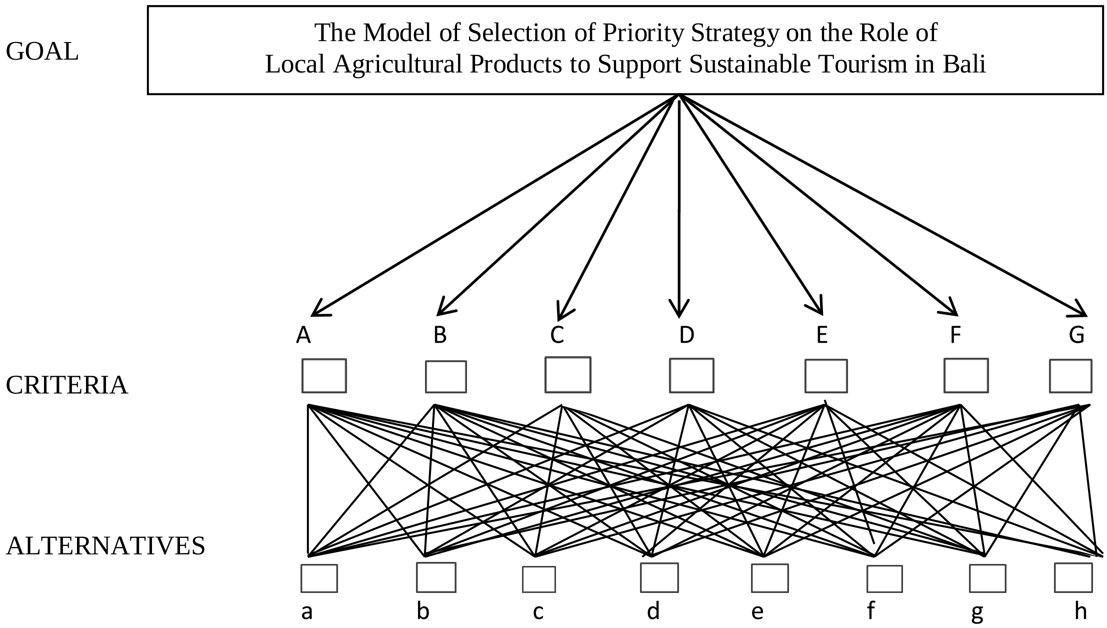

Fig. 1. Structural hierarchy model of priority strategy on the role of local agricultural products to support sustainable tourism in Bali.

Community (C) is the whole local people in destination, community leader (D) are the leaders who are in charge of managing destination and community organization, (E) are varieties of local organization. In Bali, there are a lot of traditional organizations which are in charge of managing the tourism industry developed by the local Balinese community, such as the traditional water supply organization called "subak", as well as farmer groups, buyers groups, security groups, etc which are managed traditionally based on the collaboration group systems which is very famous in Bali.

Comparative Judgment

Comparative judgment was undertaken based on experts' judgment about the relative importance of two elements at a certain level in relation to element at the top level. This assessment is the core of AHP and it affects the order of priority of its elements. Assessment indicates the scale of interest which result in assessment in numeric scale. The seven criteria were compared based on the intensity of interest and were constructed to become a pairwise matrix which result in a priority scale when it was combined. Pairwise Matrix allows different criteria of the different alternatives to be considered. This makes a powerful technique to analyze each criteria and between single criteria for assessing alternatives. Priority determination in this research was assessed based on the intensity of the value (Saaty 2005). Preference scale of 1 to 9 was used in this research, where 1 indicates the lowest interest rate (equal importance) and scale 9 shows the highest level of importance, and ½, etc. indicate intensity of the value is reversed (Table 3).

Table 3. Intensity scale of importance of criteria and alternatives

Intensity of the Value	Remarks
1	Both of elements are equally important
3	One element is slightly important than the other element
5	One element is more important than the other element
7	One element is clearly more important than the other element
9	One element is absolutely more important than the other element
2,4,6,8	Values between the two values have considerations of adjacent
½, 1/3.etc.	Intensity of the value is reversed

Logical Consistency

The eigenvector is calculated, showing a list of the relative weights, importance or value of the factors which are relevant to the problem. The final stage is to calculate a Consistency Ratio (CR) to measure how consistent the judgments have been relative to large samples of purely random judgments. Acceptable level of inconsistency is under 10%. If the value of the consistency ratio (CR) is ≤ 0.1 (10%), the comparison of preferences is consistent and vice versa. If it is not consistent, then there are two options, namely: (i) repeat the comparison preference; or (ii) do auto correction process (Eriyatno and Larasati 2013).

RESULTS AND DISCUSSION

Important criteria of the role of local agricultural products

Based on the AHP, the results of the expert survey showed that "community based tourism" was the priority criteria which means that development of tourism should give economic benefits for Balinese community. The second criteria was "increase in provincial income of Bali Province" reflecting a need to increase economic benefits for the local community, thereby contributing to increased income (Fig. 2).

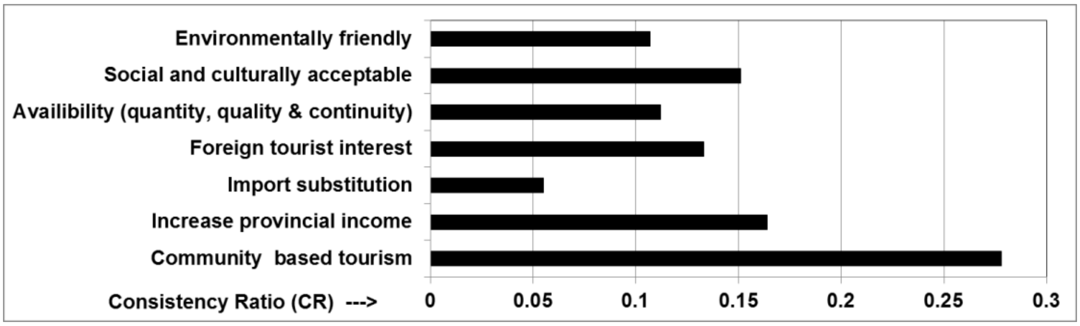

Fig. 2. Priority criteria of the role of local agricultural products to support sustainable tourism

Priority strategies for the role of local agricultural products to support sustainable tourism in Bali

Priority Strategy based on the Criteria Community Based Tourism

Priority strategy based on the criteria "Community Based Tourism" shows that the most important strategy was to empower the community, followed by to optimize the potential of local product and to develop agriculture, fisheries and handicraft. Inconsistency ratio was 0.04 (under 0.1), indicating that the comparison of preferences were consistent (Fig. 3).

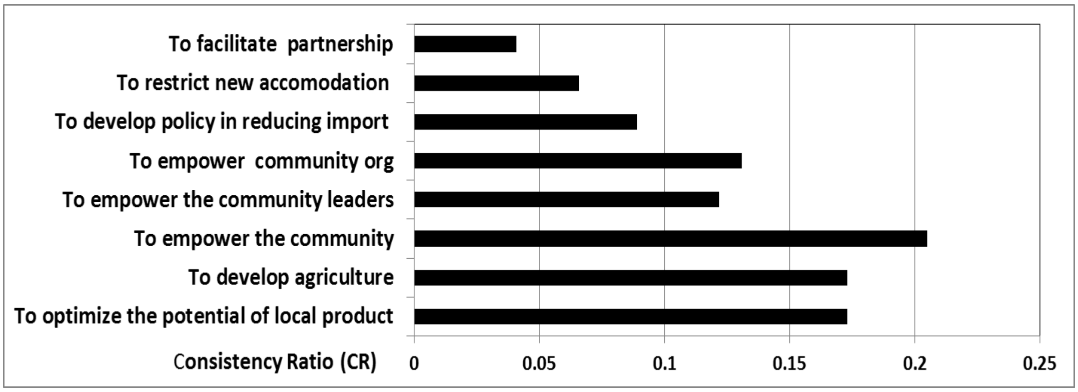

Fig. 3. Priority strategy based on the community based tourism criteria

Priority Strategy based on the Criteria Increase Provincial Income

The priority strategy based on the criteria "Increase Provincial Income" was to optimize the potential of local products, followed by to develop agriculture, livestock, fisheries and handicraft and to develop policy in reducing import and increase export of local product. Inconsistency ratio was 0.02 (under 0.1), indicating that the comparison of preferences were consistent (Fig. 4).

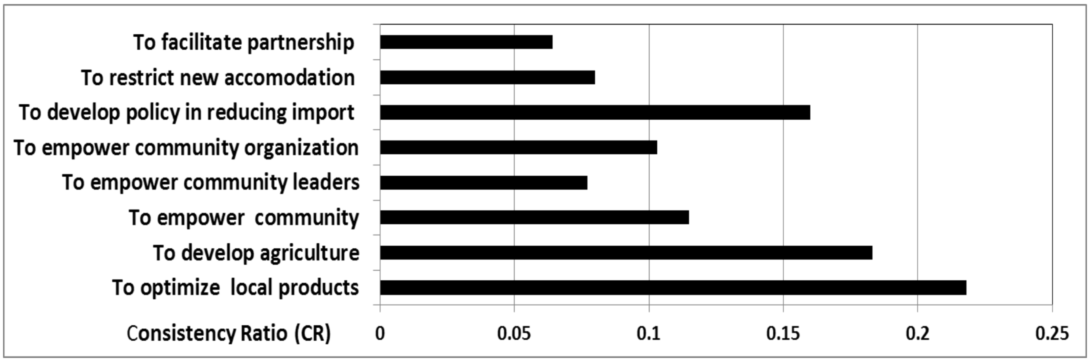

Fig. 4. Priority strategy based on the increase provincial income criteria

Priority Strategy based on the Criteria Import Substitution

The priority strategy based on the criteria of "Import Substitution" was to develop agriculture, livestock, fisheries and handicraft, followed by to develop policy in reducing import and increase export of local product and to optimize the potential of local product (Fig. 5).

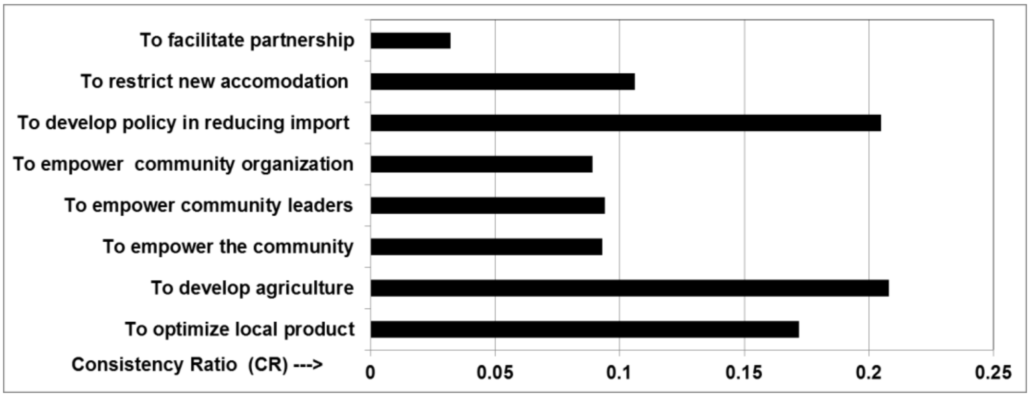

Fig. 5. Priority strategy based on the import substitution criteria

Priority Strategy based on the Criteria Foreign Tourist Interests

The priority strategy based on the criteria of "Foreign Tourist Interests" was to develop agriculture, livestock, fisheries and handicraft, followed by to optimize the potential of local product, and to empower the community organization (Fig. 6).

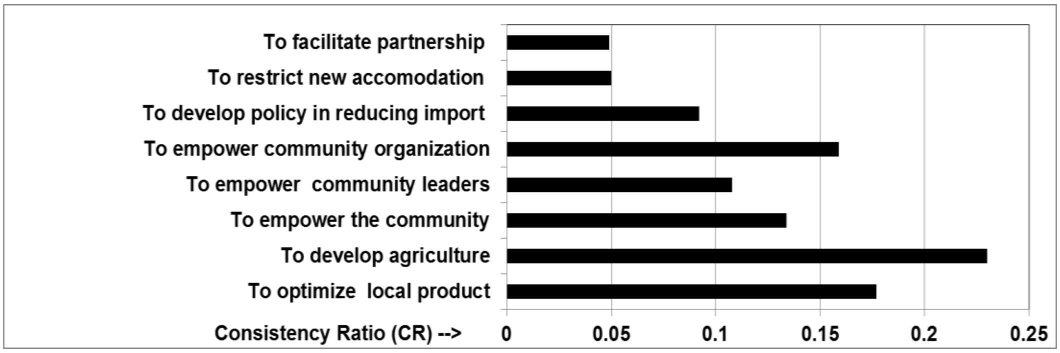

Fig. 6. Priority strategy based on the foreign tourist interest criteria

Priority Strategy based on the Criteria Availability (Quantity, Quality and Continuity)

The priority strategy based on the criteria of "Availability (Quantity, Quality and Continuity)" was to develop agriculture, livestock, fisheries and handicraft, followed by to optimize the potential of local product and to empower the community organization (Fig. 7).

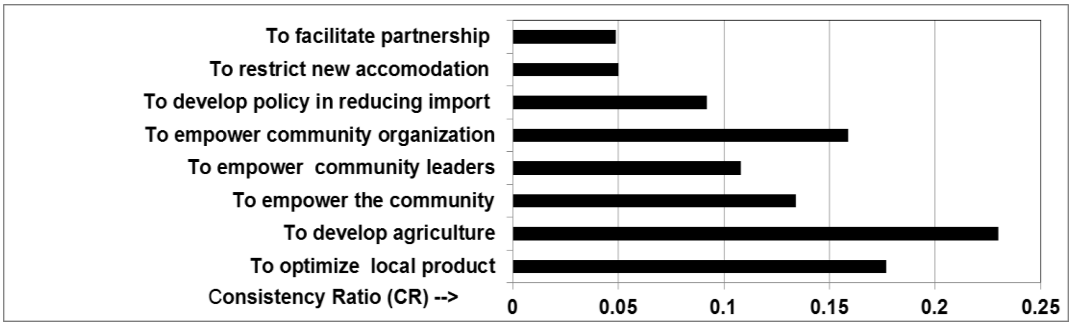

Fig. 7. Priority strategy based on the availability (quantity, quality and continuity) criteria

Priority Strategy based on the Criteria Socially and Culturally Acceptable

The priority strategy based on the criteria of "Socially and Culturally Acceptable was to empower the community leaders, followed by to empower the community and to empower the community organization (Fig. 8).

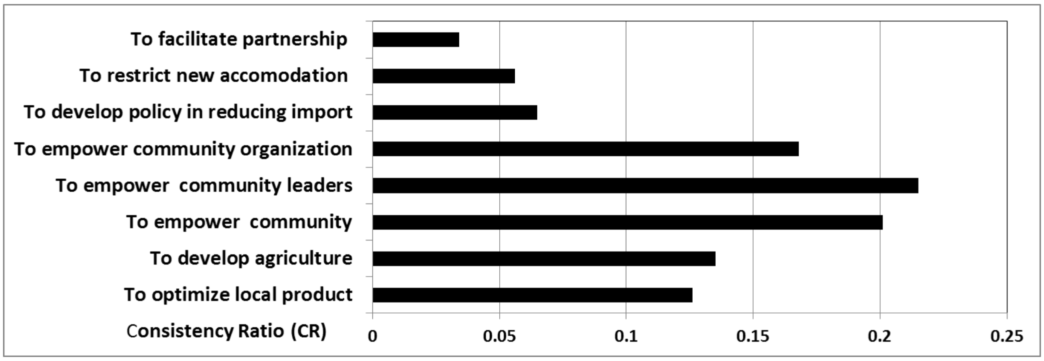

Fig. 8. Priority strategy based on the socially and culturally acceptable criteria.

Priority Strategy based on the Criteria Environmentally Friendly

The priority strategy based on the criteria of "Environmentally Friendly" shows that the most important strategy was to empower the community, followed by to restrict new accommodation development in order to prevent agricultural land use change and to develop agriculture, livestock, fisheries and handicraft. Inconsistency ratio was 0.03 (under 0.1), indicated that the comparison of preferences were consistent (Fig. 9).

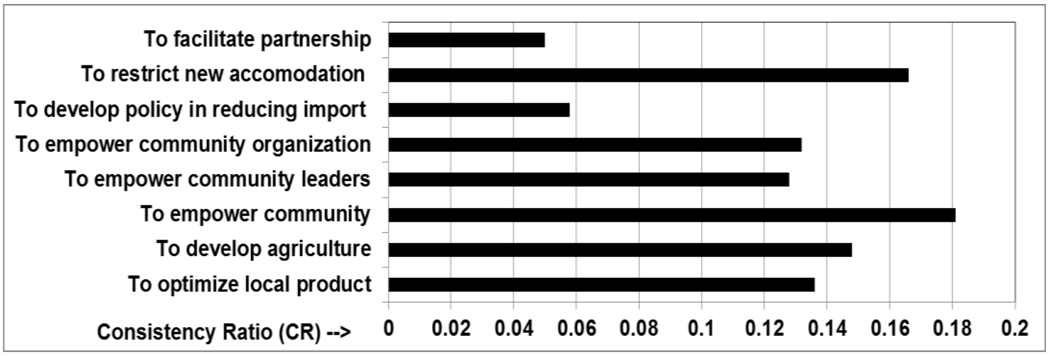

Fig. 9. Priority strategy based on the environmentally friendly criteria.

<u>Priority Strategy based on Combined Criteria</u>

The priority strategy based on combined criteria shows that the most important strategy was to develop agriculture, livestock, fisheries and handicraft, followed by to optimize the potential of local product and to empower the community (Fig. 10).

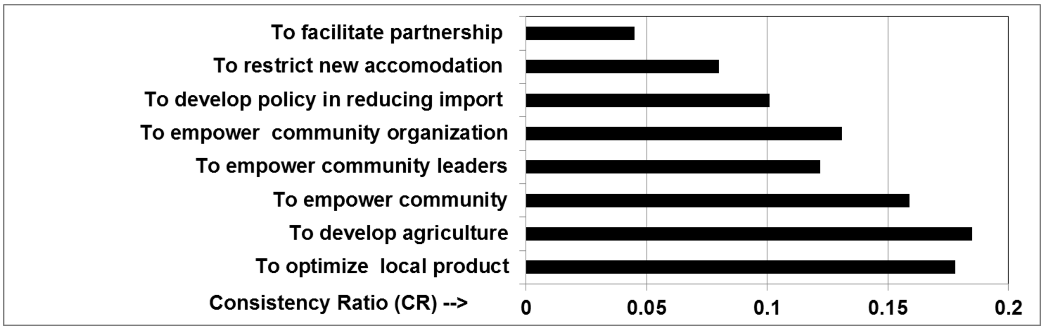

Fig. 10. Priority strategy based on combined criteria.

The criteria of logical consistency requirements in all of the priority strategies were consistent. These indicate that the comparison of preferences are consistent and that the selected experts as respondents was correct. As the main purpose of AHP is to have a functional hierarchy with the main input of human perception, the selected experts proved to have the ability in understanding the situation faced by the tourism industry in Bali, especially in terms of linkages between tourism and agriculture, as well as have comprehensive understanding in comparative judgment related to the role of local agricultural products to support sustainable tourism in Bali.

DISCUSSION

The model shows that the first important priority strategy is to develop agriculture, livestock, fisheries and handicraft. The second priority strategy is to optimize the potential of local product, and the third priority strategy is to empower the community. The priority strategy that is to develop agriculture, livestock, fisheries and handicraft appears mostly in all of the criteria developed in this research. These indicate that agriculture plays a crucial role in supporting development of tourism, thus links between agriculture and tourism are significant. The strategy to optimize the potential of local product also appears in all of the criteria developed in this research. These indicate that optimalization of the use of local agriculture products will increase linkage between agricultural and tourism sectors.

These findings are consistent with the study by Ashley *et al*. (2002) who found that linkage between tourism and the local agricultural sector will benefit both sectors. The tourism benefits will also be more useful if the tourism industry offers local produce to the visitors. Conversely, availability of local agricultural products, livestock and fisheries need market for the local agricultural produce. As agricultural products are perishable and bulky, this situastion needs efficient delivery. The tourism industry is the solution to accomodate abundant agricultural produce. However, in many destinations, local produce do not meet the requirements of the tourism industry, linkages between agriculture and tourism industry have failed due to numerous challenges faced by local agricultural industry such as quality, quantity and continuity of the local produce. The tourism industry in developing countries is hampered by poor product development and management, poor linkages within the local economy, poor infrastructure, poor institutional and technical capabilities, and skilled personnel (Momsen 1973; Mitchell 2006). These conditions indicate the inability of the local agricultural produce to meet hotel demands. The importation of agricultural products can not be avoided as hotels and restaurants require high quality products (Driscoll 2005).

The strategy to empower the community appears in nearly all of the criterias developed in this research. The development of agriculture in Bali has been critically discussed by stakeholders, including the local government of Bali, central government of Indonesia, tourism industry, agricultural industry, Balinese community as well as academics. However, the rapid development of the tourism sector can not be followed by development of agriculture in Bali. Efforts in agricultural and livestock developments have been made, as Bali has the potential to produce agricultural products to satisfy visitors' needs in terms of both quality and quantity. Development of agriculture must be without degradation of farmland fertility and environmental impacts, which may result from intensive horticulture and animal husbandry.

Among the identified strategies, the priority strategy that needs to be implemented, has not been undertaken so far. The sequence of priority strategies which need to be developed is (i) to develop agriculture, livestock, fisheries and handicraft industry, (ii) to optimize the potential of local and (iii) to empower the local community.

Limitation

By applying AHP in this research, various prioritizations have been produced as alternative strategies to minimize tourism leakage in order to support sustainable tourism in Bali. The selection process of chosen criterias can be quite difficult to understand. All criteria must be fully exposed and accounted for at the beginning of the selection process. In addition, choosing respondents as experts who undertand the situation in order to avoid inconsistent point of view, belief and knowledge is difficult. However, attention must be given to the Consistency Ratio (CR) which indicates the consistency of the experts' judgement.

CONCLUSION

The role of local agricultural products to support sustainable tourism in Bali is really important. The model shows that the most important strategy was to develop agriculture, livestock, fisheries and handicrafts, followed by optimization of the potential of local products, and lastly community empowerment. Strengthening inter-sector linkages reduces economic leakage of tourism, since increased linkages could reduce importation through substitution of foreign imports of goods and services with locally-produced supplies. All stakeholders play an important role to strengthen the quality, continuity and consistency of the local products. All stakeholders need to create good coordination and communication among hoteliers, local community, local Government of Bali and Central Government of Indonesia, in order to gain competitiveness of local agricultural products.

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SOIL AND MICROCLIMATE AMELIORATION OF SHORT ROTATION FORESTRY-BASED AGROFORESTRY IN CUENCA, BATANGAS, PHILIPPINES

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ABSTRACT

Marginal uplands are among the highly vulnerable areas exposed to extreme environmental harsh conditions. To ensure the ecological stability of the watershed, rehabilitation strategies of these marginal degraded uplands is of urgency. Among the promising rehabilitation species is *Jatropha curcas* L. Jatropha is receiving heightened attention for its ability to grow on marginal land characterized by infertile soil and with limited rainfall. Similarly, the widely distributed oil-bearing woody Jatropha receives a lot of attention from Clean Development Mechanism project developers all over the tropical world. The study assessed the influence of the Short Rotation Forestry (SRF)-based agroforestry production systems on the microclimate and soil properties at marginal upland condition of Cuenca, Batangas, Philippines from February 2008 to February 2010. *Jatropha curcas* L. was planted in different spacing of 2 x 2 m and 3 x 3 m in the monoculture plantation and 2 x 2 m as an intercrop in the SRF-based agroforestry system. The SRF species were *Acacia mangium*, *Pongamia pinnata* and *Eucalyptus deglupta.* Production systems have significant influence on the change in topsoil organic matter, total nitrogen and available phosphorus, and the subsoil pH. Microclimate amelioration was observed with air and soil temperature, and wind velocity as significantly influenced by the production systems but not relative humidity. Results of this study provided significant benchmark information on establishing the potential of Jatropha as a rehabilitation species in the upland marginal condition and a suitable species in an agroforestry-based production system vis-à-vis its amelioration in the soil and microclimate. The SRF species namely, *A. mangium* and *E. deglupta* proved to have beneficial influence on the site factors.

Key words: marginal upland, rehabilitation, site factors

INTRODUCTION

In the Philippines, uplands cover 17.6 M hectares, which is 59 percent of the total land area of the country (Fortenbacher and Alave, 2014). It is a home to 24 M Filipinos (Payonga and Gonzalez, 2009). However, population pressure, commercial logging and extraction activities alarmingly led to the land conversion, agricultural expansion and slash and burn farming in the fragile uplands. The potential suitability of Jatropha in the country is based on its inherent drought resistant characteristics having robust growth even on marginal areas. Moreover, it is not browsed by animals and has few pests and diseases (Gu¨ bitz *et al.*, 1999; Openshaw, 2000 and Augustus *et al*., 2002). Jatropha is a valuable multi-use crop that can alleviate soil degradation, desertification and deforestation. In addition to ameliorating the edaphic properties, atmospheric condition is likewise benefited through its contribution towards making the objectives of stabilizing Green House Gas (GHG) emission. Moreover, the seed production and by-products that could be developed from Jatropha have the potential to increase income of rural farming families (Tomomatsu and Bent 2007). Godilano (as cited by Villancio, 2006) studied the suitable planting areas in the Philippines for Jatropha which is estimated at 12,992.812 hectares. Ecologically, Jatropha has a niche in the Philippine uplands and in the coconut-based agroforestry system. A recent study showed that Jatropha grown on marginal soils improved soil aggregation thereby decreasing soil erosion. Jatropha has the potential to increase soil carbon sequestration and nutrient content. The use of Jatropha to reclaim marginal lands could help to improve future availability of food (Ogunwole *et al*. 2008).

Meanwhile, *Acacia mangium* Willd., a fast growing nitrogen-fixing species has also gained an increasing interest for reforestation and rehabilitation programmes in the humid tropics for its remarkable growth potential even on marginal land which are very acidic and infertile soils (Yamamoto *et al*. 2003). *Eucalyptus deglupta* has been used in reforestation and in enriching planting trials in logged-over forest (Orwa *et al*. 2009). Given the environmental impacts of inorganic fertilizer including its cost, combining nitrogen fixing species with other short rotation species is a silvicultural prescription that could facilitate rehabilitation efforts. There is increment in biomass production of eucalypt plantations when acacia is introduced as an understorey (Laclau *et al*. 2008). Hence, this study was conducted to assess the influence of the Short Rotation Forestry (SRF)-based agroforestry production systems intercropped with *Jatropha curcas* on the site factors. Specifically, the study determined the resulting influence of the SRF-based agroforestry system on the microclimate and soil properties of marginal upland conditions in Cuenca, Batangas, Philippines.

MATERIALS AND METHODS

Experimental Site

The experiment was established in Mt. Makulot, San Isidro, Cuenca, Batangas, Philippines. Mt. Makulot is located at the southern portion of Taal Volcano Caldera in the Municpality of Cuenca, Batangas, which is about 94 kilometers from Metro Manila. The climate in the area belongs to the Type I classification with pronounced dry season from November to April and wet season from May to October. The weather station in Ambulong, Batangas had recorded that from 1998-2007 the annual average rainfall, maximum and minimum air temperatures were 1679.4 mm, 31.69 and 23.78^{o}C, respectively. The soils of the Municipality of Cuenca are mainly derived from volcanic materials which are either deposited by air or reworked by water. Soil texture ranged from silt loam to light clay which are friable and have very favorable tillage properties. Soil type at San Isidro belongs to the Ibaan series. The topsoil is light reddish brown, brown to dark brown, friable, blocky and coarse granular clay loam to loam with 20 to 35 cm depth. The soil origin is volcanic tuff. The experimental site is located from 650 to 700 masl with a slope ranging from 35-60%.

Experimental Design and Treatments

The experiment was arranged using Randomized Complete Block Design (RCBD) with 3 replications. T_1 and T_2 represented the pure plantation of *Jatropha curcas* at two different spacing. T_3 and T_4 were the SRF-based agroforestry system intercropped with nitrogen fixing species while T_5 was the SRF-based agroforestry system intercropped with non-nitrogen fixing species. Specifically, the experimental treatments were: T_1: control plots purely planted with *J. curcas* at 2 x 2 m in quincunx design; T_2: purely planted with *J. curcas* at 3 x 3 m spacing; T_3: *Acacia mangium* + *J. curcas*; T_4: *Pongamia. pinnata* + *J. curcas*; and T_5: *Eucalyptus deglupta* + *J. curcas*. The distance between each treatment plot was 3 m. The SRF are fast growing species planted at 4 x 2 m. The *J. curcas* planted as intercrop in the SRF agroforestry-based systems is also planted at 2 x 2 m. The experimental plots were established and maintained from February 2008 until February 2010.

Data Collection and analysis

Soil chemical properties. Benchmark information on the soil properties prior to the establishment of the study was determined on February 2008. The measured soil parameters were soil pH, organic matter content (%), total nitrogen (%), available phosphorus (ppm), exchangeable potassium (me/100g soil) and cation exchange capacity (cmo(+)/kg soil) which were analyzed using standard procedure of potentiometric method, Black and Wakley procedure, computation based on organic matter content; Bray No. 2 method and ammonium acetate, respectively. The laboratory analyses were conducted at the Analytical Services Laboratory, Agricultural Systems Cluster, College of Agriculture, University of the Philippines Los Baños. Final measurement of soil chemical properties was done on February 2010.

Microclimate parameters. The above canopy air temperature and relative humidity were measured using a thermo hygro digital meter from 1000-1030H. It was assessed that during period that more or less a balance among the microclimate parameters being measured exists, thereby avoiding extreme influence of air temperature on other parameters. Soil temperature at 5 cm depth and wind velocity above the vegetation canopy were measured using soil thermometer and wind anemometer, respectively. The microclimate parameters were determined monthly starting from November 2009, when the crops planted have already established growth and survival after outplanting, until February 2010.

The data were subjected to ANOVA using the SAS 9.1.3. (TS1M3) software for Microsoft Windows. Significant differences among treatment means were determined using LSD.

RESULTS AND DISCUSSION

Soil Chemical Properties

The extent and rate of soil quality improvement as influenced by tree-mediated processes have been proven (Chirwa *et al*. 2007; Sileshi *et al*. 2007). Specifically, these include increased nitrogen (N) input through biological N fixation, enhanced availability, greater uptake and utilization of nutrients, increased activity of soil biota and improved water dynamics. The succeeding discussion shows the influence of the different production systems on the edaphic chemical properties (Table 1) in the marginal lands of Mt. Makulot, San Isidro, Cuenca, Batangas.

Initial Topsoil and Subsoil Chemical Properties. Among the six chemical properties, only the available phosphorus had difference in its initial soil condition (Table 1). *A. mangium* + *J. curcas* plot had the highest available phosphorus, and yet, it decreased after the experiment period. In terms of the influence of the available phosphorus that decreased in *A. mangium* + *J. curcas* it could be due to the requirement of leguminous species for phosphorus uptake for nodule development, nitrogen fixation and root development (Bargaz *et al*. 2012). The organic matter content serves as reserve for the amount of nitrogen that could be released. Hence, the increase in the organic matter regardless of treatments resulted in increase in total nitrogen except for T_4.

Final Topsoil and Subsoil Chemical Properties. The total nitrogen is the only topsoil chemical property that was significantly influenced by the different agroforestry production systems (Table 1). The highest and lowest total nitrogen were observed in T_5 (0.22%) and T_1 (0.19%), respectively. T_5 had the highest topsoil total nitrogen content because the fast growing nature of *E. deglupta* could have absorbed soil nutrient from the lower soil horizon and returned it to the soil surface via the nutrient pumping phenomena (Lasco and Visco 2003). T_3 and T_4 which had nitrogen-fixing SRF species could have significantly contributed to the total topsoil nitrogen content. The SRF-based agroforestry production systems proved to have beneficial effect on the topsoil total nitrogen. T_2 had the lesser plant density of Jatropha which absorbs nitrogen from the topsoil. This is validated by Chaudhary *et al*. (2007) wherein the soil N availability increased significantly with increase in spacing vis-à-vis T_1 and T_2.

Table 1. Top and subsoil properties as influenced by the different production systems of Jatropha.

Soil Properties/ Treatment	Measurement Period					
	Topsoil			Subsoil		
	Initial	Final	Difference	Initial	Final	Difference
pH						
T_1	5.6 a	5.8 a	0.17 a	5.7 a	5.8 ab	0.17 ab
T_2	5.5 a	5.7 a	0.17 a	5.5 a	5.6 c	0.10 b
T_3	5.7 a	5.9 a	0.17 a	5.7 a	5.9 a	0.27 a
T_4	5.6 a	5.8 a	0.17 a	5.7 a	5.8 abc	0.07 b
T_5	5.7 a	5.7 a	0.00 a	5.6 a	5.7 c	0.13 ab
Organic Matter (%)						
T_1	4.13 a	5.20 a	1.07 ab	3.69 a	4.39 a	0.70 a
T_2	4.40 a	5.91 a	1.50 ab	3.77 a	5.28 a	1.15 a
T_3	3.69 a	5.36 a	1.67 a	3.44 a	4.80 a	1.37 a
T_4	5.07 a	5.40 a	0.33 b	3.68 a	4.66 a	0.98 a
T_5	4.38 a	5.54 a	1.16 ab	3.74 a	4.82 a	1.08 a
Total Nitrogen (%)						
T_1	0.18 a	0.19 b	0.001 ab	0.20 a	0.17 a	-0.030 a
T_2	0.02 a	0.21 ab	0.03 a	0.21 a	0.20 a	-0.01 a
T_3	0.02 a	0.20 ab	0.02 ab	0.17 ab	0.17 a	0.0003 a
T_4	0.23 a	0.20 a	-0.04 b	0.13 b	0.18 a	-5.56 a
T_5	0.20 a	0.22 a	0.02 ab	0.18 ab	0.18 a	-0.003a
Available Phosphorus (ppm)						
T_1	0.95 b	1.67 a	1.23 a	1.06 a	1.67 a	1.03 a
T_2	0.95 b	1.33 a	0.90 a	1.06 a	1.33 a	0.70 a
T_3	1.81 a	1.33 a	-1.57b	1.09 a	1.33 a	0.63 a
T_4	1.24 b	1.67 a	0.60 a	1.09 a	1.67 a	0.97 a
T_5	1.09 b	1.67 a	0.97 a	1.32 a	1.33 a	0.03 a
Exchangeable Potassium(me/100 g)						
T_1	3.35 a	3.92 a	0.58 a	3.12 a	3.43 ab	0.31 a
T_2	3.24 a	3.00 a	-0.24 a	3.08 a	2.92 ab	-0.16 a
T_3	3.63 a	3.77 a	0.14 a	3.18 a	3.49 a	0.31 a
T_4	3.47 a	2.92 a	-0.56 a	3.41 a	2.83 b	0.57 a
T_5	3.42 a	3.04 a	-0.39 a	3.05 a	3.11 ab	0.06 a
CEC (cmol(+)/kg soil)						
T_1	29.55 a	28.63 a	-0.02 a	28.37 a	28.30 a	0.00 a
T_2	30.00 a	29.97 a	0.00 a	25.73 a	29.17 a	2.70 a
T_3	27.10 a	30.70 a	3.60 a	29.97 a	29.70 a	0.43 a
T_4	29.90 a	29.57 a	-0.33 a	29.47 a	28.70 a	-0.08 a
T_5	28.29 a	30.20 a	1.91 a	27.43 a	29.73 a	2.30 a

Means followed by the same letters within a row are not significantly different at 5%.
MAO – Months after Outplanting,
T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

The treatment means of the topsoil chemical properties which were not significantly different were pH, organic matter content, available phosphorus, and cation exchange capacity (CEC) (Table 1). The observed topsoil pH and CEC for all the treatments are within the critical level range of 5.5-6.5 and 15-35 cmol (+)/kg soil, respectively. The topsoil organic matter and exchangeable potassium content for all the treatment plots was qualitatively high. The available phosphorus for all the production systems had low quantity which could be attributed to the soil pH which is slightly acidic. The subsoil pH and exchangeable potassium were significantly influenced by the different production systems (Table 1). The subsoil pH for all the production systems was within the critical level range. T_3 had the highest subsoil pH of 5.9 while the least was recorded in T_2 (5.6) and T_5 (5.7). The differences could be attributed to the different species in the production systems, which exerts varying nutrient uptake and safety net mechanisms to prevent leaching that would affect the protonation in the soil (Binkley as cited by Mead and Cornforth 1995).

Four subsoil chemical properties namely, organic matter content, total nitrogen, available phosphorus and CEC were not significantly influenced by the different production systems (Table 1). Highest subsoil organic matter (5.28%), total nitrogen (0.20%) and CEC (29.17 cmol (+)/kg soil) were noted in T_2 which has lesser plant density resulting in lesser potassium uptake.

Topsoil Properties Difference. All treatments had positive effect on P except T_3. The change in the topsoil pH, K and CEC before and after the experimentation were not significantly influenced by the different production systems (Table 1). The exchangeable potassium increase in T_1 could be accounted for by the significant Jatropha litter fall production of 1.63 t/ha monitored from this production system. T_2 to T_5 had similar litterfall production of 0.83, 1.13, 0.93 and 1.00 t/ha, respectively. The agroforestry production systems significantly influenced topsoil organic matter, total nitrogen and available phosphorus. The highest mean increase in organic matter was observed in *A. mangium* + *J. curcas* (1.67%) and the least was noted in *P. pinnata* + *J. curcas*. Nutrients are released from trees into the soil through prunings, litter and dying roots, or are leached from the crown by throughfall and stemflow (Schroth *et al*. 2001) which is in warmer temperatures (Leiros *et al*. 1999). The relatively higher organic matter content in T_1 could have been influenced by the relatively higher air temperature prevailing in the locality (Table 2), coupled with the highest litter fall production. On the other hand, the highest increase of organic matter content in T_3 could be attributed to the beneficial influence of *A. mangium* biomass (Galiana *et al*. 2002) leading to soil fertility improvements.

Subsoil Properties Difference. Only the subsoil pH had significant treatment mean difference (Table 1). The production systems elicited an increase in the subsoil pH. The highest subsoil pH increase of 0.27 was observed in T_3 indicating the SRF-based agroforestry production systems had amelioration effect on subsoil.

Microclimate

Microclimate refers to the atmospheric characteristics prevailing in the layer near the ground that is affected by the ground surface. It influences humidity (by evapotranspiration), temperature and wind (Wood and Burley 1991).

Air temperature. The air temperature was influenced significantly by the production systems from the 18th to the 22nd month of monitoring. Both the monocropping production systems vis-à-vis T_1 (33.83ºC) and T_2 (33.73ºC) recorded the highest air temperature. The vegetation cover from these monocropping production systems received direct and diffuse sunlight, thereby, increasing air temperature (Shanker *et al*. 2005). The study of Silva (as cited by de Souza *et al. 2010)* proved that the environment receiving direct radiation from the sun, heats and stores this transformed energy.

The SRF-based agroforestry systems (T_3, T_4 and T_5) had lower air temperatures from the 18th to the 21th months of monitoring compared to the monocropping of Jatropha. This could be attributed to the shading effect of the SRF intercrops. However, on the 22nd month, the monocropping of Jatropha in T_1 (27.36ºC)) and T_2 (27.91ºC) had significantly lower air temperature similar with T_5 (28.36ºC). The greater air movement in T_2 due to the relative faster wind velocity (26.66 km hr^{-1}), lowered the prevailing air temperature in this production system. The significantly highest air temperature in T_3 could be due to the dense canopy of this SRF-based agroforestry system compared to the other two SRF-based agroforestry systems (T_4 and T_5) which prevents the latent heat flux dissipation (Hardwick *et al*. 2015). The significantly highest soil temperature, from 19th to 21st months of monitoring, was observed in T_1 and T_2 which coincided with the occurrence of the highest air temperatures. The pattern of the soil temperature is similar to that of the air temperature observed in each of the production systems which indicates the prevailing air temperature influenced the soil temperature (Egziabher 2006; Anderson *et al*. 2007). Moreover, in the study of Binkley (as cited by Mead and Conforth 1995) the presence of varying canopy cover in T_3 to T_5 as compared to the monoculture production systems probably had more influence on the light attenuation reaching the soil and long wave emissions from the soil.

Wind velocity. The production system had also significant influence on wind velocity during the last five months of monitoring. Consistently, T_5 had the highest wind velocity measurement among the production systems. The greater height difference of the intercrops in this SRF-based agroforestry system formed a rougher canopy surface which creates greater air turbulence (Pennypacker and Baldocchi 2015). Similarly, the prevailing high wind velocity in T_2 was comparable to that of T_5 from the 18th to the 21st month of monitoring. The observed wind velocity in T_2 could be attributed to the wider spacing in this treatment allowing greater space for air movement within and above the canopy. During the last monitoring month (22nd), all production systems had statistically similar wind velocity except for T_4 with 38.50 km hr^{-1}. During this period, *P. pinnata* created rougher canopy effect facilitating greater air movement. *P. pinnata* is a documented species adapted to wind exposed areas (Schmidth 2009).

The production systems elicited significant influence on relative humidity for the first two months, and on the 18th, 19th and 21st months of monitoring (Table 2). The young vegetation cover of the production systems on the 1st month elicited significant influence on relative humidity. The significantly highest relative humidity was observed in T_1 (60%) which could be attributed to the higher plant density and leaf area index which yields higher transpiration rate, and consequently more atmospheric water vapor. The comparable higher relative humidity in T_2 (57%) could be attributed to the exposed soil surface subjected to evaporation. The least relative humidity was measured in T_3 (49.6%). On the 2nd month, T_5 (69.5%) had the highest air temperature. This is comparable to the two SRF-based agroforestry systems, T_3 and T_4 with a relative humidity of 66.87% and 66.66%, respectively. The uneven canopy cover caused more air turbulence increasing the rate of transpiration in this production system. While the comparable relative humidity in T_1 (64.32%) could still be attributed to the higher plant density and leaf area. On the 18th and 19th months, the pattern of influence of the production systems on relative humidity is reflective also of the influence of air temperature on relative humidity. These results are consistent with the findings of Medeiros *et al*. (2006) about the inverse relationship between air temperature and relative humidity. On the 21st month, the observed relative humidity measurements were significantly different among the five production systems. The influence of the SRF-based agroforestry system intercropped with Jatropha shows that T_4 had significantly the highest prevailing relative humidity of 75%, followed by T_3 (73%) and T_5 (72%). The ordinal ranking observed for the relative humidity on the 21st month of monitoring could be attributed to the exposed canopy transpiring. The varying foliage and crown canopy of the SRF species elicited the observed relative humidity. The larger leaf size of *P. pinnata* and *A. mangium* compared to that of *E. deglupta* probably influenced rate of water vapor removal at the canopy surface. Moreover, the greater height difference of *E. deglupta* with Jatropha provided greater roughness to facilitate air mixing, thus, its lower relative humidity compared to that of the other two SRF-based agroforestry systems. The monoculture of Jatropha planted in 2 x 2 m spacing and 3 x m spacing have the lowest prevailing relative humidity. The lower number of planting density in T_2 resulted in the least relative humidity (70.3%) in its immediate surface compared to T_1 (71%) Jatropha trees were found to be conservative in their water use, and were unlikely to transpire more water (Gush 2008).

Table 2. Microclimate parameter means as influenced by the different agroforestry production systems.

MAO	T_1	T_2	T_3	T_4	T_5
			Air Temperature (°C)		
18	33.83 a	33.73 a	32.50 b	31.60 c	30.50 d
19	32.10 a	32.03 a	30.70 b	29.87 c	28.70 d
20	28.93 a	28.80 a	27.50 b	26.60 c	25.50 d
21	27.87 ab	28.27 a	26.93 bc	26.33 cd	25.67 d
22	27.36 c	27.91 c	31.99 a	29.31 b	28.36 bc
			Soil Temperature (°C)		
19	30.53 a	31.07 a	29.57 b	28.97 b	28.20 c
20	27.37 a	27.83 a	26.37 b	25.70 b	25.00 c
21	26.83 b	27.43 a	26.00 c	25.20 d	25.00 d
22	27.36 c	27.91 c	31.99 a	29.31 b	28.36 bc
			Relative Humidity (%)		
1	60.00 a	57.00 ab	49.67 c	53.67 bc	53.67 bc
2	64.32 ab	60.62 b	66.88 ab	66.66 ab	69.55 a
18	65.67 a	62.67 ab	55.33 c	59.00 bc	59.00 bc
19	63.00 d	62.33 e	65.00 b	67.00 a	64.00 c
21	71.00 d	70.33 e	73.00 b	75.00 a	72.00 c
			Wind Velocity (km hr^{-1})		
18	12.67 c	18.67 ab	16.00 bc	15.00 bc	23.33 a
19	15.00 c	21.67 ab	20.00 abc	18.33 bc	25.00 a
20	14.00 b	20.00 ab	20.00 abc	16.67 ab	25.00 a
21	18.00 b	24.00 ab	25.33 ab	21.67 b	31.00 a
22	22.00 b	26.67 b	22.67 b	38.50 a	22.67 b

Means followed by the same letters within a row are not significantly different at 5%

MAO – Months after Outplanting, T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

Final air temperature. Air temperature was significantly affected by the production systems (Fig. 1). The lowest air temperature (28.9°C) was noted with T_5 while significantly higher air temperatures were noted in T_1, T_2 and T_3 at 30.48°C, 30.63°C, 30.62°C, respectively. The canopy structures for the plantation treatments of 2 x 2 and 3 x 3 m spacing are of uniform height which had less air turbulence compared to those treatments with SRF species intercropped with Jatropha. Moreover, the wind velocity in T_1 had significantly the slowest speed (16.19 km hr^{-1}). The lower air temperature in T_5 could also be attributed to the significantly fastest wind speed (22.57 km hr^{-1}) that could have aided the air mixing. Moreover, evaporative cooling induced by transpiration reduces the maximum plant surface temperature by about 15 °C on a hot and dry day (Novák and Havrila 2006). This could also account for the lower temperatures observed in the SRF-based agroforestry systems in T_5 and T_4. The intercropping of two species yielded higher transpiration resulting in lower above canopy air temperature. This also indicates the effective air temperature amelioration of the SRF-based agroforestry particularly T_5.

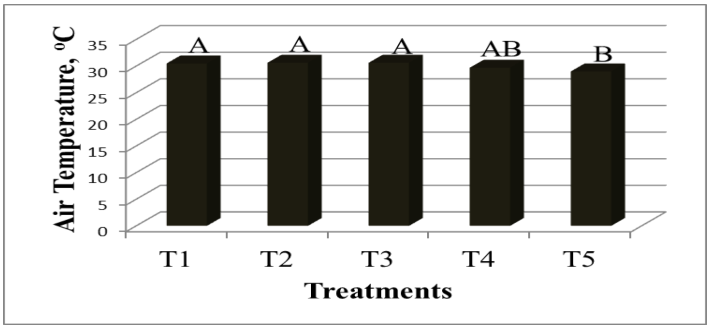

Fig. 1. Final air temperature above the canopy of the experimental site as influenced by the different agroforestry production systems.

Means followed by the same letters are not significantly different at 5% . T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

Final relative humidity. Relative humidity was not significantly influenced by either a plantation or agroforestry production systems (Fig. 2). Vegetation cover of the production systems may not reach the expanse of canopy to affect relative humidity (Brom *et al*. 2009). Air temperature also affects relative humidity. Thus, the statistically similar air temperature of T_1 to T_4 could have contributed to similar relative humidity in these production systems.

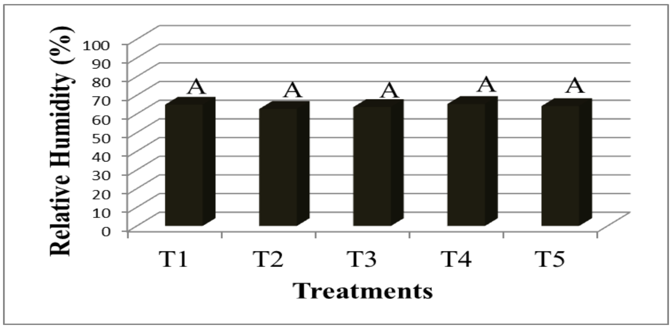

Fig. 2. Final relative humidity above the canopy of the experimental site as influenced by the different agroforestry production systems.

Means followed by the same letters are not significantly different at 5% . T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

Final soil temperature. It is suggested that moderate shading in an intercropping can result in a buffering effect on microclimate conditions (Clinch *et al*. 2009) thus less variation in soil temperature across a range of weather conditions were observed (Fig. 3). It was observed that T_5 had the significantly lowest soil temperature of 27.83°C, while T_2 and T_3 had the significantly highest soil temperature of 29.21°C and 29.07°C, respectively. The highest soil temperature in T_2 could be attributed to the lesser plant density providing soil cover (Genxu *et al*. 2008). The intercropping of *Pongamia pinnata* + Jatropha and *Eucalyptus deglupta* + Jatropha had comparable lower soil temperature and lower air temperature. These SRF-based agroforestry systems probably yielded higher transpiration rate which enhanced evaporative cooling effect resulting in lower soil temperatures. Plant transpiration has been demonstrated to modify climatic conditions at the land surface and in the soil during the vegetative season (Pokorný 2001).

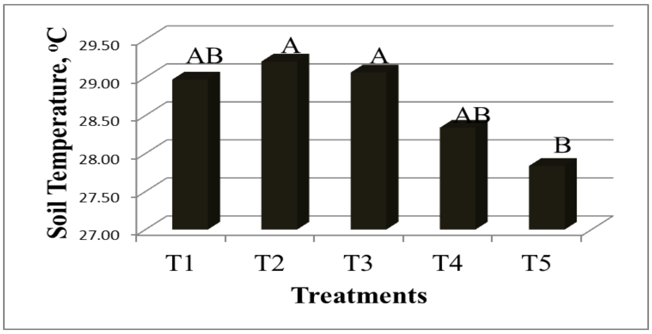

Fig. 3. Final soil temperature at 5 cm depth of the experimental site as influenced by the different agroforestry production systems. Means followed by the same letters are not significantly different at 5%. T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

Final wind velocity. The production systems significantly influenced the prevailing wind velocity (Fig. 4). Over 22 months, T_5 significantly had the highest wind velocity of 22.57 km hr^{-1}. The greater height difference of the intercrops in this SRF-based agroforestry system provided the greatest air turbulence resulting in higher wind velocity in T_5. T_2 (20.38 km hr^{-1}) and T_4 (20.17 km hr^{-1}) had comparable wind velocity with T_5 and T_3 (19.29 km hr^{-1}). Meanwhile, T_1 had the slowest wind velocity (16.19 km hr^{-1}). This could be attributed to the more dense planting density in this production system thereby restricting air movement (Youssef *et al*. 2012). The more even vegetative cover in T_1 resulting from the monoculture of *J. curcas* planted in 2 x2 m spacing created reduced wind speed as less roughness produces only a boundary layer effect rather than a perturbed turbulent air layer (Salem 1991).

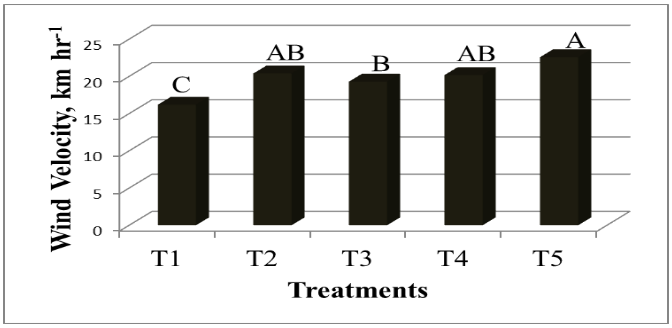

Fig. 4. Final wind velocity above the canopy of the experimental site as influenced by the different agroforestry production systems. Means followed by the same letters are not significantly different at 5%. T_1 – 2 x 2 m spacing, T_2 – 3 x 3 m spacing, T_3 – *A. mangium* + *J. curcas* L., T_4 – *P. pinnata* + *J. curcas* L., T_5 – *E. deglupta* + *J. curcas* L., T_1 and T_2 – represented the pure plantation, T_3 and T_4 – SRF-based agroforestry system with nitrogen fixing species and, T_5 – SRF-based agroforestry system with non-nitrogen fixing species

CONCLUSION

The production systems influenced significantly air and soil temperatures, and wind velocity but not relative humidity. The Short Rotation Forestry (SRF) –based agroforestry systems and the wider planting distance of monocrop Jatropha influenced positively soil chemical properties, specifically topsoil nitrogen, subsoil pH and exchangeable potassium. This study provided significant benchmark information on establishing the potential of Jatropha as a rehabilitation species in the upland marginal condition of Mt. Makulot, San Isidro Cuenca, Batangas and a suitable species in an agroforestry-based production system vis-à-vis its amelioration in the soil and microclimate. The SRF species namely, *A. mangium* and *E. deglupta* proved to have beneficial influence in the aforementioned site factors.

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CUSTOMER VALUE CREATION OF FRESH TOMATOES THROUGH BRANDING AND PACKAGING AS CUSTOMER PERCEIVED QUALITY

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ABSTRACT

This paper provides a value proposition and a development model of customer value based on consumer perceived quality to utilize branding and packaging for a particular perishable commodity such as fresh tomatoes. The terminology of customer value is varied across the analysis stage and is crucial for projecting marketing activity. However, it will be distinctive based on its definition. The study was conducted in September 2014 - January 2015 at one of the biggest hypermarket retail centers in Bandung City, with descriptive and explanatory survey data of 41 respondents. In this regard, the hypotheses were examined by describing customer value mapping and providing a conceptual framework using path analysis technique. Value proposition showed fresh tomatoes achieved superior perceived-quality with competitive price. This means branding and packaging have successfully increased the external marketing value at a considerable price. Path analysis model defined that branding and packaging provide significant contribution to customer value. This indicated that explicit focus on customer role as the driver for premium fresh vegetables market was successful. Hence, the value conceptualization is needed to facilitate a better understanding of fresh produce consumer behavior.

Key words: marketing, value proposition, consumer behavior, product attribute, vegetables

INTRODUCTION

Customer value terminology is varied across analysis stage. Customer value concept is a proposition of customer relative perspective on benefit and cost (Kotler and Keller 2006), adjustment on perceived quality (Gale and Wood 1994), and customer appraisal on benefit and cost for buying a product (Nilforushan and Haeri 2015). The process of defining customer value can be distinctive based on the subjectivity of its definition. Differentiating horticultural product is important to win the market competition nowadays (Utami and Sadeli 2013). Packaging and branding as vegetable product attributes could enhance product value with its appealing display and uniqueness. These two product attributes are important for evaluating product quality (Ludwig and Spiller 2007; Ulaga and Chacour 2001). This value could be useful as a reference and feedback for commodity supply chain actors nowadays in considering the consumer's awareness on the branding and packaging, especially for the fresh produce in modern retails.

Branding is one of the focal points in the Asian marketing (Fam and Merrilees

2000), and a source of customer loyalty (Chaudhuri and Holbrook 2001). Several fruits and vegetables brands complement each other and ensure different quality attributes to consumers. In order to be successful in agribusiness sector, building a strong brand of food product is urgently needed to establish a customer top-of-mind (Miles et al. 1997; Pierce and Hogan 2000), and to discharge price competition (Aaker and Joachimsthaler 2000).

Packaging is one of the product elements to differentiate from other relatively homogenous perishable consumer goods (Ampuero and Vila 2006). In collectivist developing countries, consumer orientation on product packaging may focus more on its function (Lal et al. 2015). Moreover, it can be developed as a technique to increase the perishable crops quality such as tomato (Saeed et al. 2010). The packaging on fresh produce is a part of the product attributes which consumer needs and values.

There are many perspectives on customer value creation and its measurements. The exchange value of fresh produce like fresh tomatoes is relevant to analyze. The basic function of a product is to fulfill consumer's basic needs and the benefits are valued by product attributes on branding and packaging. Packaging utility was investigated by the importance of packaging application and by packaging function, while branding utility was examined by basic function of branding. Customer perceived value comes after its perceived quality. Consumer's perceived value is defined as a trade-off between customer perception and product quality or benefit and the price that he or she is willing to pay (Monroe 1990). Customer perception on quality (Zeithmal 1988) affected customer perceived value (Ranjbarian et al. 2012). Some studies further examined the value as a driver for customer satisfaction and loyalty (e.g. Cretu and Brodie 2007; Koller et al. 2011; Spiteri and Dion 2004; Sugiati et al. 2013). However, they did not present sufficient information on the proposition of the value which elaborates the factors of each and/or overall value aspect that affects customer value creation. Cost was identified by how much the consumer is willing to spend for certain product. The benefit of fresh produce branding and packaging needs further research to proof its competitive advantages. This study particularly investigated the customer value on premium tomatoes which are using packaging and branding as product attributes based on its utilities and market demands (Nilforushan and Haeri 2015). These were applied as evaluation determinant of value proposition which compares product utility and how much consumer is willing to pay. They are also applied as customer's rationalization of a value.

In developing countries, many consumers are still anxious on the branding and packaging, especially on vegetables. Recently, most of the studies present the customer value on manufactured goods, yet there are only limited studies on the agricultural products. Modern retail should consider the exact key value needed in the product development, including packaging and branding, to gain consumer interest in premium vegetables, due to the restricted amount available in the market. This study replicates the previous researches on customer value, with additional study on the importance of product attributes, such as branding and packaging as product's perceived quality, as the driver for customer perceived value. Table 1 summarizes the studies development with customer value as the major contexts with its influential factors.

The above literature references showed that there were limited researches that observed or investigated the antecedent variables of customer value, in particular, the branding and packaging as basic attributes of tangible products that represent the product quality and their contribution proportion and effect in the customer value of branded and premium packaged tomatoes. There are less concern in developing research on customer value model and its construction which focused on experiencing product value of premium vegetables and its attributes, such as branding and packaging. On that account, vegetables are commonly sold in the undifferentiated condition without additional product attributes. This results in slightly different customer perception between a particular product and its competitors (Christopher 1996). In Indonesia, agricultural product especially fresh produce, are commonly sold in traditional market. Only limited numbers are sold in modern market with up-to-date marketing. Due to the increasing number of modern retail in emerging economy as in Indonesia, marketers have shifted their sales of premium vegetables from the traditional into a modern market to fulfill today customer food choice.

Table 1. Studies development on customer value creation and the antecedents

Reference and Study Objective	Value Aspect	Independent Variable	Dependent Variable
Zeithaml (1988), company and consumer	Value proposition	Price and perceived quality	Perceived value
Ulaga and Chacour (2001), industrial business market	Customer value	Value through buyer's and seller's perspective	value creation through networks
Evans (2002), company marketing campaign	Customer value management	Price and non-price drivers to customer satisfaction	Customer loyalty
Spiteri and Dion (2004), intensive industry	New customer value scale	Perceived relationship benefits	Customer value, Buyer satisfaction, end-user loyalty, market performance
Fernandez and Bonillo (2007), literature review	Perceived value	Uni-dimensional and multi-dimensional model	Measurement of perceived value
Cretu, and Brodie (2007), business market	Customer value	Brand image, company reputation	Perceived quality, perceived customer value, loyalty
Jin *et al.* (2008), fresh produce vs other products	Brand value	Product value for consumer	Willingness to pay
Sial *et al.* (2011), young consumer	Value of Brand	Packaging and labeling	Brand image and consumer buying behavior
Koller *et al.* (2011), non-green product	Ecological value	Functional value, economic value, emotional value, and social value	Loyalty intention
Mensonen and Haloka (2012), beverage packaging	Novel value perception	Role of packaging in the value chain, role of advertisement on the packaging	Value of packaging
Agariya *et al.* (2012), manufacture product	Branding value process	Brand communication	Brand value for customer
Sugiati *et al.* (2013), retail store consumer	Customer value	Customer value, customer satisfaction	Customer loyalty
Taranko and Chmielewski (2014), manufacture industry	Brand value for buyers and owners	Brand value equity	Customer value

Based on the context, the following conceptual model (Fig. 1) was applied. This investigated the effect of customer perception towards utility of branding and packaging as consumer perceived quality on customer value. Utility is one value concept as the desirable product from a customer perspective (Fernandez and Bonillo 2007). It was assumed that branding and packaging affected customer perceived value as product perceived quality based on customer experience on buying branded and packaged fresh tomatoes.

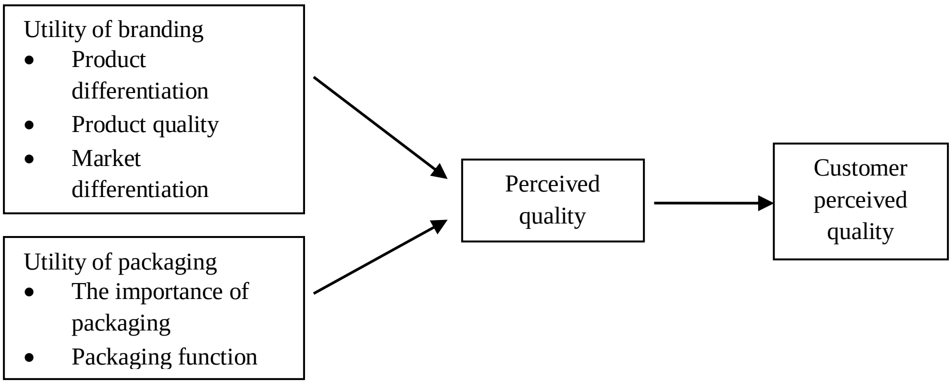

Fig. 1. The conceptual framework

Tomato is one of the premium vegetable commodities, sold in modern market such as supermarket in Bandung City, Indonesia. The city is a metropolitan with prominent tomato production center in Pangalengan District. The area has been formed as an agribusiness cluster and one of the farmer groups has penetrated modern market and been affiliated as partner of Bank of Indonesia. They distributed new product of premium tomatoes to supplier which sold almost 80% of the produce to supermarket. They started to adapt a modern marketing strategy by adding branding and packaging attributes to create a more competitive product. The knowledge and requirements of the product attributes are delivered by supplier companies as modern retail buyer. They require product specifications to standardize the product quality and tag five to ten times price, higher than its competitors' in local or traditional market. This is an opportunity for all parties in the tomatoes supply chain to gain more profit. In particular, local farmers will be able to trade for a fair and stable price, thus to be more competitive in the market. Above all, tomato is one of the famous horticultural crop commodities, used for medical and nutritional purpose (Saeed et al. 2010). Therefore, our study's objective is to analyze the proposition of customer value on packaged and branded fresh tomatoes based on relative product benefit and production cost, and to investigate factors that drive consumers' evaluation when it comes to experience the value of vegetables product such as branded and packaged tomatoes.

MATERIALS AND METHODS

Survey Instrument Development

In order to gain insight of value proposition and the effect of utility of branding and packaging on customer value, data were collected through a consumer survey. The research was done at one of hypermarket retail in Bandung City as one of the biggest retails in West Java Province and partnering with farmer group who produces the supplied fresh tomatoes. A four-part questionnaire (customer demographic, utility of brand, utility of packaging, and customer value) was developed as survey instrument. The questionnaire was designed based on literature and previous studies.

Participants responded to a total 32 questions. There were several response choices for each section of the questionnaire. In demographic section, response choices included multiple choice and fill-in-the-blank answers. On the other part of the questionnaire, response choices comprised multiple response options for brand utility and packaging utility, Likert's scale (1=strongly agree to 5=strongly disagree), 5-point-inclined-rating for overall product benefit scale response (1=extremely low to 5=extremely high) and 5-point-agreement-rating for overall monetary cost scale response ((1=strongly agree to 5=strongly disagree), the last two respectively measured customer value. After pilot test, the questionnaire was revised to improve clarity and consistency thus maximizing data collection quality. We only included questionnaire items with acceptable level of validity and reliability (Cronbach's alpha = 0.829). The final version of the questionnaire contained five indicator items of the utility of branding and it was computed using factor weights from utility of brand as product differentiation, product quality, and market differentiation. The utility of packaging was represented by nine indicator items and was calculated using factor weights from utility of packaging as its importance for the product and its functions. Whereas, customer value was embodied by eleven indicator items and was computed as a ratio of brand and packaging benefit to monetary sacrifices.

Data Collection

This study applied descriptive survey method using questionnaire and face-to-face interview with 41 customers who bought branded and packaged tomatoes during September 2014 to January 2015 at one of the biggest retails in Bandung City, West Java, Indonesia. The desired level to determine sample size for multiple regression analysis is between 15 to 20 observations for each independent variable (Hair et al. 2006). This present study had two independent variables; branding and packaging as the drivers for product perceived quality and one dependent variable that is customer value; hence 41 participants met the appropriateness of sample size.

Data Measurement

The study was conducted in three phases after collecting data from the questionnaire. The first phase was preparation phase to collect and check the filled questionnaires. Afterwards, we did tabulation to describe value proposition based on customer value mapping. The last phase was data application phase using customer value mapping to describe the value proposition and path analysis to investigate a complete correlation among each observed variable.

Customer Value Mapping

Customer value mapping was used to describe the position of premium fresh tomato products with their branding and packaging attributes. Firstly, customer value analysis was applied before developing customer value mapping in four-quadrants of mapping, in which vertical axis represented relative benefit and horizontal axis represented cost relative of the analyzed product. The customer value analysis was measured by calculating the ratio or comparison of benefit and cost, and counting each scores of product overall benefit and cost overall product. Afterwards, the ratio of customer value score was counted. The score indicated customer value position of fresh tomatoes based on the product value of brand and packaging, and the product monetary cost.

Path Analysis

We tested the effect of branding and packaging on customer value using path analysis, assisted by SPSS 15.0 program, as described in Figure 2. Path analysis was chosen to assess the pattern of causation of branding and packaging or both variables on the observed customer value variable. The analysis elucidated the distinctive features between marginal coefficient if the response variable is regressed by single regression variable and the partial regression coefficient if one or more extra regression variables are involved when the causal explanation are not appropriate (Bartholomew et al. 2008).

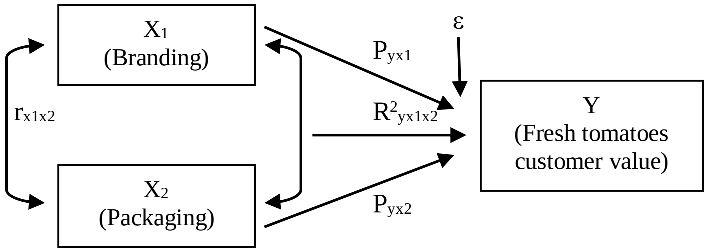

Fig. 2. Path diagram of correlation of branding and packaging on customer value
Structured equation for path diagram:

$$Y = \rho_{yx1}X1 + \rho_{yx2}X2 + \varepsilon$$

The hypothesis in this research was that there is an effect of branding and packaging towards customer value in terms of utility of branding, utility of packaging as customer perceived value, and customer value based on product benefit and material cost. Furthermore, customers may have different point of views on utility of branding as product identification, market differentiation, and product quality. Also, they may have different perspectives on utility of packaging and its importance and functions. In order to define the influence of branding and packaging on customer value, the following hypothesis were set:

a. Hypotheses for the influence of branding and packaging on customer value.
   H_0 : there are no significant influences of utility of branding and packaging on branded and packaged fresh tomatoes customer value
   H_1 : there are significant influences of utility of branding and packaging on branded and packaged fresh tomatoes customer value

b. Hypotheses for the influence of branding in terms of utility of branding on customer value.
   H_0 : there is no significant influence of utility of branding in terms of brand as product identification, market differentiation, and product quality on branded and packaged fresh tomatoes customer value
   H_2 : there is a significant influence of utility of branding in terms of brand as product identification, market differentiation, and product quality on branded and packaged fresh tomatoes customer value

c. Hypotheses for the influence of packaging in terms of utility of packaging on customer value.
   H_0 : there is no significant influence of utility of packaging in terms of the importance of packaging and packaging function on branded and packaged fresh tomatoes customer value
   H_3 : there is a significant influence of packaging in terms of the importance of packaging and packaging function on branded and packaged fresh tomatoes customer value

RESULTS AND DISCUSSION

Socio – demographic Profile

There was a significant difference in the age distribution of customers (Table 2). The majority of customers were females aged over 45 years-old. Different customer gender could give different point of view, for instance, female prefers to choose fresh produce with more information and attributes on packaging compared to male (Ragaert et al. 2004). It was also highlighted that almost half the proportion of customers had moderate family income level between IDR 2-5 million, and had no specific occupation (housewives). Nearly a quarter of the customers worked as professionals and government employees. This customer profile describes the market segment and market target of branded and packaged tomatoes.

Table 2. Socio-demographic customer profile of branded and packaged fresh tomatoes

Description	n (n = 41)	%
Age Group		
18 – 35 years	7	17.07
36 – 45 years	12	29.27
Over 45 years	22	53.66
Sex		
Male	2	5.13
Female	39	95.12
Income		
IDR 2 million – IDR 5 million	20	48.78
IDR 5 million – IDR 10 million	18	43.9
> IDR 10 million	3	7.32
Occupation		
Non-professional	5	12.20
Professional	9	21.95
Government Employee	10	24.39
Never worked (housewife)	17	41.46

Customer Value Analysis

Value proposition mapping aims to describe and to evaluate competencies and capabilities of producers in delivering efficient and effective value proposition to customer to satisfy both parties (Martinez and Bititci 2001). Each customer has unique and dynamic values which are indicated by different behavior overtime (Ulaga and Chacour 2001). Values of customer might change in a different time span and business environment. The results of customer value analysis in this study are summarized in Table 3.

Customer value is a comparison of the benefits that consumers gain from the purchase of branded and packaged tomatoes based on applied benefits with the use of branding and packaging for tomato products compared to the total cost incurred by consumers including the rationality, affordability and the cheaper price. Customer value approach was used to identify how consumers assess competitive offers from various kinds of the same product and then make the assumption that their buying decisions is associated with the product value as the key driver (Evans 2002). Analysis of branded and packaged tomatoes customer value toward assessment of customer value dimensions to produce a position map is shown in Table 2 and Fig. 3.

Table 3. Customer value analysis

	Customer Score Component	Score	Benefit Total Score	Benefit Average Score	Cost Total Score	Cost Average Score	Customer Value Score
	Benefit						
1	Brand utilization	131	-	3,20	-	-	
2	Package utilization	157	-	3,83	-	-	
3	Brand and package as product quality	158	-	3,85			
4	Brand and package as positive impression reference	159	-	3,88			
5	Brand and package as nutrient reference	159	-	3,88			
		-	764	**3,73**	-	-	
	Cost						
1	Monetary Cost	-	-	-	-		
	a. Reasonable and affordable cost	-	-	-	137	3,34	
	b. Cheaper Cost				109	2,66	
					246	**3,00**	1,24

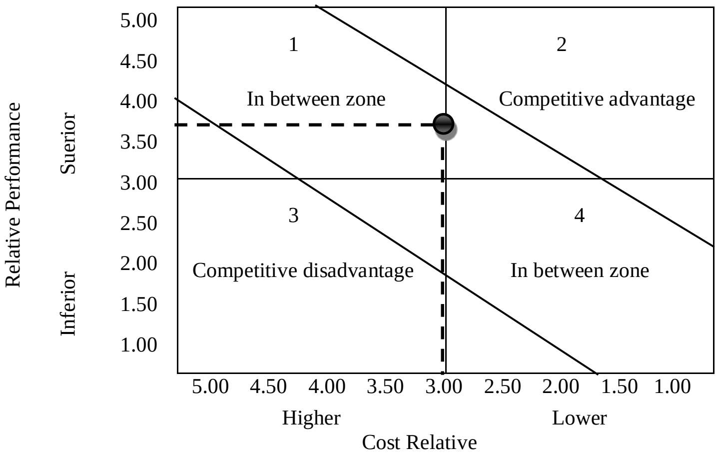

Fig. 3. Branded and packaged fresh tomatoes customer value mapping

The customer value analysis (Table 3) and customer value mapping (Fig. 3) revealed that customer perceived benefit had a high average score, while perceived cost had a fair average score. This is in line with the statement from Lovelock and Wirtz (2004) that value is subjective to each consumer and only a few of the consumers have expertise in assessing and evaluating product quality to finally recognize the value of the product. Tomatoes growers and/or distributors should have enough information of the importance of product attribute and furthermore give in-depth explanation to customers to appraise the perceived value of a product.

Customer value mapping shows that branded and packaged fresh tomatoes belong to the area called "in between zone". This area points out high or superior perceived benefits and fair perceived costs by customers. It means customers see branded and packaged tomatoes as the high value products based on their high average benefits. Branding and packaging attributes could be considered as the triggers for tomatoes to be more than just a generic vegetable that are mostly sold in the market. A fair average cost perceived by customer is the key that should be considered by the tomato producers and/ or tomato distributors (wholesalers or suppliers) who used the two products attributes as marketing tools to increase the product value. The product average cost performance should be reduced in order to create lower product cost.

Correlation among Variables

Data analysis using SPSS 15.0 yielded the coefficient correlation between each variable branding and packaging on customer value (Table 4). The calculation result between utility of brand and customer value was 0.611. This indicated that these two variables had a strong relationship because it stood above 0.4 with positive heading. A strong positive connection between the utility of packaging and customer value was also found (coefficient correlation = 0.519).

Table 4. Correlation matrix among variables

	X1 (Utility of Brand)	X2 (Utility of Packaging)	Y (Customer Value)
X1 (Utility of Brand)	1.000	0.457*	0.611*
X2 (Utility of Packaging)	0.457*	1.000	0.519*
Y (Customer Value)	0.611*	0.519*	1.000

* Significant at the level 0.05 (2-tailed)

Path Coefficient

This research used a structured model consisted of two independent variables and one dependent variable. Path coefficient was signified as Beta coefficient (Table 5).

Table 5. Path coefficient

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig
	B	Std. error	Beta		
1 (constant)	0.084	0.227		0.371	0.713
X1	0.118	0.034	0.473	3.483	0.001*
X2	0.144	0.064	0.303	2.236	0.031*

*Significance at the 0.05 level dependent variable Y

Coefficient Determination

Path coefficients ($\rho_{y\varepsilon}$) for other variables which were not involved in this research (Table 6) were measured by calculating the coefficient using this formula:

$$\rho_{y\varepsilon} = \sqrt{(1 - 0.447)} = 0.74364$$

Table 6. Path coefficient for other variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.668[a]	0.447	0.417	0.12195

a. Predictors: (constant).

The structured equation model of the influence of branding and packaging on customer value was as follows:

$$Y = 0.473X1 + 0.303X2 + 0.743$$

Model diagram of the influence of X1 (branding) and X2 (packaging) towards Y (fresh tomatoes customer value) was depicted in Fig. 4:

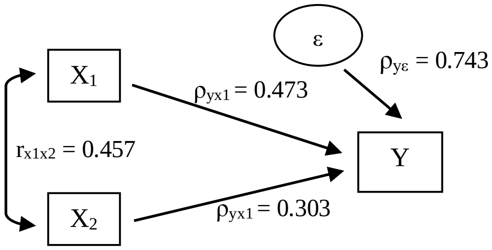

Fig. 4. Model diagram

Path Coefficient Testing

Verification of the influence of branding and packaging towards tomatoes customer value was done through two-stage statistical hypothesis testing. The first stage was the simultaneous testing to identify the significance of both branding and packaging towards customer value; followed by the identification of the partial significance of each branding and packaging on tomatoes customer value.

Table 7 illustrates the effect of branding and packaging on tomatoes customer value with F – test = 15.327 and was significant at the 5% level, confirming the model fitness. Furthermore, there were also significant influences of: (1) utility of branding towards tomatoes customer value (t – test = 3.483) and (2) utility of packaging towards customer value (t – test = 2.236), which were subsequently compared with t-student distribution for α=5%. These results confirmed the hypothesis that both branding and packaging influence tomatoes customer value.

Table 7. Estimation model customer value

Variable	Model	Coefficient	Std. Error	t-statistic	Prob.
	1 (constant)		0.227	0.371	0.713
Brand	X1	0.473	0.034	3.483	0.001
Packaging	X2	0.303	0.064	2.236	0.031
Brand and Packaging	F-statistic	15.327			
	Prob (F-statistic)	0.000			

a. Predictors: (constant), X1, X2
b. Dependent variable: Y

The Effect Proportion

Each variable of brand and packaging gave different effect proportion towards tomatoes customer value as described as follows:

a. Branding directly determines the changes of fresh tomato customer value by 22.4%, and, along with the use of packaging, indirectly influences customer value by 6.6%. Thus, the total effect of branding on fresh tomato customer value changes was 29%.

b. Packaging directly determines the changes of fresh tomato customer value by 9.2%, and, along with the use of packaging, indirectly influences customer value by 6.6%. Therefore, the total effect of packaging on fresh tomato customer value changes was 15.8%.

c. Branding and packaging altogether affects fresh tomato customer value by 44.7%. Meanwhile, other variables that were not involved in the research have 55.2% proportional effect on fresh tomato customer value.

Customer value mapping analysis shows that branded and packaged tomatoes stood in an area called “in between zone” which might bring superior competitive advantage on fresh tomato marketing. Contribution of branding and packaging in creating customer value was also corroborated in this study. This means that both attributes have successfully increased fresh tomato value although the customers were aware of its higher price. Branding and packaging are examples of proactive innovation aiming at gaining superior customer value, unlike reactive innovation which merely offers an equal customer value compared to the competitors (Ingenbleek et al. 2001). Brand and packaging might increase the perceived value of commodity product such as fruits and vegetables, thus might impact consumer’s choice or decision making to buy certain fresh produce (Halaswamy and Subhas 2014; Koutsimanis et al. 2012). Brand value could contribute to reduce fresh product risk quality (Jin et al. 2008), and to nurture financial growth and prosperity of agribusiness industry (Nijssen and Trijp 1998). Therefore, producers and suppliers of premium fresh tomatoes need to sustain innovative branding and packaging to achieve superior customer value and increase their competitiveness.

CONCLUSION

Based on the study findings, it is necessary to educate farmers or producers and distributors of premium quality tomatoes regarding the importance of branding and packaging to enhance the customer value of their product. This value creation would escalate the product benefits which worth its premium price that will, in turn; increase the growth of agribusiness industry. The present study affirms the positive effects of product attributes, particularly branding and packaging, on creating value of tomato commodity.

Research concerning customer value creation of fresh vegetables, is not a common issue in marketing. Compared to studies on industrial products, research on customer value creation in agribusiness is still limited. Accordingly, further studies to assess variables which are not included in this research might add more values for producers, marketing actors, and also customers of the perishable commodity such as tomato.

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EFFECT OF EXOGENOUS APPLICATION OF SALICYLIC ACID ON THE SEVERITY OF TOMATO LEAF CURL DISEASE

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ABSTRACT

Salicylic acid (SA) is a natural plant hormone involved in natural plant defense against diseases by acting as the signaling molecule for triggering systemic acquired resistance. In the absence of the plant innate natural defense, the resistance can be induced through exogenous application SA or its functional analogue. In this study, the effect of SA treatment on the severity of leaf curl disease of tomato (*Solanum lycopersicum* L.) was evaluated under screen house conditions in two experimental trials at the Crop Protection Cluster, University of the Philippines Los Baños from 2012 to 2013. The study sought to determine the concentration of SA applied at different time of induction which can effectively reduce the severity of the disease. Healthy seedlings of susceptible tomato variety, Apollo White were treated by spraying with 50, 250 or 500µM SA at 5, 10 or 15 days before inoculation (dbi). At induction time of 5 dbi, treatment with 250µM SA had lowest leaf curl infection compared with the untreated control, while at 10 and 15 dbi, leaf curl infection was lowest with treatment of 50µM SA. Likewise, treatment with 50µM SA regardless of induction time had consistently delayed and reduced the severity of leaf curl disease. Generally, plants treated with 50µM SA had reduced amount of disease (AUDPC values), lower symptom severity score and lower disease index (DI) than the untreated control. The severity of the disease was also reduced with 250 and 500 µM SA treatment but the effect was more consistent with 50µM.

Key words: induced resistance, systemic acquired resistance

INTRODUCTION

In the Philippines, tomato leaf curl, the most destructive virus disease of tomato is caused by different whitefly-transmitted *Begomovirus* species with the *Tomato leaf curl Philippines virus* (ToLCPV) (Kon et al. 2002; Fauquet et al. 2008; Tsai et al. 2011) being the most prevalent. The disease is widespread and greatly affects the tomato production in the country causing up to 65% reduction in crop yield or even complete loss of the crop with severe infections (Mendoza 2005). Several practices have been employed to manage tomato leaf curl including the control of insect vector, mulching, early planting, seedling protection, seedling treatment, host-free period, sanitation and use of resistant varieties (Ioannou 1987; Ellsworth and Carillo 2001; Polston and Lapidot 2007). However, effective management of the disease remains a great challenge because of the limitations of these methods. The use of resistant varieties would be the most practical and effective means to manage virus diseases including leaf curl disease. However, there are limited virus resistant varieties, and only few tolerant are commercially available. Thus, other approaches for leaf curl management must be explored. The strategy is not necessarily to prevent infection but to reduce the severity of the leaf curl disease.

One approach, known as induced resistance (IR), has been shown to have potential for conferring resistance against plant viruses (Agrios 1988). The resistance is in the form of systemic acquired resistance (SAR) which can be triggered by exposing the plant to virulent, avirulent, or nonpathogenic microbes, or it can be induced artificially by a chemical agent (Vallad and Goodman 2004). The other form is induced systemic resistance (ISR) which is potentiated by a growth promoting rhizobacteria. In both SAR and ISR, the plant defense is preconditioned by prior infection or treatment with the inducer that results in resistance (or tolerance) against subsequent infection by a pathogen (Vallad and Goodman 2004).

Salicylic acid (SA) is a natural plant hormone (Khan 2010), and is known to be involved in natural plant defense against diseases. It acts as the signaling molecule for triggering SAR (Durrant and Dong 2004; An and Mou 2011). The induction of SAR is mostly associated with the accumulation of SA (Sticher et al. 1997;

Vlot et al. 2009), and the production of pathogenesis-related (PR) proteins. In the absence of plant's innate natural defense, the resistance can be induced artificially by exogenous treatment with SA or its functional analogue**,** 2,6-dichloro-isonicotinic acid (INA) or benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester (BTH) (Sticher et al. 1997). The success of inducing resistance depends on the right concentration and proper timing of induction. In the induction of resistance, a certain period of time between the treatment of the inducer and inoculation or exposure to the invading pathogen is also required for the establishment of SAR, and these corresponds to the time required for the coordinated accumulation of PR proteins and SA throughout the plant (Uknes et al. 1992; Cameron et al. 1994). Some studies have shown the role of SA for inducing resistance to plant viruses including *Tobacco mosaic virus* (TMV), *Cucumber mosaic virus* (CMV), *Tomato spotted wilt virus* (TSWV) and *Pepper golden mosaic virus* (PGMV) (Van Loon and Antoniw 1982; Malamy et al. 1990; Metraux et al. 1990; Anfoka 2000; Vallad and Goodman 2004; Vlot et al. 2009; Trejo-Saavedra et al. 2013). The resistance induced is either through the application of SA or BTH. This study aimed to manage tomato leaf curl through the induced resistance approach using SA as the inducer. Thus, the efficacy of exogenous application of SA in reducing the severity of tomato leaf curl was evaluated as an initial study to determine the potential of induced resistance for tomato leaf curl management. The objectives were to determine the concentration of SA and the proper timing of induction which can effectively reduce the severity of the disease.

MATERIAL AND METHODS

The effect of SA treatment on the severity of leaf curl disease was evaluated using Apollo white tomato variety in two experimental trials under screen house conditions at the Crop Protection Cluster, University of the Philippines Los Baños (UPLB). Trial 1 was conducted in the wet season (August-November 2012), while trial 2 in the dry season (March-June 2013). The effect of SA was determined by spraying the plants with varying concentrations at different time of induction. The study was conducted in a 4 x 3 factorial experiment, consisting of four concentrations (factor A) (0 or untreated control, 50, 250 and 500 µM) of SA, and three induction time (factor B) (5, 10 and 15 days before inoculation). The experiment was laid out following the randomized complete block design with three replications, and with six plants per replication.

Salicylic Acid Treatment

The plants were treated by spraying the healthy tomato seedlings with solution of each concentration of SA applied at different induction time. Spraying was done until the SA solution was already dripping. The induction time refers to the time period when SA was applied on the plant several days (5, 10 and 15 days) before challenged inoculation (dbi). For induction time of 15 dbi, SA was applied on 20 day-old seedlings, while 10 dbi and 5 dbi on 25 day-old and 30 day-old seedlings, respectively. This ensured that all seedlings were of the same age (35 day-old) during inoculation.

Virus Inoculation Using the Whitefly Vector

The leaf curl infected tomato plants served as the source of virus inoculum. The whiteflies were confined in screened nets, and allowed to feed and build up their population on the infected plants for about 30 days. Inoculation was subsequently conducted by exposing the SA treated and the untreated 35-day-old healthy tomato seedlings on the viruliferous whiteflies. In order to ensure uniform inoculation, the leaf curl infected tomato plants that served as the virus source were distributed in between rows for each treatment. The inoculated plants were observed for the development of the disease.

Disease Assessment

The effect of SA was assessed in terms of delay in disease development and reduction of disease severity. The delay in disease development was measured based on the leaf curl infection taken at different time period during the infection, and expressed as the disease progress curve. The reduction of disease severity was measured using parameters such as percent infection, symptom severity, Area under the disease progress curve (AUDPC) values and disease index (DI).

Leaf curl infection and disease progress curve. The presence of leaf curl disease was determined by visual observation of disease symptoms in the inoculated plants. Leaf curl infection was computed as the proportion of plants displaying symptoms over the total number of inoculated plants. The disease progress curve represented the percentage leaf curl infection plotted against time of 1, 2, 3 and 4 week post inoculation (wpi).

The area under the disease progress curve. The amount of disease was determined based on AUDPC values and computed using the following formula:

$$\text{AUDPC} = \sum_{i}^{n-1} \left(Yi + Yi + \frac{1}{2}\right)(ti + 1 - ti)$$

Where:
AUDPC =area under the disease progress curve (percent-days or proportion-days); *n* = number of assessment times; *y* = disease incidence; *t* = time

Symptom severity. The symptom severity was determined at 4 wpi, following the rating scale presented in Table 1.

Table 1. Rating scale used in evaluating the symptom severity of tomato leaf curl.

Symptom severity score	Symptom description
0	No leaf curl disease symptom
1	Leaf curl disease symptom on the shoot apex
2	Leaf curl disease symptom on the shoot apex, and on the first and second leaf petioles
3	Leaf curl disease symptom on upper half portion of the plant
4	Leaf curl disease symptom on the whole plant
5	Leaf curl disease symptom on the whole plant with severe stunting

Disease index (DI). It is a measurement of disease severity based on the proportion of plants with different symptom severity score, and computed as:

$$\frac{[n(1)+n(2)+n(3)+n(4)+n(5)]}{t(n)}$$

where n(1), n(2), n(3), n(4), n(5) = number of plants showing a reaction scale (1), (2), (3),(4), (5), respectively and t(n) = total number plants scored.

Statistical analysis

The Analysis of Variance (ANOVA) for leaf curl infection (%) and AUDPC values were analyzed using the Statistical Tool for Agricultural Research (STAR version 2.0.1). The treatment means were compared using the Least Significant Difference Test (LSD, $p \leq 0.05$) and the symptom severity score data was analyzed by Non-Parametric Analysis.

RESULTS AND DISCUSSION

Leaf Curl Infection

Salicylic acid treatment generally reduced leaf curl infection compared with the untreated control. The efficacy was affected by the concentration, and by the induction time depending on the concentration of SA (Fig. 1). In trial 1, leaf curl infection at 2 wpi was lower in plants treated with varying concentrations of SA at 5, 10 or15 dbi compared with the control (Fig. 1A). Infection also varied with varying concentrations of SA. At induction time of 5 and 10 dbi, treatment with 50µM SA resulted to lower infection (both 11%) compared to 250µM (22% and 16%) and 500 µM (22 and 33%). However, at induction time of 15 dbi, infection was not yet observed with 250 and 500µM treatments, while 6% of the 50µM treated plants were already infected. At 4 wpi, treatment with 250µM at 5 dbi was slightly lower (72%) than with 50µM (78%), while the 500µM treated and the untreated control had comparable infection (83%) (Fig. 1B). However, treatment at 10 and 15 dbi with 50µM resulted to lower infection (66% and 61%) than 250µM (100 and 83%) and 500µM (83 and 77%). In trial 2, infection at 2 wpi was also lower in SA treated plants than the untreated control (Fig. 1C). Both 250 and 500µM treatments at 5 dbi had infection of 55%, while 50µM had 66%. However, infection was slightly lower with 50µM treatment at 10 (38%) and 15 dbi (38%), while 250µM had 44% at 10 dbi and 66% at 15 dbi. At 4 wpi, treatment with 250µM at 5 dbi had the lowest infection (83%); however, at 10 and 15 dbi, the 50µM treatment had the lowest with 77% and 55%, respectively.

The effect of varying concentrations of SA was also observed when the mean infection regardless of induction time was considered in the analysis. Generally, SA treatment regardless of concentration resulted in lower infection as well as delayed infection compared with the untreated control (Fig. 2). The effect was more apparent with treatment of 50 µM than 250 and 500 µM. In both trials, the development of the disease shown as the disease progress curve was delayed in the SA treated plants (Fig. 2). In trial 1, the SA treated plants regardless of concentration had significantly lower infection (less than 10%) at 1 wpi than the untreated control (35%) (Fig. 2A). At 2 wpi, the disease did not progress rapidly wherein the treated plants remained to have significantly lower infection (9-18%) than the untreated plants (50%). However, at 3 wpi, only the 50µM treated plants had lower infection (44%) than the control (69%). Infection increased rapidly in the 250µM (74%) and 500µM (70%) treated plants comparable with the untreated control (69%). At 4 wpi, only the 50µM treated plants had significantly lower infection (68%) than the untreated control (87%). In trial 2, similar result was observed at 1-2 wpi, wherein the SA treated plants had lower infection than the control. Infection started to increase at 3 wpi in plants treated with 500 µM (89%), but not with 50µM (62%) and 250µM (65%) (Fig. 2B). At 4 wpi, only those treated with 50µM SA (75%) had significantly lower infection than the control (100%).

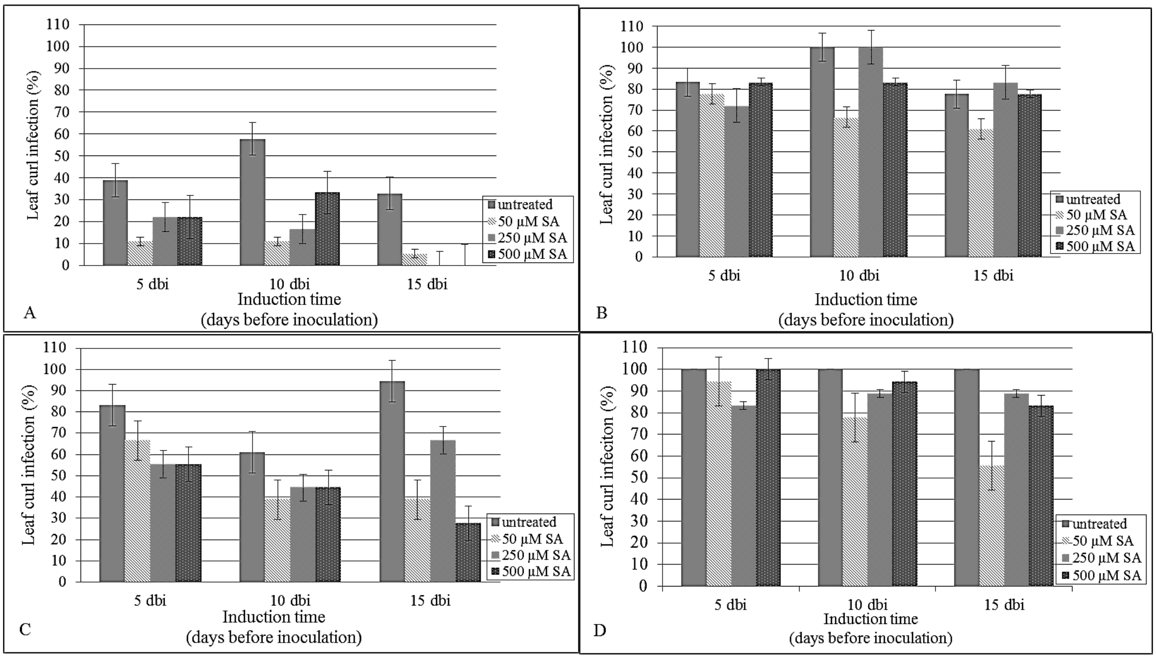

Fig. 1. Leaf curl infection of tomato plants treated at different induction time with varying concentrations of salicylic acid. A-B) Trial 1 at 2 and 4 weeks post inoculation (wpi); and C-D) Trial 2 at 2 and 4 wpi.

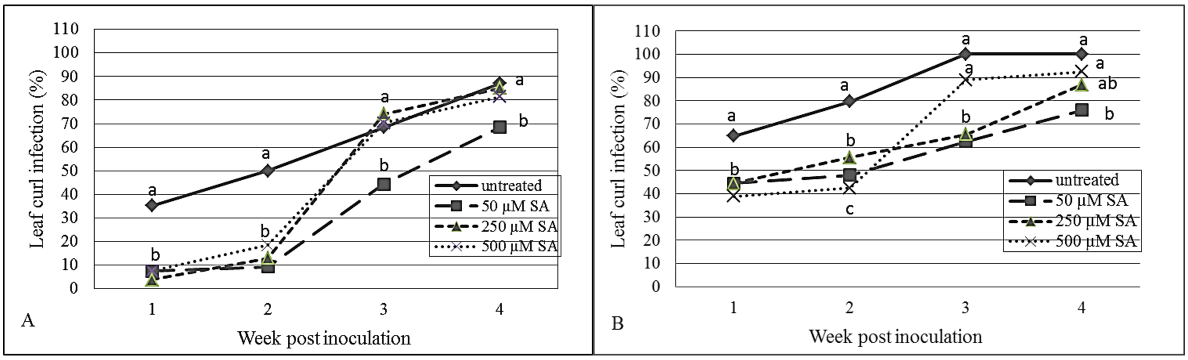

Fig. 2. Disease progress curve for tomato leaf curl infection in plants treated with varying concentrations of salicylic acid in Trial 1 (A) and Trial 2 (B). At each time point (weeks post inoculation), values with the same letter are not significantly different at 5% Least Significant Difference.

Area Under Disease Progress Curve (AUDPC)

The amount of leaf curl disease measured as AUDPC values was reduced with SA treatment (Table 2). In both trials, SA treatment regardless of concentration had significantly lower AUDPC values than the untreated control. In trials 1 and 2, plants treated with 50µM SA had AUDPC value of 641%-days and 1199%-days, respectively which were significantly lower than the control (1257%-days and 1834%-days). In trial 1, treatment with 50µM SA had significantly lower AUDPC value (641%-days) than 250 (907%-days) and 500µM

(933%-days). In trial 2, the AUDPC values were not significantly different among the 50, 250 and 500µM SA treatments. However, AUDPC value was lowest (1199%-days) with 50µM SA treatment.

Table 2. Area Under Disease Progress Curve (AUDPC) based on percentage leaf curl infection of plants treated with varying concentrations of salicylic acid.

Salicylic acid concentration (µM)	AUDPC(%-days)[1,2]	
	Trial 1	**Trial 2**
0	1,257 ± 332 a	1,834 ± 107 a
50	641 ± 108 c	1,199 ± 118 b
250	907 ± 125 b	1,307 ± 92 b
500	933 ± 257 b	1,380 ± 216 b

[1]In a column, values with the same letter are not significantly different at 5% LSD

[2] (±) standard deviation for each treatment

Symptom Severity

The treatment with lower concentration of SA reduced the symptom severity of leaf curl disease. At 4 wpi, significant differences among the treatments with varying concentrations of SA was found, but not with different induction time. Analysis of symptom severity score of treated plants regardless of induction time showed that those treated with 50µM had consistently lower symptom severity score than the untreated control in both trials (Table 3). In trial 1, plants treated with 50µM had significantly lower symptom severity score (1.6) than the control (ss=2.8). Likewise, symptom severity of the 250µM SA treated plants (ss=2.1) was significantly lower than the control, but not those treated with 500µM (ss=2.4). In trial 2, similar reduction in symptom severity at 4 wpi was observed with SA treatment at lower concentration but not at higher concentration. Treatment with 50µM SA resulted in consistently lower symptom severity score than the control. Plants treated with 50µM had symptom severity score of 2.1 which was significantly lower than the control (ss= 2.7). However, symptom severity scores of plants treated with 250 (ss=2.5) and 500µM (ss=2.7) were not significantly different with the untreated plants (Table 3). The 50 µM SA treated plants with mean severity score of 2.1 was closest to severity score=2, wherein most of the treated plants had symptoms on the shoot apex, and on first and second leaf petioles (Fig. 3B). The untreated plants had severity score closest to ss=3, wherein the upper half portion of the plant had already leaf curl disease symptoms (Fig. 3 C).

Table 3. Symptom severity score and disease index for tomato leaf curl at 4 weeks after inoculation of plants treated with varying concentrations of salicylic acid.

Salicylic acid concentration (µM)	Mean symptom severity score [1,2]		Disease Index (%) [3]
	Trial 1	**Trial 2**	
0	2.8 ± 0.18 a	2.7 ± 0.18 a	78
50	1.6 ± 0.23 c	2.1 ± 0.54 b	36
250	2.1 ± 0.23 b	2.5 ± 0.16 a	55
500	2.4 ± 0.41 ab	2.7 ± 0.43 a	65

[1] Symptom severity score: 0-no leaf curl like symptoms; 1-leaf curl disease symptom on the shoot apex; 2- leaf curl disease symptoms on the shoot apex and on the first and second petioles of the plant; 3- leaf curl disease symptoms on upper half portion of the plant; 4- leaf curl disease symptoms on the whole plant; 5- leaf curl disease symptoms on the whole plant and severe stunting. In a column, values with the same letter are not significantly different at 5% LSD.

[2] (±) standard deviation for each treatment

[3] Mean of two trials

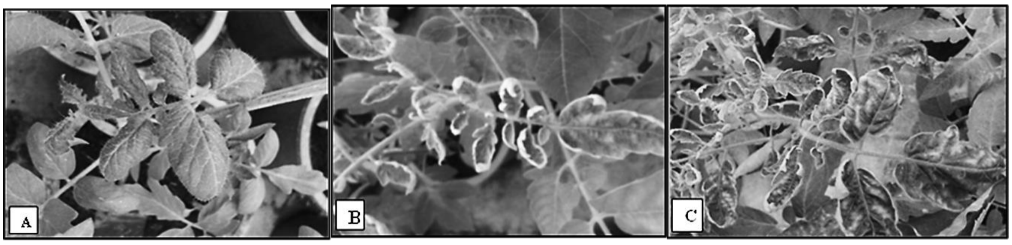

Fig. 3. Symptom severity for tomato leaf curl disease, A) severity score (ss) = 1, leaf curl symptom on the shoot apex; B) ss = 2, symptoms on the shoot apex and on the first and second leaf petioles; C) ss=3, leaf curl symptoms on upper half portion of the plant.

Disease Index

The SA treatment regardless of concentration resulted in lower disease index (DI) compared with the untreated control (Table 4). Among the SA concentrations, treatment with 50µM gave the lowest DI of 36%, while the untreated control had 78%. Treatment with 250µM and 500µM also resulted in lower DI, but the effect was more apparent with 50µM. Plants treated with 250µM SA had DI of 55%, while those treated with 500µM had 65% DI.

The efficacy evaluation conducted in this study showed that exogenous application of SA can delay the development and reduce the severity of tomato leaf curl disease. At shorter induction time of 5 dbi, treatment with 50 and 250µM SA effectively reduced leaf curl infection compared with the untreated control, but the reduction was greater with treatment of higher concentration (250µM) than lower concentration (50µM). However, at longer induction time of 10 and 15 dbi, reduction of leaf curl infection was highest with treatment of 50µM SA. Overall, reduction in the severity of tomato leaf curl was consistent with treatment of 50µM SA at 15 days before inoculation.

Since SA was applied on plants at different ages of 20, 25 and 30 day old for 15 dbi, 10 dbi and 5 dbi treatments, respectively, the difference in leaf curl infection cannot be attributed mainly to differences in the length of induction time. In this study, SA treatment was imposed at different ages of seedlings to allow the inoculation of the virus on seedlings of the same age (35 day-old). Thus, in future studies, the effect of seedling age must be evaluated in order to clearly determine the effect of induction time on the efficacy of SA treatment. In this case, the SA will be applied on seedlings of the same age, but the plants will be of different ages during inoculation. Considering the effect of SA concentration regardless of induction time, the result showed that treatment with 50µM SA compared to 250 and 500 µM delayed the development and reduced the severity of the disease. The disease progress curve clearly showed that the development of leaf curl infection was delayed in the SA treated compared with the untreated control. The effect was more consistent with treatment of 50µM, which resulted to delayed disease development from the early to later stages of infection (1-4 wpi), compared with the untreated control and 250 and 500µM treatments. Likewise, SA treatment had reduced the severity of the disease. The amount of leaf curl disease expressed as AUDPC values were consistently lower in the treated than the untreated control. The effect was more apparent with 50µM than 250 and 500µM concentration. The lower disease index of 50µM SA treated plants compared with those treated with 250 and 500µM, and the untreated control, showed that SA treatment at low concentration of 50 µM can reduce the severity of leaf curl disease.

Several studies have demonstrated the efficacy of exogenous application of SA analogue (BTH) for controlling fungal and bacterial diseases (Siegrist et al. 1997; Cole 1999), the effect of which is in the form of induced resistance. However, induced resistance to viruses through exogenous application of SA or its functional analogue has been demonstrated in only few studies. The resistance of tobacco to subsequent infection of TMV is found to be enhanced by pre-treatment of plants with aspirin or SA (White 1979). Likewise, the application of 100µM BTH as a soil drench, 7 days before inoculation with CMV-Y, protected plants against the virus (Anfoka 2000). The resistance is expressed as decrease in disease incidence and severity in BTH-treated plants. At 21 days after challenge inoculation with CMV-Y, the disease incidence in plants did not exceed 12.5% while 91.7% of control plants are severely infected, and the development of the disease is delayed for 7 days. Resistance to PepGMV infection is also induced in pepper plants by BTH treatment (Trejo-Saavedra et al. 2013). Treatment of pepper plants with 150-300 mg L^{-1} BTH reduced the symptom severity and percentage of infected plants. The reduction is directly correlated with the concentration of BTH, and the time period between BTH application and the inoculation with the virus. The protection obtained with BTH treatment is less evident in plants inoculated 10 or 15 days compared with 5 days after the BTH treatment. In their result, it was shown that the efficacy of BTH protection decreases over time. Our results showed that 50µM SA applied at 15 dbi was the most effective treatment in reducing the severity of leaf curl disease. It appeared that protection was correlated with induction time but depending on the concentration of SA. In our study, the efficacy decreased at longer induction time (15 dbi) when plants were treated with 250µM SA, while the efficacy increased at longer induction time with lower concentration of 50µM. Among the SA concentrations, the 50µM compared with 250 and 500 µM can effectively reduce the disease severity. The 50µM was lower than the SA concentration of 1.5mM which is effective for inducing plant natural defenses to abiotic and biotic stresses (War *et al*. 2011). Resistance to CMV-Y in tomato was induced by treatment with 0.1mM BTH applied as soil drench at seven days before challenged inoculation with the virus (Anfoka 2000). Treatment of pepper with BTH at 300 mg-L^{-1} was found effective for inducing resistance to PepGMV (Trejo-Saavedra 2013).

The efficacy of SA in reducing the severity of leaf curl disease needs to be confirmed under field conditions, and may also be evaluated by comparing the response to SA treatment in susceptible and tolerant varieties. The resistance response can be further evaluated by measurement of the virus titre in plant. Although, the virus titre was not measured in this study, the observed reduction in disease severity would indicate resistance response to virus infection. The parameters that were used to assess disease severity such as percent infection, symptom severity score, AUDPC values and disease index have been used to assess resistance to virus infection (Alviar et al. 2012). The resistance to CMV in tomato induced by BTH treatment was also measured based on reduction of disease severity (Anfoka 2000). In this study, the efficacy of SA treatment was more apparent with induction time of 15 dbi compared with 5 and 10 dbi, and this may indicate an induced resistance response. In the induction of resistance, a certain period of time between the treatment of the inducer and exposure to the invading pathogen is required. However, in order to determine if the response observed is induced resistance, analyses of SA and PR protein accumulation need to be conducted in future studies. Resistance in tobacco against TMV as induced by BTH treatment is accompanied by the induction of SAR genes (Friedrich et al. 1996). Moreover, Lawton et al. (1996) showed that the resistance induced by BTH treatment on *Arabidopsis* plants to *Turnip crinkle virus* (TCV) is accompanied by PR protein accumulation. Resistance to a geminivirus PepGMV infection is also induced in pepper plants by treatment with BTH, and the resistance is through the activation of the SA pathway (Trejo-Saavedra 2013). SA is an endogenous signal for the activation of certain plant defense responses, including PR-gene expression and the consequent establishment of enhanced resistance (Klessig 2000). Moreover, the use of other inducer such as BTH, and the recently identified priming activators such as azelaic acid (AZA) and pipecolic acid (PA) can also be evaluated, as they may also have potential in providing protection against virus diseases (Conrath et al. 2015).

CONCLUSION

Exogenous application of SA can reduce the severity of tomato leaf curl disease. The efficacy was affected by the concentration, and by the induction time depending on the concentration of SA. Treatment with 50µM SA at induction time of 15 dbi reduced leaf curl infection more effectively than at 5 and 10 dbi. Likewise, 250µM SA also reduced the severity of the disease, but at shorter induction time of 5 dbi. Overall, treatment with 50µM SA is the most effective. The severity of the disease was also reduced with 250 and 500 µM SA treatments but the effect was more consistent with 50µM.

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