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CHANGES IN SOME SOIL CHEMICAL PROPERTIES AND PRODUCTION OF SWEET POTATO, *Ipomoea batatas* (L.) Lam, TREATED WITH FISHPOND SEDIMENT AND WATER IN PETIR VILLAGE, DARMAGA, BOGOR, INDONESIA

Arief Hartono[1], Kenji Yokota[2], Tadashi Baba[3], and Bambang Subroto[1]
[1]Department of Soil Science and Land Resource, Faculty of Agriculture
Bogor Agricultural University, Jl. Meranti, Kampus IPB, Darmaga, Bogor 16680, Indonesia
[2]Department of Applied Biology and Chemistry, Tokyo University of Agriculture,
1-1-1 Sakuragaoka, Setagaya, Tokyo, Japan
[3]Department of Agriculture, Tokyo University of Agriculture, Atsugi, Japan
Corresponding author: hartono@apps.ipb.ac.id

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ABSTRACT

Bogor is situated about 70 km south of Jakarta, Indonesia. Bogor is situated upstream of the rivers via Jakarta. The water from Salak mountain is used by farmers not only for agriculture but also for fresh water fishponds. The study sought to clarify the nutrient content of fishpond sediment and fishpond water, evaluate their effects on soil chemical properties and determine the production of sweet potato in Petir village, Darmaga, Bogor in September 2013. Fishpond sediment and fishpond water were analyzed for selected chemical properties. The treatments in the field experiment were without any fertilizer, fishpond sediment, fishpond water, combination of fishpond sediment and fishpond water, and conventional fertilizer, arranged in completely randomized design with three replications. After 2 weeks of incubation and before planting sweet potato, the soil samples of each plot were collected and analyzed. Sweet potato were harvested after four months. The results showed that the fishpond sediment contained high levels of total nitrogen and available phosphorus, and very high organic carbon and basic cations (Ca, Mg, K and Na). The fishpond water contained relatively high total inorganic nitrogen and phosphate. From the field experiment, fishpond sediment and fishpond water improved some soil chemical properties better compared to conventional fertilizer. The combination of fishpond sediment and fishpond water was the best treatment as it resulted in the highest sweet potato yield. The results suggested that a combination of fishpond sediment and fishpond water can be recommended as soil ameliorant or fertilizer for sweet potato production.

Key words: contamination, nitrate, phosphate, upstream, waste

INTRODUCTION

Bogor is a city in West Java Province of Indonesia, and is located in approximately 70 km south of Jakarta, the capital city of Indonesia. Mount Salak is located on the south side of Bogor, and contributes to its annual rainfall of more than 3000 mm. Most of the fresh water, which flows out from Mt. Salak, is used for agriculture and fresh water fishponds in the surrounding areas of down town Bogor. These streams are upstream of rivers in Jakarta, and the rivers flow out to Jakarta Bay.

Fishponds use formulated complete feed (pellet) and chicken manure as feed. Farmers use fishpond sediments as concrete to harden the border of fishponds and fishpond water is allowed to flow into the canals. The fishpond sediment and fishpond water may contaminate the rivers flowing to Jakarta as feeding fish with pellets and chicken manure can result in accumulation of organic matter, nitrogen (N) and phosphorus (P). Accumulation of 30-95% of N and P have been reported in sediment (Olah *et al*. 1994; Boyd 1995). Muendo *et al.* (2014) reported that up to 173 tons of sediment ha^{-1} $cycle^{-1}$ accumulated in the semi-intensive tilapia production ponds in their experiments at the World Fish Center in Egypt. It contained high N, P, potassium (K) and organic matter.

Some countries have problems with nitrate level in groundwater where concentrations are above the permissible limit (Almasri 2007). P is also a potential pollutant that restricts the use of surface water (Foy and Withers 1995). The eutrophication of Jakarta Bay has been reported to be due to the increase in nitrate and P in the form of phosphate concentrations. Phosphate increased 10 times higher from the period of 1975-1979 to 2000-2004 (Arifin 2004). Lapointe *et al*. (1992) suggested that dissolved inorganic N and soluble reactive phosphate concentrations of more than 1.0 and 0.1 µM, respectively, caused blooming of micro-algal population. It was reported that massive fish kills have been observed in Jakarta Bay, and the oxygen depletion by intense algal blooms is suspected as key factor. Arifin (2004) observed that nitrate and phosphate concentrations in Jakarta Bay were higher at < 5 km from the coastal line than that of >10km. Nitrate and phosphate input is generally higher during rainy season. It is suspected that the anthropogenic nutrients input by agriculture and industry to the rivers of Jakarta Bay basin is a main factor for the eutrophication of Jakarta Bay's coastal marine ecosystem (Arifin 2004). Discarding fishpond sediment and fishpond water, as waste, contaminates the environment especially with nitrate and phosphate. However, there is minimal data on the chemical properties of fishpond sediment and fishpond water in agricultural sites in Bogor to support the potential reuse of fishpond s ediment and fishpond water for agriculture field as soil ameliorant or fertilizer.

This study sought to determine the nutrient content of fishpond sediment and fishpond water and to evaluate the impact of the utilization of fishpond sediment and fishpond water on soil chemical properties and production of sweet potato in Petir village, Darmaga, Bogor which is located in the foot of Mount Salak and the upstream of rivers flowing to Jakarta.

MATERIALS AND METHODS

The research was conducted from September 2013 to May 2014. The first step of this research was to evaluate the fishpond sediment and fishpond water in Petir village, Darmaga, Bogor where there are numerous fresh water fishponds (Fig. 1).

The materials which were used in the field experiment were fishpond sediment, fishpond water, urea, SP 36, KCl and sweet potato. Evaluation of the fishpond sediment and fishpond water as fertilizer was conducted by making comparison with without any fertilizer and conventional fertilizer (N, P and K fertilizer). Therefore the treatments were plot without any fertilizer (C), plot of fishpond sediment (FS), plot of the fishpond water (FW), plot of combination of fishpond sediment and fishpond water (FS + FW) and plot of conventional fertilizer (CF), namely N fertilizer in the form of urea, P fertilizer in the form of SP 36, K fertilizer in the form of KCl. The rate of fishpond sediment was 33.3 ton $ha^{-1}$and the fishpond water was 20 L per week. The rate for conventional fertilizers were 100 kg urea ha^{-1}, 100 kg SP 36 ha^{-1} and 200 kg KCl ha^{-1}. Urea and KCl were split twice in application while SP 36 was applied once. The treatments were conducted with three (3) replications. The size of the plot was 9m x 2m and arranged in completely randomized block design. This experimental design was selected because the field was flat.

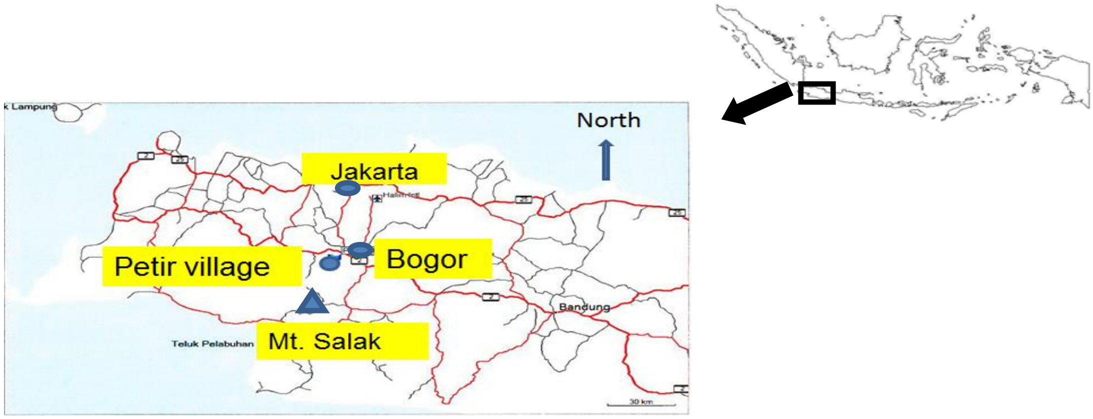

Fig. 1. The position of Petir village

The treatments were applied and incubated two weeks before planting The treatments were applied along the bed. After two weeks incubation, soil samples were collected and analyzed in each plots to evaluate the changes of chemical properties. After soil samples collection, sweet potato was planted along the bed. Observation of the sweet potato was conducted by measuring the production of tuber.

One (1) year old fishponds were selected with a size of 168 m^2 and depth of 50 cm. The top layer (0-20 cm) of fishpond sediment and the fishpond water were collected and analyzed. pH was measured in a 1:1 (w/v) water solution using a pH meter (Eutech Instruments pH 2700). Electric conductivity (EC) was measured with EC meter (WTW Cond 3110 Set 1). Exchangeable aluminum (Al) was extracted with 1 mol L^{-1} KCl. The content of organic carbon (C) in soil was determined with Walkley and Black method and total N was determined by Kjeldahl method. Available P content was obtained by the Bray 1 method (Bray and Kurtz 1945) while potential P was determined by digesting the soil sample using HCl 25%. Their absorbance at 693 nm was determined using a UV-VIS spectrophotometer (Shimadzu UV-1280).

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 (Ca^{2+}) and magnesium (Mg^{2+}) were determined by atomic absorption spectrophotometer (Shimadzu AA 6300) while those of exchangeable K^+ and sodium (Na^+) were determined by flame emission spectrophotometer (Corning 405). Base saturation (BS) was defined as the ratio of total exchangeable bases to CEC, expressed as a percentage. Analyses for fishpond water were pH, ammonium (NH_4^+), nitrate (NO_3^-) and phosphate (PO_4^{3-}). pH was measured using a pH meter. NH_4^+ and NO_3^- were determined by distillation process and titration while PO_4^{3-} was determined colorimetry using a UV-VIS spectrophotometer (Shimadzu UV-1280) (Murphy and Riley 1962).

Analyses of variance followed by a Tukey's test were applied to evaluate the effect of treatments to the parameters for the field experiments.

RESULTS AND DISCUSSIONS

Chemical properties of fishpond sediment and fishpond water

Chemical properties of the fishpond sediment and fishpond water were presented in Table 1 and Table 2, respectively. Some fishpond sediment properties status were judged according to criteria of nutrient status of soil fertility published by Soepraptohardjo *et al.* (1983). The criteria of nutrient status of soil fertility is presented in Table 3.

The fishpond sediment pH was slightly acid. The exchangeable Al was not detectable so the Al saturation was not detectable or zero. Organic C was very high, total N was medium. Available P content (Bray 1-P) was high. The potential P or P extracted by 25% HCl (HCl 25%-P) content was medium. The soil cation exchange capacity (CEC), Ca, Mg, K, and Na content were very high. The fishpond sediment base saturation was likewise very high.

Fishpond water contained 13.1 mg L^{-1} total inorganic nitrogen (TIN) and 0.22 mg PO_4^{3-} L^{-1}. Fried *et al*. (2003) suggested that the PO_4^{3-} levels should be less than 0.05 mg PO_4^{3-} L^{-1} to prevent algal growth. This fishpond water contained PO_4^{3-} higher than 0.05 mg PO_4^{3-} L^{-1}. With the size 168 m^2 and the depth 50 cm, at the end of cultivation (harvest time) it was flowed out to the canal 1.10 kg TIN and 0.02 kg PO_4^{3-}.

Table 1. Chemical properties of fishpond sediment

Parameter	Unit	Value
pH (H_2O)		5.10
Organic C	g kg^{-1}	54.2
Total N	g kg^{-1}	4.20
Available P (Bray-1)	mg P kg^{-1}	14.9
Potential P (HCl 25%-P)	mg P_2O_5 $100g^{-1}$	32.5
CEC	$cmol_c$ kg^{-1}	21.9
Exchangeable Ca	$cmol_c$ kg^{-1}	25.1
Exchangeable Mg	$cmol_c$ kg^{-1}	9.12
Exchangeable K	$cmol_c$ kg^{-1}	1.22
Exchangeable Na	$cmol_c$ kg^{-1}	1.16
Exchangeable Al	$cmol_c$ kg^{-1}	nd
Aluminium Saturation	%	0
Exchangeable H	$cmol_c$ kg^{-1}	0.26
Base Saturation	%	167

Compared to other fishpond sediment from the previous researches, the total N of this fishpond sediment (4.20 g kg^{-1}) was higher than that of Rachman *et al*. (2004) who reported a 2.80 g kg^{-1} total N of fishpond sediment. The potential P also of this fishpond, 142 mg P kg^{-1} was higher than that of Wahab *et al*. (1984), who reported a 70 to 110 mg P kg^{-1} potential P of fishpond sediment. This fishpond sediment contained 54.2 g kg^{-1} organic C which was comparable with the findings of Avnimelech *et al*. (1999) who reported 49.8 - 62.0 g kg^{-1} organic C in fishpond sediment.

The data showed that fishpond sediment and fishpond water contained high levels of organic C, available P, CEC, basic cations, medium in total N and non-detectable exchangeable Al, so these had the potential use as ameliorant or fertilizer for crop production in Petir Village, instead of releasing it to nearby canals and rivers.

Table 2. NO_3-N, NH_4-N, total inorganic nitrogen (TIN) and phosphate content in water samples

Parameter	Value
pH	6.00
NH_4^+	9.80 mg L^{-1}
NO_3^-	3.30 mg L^{-1}
TIN	13.1 mg L^{-1}
PO_4^{3-}	0.22 mg L^{-1}

TIN = total inorganic nitrogen (NH_4^+ + NO_3^-)

Table 3. Criteria of nutrient status of soil fertility (Soepraptohardjo *et al*. 1983)

Chemical properties	Very low	Low	Medium	High	Very high
Organic C (g kg^{-1})	< 10.0	10.0-20.0	20.1-30.0	30.1-50.0	> 50.0
Total N ((g kg^{-1})	< 1.00	1.00-2.00	2.10-5.00	5.10-7.50	> 7.50
HCl 25 %-P (mg P_2O_5 100g^{-1})	< 10.0	10.0-20.0	21.0-40.0	41.0-60.0	> 60.0
Bray 1-P (mg P kg^{-1})	< 4.40	4.41-7.00	7.10-10.9	11.0-15.3	> 15.3
CEC ($cmol_c$ kg^{-1})	< 5.00	5.00-16.0	17.0-24.0	25.0-40.0	> 40.0
Basic cations:					
K ($cmol_c$ kg^{-1})	< 0.10	0.10-0.20	0.30-0.50	0.60-1.00	> 1.00
Na ($cmol_c$ kg^{-1})	< 0.10	0.10-0.30	0.40-0.70	0.80-1.00	> 1.00
Mg ($cmol_c$ kg^{-1})	< 0.40	0.40-1.00	1.10-2.00	2.10-8.00	> 8.00
Ca ($cmol_c$ kg^{-1})	< 2.00	2.00-5.00	6.00-10.0	11.0-20.0	> 20.0
Basic Saturation (%)	< 20.0	20.0-35.0	36.0-50.0	51.0-70.0	> 70.0
Aluminium Saturation (%)	< 10.0	10.0-20.0	21.0-30.0	31.0-60.0	> 60.0
pH (H_2O)	Acid	Slightly acid	Neutral	Slightly alkaline	Alkaline
	4.50-5.50	5.60-6.50	6.60-7.50	7.60-8.50	> 8.50

Changes in selected chemical properties after two weeks incubation

Soil pH, electric conductivity (EC) and exchangeable Al

The effect of treatments to the soil pH, EC, and exchangeable Al after two weeks incubation is presented in Table 4. Statistically, the treatments did not affect the soil pH, EC, and exchangeable Al. However, the soil pH increased by 0.11 pH unit upon the application of a combination of fishpond sediment and fishpond water. The conventional fertilizer decreased by 0. 9 pH unit. The pH of the soils were classified as acid soil. The EC increased slightly upon the application of fishpond sediment, fishpond water, combination of fishpond sediment and fishond water and conventional fetilizer. The values of EC were below 2 mmho cm^{-1}, indicating normal soil.

The exchangeable Al decreased with the application of fishpond sediment and combination of fishpond sediment and fishpond water. On the other hand, the application of fishpond water, and conventional fertilizer, increased the exchangeable Al.

Table 4. The effect of treatments on soil pH, EC and exchangeable Al

Treatments	**pH H_2O (1:1)**	**EC (mmho cm^{-1})**	**Exch. Al ($cmol_c$ kg^{-1})**
Control- no fertilizer	5.19±0.05	0.05±0.00	0.57±0.32
Fishpond Sediment (FS)	5.15±0.04	0.07±0.02	0.36±0.12
Fishpond Water (FW)	5.25±0.02	0.05±0.01	0.65±0.21
FS+FW	5.30±0.06	0.06±0.01	0.23±0.22
Conventional Fertilizer	5.10±0.14	0.07±0.02	0.71±0.12

Soil organic C and total N

The combination of fishpond sediment and fishpond water resulted in significantly higher organic carbon than that of control, fishpond sediment, fishpond water and conventional fertilizer (Table 5). Although statistically not significant, the values of organic C of fishpond sediment treatment, and fishpond water treatment were higher than that of control and conventional fertilizer. The significant increase of organic C in treatments of combination fishpond sediment and fishpond water because of the high organic C content in fishpond sediment.

The treaments affected the soil total N values significantly. The highest value of total N was in fishpond sediment treatment, followed by the combination of fishpond sediment and fishpond water treatment. The N content in the fishpond sediment and fishpond water increased the total N of the soil treated by fishpond sediment or treated by combination of fishpond sediment and fishpond water.

Table 5. The effect of treatments on soil organic carbon (C) and total nitrogen (N).

Treatments	**% Organic C**	**% Total N**
Control- No Fertilizer	1.73±0.23 a	0.16±0.01 ac
Fishpond Sediment (FS)	2.25±0.05 ab	0.19±0.01 a
Fishpond Water (FW)	2.15±0.17 ab	0.14±0.02 bc
FS+FW	2.55±0.29 b	0.18±0.02 ad
Conventional Fertilizer	1.83±0.18 ab	0.15± 0.00 cd

Means followed by the same letter within a column are not significantly different (Tukey`s test, $P < 0.05$)

HCl 25%-P and Bray 1-P

The HCl 25%-P was potential P to be available P. Bray 1-P was available P (Soepraptohardjo *et al*., 1983) (Table 6). Statistically, the effect of the treatments on the HCl 25%-P was not significantly different. However, the value of HCl 25%-P of combination fishpond sediment and fishpond water was higher than that of control suggesting that this combination has the potential to increase the amount of P in the soil. As for Bray 1-P, statistically, the combination fishpond sediment and fishpond water treatment increased significantly the amount of available P in the soil compared to control.

Table 6. The effect of treatments to the soil HCl 25%-P and Bray 1-P

Treatments	HCl 25%-P ($mg\ P_2O_5\ 100g^{-1}$)	Bray 1-P ($mg\ P\ kg^{-1}$)
Control- no fertilizer	151 ± 5.97 a	36.5 ± 5.38 a
Fishpond Sediment (FS)	147 ± 10.1 a	42.1 ± 2.95 ab
Fishpond Water (FW)	145 ± 14.4 a	43.0 ± 0.23 ab
FS+FW	166 ± 9.95 a	46.6 ± 1.71 b
Conventional Fertilizer	166 ± 9.67 a	41.0 ± 4.16 ab

Means followed by the same letter within a column are not significantly different (Tukey`s test, $P < 0.05$)

Cation exchange capacity (CEC), basic cations and base saturation (BS)

The combination fishpond sediment and fishpond water treatment increased significantly the CEC, Mg and Na compared to control treatments. The treatments did not increase the base saturation compared to control (Table 7). The increase of CEC of the treatment combination fishpond sediment and fishpond water were about 4 $cmol_c\ kg^{-1}$ higher than those of control and conventional. This was due to the increase in organic matter in the soils. The increase of soil organic matter increased variable charge of soils because the increase of organic colloid (Bohn *et al*. 1979).

Table 7. The effect of treatments on soil cation exchange capacity (CEC), exchangeable basic cations and base saturation (BS)

Treatments	CEC	Ca	Mg	K	Na	BS
	....		$cmol_c\ kg^{-1}$		....	(%)
Control- no fertilizer	18.4±3.26a	4.60±0.72ab	2.50±0.18a	0.44±0.01a	0.29±0.03a	42.9±3.20a
Fishpond Sediment (FS)	23.0±1.05bc	5.41±0.44ab	2.76±0.16ab	0.67±0.14a	0.49±0.05b	40.8±4.35a
Fishpond Water (FW)	22.4±0.14abc	4.15±0.40a	2.50±0.24ab	0.51±0.08a	0.33±0.02ad	33.4±2.78a
FS + FW	23.6±0.68c	5.56±0.53b	3.03±0.22b	0.77±0.27a	0.53±0.11bc	41.9±4.42a
Conventional Fertilizer	19.1±0.12ab	4.27±0.34ab	2.43±0.14ab	0.45±0.01a	0.29±0.04ab	39.0±2.95a

Means followed by the same letter within a column are not significantly different (Tukey`s test, $P < 0.05$)

Production of sweet potato

The treatments did not affect the production of sweet potato (Fig. 2). However, the combination of fishpond sediment and fishpond water treatment resulted in the highest value for the production of sweet potato. This higher production may be due to the improvement of soil chemical properties. Rahman and Yaupitiyage (2006) reported that the treatment of fishpond sediment at 60 kg in 1 x1 m^2 plot combined with N and K fertilizer resulted in similar yields of fresh and dry matter of morning glory (*Ipomoea reptans*) with the conventional fertilizer control plot.

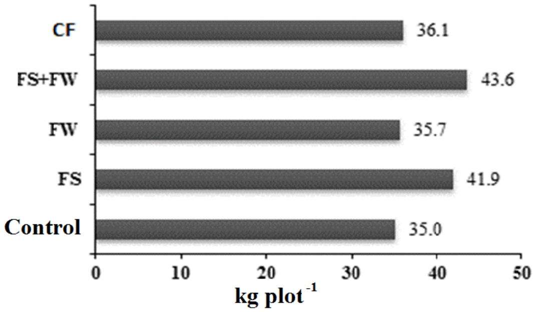

Fig. 2. Yield of sweet potato

CONCLUSIONS

High amounts of total inorganic N and phosphate were found in fishpond water. Fishpond sediment also contained high values of total N, available P, and base saturation. Fishpond water and fishpond sediment had the potential to be used as fertilizer and ameliorant for crops. The field experiment results suggest that the combination of fishpond sediment and fishpond water were the best treatment in improving the soil fertility status and plant growth.

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REFERENCES

Almasri, MN. 2007. Nitrate contamination of groundwater: A conceptual management framework. Environmental Impact Assessment Review. 27: 220-242.

Arifin, Z. 2004. Local millenium ecosystem assessment: Condition and trend of the greater Jakarta Bay ecosystem. The Ministry of Environment Republic of Indonesia. 30 p.

Avnimelech, Y., JA Hargreaves, and M. Kochva. 1999. Sedimentation and resuspension in earthen ponds, Journal of World Aquaculture Society. 30:401-409.

Bohn, HL., BL. Mcneal, GA. O'Connor. 1979. Soil Chemistry. A Willey-Interscience Publ. John Wiley and Sons. New York, Brisbane, Chichester, Toronto. 329 p.

Boyd, CE. 1995. Bottom Soil, Sediment, and Pond Aquaculture. New York: Chapman and Hall. 348 p.

Bray, RH. and LT. Kurtz. 1945. Determination of total, organic, and available forms of phosphorus in soils. Soil Sci. 59: 39-45.

Foy, RH. and PJA. Withers. 1995. The contribution of agricultural phoshorus to eutrophication, pp. 1-32 In Proc. No. 365 The Fertilizer Society Greenhill House, Thorpe Wood, Petersborough, UK.

Fried, S., B. Mackie, and E. Nothwehr. 2003. Nitrate and phosphate levels positively affect the growth of algae species found in Perry Pond. Tillers. 4: 21-24.

Lapointe, BE., MM. Littler and DS. Littler. 1992. Modification of benthic community strucure by natural eutrophication: The Belize barrier reef, pp. 323-334 In Proceedings of the Seventh International Coral Reef Symposium, Guam.

Muendo, PN., MCJ. Verdegem, JJ. Stoorvogel, AME. Gamal, PM. Duc, and JAJ. Verreth. 2014. Sediment accumulation in fishponds: its potential for agricutural use. International Journal of Fisheries and Aquatic Studies. 1: 228-241.

Murphy, J. and JP. Riley. 1962. A modified single solution method for determination of phosphate in natural waters. Anal. Chim. Acta. 27: 31-36.

Olah, J., F. Pekar and P. Szabo. 1994. Nitrogen cycling and retention in fish-cum-livestock ponds. Journal of Applied Ichtyology. 10: 341-348.

Rahman, MM., A. Yakupitiyage and SL. Ranamukhaarachchi. 2004. Agricultural use of fishpond sediment for environmental amelioration. Thammasat Int. J. Sc. Tech. 9:1-10.

Rahman, MM. and A Yakupitiyage. 2006. Use of fishpond sediment for sustainable aquaculture-agriculture farming. Int. J. Sus. Dev. Plann. 1:192-202.

Soepratohardjo, M., H. Subagjo, Suhardjo, Ismangun, DS. Marsoedi, A. Hidayat, Y. Dai, A. Adi, M. Supartini, Mursidi, and JS. Adiningsih. 1983. Terms of reference survey of soil capability. Center for Soil Research, Bogor (In Indonesian). 52 p.

Wahab, MA., Haque, AKM. Aminul, and ZH. Bhuiya. 1984. Nutrient status of bottom soils of two ponds in BAU (Bangladesh Agricultural University) campus, Bangladesh Journal of Fisheries. 6:l-10.

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PRE-HARVEST CALCIUM NITRATE APPLICATION REDUCES FLORET BUD DROP OF *DENDROBIUM* SONIA 'EARSAKUL'

Supatida Abdullakasim, Sornsawan Meenpran, Wachiraya Imsabai and Parson Saradhuldhat
Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen,
Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand
Corresponding author: fagrsds@ku.ac.th

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ABSTRACT

Yellowing of floret buds (un-opened) prior to harvest is a serious problem for the production of *Dendrobium* Sonia 'Earsakul' cut flowers. One factor that may be associated with this is calcium deficiency during flowering. To prevent this symptom, calcium nitrate ($Ca(NO_3)_2$) at 0, 1.65, 3.30 or 5.00 gL^{-1} was applied weekly to the floral buds and pseudo-stems of the two-year-old plants for four weeks prior to harvest. The experiments were conducted during January-March and October-December, 2013 at the 'Jittrakarn' commercial orchid farm in Phanom Tuan District, Karnchanaburi Province. The results showed that pre-harvest application of $Ca(NO_3)_2$ could reduce the number of inflorescences with yellowing bud, it was most effective at 5.00 gL^{-1} . The number of yellowing buds of harvested inflorescence in December was higher than those in March. In March and December 2013, the percentage of harvested inflorescence with yellowing bud were 0% and 12.5% respectively when applied with 5.00 gL^{-1} $Ca(NO_3)_2$ compared to 12.5% and 32.5% in the control (non-calcium treatment). In addition, the application of 5.00 gL^{-1} $Ca(NO_3)_2$ increased significantly the inflorescence length from 48.86 to 53.14 cm and increased the mechanical strength of the pedicel and also the calcium and nitrogen contents in bud parts and fully open florets.

Key words: orchid**,** fertilizer, pseudo-stem, pedicel, inflorescence

INTRODUCTION

Dendrobium Sonia 'Earsakul' is a mutant clone derived from a mutation of *D.* Sonia 'Red Bom Joe' during micro-propagation. It is a popular cultivar for cut flower that has a beautiful flower color, long flower spike, a lot of florets per inflorescence, long vase life and year round flowering. One serious problem in the production of *D.* Sonia 'Earsakul' is floret bud yellowing and floret bud drop prior to harvest. The inflorescences with floret bud drop cannot be sold as a premium grade even though have a long raceme and a high number of florets per inflorescence. The causes of this floret bud drop may involve several factors such as plant genetic background, nutrient imbalance (Hew and Yong 2004), response of plant to ethylene (Bunya-atichart *et al.* 2006), and environmental factors such as light intensity, temperature and relative humidity during flower development (Sarntinoranont and Wannakrairoj 2010). The number of flower bud drops per inflorescence in *D.* Jaquelyn Thomas study in Hawaii was highest during cool season in April every year, for the years 1972-1977 (Paull *et al.* 1995). In Thailand, the highest number of flower bud drops in *D.* Sonia 'Earsakul'was during the seasonal change from rainy to cool season (Sarntinoranont and Wannakrairoj 2011). In addition, flower bud drop in some orchids was due to the death of the pollinia during flower development (Hew and Yong 2004).

Calcium is an essential nutrient for plant growth and development. Ca^{2+} functions as a cross linkage of acidic pectin residues in the middle lamella of the cell wall (Dematry *et al*. 1984; Hepler 2005), it is involved in cell division since enhancing Ca^{2+} to cell can promote initial bud formation in mosses (Saunders and Hepler 1982). Also, the cytosolic Ca^{2+} gradient is necessary for pollen germination and tube growth (Steinhorst and Kudla 2013). Pre-harvest $CaCl_2$ sprayed at 4% strengthened the flower spike and increased the flower spike length in herbaceous peonies (Li *et al.* 2012). Dipping of 2% or 3% $CaCl_2$ improved better loquat fruit qualities such as firmness, total soluble solids and ascorbic acid content (Akhtar *et al*. 2010). In *Oncidium* orchids grown on rockwool medium, application of calcium nitrate at 0.30 gL^{-1}, three times, significantly improved the inflorescence quality with longer stalks and more florets compared to other calcium treatments i.e. $CaCl_2$ and CaO (Hsu *et al*. 2010). In addition, spraying a combination of 2% calcium nitrate and 0.50 gL^{-1} boric acid was found to increase fruit set percentage and flesh weight of the Amhat date palm (Sarrwy *et al*. 2012).

As several reports showed the usefulness of calcium utilization on promoting better quality of fruits and flowers, in this study, we aimed to evaluate the effect of spraying calcium nitrate on reducing floret bud drop and improving flower quality of the *Dendrobium* Sonia 'Earsakul'. We hypothesized that exogenous calcium application may strengthen the flower's cell wall and prevent flower bud drop. The experiment was carried out over a two period in January-March and October-December 2013 as these are the transition periods from cool to summer and rainy to cool season, respectively.

MATERIALS AND METHODS

Two-years-old *D.* Sonia 'Earsakul' grown on coconut husk was used as the plant material. The plants were grown in coconut husks under approximately 50% shade, watered once a day, and fertilized once a week. The experiments were conducted at the 'Jittrakarn orchids farm' in Karnchanaburi Province, Thailand. Two fertilizer formula were used on the farm i.e. N:P:K 20-20-20 and 16-21-27, which were rotated weekly. Pesticides: carbosulfan, imidazole, abamectin, chlorpyrifos and methomyl were sprayed to control disease and insects. Calcium nitrate solutions, in the form of $Ca(NO_3)_2.4H_2O$, were sprayed on the plants during two periods; January-February and October-November, 2013. The experimental design was completely randomized (CRD) with four calcium nitrate concentrations of 0, 1.65, 3.30 and 5.00 gL^{-1}. Each plant (the part consisting of the young flower buds (less than 5 cm-long) and the pseudo-stem of *Dendrobium* orchids) was given an application of 70 ml calcium nitrate solution mixed with a surfactant solution. One hundred sixty (160) plants were used for the whole experiment from which 40 pots *Dendrobium* orchid plants were chosen for each treatment with four replications per treatment and ten plants per replication. The calcium nitrate solutions were applied weekly to the plants over the four weeks prior to harvest. The inflorescences were harvested when four fully open florets were obtained and these were measured for inflorescence length and diameter, flower width, the number of florets per inflorescence and inflorescence fresh weight. The diameter of an inflorescence was measured using a Vernier caliper. The percentage of inflorescence with floret bud yellowing was calculated and the results were compared.

The pedicel of the floret buds and the fully opened florets were analyzed with a force gauge to evaluate the breaking force required to split floral bud or fully open flower pedicel from the main peduncle. The un-opened floret and fully opened floret were analyzed for calcium and nitrogen accumulation. The samples were dried at 70°C, fine grained then digested with nitric acid and water (1:1, v/v). Calcium accumulation was determined using an atomic absorption spectrophotometer (Analytic Jena Vario 6, Germany). Analysis for nitrogen concentrations was performed using a protein/nitrogen analyzer (LECO FP-528, USA). For statistical analysis, the Duncan's New Multiple Range Test (DMRT) test was used to compare the treatment effects at a significance level of 0.05, one-way ANOVA. The data for rainfall, cloud percentage, average temperature, and sunlight hours per day were obtained from a weather station located in Kasetsart University, Kamphaeng Saen Campus which is 40 kilometers from the experimental site.

RESULTS AND DISCUSSION

Reduction in bud yellowing in the *Dendrobium* orchids using $Ca(NO_3)_2$ sprays

The bud yellowing in *Dendrobium* orchid usually occurs on some floret buds located in the middle part of the inflorescence adjacent to the fully opened florets (Fig. 1). The floret buds turn yellow, wilt and rapidly drop from the inflorescence. The bud yellowing is different from the symptom of floret bud infected with orchid midge (*Contarinia* sp.). The orchid midge usually causes deformed and discoloration of the bud and blossom (Hara 2002), also make the tissue becomes juicy. In *Dendrobium* orchids, symptoms of midge infection mostly appear on the tip of flowering inflorescence.

Fig. 1. Symptom of bud yellowing in *Dendrobium* Sonia 'Earsakul'

The results from this research showed that the bud yellowing in *Dendrobium* orchid was largely detected in the December harvest at 32.5% but only 12.5% in March harvest (Table 1). According to the results, some climate variability may affect the occurrences of the bud yellowing. Considering the climate data during January-March and October –December 2013, the average temperatures during January to March and October to November were 25.85-29.7 ºC and 22.15-27.05 ºC respectively. A highest total rainfall (105.6-201.3mm/month) and cloudiness (55-59%) was reported during October to November, whereas only 0 -12.9 mm of total rainfall and 15-26% cloudiness during January to March (Figure 2). Heavy cloud cover can reduce irradiance, limit CO_2 uptake and photosynthesis of leaves fully exposed to the sun in tropical rainy seasons (Graham *et al*., 2003). This may resulted in reduction in the availability of photoassimilate contribution from leaves to the inflorescence. In addition, during flower development, floret buds have a higher respiratory rate than fully open florets (Hew and Yong 2004). Reduction in photoassimilate from leaves to the inflorescence may cause un-opened floret yellowing in the *Dendrobium* orchids resulting in the dropping of un-opened floret buds prior to harvest.

Table 1. Effect of calcium nitrate sprays on the percentage of inflorescence obtained floret bud drop.

Treatments	Inflorescence obtained floret bud drop (%)	
	Harvested in March 2013	Harvested in December 2013
Control (water spray)	12.5	32.5
$Ca(NO_3)_2$ 1.65 gL^{-1}	0	27.5
$Ca(NO_3)_2$ 3.30 gL^{-1}	0	27.5
$Ca(NO_3)_2$ 5.00 gL^{-1}	0	12.5

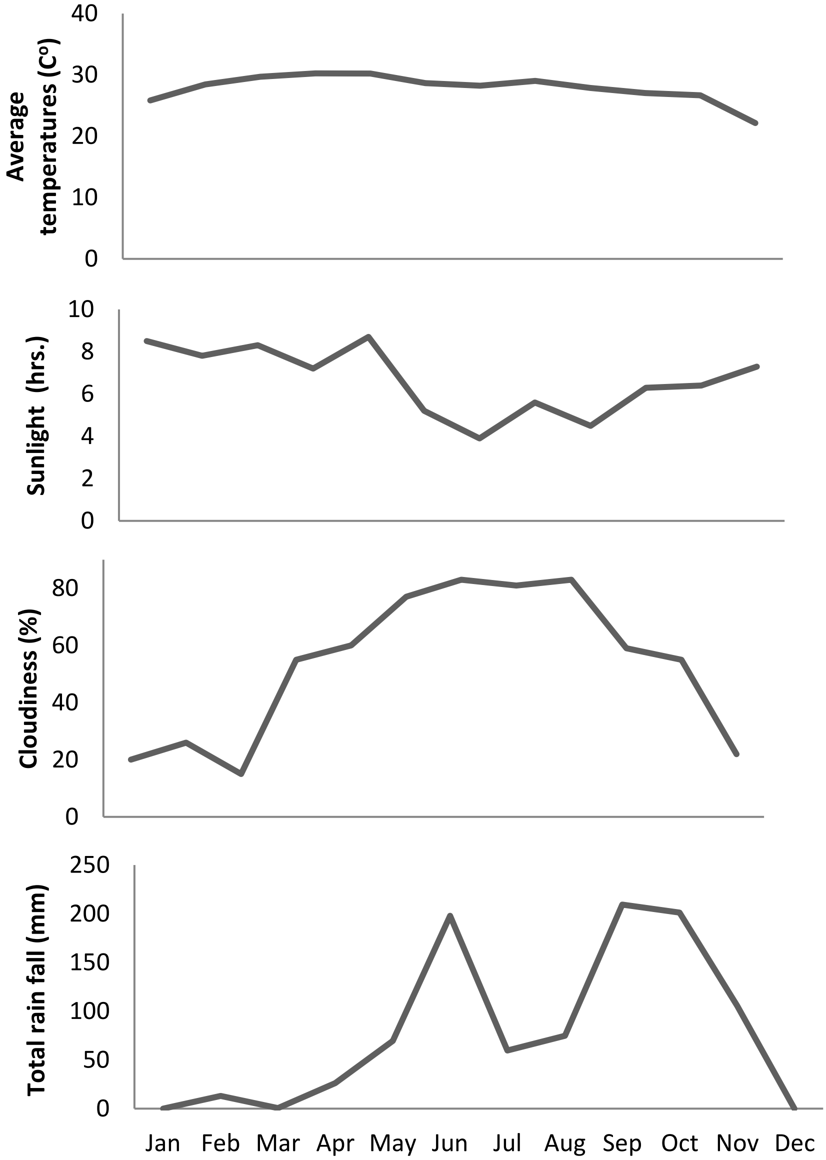

Fig. 2. Climate data at Kamphaeng Saen District during January-December 2013. The experiments were conducted during January-March and October-December 2013, respectively.

In this study, $Ca(NO_3)_2$ was used to prevent bud dropping. Applications of 1.65-5.00 gL^{-1} $Ca(NO_3)_2$ during January-March 2013 were successful in controlling the dropping of un-opened florets, since none of the inflorescence developed floret drop, whereas 12.5% of the inflorescence displayed floret drop in the control treatment (Table1). Higher numbers of inflorescence displayed floret drop during October to December; however, the application of 5.00 gL^{-1} $Ca(NO_3)_2$ significantly reduced the number of inflorescence that developed floret drop from 32.5% of the control to only 12.5% in the calcium treatment. (Table1). In addition, 5.00 $gL^{-1}Ca(NO_3)_2$ spray has demonstrated that it improves the mechanical strength of the pedicel, since the force required to break floret buds or fully open florets from its main inflorescence were significantly increased (Table 2) Correlated with the mechanical strength data, the highest amount of calcium accumulation was found in the part of floret bud or fully open floret with pedicels when 5.00 $gL^{-1}Ca(NO_3)_2$was applied (Table 3). Calcium is an important component involved in the strength mechanism of the cell wall. The high level of calcium accumulation correlated to a rising ratio of water insoluble pectin to water soluble pectin (Li *et al*., 2012), in which the pectin works as cross-linked chains for the stability of the cell wall. Our data indicated that calcium application could fortify the strength of pedicel's cell walls since a higher force was required to break the floret with pedicel from the main peduncle, especially in the 5.00 gL^{-1} $Ca(NO_3)_2$ treatment. Furthermore, application of calcium can protect cell membrane from enzyme lysis (White and Broadley, 2003).

Table 2. Effects of calcium nitrate sprays on peduncle breaking force.

Treatments	**Breaking force (Newton)** [1/]	
	Floret bud's pedicel	**Blooming floret's pedicel**
Control (water spray)	4.03±1.76 b	4.27±1.22 c
$Ca(NO_3)_2$ 1.65 gL^{-1}	5.64±2.49 ab	6.68±1.88 b
$Ca(NO_3)_2$ 3.30 gL^{-1}	5.81±1.99 ab	7.74±1.71 ab
$Ca(NO_3)_2$ 5.00 gL^{-1}	6.18±1.54 a	8.49±0.98 a
F-test	*	*
C.V. (%)	36.48	21.93

[1/]In each column, mean values (±S.D) followed by the same letter are not significantly different at $p < 0.05$

Table 3. Effect of calcium nitrate sprays on calcium and nitrogen accumulation in floret bud and fully open floret with their peduncle.

	Calcium (mg/kg)[1/]		**Nitrogen (%)**[1/]	
Treatments	**Floret bud**	**Blooming floret**	**Floret bud**	**Blooming floret**
Control (water spray)	348.33±22.71 c	283.10±23.31c	0.93±0.07 b	0.88±0.03 b
$Ca(NO_3)_2$ 1.65 gL^{-1}	401.20± 26.64 ab	313.70±14.60 b	0.88±0.05 b	0.82±0.06 c
$Ca(NO_3)_2$ 3.30 gL^{-1}	384.17±27.69 bc	326.90±26.37 b	1.01±0.04 a	0.95±0.05 a
$Ca(NO_3)_2$ 5.00 gL^{-1}	442.50±35.58 a	359.37±39.77 a	1.02±0.04 a	0.95±0.02 a
F-test	**	**	**	**
C.V. (%)	9.33	7.88	4.86	4.79

[1/]In each column, mean values (±S.D) followed by the same alphabet are not significantly different at $p < 0.01$

Qualities of inflorescence after the $Ca(NO_3)_2$ application

The applications of 3.30 and 5.00 gL^{-1} $Ca(NO_3)_2$ increased significantly the length of the inflorescence in *Dendrobium* orchids. In the 5.00 gL^{-1} $Ca(NO_3)_2$ treatment, the length of inflorescence was the longest at 53.14 cm, significantly different from the control (48.86 cm) (Table 4). The $Ca(NO_3)_2$ sprays also increased inflorescence fresh weight. For the 5.00 gL^{-1} $Ca(NO_3)_2$ treatment, the inflorescence fresh weight was the highest at 25.34 g while the control treatment was only 22.60 g (Table 4). However, there was no significant difference in inflorescence diameter, floret width and floret numbers when the $Ca(NO_3)_2$ concentrations were applied (Table 4).

Table 4. Effects of calcium nitrate sprays on flower qualities of *Dendrobium* Sonia 'Earsakul'.

Treatment	Inflorescence length (cm) [1/]	Inflorescence diameter (cm) [1/]	Flower width (cm) [1/]	Number of flower per inflorescence (flowers) [1/]	Fresh weight (g) [1/]
Control (water spray)	48.86±6.11 c	0.60±0.10 ab	8.45±0.64	10.78±1.43 a	22.60±1.82 b
$Ca(NO_3)_2$ 1.65 gL^{-1}	50.52±4.99 bc	0.58±0.08 b	8.57±0.32	10.03±1.62 b	23.10±3.27 ab
$Ca(NO_3)_2$ 3.30 gL^{-1}	51.49±4.74 ab	0.60±0.10 ab	8.44±0.47	10.94±1.39 a	24.41±2.53 ab
$Ca(NO_3)_2$ 5.00 gL^{-1}	53.14±5.08 a	0.63±0.09 a	8.36±0.41	10.81±1.45 a	25.34±1.28 a
F-test	**	*	ns	*	*
C.V. (%)	10.31	15.54	5.62	13.85	9.83

[1/]In each column, mean values (±S.D) followed by the same alphabet are not significantly different at $p < 0.05$. ns indicates not significant.

Similar results were found in *Oncidium* orchids grown in rockwool medium with three applications of 0.30 gL^{-1} calcium nitrate to the mature flower stalks (5-15 cm length) this greatly improved the length of the flower stalks, branching and total floret numbers (Hsu *et al.* 2010). In this study, the highest nitrogen content was found in the flower organs of orchids sprayed with 3.30-5.00 gL^{-1} $Ca(NO_3)_2$ (Table 2). The nitrate (NO_3^-) is the main form of nitrogen taken up and assimilated by most crop plants (Andrew *et al*. 2013). High nitrogen uptake and assimilation may enhance orchid flower development since nitrogen is an essential element for several processes during plant growth such as being a component of DNA, RNA, protein and hence enzymes (Raven *et al*. 2004; Andrew *et al.* 2013). From the overall results, the application of 5.00 gL^{-1} $Ca(NO_3)_2$, weekly for four weeks, prior to harvest showed a high potential of preventing bud drop and promoting a better quality of inflorescence in *D.* Sonia 'Earsakul'.

CONCLUSION

The floret drop during inflorescence development of *Dendrobium* Sonia 'Earsakul' was detected to a greater extent in December than March. The application of $Ca(NO_3)_2$ at 5 gL^{-1} reduced significantly bud drop and improved other flower qualities such as the length and fresh weight of the inflorescence. The $Ca(NO_3)_2$ application will help orchid growers increase the number of long graded inflorescences and ultimately increase total product volume for sale. These results are very useful to *Dendrobium* growers in Asia-Pacific region to prevent and solve the serious problem of flower drop during high market demand from December to January.

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REFERENCES

Akhtar, A., N.A. Abbasi and A. Hussain. 2010. Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. Pak. J. Bot. 42(1):181–188.

Andrews, M., J.A. Raven and P.J. Lea. 2013. Do plants need nitrate? The mechanisms by which nitrogen form affects plants. Ann. Appl. Biol. 163:174–199.

Bunya-atichart, K., S. Ketsa and W.G. van Doorn. 2006. High floral bud abscission and lack of open flower abscission in *Dendrobium* cv. Miss Teen: rapid reduction of ethylene sensitivity in the abscission zone. Funct. Plant Biol. 33: 539-546.

Dematry, M., C. Morgan and M. Thellier. 1984. Calcium and the cell wall. Plant Cell and Environ. 7: 441-448.

Graham E.A, S.S. Mulkey, K.Kitajima, N.G. Phillips and S.J. Wright. 2003. Cloud cover limits net CO_2 uptake and growth of a rainforest tree during tropical rainy seasons. Proc. Natl. Acad. Sci. U S A. 100(2):572-576.

Hara, A. H. and R.Y. Niino-DuPonte. 2002. Blossom midge in Hawaii-A pest on ornamentals and vegetables. College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. 3p.

Hepler, P.K. 2005. Calcium: A central regulator of plant growth and development. Plant Cell. 17:2142–2155.

Hew, C.S. and J.W.H. Yong. 2004. The Physiology of Tropical Orchids in Relation to the Industry. World Scientific Publ. Co. Pte. Ltd., Singapore. 370p.

Hsu, J.H., Y.H. Lin, M.M.C. Wang and R.S. Lin. 2010. Improving inflorescence quality of *Oncidium* 'Gower Ramsey' by calcium supplement. Acta Hort. 878:277-281.

Li, L.C., J. Tao, D. Zhao, C. You and J. Ge. 2012. Effect of calcium sprays on mechanical strength and cell wall fractions of herbaceous peony (*Paeonia lactiflora* Pall.) inflorescence stems. Int. J. Mol. Sci. 13: 4704-4713.

Paull, R.E., K.W. Leonhardt, T. Higaki and J. Imamura.1995. Seasonal flowering of *Dendrobium* 'Jaquelyn Thomas' in Hawaii. Sci. Hort. 6: 263-272.

Raven J.A., Handley L.L., Andrews M. 2004. Global aspects of C/N interactions determining plant – environment interactions. J. Exp. Bot. 55: 11–25.

Sarntinoranont, V. and S. Wannakrairoj. 2010. The relationship between environmental factors during the rainy season and un-opened floret yellowing in *Dendrobium* Sonia 'Ear-Sakul'. Kasetsart J. (Nat. Sci.) 44 : 1016 – 1025.

Sarntinoranont, V. and S. Wannakrairoj. 2011. Factors affecting flower bud yellowing in *Dendrobium* Sonia 'Ear-Sakul'. Thai Agricultural Research J. 29: 73-84. (in Thai)

Sarrwy, S. M. A., E. G. Gadalla, and E. A. M. Mostafa. 2012. Effect of calcium nitrate and boric acid sprays on fruit set, yield and fruit quality of cv. Amhat date palm. World J. Agri. Sci. 8(5): 506-515.

Saunders, M.J. and P.K. Hepler. 1982. Calcium ionophore A23187 stimulates cytokinin-like mitosis in Funaria. Science. 217: 943–945.

Steinhorst, L. and J.Kudla.2013. Calcium - a central regulator of pollen germination and tube growth. Biochimica et Biophysica Acta. 1833:1573–1581.

White, P.J. and M.R. Broadley. 2003. Calcium in plants. Ann. Bot. 92: 487-511.

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RESPONSES OF TUNGRO RESISTANT RICE VARIETIES AND DONOR PARENTS AGAINST FIVE TUNGRO VIRUS ISOLATES FROM INDONESIA

Fausiah Thamrin Ladja[1,2], Sri Hendrastuti Hidayat [2], Tri Asmira Damayanti [2], Aunu Rauf[2]
Department of Plant Protection, Bogor Agricultural University
Jalan Kamper, Darmaga Campus, Bogor 16680
Corresponding author: protanipb@ipb.ac.id

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ABSTRACT

Rice tungro disease is the most important viral disease of rice in Indonesia and is major constraint in stable rice production in the region. This disease is caused by infection of two viruses, *i.e. Rice tungro bacilliform virus* (RTBV) and *Rice tungro spherical virus* (RTSV). The use of resistant varieties is the most important component in managing the disease. Incorporation of resistance genes to RTBV and RTSV has become an important breeding objective for rice improvement. The study was conducted to determine response of five tungro resistant varieties (Tukad Petanu, Tukad Balian, Tukad Unda, Kalimas, Bondoyudo) and seven donor parents [Utri Merah, Utri Rajapan, Habiganj Deep Water (DW) 8, Tjempo Kitjik, TKM 6, ARC 10312, ARC 12596] to five tungro isolates from Indonesia. Taichung Native 1 (TN1) was used as a susceptible host for virus propagation. Insect transmission was done by test tube method on ten-day-old seedlings. Type of symptoms, incubation period, disease incidence and severity of symptoms were observed from one until 28 days after planting. The results showed that five resistance varieties, *i.e*. Tukad Petanu, Tukad Balian, Tukad Unda, Kalimas, Bondoyudo showed different response to different tungro virus isolates. Tukad Petanu and Kalimas are considered as resistant variety based on the disease index, and can be recommended for tungro endemic area in rotation with other varieties. Utri Merah is a good source of resistant genes for breeding new tungro resistant varieties.

Key words: resistance, response, variety, viral disease

INTRODUCTION

Rice tungro disease (RTD), which caused by infection of two viruses, *i.e*. *Rice tungro bacilliform virus* (RTBV) and *Rice tungro spherical virus* (RTSV), is one of the most damaging and destructive diseases of rice in South and Southeast Asia. In severe cases, it may cause as high as 100% yield loss when infected tungro susceptible varieties at an early growth stage (Cabauatan *et al.* 1998). In Indonesia, incidence of tungro disease is often found in several rice production regions, *i.e.* South Sulawesi, Bali, West Java, and Central Java (Ladja and Pakki 2010). It was reported recently that the disease occurred in 27 provinces in Indonesia affecting 6.441 ha and causing total yield loss around 151 ha (Ditlin 2013). Although several control methods against the disease have been recommended and implemented, epidemics of RTD were still observed periodically.

Extensive cultivation of susceptible varieties, asynchrony of rice planting and increase of vector population were determined as the major factors influencing the disease epidemics (Cabunagan *et al.*, 2001). The use of resistant varieties, therefore, is considered an effective strategy for minimizing losses from the disease. Planting tungro resistant varieties can reduce spread of causal virus(es) in the field (Holt and Chancellor 1999). Unfortunately, the number of tungro resistant variety in Indonesia is still limited. Tukad Petanu and Inpari 7 Lanrang are tungro resistant varieties, which was developed using Utri Merah as the source of resistant genes (Ladja and Widiarta 2012). Resistance of these varieties are site-specific and it is recommended for planting resistant varieties by considering the type of virus strain or genetic variation (Daradjat *et al.,* 1999).

Genetic diversity of both RTBV and RTSV has been reported (Shen *et al.* 1993; Arboleda and Azzam 2000; Azzam *et al.* 2000), including those in Indonesia (Suprihanto 2005). Distribution map showing planting site of resistant varieties and their respective tungro strain has been developed for some rice production areas in Indonesia (Ladja and Widiarta 2012). Considering fast changes in genetic variability of tungro virus, it is very important to reconfirm the response of resistant varieties against the recent collected virus isolates. This paper reports the latest information regarding response of resistant varieties and donor parents to five virus isolates collected in 2013 from different regions in Indonesia.

MATERIALS AND METHODS

Virus Isolates

Five tungro isolates were collected in 2013 from different regions in Indonesia, *i.e.*: Bogor (West Java), Sidrap (South Sulawesi), Badung (Bali), Pesisir Selatan (West Sumatera), and West Papua (Papua). Each isolate was propagated through insect transmission using *Nephotettix virescens* as a vector and maintained on rice variety, Taichung Native 1 (TN1).

Plant Materials

Five resistant varieties (Tukad Petanu, Tukad Balian, Tukad Unda, Kalimas, Bondoyudo), and seven donor parents [Utri Merah, Utri Rajapan, Habiganj Deep Water (DW) 8, Tjempo Kitjik, TKM 6, ARC 10312, and ARC 12596] were obtained from Indonesian Center of Rice Research, Subang, West Java. TN1 was obtained from Tungro Disease Research Station, Sidrap, South Sulawesi and it was used as susceptible control variety (Table 1).

Table 1. Cross history and native country of several varieties that used in this research

No.	Variety Name	Cross History	Native Country
1	Tukad Balian	IR48613-54-3-3-1/IR28239-94-2-3-2	Indonesia
2	Tukad Unda	Balimau Putih/^{4}*IR64	Indonesia
3	Tukad Petanu	IR52256-84-2-3/IR72//^{2}*IR1561-228-3/ Utri Merah	Indonesia
4	Bondoyudo	IR72/IR48525-100-1-2	Indonesia
5	Kalimas	PSBRC2/IR39292-142-3-2-3	Indonesia
6	Utri Merah	Local variety	Indonesia
7	Utri Rajapan	Local variety	Indonesia
8	Tjempo Kitjik	Local variety	Indonesia
9	Habiganj (DW) 8	Local variety	Bangladesh
10	TKM 6	CO 18/GEB 24	India
11	ARC 10312	Local variety	India
12	ARC 12596	Local variety	India
13	TN1	Dee Geo Woo Gen/Tsai-Yuan chan	Taiwan
14	IR 64	IR 5657-33-2-1/IR 2061-465-1-5-5	IRRI

Virus Inoculation

Virus inoculation was done following a test tube method as described by Cabauatan *et al.* (1994). Ten-day-old seedlings were used in all test tube inoculations. The insect vector, *N. virescens* was reared on IR36 variety. The insects were given 24 h acquisition feeding period on infected plants, followed by 24 h inoculation feeding period on healthy plants.

Experimental Design and Data Analysis

The experiment was conducted according to International Rice Testing Nursery (IRTN) protocols. After virus inoculation, forty (40) plants for each variety were planted in twenty pots (2 plants for each pot). Disease symptoms, incubation period, incidence and severity were observed up to 28 days after planting. Plant height was also measured at the end of the experiment.

Disease incidence and suppression of plant height was calculated using the equation below (1 and 2, respectively).

$$1)\ \text{Disease incidence} = \frac{\text{Number of plants showing tungro symptoms}}{\text{Total number of plant observed}} \times 100\%$$

$$2)\ \text{Reduction in plant height} = \frac{\text{Height of control plant - height of treated plant}}{\text{Height of control plant}} \times 100\%$$

Disease severity was evaluated based on scoring system following Standard Evaluation System for Rice (SESR) (IRRI 1996). In this scoring system, disease severity is differentiated into 5 categories, *i.e.* score 1, no symptom; score 3, 1-10% height reduction rate with no leaf discoloration; score 5, 11-30% height reduction rate with no distinct discoloration; score 7, 31-50% height reduction rate and/or yellow to orange discoloration; score 9, more than 50% height reduction rate and yellow to orange discoloration. Disease index was then calculated using the equation below (3). The severity of tungro symptoms determined the value of disease index, the higher disease index value the more severe symptoms was observed.

$$3)\ \text{Disease Index} = \frac{n(1) + n(3) + n(5) + n(7) + n(9)}{tn}$$

With n, number of plants showing corresponding score; tn, the total number of plant

Plant response against tungro isolates was then determined based on disease index. The responses were differentiated into 3 groups according to score of disease index, *i.e.*, 1 to 3 (resistant, R), 4 to 6 (moderate, M), and 7 to 9 (susceptible, S).

RESULTS AND DISCUSSION

Five tungro resistant varieties were released by Indonesian Center of Rice Research in 2000. Widiarta and Kusdiaman (2002) were then studied the response of those varieties against different tungro isolates collected from several regions in Indonesia. Based on resistant responses, they recommended Tukad Petanu to be planted in West Java, Central Java, East Java, Bali, West Nusa Tenggara, and South Sulawesi; Tukad Unda in West Nusa Tenggara and South Sulawesi; Tukad Balian in East Java, Bali, and South Sulawesi. Bondoyudo could be recommended for all regions, except West Java; whereas Kalimas only for Central Java and South Sulawesi. At the same time, Utri Merah, as the donor parent, was also evaluated and the result showed that the donor parent was resistant to all tungro isolates. Evaluation on the status of those resistant varieties has not been reported after sixteen years, though disease spread and severity was reported recently. Therefore, this research was conducted in order to confirm the resistance of those varieties and donor parents against different tungro isolates.

Generally infection of tungro viruses affects plant height and leaf color. Reduction rate of plant height and changing of leaf color into yellow or orange was commonly found in the infected plants (Fig 1). Variation in disease severity was influenced by virus strains and rice varieties.

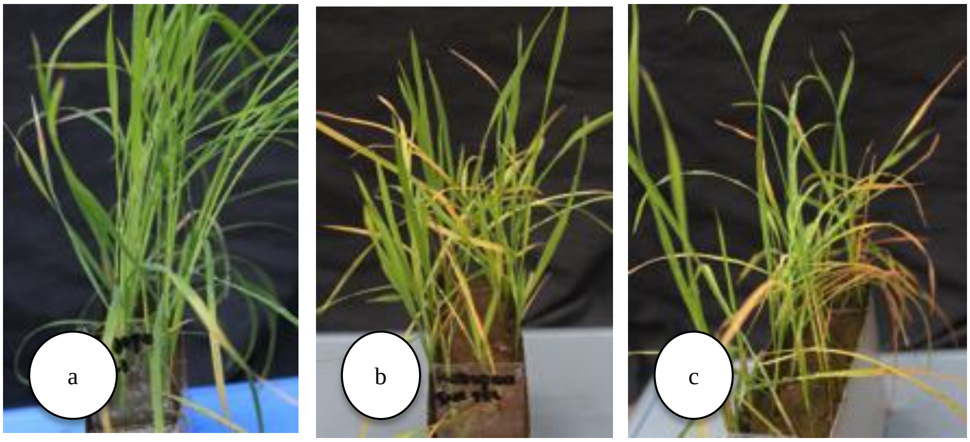

Fig. 1. Plant response to infection of Tungro virus a) Utri Merah showed resistant response against Bali isolate, b) Habiganj DW8 showed moderate response against South Sulawesi isolate, c) ARC 12596 showed susceptible response against South Sumatera isolate.

Suprihanto *et al.* (2013) and Ladja *et al.* (2011) reported that tungro isolate from Bogor, West Java was the most virulent isolate based on disease incubation period, incidence and severity. Our research also supports that all tungro isolates were considered as virulent isolates due to their short incubation period and high disease incidence (Table 2).

Specific interaction between virus strains and rice varieties was induced by variation in disease incidence and reduction rate of plant height. Compatible interaction was shown by high percentage of disease incidence and reduction rate of plant height. Infection on Bondoyudo by tungro isolates from Bogor caused 100% disease incidence and 40.72% reduction rate of plant height; while infection on Kalimas by tungro isolates from Pesisir Selatan caused 100% and 30.23 % disease incidence and reduction rate of plant height, respectively (Table 2). In contrary, incompatible interaction was shown by low percentage of disease incidence and reduction rate of plant height. Infection on Tukad Petanu by tungro isolates from Sidrap caused only 10% disease incidence and 6.45% reduction rate of plant height. Infection on Tukad Petanu by tungro isolates from Badung caused 15% and 18.46% disease incidence and reduction rate of plant height, respectively (Table 2). These two conditions, compatible and incompatible interaction, indicated that the previous resistant rice varieties did not always successfully keep its resistance against all tungro virus isolates. Therefore, it is important to understand genetic variation of tungro virus isolates from different regions in Indonesia. In addition, crop management may be involved to maintain durability of resistance. Cropping system based on the use of variety mixtures, species mixtures/mixed cropping, or multiline varieties has been recommended to maintain durable resistance (Adugna 2004).

Table 2. Incubation period, disease incidence, and plant height reduction rate of five tungro resistant varieties following inoculation by five tungro virus isolates

No.	Tungro Isolates	Rice variety	Incubation period (days)	Disease Incidence (%)	Reduction rate of plant height (%)	Response (Disease Index)
1	Bogor, West Java	Tukad Petanu	7-10	10	9.48	Resistant (1)
		Tukad Balian	7-10	95	33.75	Susceptible (8)
		Tukad Unda	8-11	80	14.37	Susceptible (7)
		Kalimas	7-11	42	13.80	Moderate (5)
		Bondoyudo	7-10	100	40.72	Susceptible (9)
		Utri Merah*	8-11	30	9.66	Resistant (1)
		Utri Rajapan*	8-11	45	3.59	Moderate (5)
		Habiganj DW8*	7-10	100	41.64	Susceptible (9)
		Tjempo Kitjik*	7-10	55	9.42	Susceptible (7)
		TKM 6*	7-11	95	9.97	Susceptible (9)
		ARC 10312*	7-10	50	5.07	Susceptible (7)
		ARC 12596*	7-10	95	47.10	Susceptible (9)
		TN1	7-10	100	34.30	Susceptible (9)
2	Sidrap, South Sulawesi	Tukad Petanu	7-10	10	6.45	Resistant (2)
		Tukad Balian	7-10	90	35.95	Susceptible (9)
		Tukad Unda	7-10	90	14.73	Susceptible (7)
		Kalimas	7-10	25	22.21	Moderate (4)
		Bondoyudo	7-10	100	37.24	Susceptible (7)
		Utri Merah*	8-10	45	25.75	Moderate (5)
		Utri Rajapan*	7-10	45	9.82	Moderate (5)
		Habiganj DW8*	7-10	75	28.82	Susceptible (8)
		Tjempo Kitjik*	7-11	50	13.59	Susceptible (7)
		TKM 6*	7-10	100	16.38	Susceptible (9)
		ARC 10312*	7-10	69	19.97	Susceptible (7)
		ARC 12596*	7-10	70	38.74	Susceptible (7)

No.	Tungro Isolates	Rice variety	Incubation period (days)	Disease Incidence (%)	Reduction rate of plant height (%)	Response (Disease Index)
		TN1	7-10	100	19.49	Susceptible (9)
3	Badung, Bali	Tukad Petanu	12-14	15	18.46	Resistant (2)
		Tukad Balian	7-10	85	24.78	Susceptible (8)
		Tukad Unda	13-14	90	10.83	Susceptible (8)
		Kalimas	7-10	25	26.29	Moderate (4)
		Bondoyudo	8-10	100	43.32	Susceptible (7)
		Utri Merah*	8-11	30	46.80	Moderate (4)
		Utri Rajapan*	8-10	55	2.38	Susceptible (7)
		Habiganj DW8*	7-10	75	24.93	Susceptible (7)
		Tjempo Kitjik*	8-10	60	12.85	Susceptible (7)
		TKM 6*	7-10	56	1.60	Susceptible (7)
		ARC 10312*	7-10	61	2.79	Susceptible (7)
		ARC 12596*	7-10	100	52.15	Susceptible (9)
		TN1	7-10	100	18.56	Susceptible (9)
4	Pesisir Selatan,	Tukad Petanu	8-11	20	18.97	Moderate (5)
	West Sumatera	Tukad Balian	7-10	90	32.72	Susceptible (7)
		Tukad Unda	7-10	75	13.21	Susceptible (7)
		Kalimas	7-10	100	30.23	Susceptible (7)
		Bondoyudo	7-10	85	33.22	Susceptible (8)
		Utri Merah*	7-11	20	23.50	Resistant (1)
		Utri Rajapan*	7-10	30	28.65	Moderate (4)
		Habiganj DW8*	7-10	65	20.73	Susceptible (7)
		Tjempo Kitjik*	7-11	40	7.35	Moderate (4)
		TKM 6*	7-10	41	1.42	Moderate (5)
		ARC 10312*	7-10	41	12.64	Moderate (5)
		ARC 12596*	7-10	60	23.70	Susceptible (7)

No.	Tungro Isolates	Rice variety	Incubation period (days)	Disease Incidence (%)	Reduction rate of plant height (%)	Response (Disease Index)
		TN1	7-10	100	6.76	Susceptible (9)
5	West Papua,	Tukad Petanu	12-14	15	8.27	Moderate (6)
	Papua	Tukad Balian	10-13	85	33.38	Susceptible (8)
		Tukad Unda	7-10	80	7.28	Susceptible (7)
		Kalimas	7-10	80	23.48	Susceptible (8)
		Bondoyudo	7-10	95	28.38	Susceptible (9)
		Utri Merah*	7-11	50	9.68	Moderate (5)
		Utri Rajapan*	7-10	25	11.44	Moderate (4)
		Habiganj DW8*	7-10	40	5.37	Moderate (5)
		Tjempo Kitjik*	7-10	47	5.15	Moderate (5)
		TKM 6*	7-10	100	5.75	Susceptible (9)
		ARC 10312*	7-10	73	7.82	Susceptible (8)
		ARC 12596*	7-10	57.8	23.58	Susceptible (7)
		TN1	7-10	100	23.97	Susceptible (9)

Note : * , donor parent of rice tungro virus

Several lines and varieties have been used as donor parents for breeding tungro resistant varieties. We found that among donor parents, only Utri Merah showed some level of resistance to five tungro isolates (Table 2). Utri Merah is a traditional rice variety from Indonesia that has been evaluated for its resistance to tungro diseases (RTBV and RTSV) in several countries, such as Malaysia and Philippines (Shahjahan *et al.* 1991). Utri Merah has been recommended as an ideal source of resistance for breeding tungro resistant varieties due to its complete resistance response to RTSV and its ability to restrict multiplication of RTBV (Azzam *et al.* 2000; Angeles *et al.* 2008). The breeding of Tukad Petanu used Utri Merah and Balimau Putih as sources of resistance genes and it produced a good level of resistance to five tungro isolates (Table 3). In comparison, different donor parents, *i.e.,* TKM6 was used for breeding of Tukad Balian and Kalimas, showed that the resistance level was low (Ladja and Widiarta 2002).

There are changes of disease index value (Table 3) from both resistant varieties and donor parents, if compared with previous research. Widiarta *et al.* (2004) reported that Tukad Petanu variety is suitable to be planted throughout tungro endemic area in Indonesia, Tukad Unda is only suitable to be planted in West Nusa Tenggara and South Sulawesi, and Tukad Balian is only suitable in Bali and South Sulawesi. Praptana *et al.* (2008) reported that donor parents, *i.e.* : Utri Merah, Utri Rajapan, and ARC 1154 were suitable against tungro isolates from South Sulawesi, West Sulawesi, Central Sulawesi, and Southeast Sulawesi.

The changes on resistance level of these varieties against tungro virus may indicate changes in virulence of the virus strain. Therefore, it is important to breed new yungro resistant varieties to anticipate the incoming more virulent virus strain. In addition, management of cropping system should be implemented in order to control insect vector population and reduce disease inoculum in the field.

Table 3. Response of resistant varieties and donor parents against 5 tungro virus isolates.

Rice variety	Tungro isolates				
	Bogor	**Sidrap**	**Badung**	**Pesisir Selatan**	**Papua**
			Resistant varieties		
Tukad Petanu	R	R	R	M	M
Tukad Unda	S	S	S	S	S
Tukad Balian	S	S	S	S	S
Bondoyudo	S	S	S	S	S
Kalimas	M	M	M	S	S
			Donor parent		
Utri Merah	R	M	M	R	M
Utri Rajapan	M	M	S	M	M
Habiganj DW8	S	S	S	S	M
Tjempo Kitjik	S	S	S	M	M
TKM6	S	S	S	M	S
ARC 10312	S	S	S	M	S
ARC 12596	S	S	S	S	S

CONCLUSION AND SUGGESTION

Two varieties *i.e*. Tukad Petanu and Kalimas, are still recommended as tungro resistant varieties. Tukad Petanu showed resistant response against tungro isolates from West Java, South Sulawesi, and Bali, but showed moderate response against those from West Sumatera and Papua. Kalimas showed moderate response against tungro isolates from West Java, South Sulawesi, and Bali. On the other hand, three varieties *i.e*. Tukad Balian, Tukad Unda, and Bondoyudo showed susceptible response against all tungro virus isolates. The planting of susceptible varieties should be based on the tungro virus strain in that region.

It is suggested that breeding resistant varieties should consider Utri Merah as a source of resistant gene, due to its stability as shown on Tukad Petanu. Survey and monitoring of virus strain across the country should be conducted frequently to maintain durability of resistant varieties.

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REFERENCES

Adugna, A. 2004. Alternate approaches in deploying genes for disease resistance in crop plants. Asian J. Plant Pathol. 3(5):618-624.

Angeles, ER., RC. Cabunagan, RE. Tabien, and GS. Khush. 2008. Resistance to tungro vectors and viruses. *In:* E.R. Tiongco, A.E. Angeles, and L.S. Sebastian (eds.). The rice tungro virus disease: A paradigm in disease management. Philippines Phil-Rice 93-141.

Arboleda, M. and O. Azzam. 2000. Inter-and intra-site genetic of natural field populations of rice tungro bacilliform virus in the Philippines. Arch. Virol. 145:275-289.

Azzam, O., MLM. Yambao, M. Muhsin, KL. McNally, and KML. Umadhay. 2000. Genetic diversity of rice tungro spherical virus in tungro-endemic provinces of the Philippines and Indonesia. Arch.Virol.145(6):1183-1197.

Cabauatan, PQ., M. Arboleda, and O. Azzam. 1998. Differentiation of rice tungro bacilliform virus strains by restriction analysis and DNA hybridization. J. Virol. Methods 76(1-2):121-126.

Cabauatan, PQ, RC. Cabunagan, and H. Koganezawa. 1994. Biological variants of rice tungro viruses in the Philippines. Phytopathology 85(1):77-82.

Cabunagan, RC., N. Castilla, EL. Coloquio, ER. Tiongco, ER. Angeles, LS. Sebastian, XH. Truong, J. Fernandez, M.J. Du, B. Zaragosa, RR Hozak, S. Savary and O. Jefferson . 2001. Synchrony of planting and proportions of susceptible varieties affect rice tungro disease epidemics in the Philippines. Crop Protection 20:499-510.

Daradjat, AA, IN. Widiarta, and A. Hasanuddin. 1999. Breeding for rice tungro virus resistance in Indonesia, pp 30-37, In Proc. Rice tungro disease management. Los Banos International Rice Research Institute.

Ditlin TP. 2013. Annual report of Directorate of Food Crops Protection 2012. Jakarta: Directorate of Food Crops Protection. Directorate General of Food Crops. 49 p.

Holt, J., and T. Chancellor. 1999. Modelling the spatio-temporal deployment of resistant varieties to reduce the incidence of rice tungro disease in a dynamic cropping system. Plant Pathology 48:453-461.

International Rice Research Institute. IRRI. 1996. Standard evaluation system for rice. 4th Ed. July 1996, INGER Genetic Resources Center, Manila, Philippines 52 p.

Ladja, FT., and S. Pakki. 2010. *Technical guiandce of introduction and management of tungro disease.* Bogor: Indonesian Centre for Food Crop Research and Development. 62 p.

Ladja FT, Santoso T and Nurhayati E. 2011. Potential entomopathogenic fungi *Verticillium lecanii* and *Beauveria bassiana* to control green leafhopper and suppress tungro disease incidence. Food Crop Journal 30:114-122.

Ladja, FT., and IN. Widiarta. 2012. New high yield varieties to anticipate outbreak of tungro disease. Science and Technology Journal 7(1): 18-24.

Praptana, RH., FT. Ladja, A. Muliadi, A. Bastian, and A. Burhanuddin. 2008. Suitability of tungro donor parents, pp 90-97 In Proc. Status of Research Program of tungro disease supporting sustainability of The National Rice Production, Makassar, South Sulawesi.

Shahjahan, M., AH. Zakri, T. Imbe, BS. Jalani, and T. Omura. 1991. Efficient method of determining tungro virus resistance in rice (*Oryza sativa* L.). Crop Protection 10(3):195-198.

Shen, P., M. Kaniewska, C. Smith, and RN. Beachy. 1993. Nucleotide sequence and genomic organization of rice tungro spherical virus. Virology 193(2):621-630.

Suprihanto. 2005. Differentiation of several *rice tungro virus* isolates using differential rice cultivar and PCR-RFLP. MS Thesis, Faculty of Agriculture, Bogor Agricultural University, Bogor, 49 p.

Suprihanto, S., E. Nurhayati and J. Harjosudarmo. 2013. Virulence of rice tungro isolates from several endemic area in Indonesia. J. Fitopatol. Indones. 9(1):29-37.

Widiarta, IN., Burhanuddin, AA. Daradjat, and A. Hasanuddin. 2004. Status and research program of Tungro disease integrated control, pp. 61-89. *In*: Proc. Status of research program of tungro disease supporting sustainability of The National Rice Production, Makassar, South Sulawesi.

Widiarta, IN, and D. Kusdiaman. 2002. Identification of tungro virus strain. Research Result Report 2001. Rice Research Institute, Subang, West Java, pp 18.

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THE IMPACT OF LOGISTIC PERFORMANCE ON THE INDONESIAN AGRICULTURAL EXPORT

Arief Daryanto[1,2] and Sahara[1,3]
[1]Department of Economics, Faculty of Economics and Management,
Bogor Agricultural University.
[2] Business School, Bogor Agricultural University
[3]International Center for Applied Finance and Economics,
Bogor Agricultural University
Corresponding author: adaryant@sb.ipb.ac.id

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ABSTRACT

A good logistic service can reduce transaction costs and increase competitiveness of agricultural products in international trade. Lack of logistic systems lead to increase risks in the agricultural export that can impact the availability, delivery time, traceability, and quality of products. In such situation, logistic services can be considered as an important barrier in international trade. While previous research more focused on the impact of tariff barriers on trade, this research focuses on the impact of non-tariff barriers, i.e. logistic services on Indonesian agricultural export. This study uses panel data covering export of agricultural products from Indonesia to 21 importing countries over the period 2005-2013. The logistic services indicated by Logistic Performance Index (LPI) are utilized as an independent variable in the model. We also control our model with several independent variables including gross domestic product (GDP), distance, tariff, population, information technology, governance index, and trading cost borders. We find that LPI is associated with an increase in Indonesian agricultural exports, even after we controlled with other independent variables. The results suggest that improving logistic performance has become an important development policy for Indonesian government. The fact that Indonesia has developed the blueprint of national logistic system can provide a useful strategy for Indonesian government to deal with challenges in the logistic services particularly in agricultural exports.

Key words: agricultural products, logistic performance index

INTRODUCTION

Various barriers emerge in international trade including tariffs and non-tariffs. While the majority of previous studies have focused on the tariffs as the significant source of barriers to trade, current studies are interested in examining the relative importance of non-tariff measures (NTM) to trade especially from the developing countries' perspectives (Francois and Manchin, 2013; Hoekman and Nicita, 2011; Ikenson, 2008; Perez and Wilson, 2012). Among the NTM, logistic cost has a significant effect on trade flows. Hausman, *et al.* (2005) reported the quality and performance of logistic services differ markedly among countries. For example, in Kazakhstan it takes about 93 days to export a 20-foot full container load container of cotton apparel. In Mali, it takes about 67 days, while in Sweden it takes only about 6 days. The variation in time across countries is not only determined by physical infrastructure (road, rail, waterways, port services, and interfaces), but also by other logistic services including procedural red tape, contract enforcement, enforcement of rules of engagement, customs, ports and border crossings, pilferage in transit, and protocols on movement of cargo.

Good logistic performance can reduce risks and uncertainties in exporting products. This will reduce transaction costs and increase competitiveness of exported products (Hausman, *et al.*, 2005; Weerahewa 2009). On the other hand, lack of logistic system increases risks both cost and time during exporting process. Hausman (2004) reported the costs during an exporting activity involving not only the direct costs of transporting products but also indirect costs such as inventory holding costs. The longer the transit time, the higher are the costs. Indirect costs also appear when delivery times and reliability are uncompetitive. Product value often declines with time while in transit (Hausman, *et al.*, 2005). For perishable products, e.g., agricultural products, spoilage or wastage will increase with transit time.

In Indonesia, the agricultural sector continues to be the most important sector. It is the top two sectors in Indonesian Gross Domestic Product (GDP) together with manufacture. In 2014, agricultural sector accounted for 14% of GDP and absorbed about 35% of employment (40 million people). Agricultural sector also plays an important role in Indonesian exports. In 2014, the export value of agricultural products reaches about US$ 565.92 million or contributes about 21.84% of the total value of Indonesian exports (Table 1). This value is lower compared to manufacture sector. However, considering that agricultural sector absorbs a large number of Indonesian employment, its export contribution is matter. Export provides market opportunities for agricultural products producing by small farmers in Indonesia. According to data from Indonesian Agricultural Census around 56% of the farmers had a land holding of 0.5 ha or less (Statistic Agency, 2014).

Table 1. The value of Indonesian export in 2015.

No	Description	Value (million US$)	Share (%)
1	Agricultural products	565.92	21.84
2	Food	460.14	17.75
3	Manufactures	951.24	36.70
4	Other	614.35	23.70
5	Aggregate	2591.65	100.00

Source: WITS World Bank (2015)

Agricultural sector needs more complex logistic system compared to the logistic system of manufacture sector. Perishable products, as the main characteristic of agricultural products, need a good logistic system not only in terms of infrastructure but also in non-tariff policies and institutions. For example delays in custom, at ports and borders crossing, in transit time and highly restrictive protocols on cargo movement will increase risks (e.g., product loss) and costs of exported agricultural products. In Indonesia, logistic infrastructures such as road and warehouses are very limited. This is exacerbated by issues related to administrative and bureaucratic with respect to export procedures. In adequate logistic system that can support trade flow leads to low logistic performance index (LPI) in Indonesia reducing the capability for Indonesia to get benefit from the opportunities of expanding global trade in agricultural products. In fact as explained previously, logistic services will influence positively on agricultural trade. However, in Indonesia particularly in agricultural products, previous research tend to focus on the impacts of tariffs on trade rather than non-tariffs impact (e.g., Obado *et al*. 2009; Tseuoa *et al*. 2012). This research aims to fill the gap by measuring the impact of NTM focusing on logistic services on Indonesian agricultural export. We expect that logistic services indicating by LPI significantly affects the volume of agricultural export from Indonesia to trading partner countries.

NATIONAL LOGISTIC SYSTEMS IN INDONESIA

Indonesia is characterized by a country with high logistic cost as indicated by high ratio of logistic cost to its Gross Domestic Product (GDP). From 2004 to 2011, the ratios of logistic cost to GDP were above 20% (Table 2). The components of logistic cost consists of transportation, inventory and administration costs. Among these costs, transportation cost provides the highest contribution in the logistic cost (about 12% in the period 2004-2011). This is because low quality of transportation infrastructure in Indonesia, e.g., road, sea port, airport and railway. Indonesia was far behind in terms of the quality of overall infrastructure among worldwide countries, at the rank 92nd in 2012 (Schwab and Martin, 2013). Specifically, the ranks of Indonesia among worldwide countries with respect to quality of roads, railroad, port, air transport are 90th, 51st, 104th, and 89th, respectively. Other factors contribute to the high logistic cost in Indonesia include illegal charges causing high transaction costs, high export-import service time and the operational constraints in port services and limited capacity and network service of national logistic providers (Simatupang 2013). In such situations, it is not surprisingly that the national logistic cost in Indonesia is much higher compared to neighboring countries such as Singapore (8th), Malaysia (13th), and Thailand (20th) (World Bank 2013).

High logistic cost has led to low LPI Indonesia in worldwide ranking. In 2007, Indonesia ranked of 43rd of the 150 countries surveyed and in 2010, the rank became lower to 75th. In 2007 the position of Indonesia was higher than Philippines. However, in 2010, Philippines had improved its LPI performance and was in the rank 44th (Table 3). In the period 2012 and 2014, Indonesia's LPI indexes considerably increased and has led to Indonesia in the better rank compared to in 2010. But, the ranks were still lower than neighboring countries, except for Philippines in 2014.

Table 2. Logistic cost and its ratio to GDP in Indonesia from 2004-2011.

Year	Component of logistic cost (% to GDP)			National Logistic cost	
	Transportation	**Inventory**	**Administration**	**Percent to GDP**	**Trillion IDR**
2004	12.6	10.2	4.8	27.6	633.8
2005	12.8	9.9	4.8	27.5	762.9
2006	13.3	10.5	5.0	28.8	961.2
2007	12.3	9.0	4.5	25.7	1016.6
2008	11.0	9.6	4.3	25.0	1238.4
2009	10.9	9.7	4.3	24.9	1397.3
2010	11.8	8.0	4.2	24.0	1543.8
2011	11.6	8.7	4.3	24.6	1829.7
Average	12.0	9.5	4.5	26.0	

Source: Simatupang (2013) and World Bank (2013)

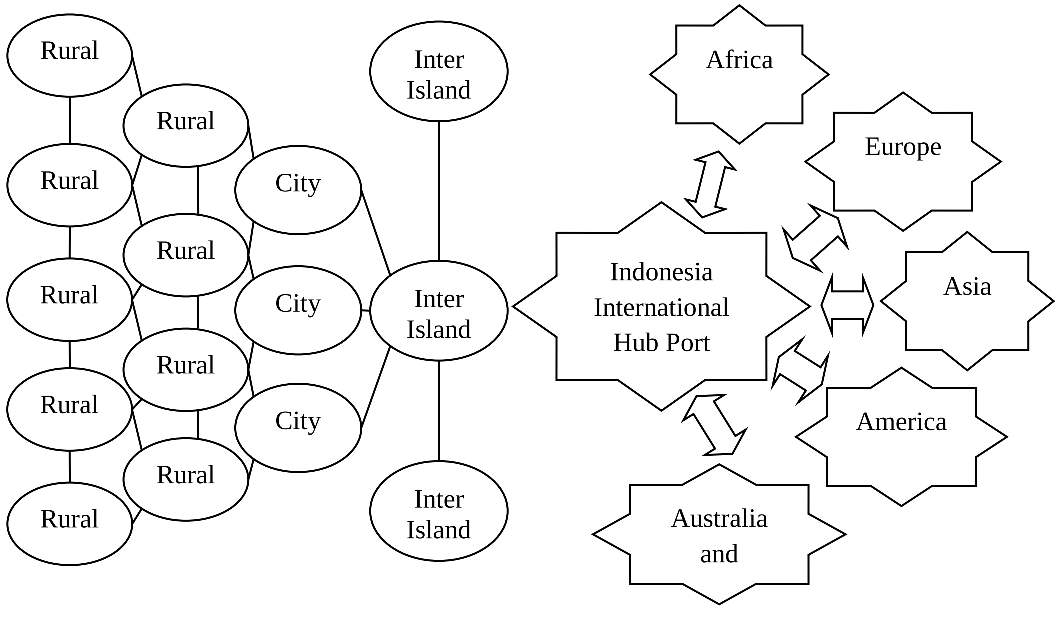
Unsatisfied performance of logistic services reveal why it is important for the Indonesian government to improve national logistic systems. Though, improving the performance of logistic sector in Indonesia is more challenging because of the geographical nature and uneven distribution of population and resources (World Bank 2013). Indonesia is the largest archipelago country in the world consisting of 17,504 islands and about 250 million population. The islands are spread over more than 5,000 kilometers from western to eastern parts of Indonesia with the sea area dominates (5,800,000 km^2) over the land area (1,860,360 km^2) (World Bank 2013). In terms of population, by about 60% of total population concentrate in Java Island and the remaining are distributed among other islands which are often very sparsely populated (Herliana and Parsons 2012). While resources are widely spread over the islands.

Table 3. LPI Indexes in Indonesia and four selected neighboring countries in 2007-2014

Country	LPI Index				Worldwide Ranking			
	2007	2010	2012	2014	2007	2010	2012	2014
Indonesia	3.01	2.76	2.94	3.08	43	75	59	53
Singapore	4.19	4.09	4.13	4.00	1	2	1	5
Malaysia	3.48	3.44	3.49	3.59	27	29	29	25
Thailand	3.31	3.29	3.18	3.43	31	35	38	35
Philippines	2.69	3.14	3.02	3.00	65	44	52	57

Source: http://lpi.worldbank.org/international/global/2014. Downloaded 25 October 2014

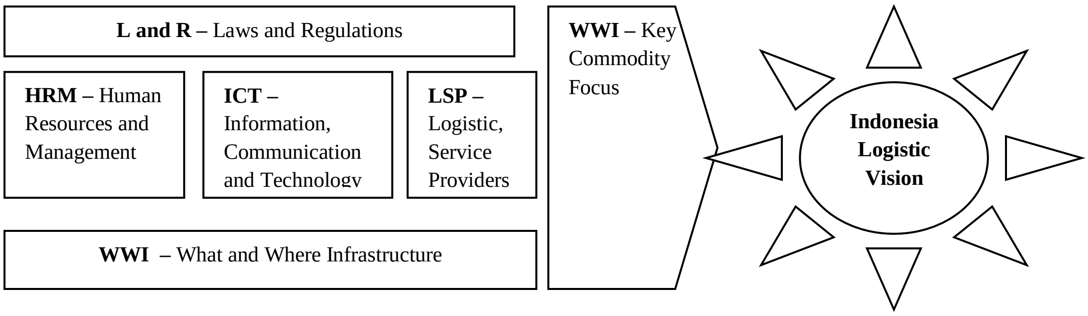
To overcome the challenges as explained above, the Indonesian government has issued Presidential Regulation No.26 year 2012 with respect to the Blueprint of National Logistic System (SISLOGNAS). Logistic in this document refers to an operating procedure of goods-flow, information flow, and cash-flow via procurement, storage, transportation, distribution, and delivery according to its type, quality, quantity, time, and location ordered by consumers, from the original point into final destination in an effective and efficient way. The blueprint was developed for 2012 to 2025 with the vision “Locally Integrated, Globally Connected for National Competitiveness and Social Welfare”. Locally Integrated means that by 2025 all logistic activities in Indonesia will be integrated effectively and efficiently at the rural, urban, interregional and inter-island levels. Meanwhile, “Globally Connected” assumes that by 2025 the National Logistic System will be connected to the regional (ASEAN) and global logistic systems via International Hub Ports (including customs and trade facilitations), backed-up by “International Gateways” information and financial networks enabling national logistic actors and service providers to compete in the global market (Fig. 1).



Source: The Blueprint of National Logistic System Development (SISLOGNAS), 2012.

Fig. 1. The network of National Logistic System

There are six key drivers to achieve the vision of the National Logistic Blueprint (NLB) including (1) key commodities, (2) logistic actors and service providers, (3) transport infrastructure, (4) information and communication technology, (5) human resources and management, and (5) laws and regulations. Figure 2 presents the six key drivers and their relations with the vision of national logistic system.



Source: The Blueprint of National Logistic System Development (SISLOGNAS), 2012.

Fig. 2. The main key drivers in the National Logistic System

METHODOLOGY

Data and empirical model

Secondary data in the form of panel data is utilized covering the trading flows of agricultural products from Indonesia to 21 importing countries (Table 4) over the period 2005-2013. The agricultural products involved in this study are presented in Table 5. Following Reardon and Timmer (2007), the agricultural products include commodity and product markets[1], therefore we utilize the terms of agri-food products to refer the two definitions.

Table 4. Importing countries of Indonesian agri-food products

No.	Country	No	Country	No	Country
1	Australia	8	South Korea	15	Thailand
2	China	9	Malaysia	16	Turkey
3	Germany	10	Netherland	17	United Arab Emirates
4	Hongkong	11	Philippines	18	England
5	India	12	Rusia	19	United State
6	Italia	13	Singapore	20	Vietnam
7	Japan	14	South Africa	21	Spain

Source: WITS, 2015

This study focuses on the impact of logistic performance on the export of Indonesian agri-food products. Therefore, we use the value of Indonesian agri-food export as a dependent variable and logistic performance index (LPI) as an independent variable in our equation. We also control our

[1] Commodity refers to standardized agricultural products that have had little or no processing and often raw materials for further processing. While products refer to subsets of a given commodity, differentiated with some attribute, such as organic or not, processed or not, branded or not, variety A versus variety B.

model with several independent variables including gross domestic product (GDP), distance (DISTEK), tariff (T_AGRIFOOD), population (POP), information technology (ICT), governance index (GOV), and trading cost borders (TAB).

Table 5. Agri-food products covered in the study.

Code	Product Description
00	Live animals
01	Meat, meat preparations
02	Dairy products, bird eggs
03	Fish, crustaceans, mollusk
04	Cereals, cereal preparations
05	Vegetables and fruit
06	Sugar, sugar preparations, honey
07	Coffee, tea, cocoa, spices
08	Animal feed stuff
09	Miscellaneous edible products and preparations
11	Beverages
12	Tobacco, tobacco manufactures
21	Hides, skins and furskins, raw
22	Oil seed, oleaginous fruit
23	Crude rubber
24	Cork and wood
29	Crude animal and vegetable materials
41	Animal oils and fats
42	Fixed vegetable fats and oils
43	Animal and vegetable fats and oils, processed
59211/2/3	Wheat-/maize starch

Table 6. Variables used in the model and the sources

No.	Variables	Definition	Unit	Source
1	$X\_AGRIFOOD^{t}$	This is the dependent variable in the model referring to the value of agri-food exports from Indonesia to importing countries in year t.	Thousand US$	World Integrated Trade Statistics (WITS) World Bank
2	$X\_AGRIFOOD(-1)^{t}$	The value of agri-food exports from Indonesia to importing countries in the previous year (t-1)	Thousand US$	World Integrated Trade Statistics (WITS) World Bank

No.	**Variables**	**Definition**	**Unit**	**Source**
3	GDP^t	Gross domestic product Indonesia ($GDP^t{}_i$) and importing countries ($GDP^t{}_j$) in year t.	Thousand US$	World Development Indicators (WDI) World Bank
4	$DISTEK^t$	Economic distance calculated by the formula as suggested by (Li *et al.* 2008): $DISTEK_{ij} = \text{Geographic distance}_{ij} * \frac{GDP_j}{\text{Total } GDP_j}$	Km	Centre d'Etudes Prospectives et d'Informations Internatioanles (CEPII)
5	$T\_AGRIFOOD^t$	Tariffs for agri-food products in each selected destination country	%	World Integrated Trade Statistics (WITS) World Bank
6	POP^t	Number of population in year t in Indonesia ($POP^t{}_i$) and importing countries ($POP^t{}_j$)	Person	World Development Indicators (WDI) World Bank
7	ICT^t	Information and communication technology in year t in Indonesia ($ICT^t{}_i$) and importing countries ($ICT^t{}_j$). It shows the extent to which a country uses information and communications technology to improve efficiency, and productivity as well as to reduce transaction costs. It contains four main indicators including (i) availability of latest technologies, (ii) firm-level technology absorption, (iii) internet users, and (iv) broadband internet subscriptions	Index from 1 (worst) to 7 (best)	World Economic Forum (WEF)
8	GOV^t	Following definition of World Bank governance indicators include (i) the process by which governments are selected, monitored and replaced; (ii) the capacity of the government to effectively formulate and implement sound policies; and (iii) the respect of citizens and the state for the institutions that govern economic and social interactions among them.	Index from -2.5 (worst) to 2.5 (best)	Worldwide Governance Indicators (WGI)
9	TAB^t	Trading across borders (TAB) measures the complexity and cost of regulatory processes including (i) number of export and import documents, (ii) time for export and import and (iii) costs for import and export	The value of TAB ranges between 0 (worst) to 100 (best)	Doing Business (DB) World Bank

To capture the effect of logistic performance on agri-food export performance, this study uses cross-section gravity model as follow:

$$\log X\_AGRIFOOD^t_{ij} = \beta_0 + \beta_1 \log X\_AGRIFOOD(-1)^t_{ij} + \beta_2 \log GDP^t_i + \beta_3 \log GDP^t_j + \beta_4 \log DISTEK^t_{ij} + \beta_5 T\_AGRIFOOD^t_{ij} + \beta_6 \log POP^t_i + \beta_7 \log POP^t_j + \beta_8 ICT^t_i + \beta_9 ICT^t_j + \beta_{10} GOV^t_i + \beta_{11} GOV^t_j + \beta_{12} TAB^t_i + \beta_{13} TAB^t_j + \beta_{14} LPI^t_i + \beta_{15} LPI^t_j + e^t_{ij}$$

where i refers to Indonesia, j refers to importing countries of agri-food from Indonesia, and t refers to time (year from 2005-2013), *e* is random error, β_0 is intercept, and β_n is coefficient. We expect that β_1, β_2, β_3, β_6, β_7, β_8, β_9, β_{10}, β_{11}, β_{12}, β_{13}, β_{14}, $\beta_{15} > 0$ and β_4, $\beta_5 < 0$. Details of each variable used in the model are explained in Table 6.

RESULTS AND DISCUSSIONS

The panel data was estimated by using fixed effect model (FEM) as presented in Table 7. To correct the heteroskedasticity across panel, we used FEM Generalized Least Squares (GLS). We also conducted normality test in order to check whether the random errors are distributed normally. The normality test shows that the random errors had a normal distribution as indicated by its probability > 0.1 (Fig. 3). The estimated model has an R-square at 98.9% of the variation of dependent variable (agri-food export from Indonesia) can be explained by its independent variables.

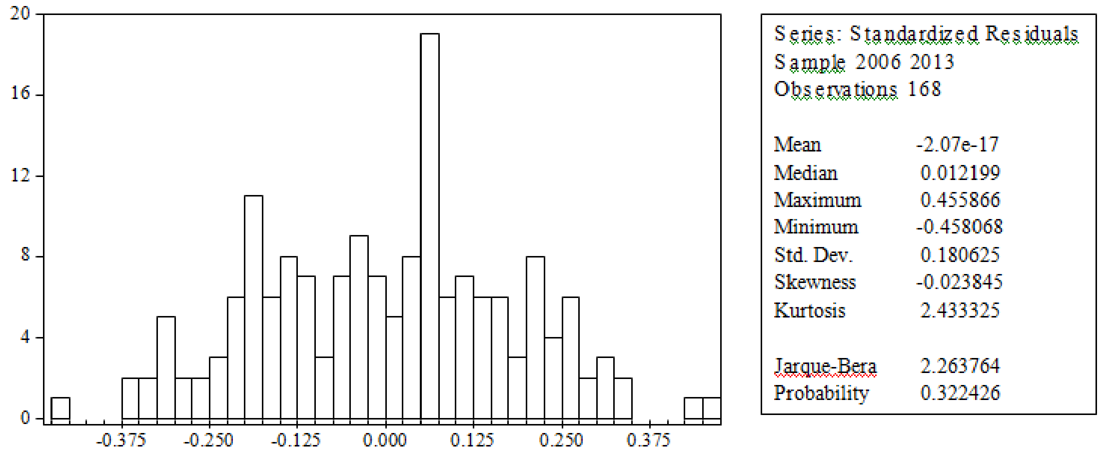


Fig. 3. Normality test for the random errors.

As explained previously, the model is specified in log-log form; therefore, the coefficient estimates show elasticity estimates with respect to various continuous variables in the model. For the variables measured in scale are included as level variables. For example, LPI is a scale ranging from 0 to 5 and once multiplied by 100, it will show percentage change in the value of agricultural export due to one unit change in the LPI (Weerahewa 2009).

As expected the quality of logistic matters for international trade of agricultural products. This indicates by the significant coefficient for LPI both for Indonesia (LPI_i) and importer countries (LPI_j). Coefficient estimates for the LPI suggest that one point increase in the LPI scores would increase agricultural export by about 36% for Indonesia and increase import for agricultural products by about 50% for importer countries. This result is consistent with previous literature (Hausman, *et al.* 2005; Weerahewa 2009).

Table 7. Results of the econometric estimation

Variable	Coefficient	Std. Error	t-Statistic
Constant	-89.878	25.607	-3.510**
LogX_AGRIFOOD(-1)	0.061	0.036	1.702*
$LogGDP_i$	-4.865	1.135	-4.284***
$LogGDP_j$	0.304	0.151	2.017**
$LogDISTEK_{ij}$	-0.107	0.110	-0.967ns
$T\_AGRIFOOD_{ij}$	-0.004	0.001	-4.427***
$LogPOP_i$	8.352	2.207	3.784***
$LogPOP_j$	1.196	0.126	9.484***
$ICT\__i$	0.177	0.026	6.812***
$ICT\__j$	-0.057	0.043	-1.316ns
$GOV\__i$	0.045	0.026	1.742*
$GOV\__j$	0.195	0.083	2.356**
TAB_i	0.056	0.026	2.181**
TAB_j	0.030	0.007	4.633***
$LPI\__i$	0.360	0.077	4.647***
$LPI\__j$	0.500	0.162	3.086**

R-square=0.989. F-statistic = 352.86. Prob (F-Statistic) = 0.000. n = 189 (consisted of 9 years and 21 countries)
Note: *** significant at 1%; ** significant at 5%; * significant at 10%;, ns denotes insignificant at 10%

Among NTM, the coefficients of LPI both for exporter and importer countries have the largest effect on trade. The results reveal that better logistic services can provide more opportunity for Indonesia to export its agricultural products since it can reduce transaction costs, increasing competitive advantage of agricultural products in the world markets. As discussed previously, the LPI index in Indonesia in 2014 was only 3.04. Therefore, there will be more room for Indonesia to improve the value of its LPI as the highest score for LPI is 5. Improving the score of LPI can be achieved by increasing efficiency in the logistic components including clearance process, infrastructure, shipment and transit, logistic services, ability for tracking, and port efficiency. Considering the characteristics of agricultural products (perishable), such efficiency can determine whether Indonesia can trade agricultural products on time and a lower cost.

Other trading facilitation including trading across border (TAB) and governance indicators (GOV) of exporter (Indonesia) as well as importers have significant impacts on the value of Indonesian agricultural export. An increase in TAB and GOV by one point leads to an increase in the value of Indonesian agricultural export by 5.6% and 4.5%, respectively. An increase in TAB and GOV by one point leads to an increase the value of importer countries for agricultural products by 3% and 19%. Similarly, the variable of information and communication technology (ICT) in Indonesia has significant impact on the value of agricultural export. One unit increase in ICT can increase exports of Indonesian agricultural products by 17.7%. The results support previous literature with respect to the importance of trade facilitation on the value of agricultural export (Hoekman and Nicita 2011; Weerahewa 2009).

As expected, the variable of tariff has significant impact on Indonesian agricultural export. A reduction in tariffs (T AGRIFOOD$_{ij}$) by 10% would increase the value of agricultural export from Indonesia by 0.04%. Although tariff has significant impact, it has small impact on the value of agricultural export in Indonesia. Ikenson (2008) reported that in most countries, tariffs are not the main barriers in their trade flow. This is in line with our findings suggesting that rather than tariffs, the main barriers persist in trade flow including the persistence of logistic system, the complexity and cost of regulatory processes, governance indicators and the quality of information and technology.

Other variables are generally typical with previous gravity models for the trade flows (e.g., Hoekman and Nicita 2011; Perez and Wilson 2012; Weerahewa 2009). Larger and more populous countries tend to import more agricultural products from Indonesia. Higher value of agricultural export from the previous year (lag of the value agricultural export), increase the current value of agricultural export. Similarly, the higher gross domestic product (GDP_j) in importing countries, the higher agricultural products will be imported. Increase in national income in the importing countries (GDP_j) by 10% will increase value of Indonesian agricultural export by 3%.

Contrary to expectations, GDP exporter country (Indonesia) has negative significant impact on the value of agricultural export. According to the results in Table 7, an increase in GDP in Indonesia by 1% will reduce its value of agricultural export by 4.8%. The result can be explained by Bennett's Law which states that as income rises, the share of the budget spent to high agricultural products such as meat, fish, dairy, fruits, vegetables, and oils increases (Reardon and Timmer 2007). In this paper, the majority of agricultural products exported by Indonesia include high agricultural products. Increasing Indonesian GDP reflects increasing national income which in turn increasing domestic demand for high-agricultural products, reducing export for agricultural products. The dramatic increase in modern retail markets in Indonesia provides new market opportunity for agricultural products in the domestic market (Sahara and Daryanto 2015).

CONCLUSIONS AND IMPLICATIONS

This study contributes to the emerging literature on the impact of NTM on Indonesian agricultural export. Among NTMs, this paper focuses on logistic services presented by LPI. This study finds that logistic service is associated with an increase in Indonesian agricultural exports, even after we controlled with other independent variables. The results suggest that improving logistic performance has become an important development policy for Indonesian government. The fact that Indonesia has developed the blueprint of national logistic system can provide a useful strategy for Indonesian government to deal with challenges in the logistic services particularly in agricultural exports.

The implementation of the blueprint of national logistic system needs a good collaboration between government agencies and the private sector in Indonesia. The collaboration should mainly focus on improving indicators of logistic performance linked to LPI. The government and the private sector should work to reduce freight costs for bilateral trade by deregulating transportation and expanding ports to increase capacity. Government can also promote the role of the third-party logistic industry in order to allow more consolidation of cargo flows. At the same time, government should also focus on how to reduce processing time and cost by reengineering process to eliminate unnecessary steps. Promoting more parallel processing for trade could be a good strategy rather than implement sequential processing. Since information technology is also important, government should also introduce advanced information technology including electronic custom clearance, documentation flows and advanced scanning technologies to shorten cargo inspection times. All these efforts might facilitate Indonesian government to improve LPI indicators including (1) efficiency of clearance process, (2) quality of trade and transport infrastructure, (3) competitively price shipment, (4) competence and quality of logistic services, (5) ability to track and trade consignments, and (6) timeliness of shipment.

This study only examines the relationships between LPI and the value of agricultural export in Indonesia for 21 countries in the nine years. Further study should use longer time period of data in order to test the relationships. Also, since this study is sector specific, i.e., agricultural products in Indonesia, further research is needed to generalize the results in the context of other sectors.

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REFERENCES

Francois, J. and M. Manchin. 2013. Institution, infrastructure, and trade. World Development. 46:165-175.

Hausman, WH. 2004. Supply chain performance measures. In Corey Billington, Terry Harrison, Hau Lee, and John Neale (Eds.), The Practice of Supply Chain Management. New York: Springer Science and Media Inc. Chapter 3: Vol 62, pp. 61 -73.

Hausman, WH., HL. Lee and U. Subramanian. 2005. Global logistic indicators, supply chain metrics, and bilateral trade patterns. World Bank Policy Research Working Paper. No.3773, November: 1-29.

Herliana and Parsons. 2012. Logistic in Indonesia. https://www.google.com/?gws_rd=ssl#q=Herliana+and+Parsons. Downloaded on 29 October 2014.

Hoekman, B. and A. Nicita. 2011. Trade policy, trade costs, and developing country trade. Word Development. 39(12): 2069-2079.

Ikenson, D. 2008. While Doha sleeps: securing economic growth through trade facilitation. Cato Institute Trade Policy Analysis. No.37.

Li K., L. Song and X. Zhau. 2008. Component trade and China's global economics integration. United Kingdom: United Nations University, pp.101-126.

Obado, J., Y. Syaukat and H. Siregar. 2009. The impacts of export tax policy on the Indonesian crude palm oil industry. Journal of ISSAAS. 15(2): 107-119.

Perez, AB. and JS. Wilson. 2012. Export performance and trade facilitation reform: hard and soft infrastructure. World Development. 40(7):1295-1307.

Reardon, T. and CP. Timmer. 2007. Transformation of markets for agricultural output in developing countries since 1950: How has thinking changed? in Evenson, R. and Pingali, P. (Eds.), Handbook of Agricultural Economics, Elsevier, Amsterdan, pp 2807-2855.

Sahara and A. Daryanto. 2015. Farmer-trader relationships in the modern food supply chain in Indonesia. Journal of ISSAAS. 21(1): 107-122.

Schwab, K. and SX. Martin. 2013. The Global Competitiveness Report 2012–2013. World Economic Forum, Geneva, pp 1-545.

Simatupang, TM. 2013. Logistic and supply chain in Indonesia: Emerging practices. School of Business and Management, Bandung Institute of Technology, Indonesia, pp 1-120

Statistic Agency. 2014. Agricultural censuses. Indonesian Statistic Agency, Jakarta. http://st2013.bps.go.id/dev2/index.php

Tseuoa, T., Y. Syaukat and DB.Hakim. 2012. The impact of the Australia and New Zealand free trade agreement on the beef industry in Indonesia. Journal of ISSAAS. 18(2):70-82.

Weerahewa, J. 2009. Impact of trade facilitation measures and regional trade agreements on food and agricultural trade in South Asia. Asia-Pacific Research and Training Network on Trade Working Paper Series, No 69, June 2009, pp 1-32

World Integrated Trade Solution [WITS] 2015. Trading data [data file]. World Bank. www.wits.worldbank.org. downloaded on 17 February 2015

World Bank. 2013. State of Logistic Indonesia. World Bank, Jakarta, pp 1-63.

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EFFECT OF MOLASSES, RICE BRAN AND TAPIOCA FLOUR AS ADDITIVES ON THE QUALITY AND DIGESTIBILITY OF CASSAVA LEAF SILAGE

Asep Sudarman*, Rizk i Nurul Amalia and Dewi Apri Astuti
Department of Nutrition and Feed Technology, Faculty of Animal Science
Bogor Agricultural University, Bogor, 16680, Indonesia
*Corresponding author: asudarman@ipb.ac.id

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) leaves, the waste of the tapioca flour industry, contain high levels of crude protein that can be used as a complementary forage for low quality field grass. The study was conducted from September to November 2009 in the Dairy Nutrition Laboratory of Bogor Agricultural University. This study sought to analyze the quality of cassava leaf silages supplemented with different additives such as molasses, rice bran and tapioca flour and to determine their digestibility and fermentability *in vitro*. This study consisted of two experiments: 1) measuring the physical properties of silages and 2) measuring the *in vitro* fermentability and digestibility of silages. A completely randomized design was used in the first experiment and a randomized complete block design in the second experiment. The treatments were: K (cassava leaves without additive) as a control, M5 (K + 5% molasses), M10 (K + 10% molasses), RB5 (K + 5% rice bran), RB10 (K + 10% rice bran), T5 (K + 5% tapioca flour) and T10 (K + 10% tapioca flour). The variables measured were colour, odour, pH, water content, NH_3, VFA, and dry matter and organic matter digestibility. Data were analyzed using Analysis of Variance (ANOVA) and any significant differences between means were further tested using Least Significant Difference (LSD). The results showed that the silages with any additives had better quality than that of the control. The quality of silages with molasses additives at either a 5% or 10% level were better than those of silages with other additives. Types and levels of additives significantly affected ($P<0.05$) *in vitro* fermentability and digestibility. In overall quality assessments, a molasses additive at a level of 5% produced the best quality of silage.

Key words : crude protein, fermentability, in vitro, physical property, sheep

INTRODUCTION

Traditional farming system usually relies on feeding sheep with field grass which is low in nutrient content thus resulting in low production. This is despite the fact that there is available crop waste containing good nutrient content that can be used as animal feed such as cassava leaves. Indonesia is one of the major cassava producing countries. Indonesia's cassava production in 2013 amounted to 23,936,921 tons with the harvested area of 1,065,572 ha (Statistics Indonesia, 2014). Utilization of cassava tubers for animal feed competes with human food need including its use after processing to become tapioca flour. Cassava leaves, on the other hand, are often a waste of tapioca flour industry therefore it has a potential to be used as animal feed. Cassava leaves are high in protein content of 20.2% (Marjuki *et al*. 2008), ranging from 23.2 to 35.9% depending on the cultivars and decreasing with age (Wobeto *et al*. 2006). It is good as a complementary forage for low quality tropical grass. Cassava leaves also contain branched amino acid of isoleucine 4.5, leucine 8.2 and valine 5.6 g/100g protein (Eggum 1970). Branched chain amino acids are beneficial for development of ruminal microorganisms and improved efficiency of ruminal fermentation *in vitro*. Provision of branched chain amino acids increase the digestibility of diet (Yang 2002), the total VFA yields and the degradability of NDF (Zhang et al. 2013). However, the utilization of cassava leaves for fodder must be careful, because they contain hydrocyanic acid (HCN) causing poison to livestock.

Indonesia, because it is located in the tropics, has two seasons which may affect the availability of forage for ruminants. In the rainy season, there is an abundance of forage sources including cassava leaves, but in the dry season the availability of forage is limited. Therefore, it needs technologies for forage preservation, one of which is silage making.

The basic principle of making silage is to create acidic conditions as soon as possible that can suppress the growth of spoilage bacteria. Besides being able to extend the shelf life, silage can also increase the palatability of forage. Therefore, during the preparation of silage, substances are often added as additives in order to accelerate the acidic conditions. One type of additives that can be added is carbohydrate source feeds. Carbohydrate-rich ingredients can stimulate the development of lactic acid bacteria (LAB) on the fermentation process (McDonald *et al*. 1991; Yitbarek and Tamir 2014). The activity of LAB causes the decrease in pH value of silage. Molasses as one of ingredients containing high water soluble carbohydrate (37.5% of DM (Man and Wiktorsson, 2002)) is usually added 3-5% (Moran 2005) up to 10% (Mühlbach 2000) during silage preparation.

Since most ruminant animals are usually reared by smallholder farmer, carbohydrate sources that can be used as additive to silage should therefore be easily obtained by them. This experiment aimed to study the effect of various sources and levels of carbohydrate use as additives on the quality of cassava leaf silage and its digestibility in vitro.

MATERIALS AND METHODS

The study was conducted from September to November 2009 in the Dairy Nutrition Laboratory of Bogor Agricultural University. This study consisted of two consecutive experiments, i.e., (1) measuring the physical quality of silage made with the addition of different levels and sources of additive and (2) measuring *in vitro* digestibility and fermentability of silage made in experiment one.

Silage Quality

Fresh cassava parts (leaves, top stalks and top trunks) obtained from the cassava flour factory waste were chopped into pieces of 2-3 cm length and withered at ambient temperature until their moisture content reached around 60% which is required for making good silage. Subsequently, 500 g of cassava leaves were thoroughly mixed with either 5% or 10% of each additives. They were then put into a five kg capacity of transparent heat resistant plastic bag. Anaerobic condition was made by removing free air from the plastic bag using a vacuum pump. The bag was then tied up and put into a black vinyl plastic bag to protect silage from sunlight to minimize heating and stored at ambient temperature for 28 days. The carbohydrate source used as additives were molasses, rice bran and tapioca flour. After 28 days of fermentation, the vinyl bags were opened and the quality of silages were assessed.

This study used completely randomized design (CRD) using seven treatments with three replicates. The treatments were: C (Control) = cassava leaves without additives, M5 = C + 5% molasses, M10 = C + 10% molasses, RB5 = C + 5% rice bran, RB10 = C + 10% rice bran, T5 = C + 5% tapioca flour, and T10 = C + 10% cassava flour. The variables measured were odour, colour, pH and moisture content of the silages.

In vitro Digestibility and Fermentability Measurement

Silages obtained from the first experiment were used in this experiment. The treatments were similar with those in first experiment, i.e., C (Control) = mixture of cassava leaves, stalk and green stem without additives, M5 = C + 5% molasses, M10 = C + 10% molasses, RB5 = C + 5% rice bran, RB10 = C + 10% rice bran, T5 = C + 5% tapioca flour, and T10 = C + 10% cassava flour.

Experimental design used was Randomized Block Design (RBD) using seven treatments with three rumen liquors of sheep as replicates/groups. Rumen liquors were obtained from slaughter house directly at the time of the animals were slaughtered. Variables measured were concentrations of NH3 (ammonia) and total volatile fatty acids (VFA) as well as dry matter and organic matter digestibility. Ammonia concentration were analyzed using method of Micro Diffusion (Conway 1962) and concentration of VFA total were measured using Steam Distillation Method (General Laboratory Procedures, 1966). Dry matter and organic matter digestibility were analyzed using the methods of Tilley and Terry (1966). All the analysis were done in the Laboratory of Dairy Nutrition of Bogor Agricultural University.

Data, except for variables of colour and smell of silages in experiment one, from both experiments were analyzed using analysis of variance (ANOVA) and treatment means were separated using Least Significance Difference (LSD) (Steel and Torrie 1980). Variables of colour and smell of silages were analyzed using descriptive statistical analysis.

Assessment of Overall Quality of Silage

Overall quality of the silages was determined using the scoring method. Score for colour of silages were 1 for brown, 2 for yellowish green, and 3 for brownish green. Score for the odour of silage were 1, 2, and 3 for silage that had a foul odour, mild sour odour, and strong sour odour, respectively. Score for pH was according to Skerman and Riveros (1990) that classified good quality silage as those having a pH of < 4.2, medium quality as having a pH of 4.3 to 4.5, and poor quality silage as having pH > 4.5. The scores given for each classification were 3, 2, and 1, respectively. Scoring for the VFA, NH3, IVDMD and IVOMD were divided into three classes, i.e., low, intermediate and high which were given the scores of 2, 4, and 6, respectively.

In vitro digestibility and fermentability of silage that would be further utilized by animal body were considered to be more important than the physical characteristics of silage produced. In determining the quality of silage, therefore, score for the odour, colour and pH were weighted by a factor of one, while scoring for VFA, NH_3, IVDMD and IVOMD were weighted by a factor of two.

RESULTS AND DISCUSSION

Silage Quality

The colour of silages produced are shown in Figure 1 and Table 1 and odour of silages produced are shown in Table 1. Except for control group (C) which had a yellowish green colour, other groups had brownish green colour (Fig. 1). All silages did not show any spoilage during the ensiling process. Odour test showed that only treatments M5 and M10 having a sour (lactic acid) smell, while the other groups had mild sour smell. Good quality silage has a characteristic yellowish green up to brownish green colour (Gallaher and Pitman 2000) depending upon silage material and has pleasant, sour and sweet smell (Kaiser et al. 2004). This indicated that the M5 and M10 had best physical properties of silages. Man and Wiktorsson (2002) reported the, silage colour turned from greenish yellow, to brownish yellow, with addition of molasses from 6 to 9%. The silage colour was getting darker with higher proportion of molasses.

Table 1. Physical properties of cassava leaf silage fermented with different additives

Treatment[1]	Colour	Odour	pH	Moisture
C	Yellowish green	Mild sour	4.30±0.01^{b}	73.39±6.56^{d}
M5	Brownish green	Sour	3.95±0.02^{a}	68.18±6.67^{bc}
M10	Brownish green	Sour	3.88±0.01^{a}	65.08±1.05^{b}
RB5	Brownish green	Mild sour	4.22±0.01^{b}	73.30±4.50^{d}
RB10	Brownish green	Mild sour	4.21±0.03^{b}	71.59±4.50^{cd}
T5	Brownish green	Mild sour	4.29±0.01^{b}	70.10±4.28^{cd}
T10	Brownish green	Mild sour	4.23±0.02^{b}	59.59±3.77^{a}
$LSD_{0.05}$			0.130	3.932

Values in the same column with different superscripts were significantly different (P<0.05).
[1]C (Control) = mixture of cassava leaves, stalk and green stem without additives; M5 = C + 5% molasses; M10 = C + 10% molasses; RB5 = C + 5% rice bran; RB10 = C + 10% rice bran; T5 = C + 5% tapioca flour; and T10 = C + 10% cassava flour

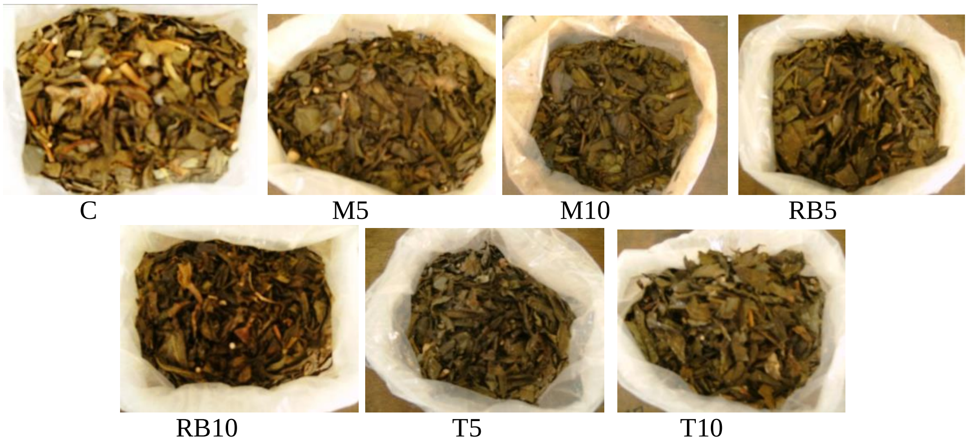

Figure 1. Colour of silages produced after fermentation process for 30 days. C (Control) = mixture of cassava leaves, stalk and green stem without additives; M5 = C + 5% molasses; M10 = C + 10% molasses; RB5 = C + 5% rice bran; RB10 = C + 10% rice bran; T5 = C + 5% tapioca flour; and T10 = C + 10% tapioca flour.

The inclusion of additives significantly (P <0.05) decreased pH and moisture content of silage. Table 1 shows that the pH values of cassava leaf silage with additives were lower compared with that of control group without additive. The water content of silages with additives were 59.52 – 73.30% while water content of that without additives was 73.39%. This suggests that the addition of additives can improve the quality of silage, so that silage can be conserved for long time. The same result was reported that molasses addition decreased pH and increased dry matter content of cassava leaf silage (Man and Wiktorsson 2002). M10 and M5 groups had significantly lower (P<0.05) pH values (3.88 and 3.95) than those of other groups (range 4.21 – 4.30). The range of silage pH in the present study was not different with the results of Nguyen Thi Loc et al. (2000) that pH of cassava leaf silage after fermentation for 28 days have pH values ranging from 3.6 to 4.2. Moran (2005) stated that the lower the pH of the silage the lower the activity of spoilage bacteria.

The lowest moisture content, in the present study was of T10 group (59.59%) while the highest was of C group (73.39%). All the silages could be categorized into good quality silages. According to Moran (2005) good silage has moisture content ranged between 50-75%. Our results were also similar with those of Nguyen Thi Hoa Ly et al. (2000) that the cassava leaf silage fermented for 28 days has a moisture content ranging from 66.2 to 71.2%. Moisture content above 75% will reduce palatability and feed intake (Moran 2005).

In vitro Digestibility and Fermentability Measurement

Digestibility of nutrients is one important measure in determining the quality of the feed material. The addition of additives into cassava leaf silage significantly (P <0.05) increased dry matter digestibility (DMD) and organic matter digestibility (OMD). Table 2 shows that silages with the addition of any additive had DMD and OMD values higher than that of control group (without additive addition). The highest DMD and OMD values of T10 (10% tapioca flour) treatment (64.77% and 62.87%, respectively) were due to dry matter and organic matter contents of T10 was higher compared to other treatments.

Table 2. IVDMD, IVOMD, and concentration of VFAs and ammonia of cassava leaf silage fermented with different additives.

Treatment	IVDMD (%)	IVOMD (%)	VFA (mM)	NH3 (mM)
C	51.49±2.34^{a}	49.13±2.06^{a}	143.51±35.37^{b}	16.71±2.62^{b}
M5	57.17±2.74^{b}	54.20±2.68^{c}	161.71±33.18^{cd}	13.25±2.77^{a}
M10	57.18±1.28^{b}	53.87±0.82^{bc}	148.91±21.51^{bc}	13.65±2.12^{a}
RB5	52.30±1.05^{a}	49.47±1.07^{a}	177.17±10.34^{d}	16.70±0.64^{b}
RB10	51.66±2.87^{a}	53.40±5.15^{bc}	170.25±12.13^{d}	16.27±2.75^{b}
T5	55.54±1.68^{b}	51.83±3.95^{b}	171.71±12.00^{d}	13.07±1.47^{a}
T10	64.77±4.75^{c}	62.87±4.07^{d}	107.03±21.54^{a}	12.01±0.82^{a}
$LSD_{0.05}$	2.151	2.142	17.534	1.686

Values in the same column with different superscripts were significantly different (P<0.05).
[1]C (Control) = mixture of cassava leaves, stalk and green stem without additives; M5 = C + 5% molasses; M10 = C + 10% molasses; RB5 = C + 5% rice bran; RB10 = C + 10% rice bran; T5 = C + 5% tapioca flour; and T10 = C + 10% cassava flour.

The addition of rice bran, in average, caused lower DMD and OMD of silage than that of silage with the addition of molasses or tapioca flour. Since rice bran contains higher fiber than that of cassava flour and molasses (Winugroho 1999; Hermiati et al. 2011), therefore the addition of rice bran increased crude fiber content of silage. It is well known that the higher the fiber content of the feed the lower the digestibility of the feed (Migwi et al. 2013). Other possible reason of lower DMD and OMD of rice bran addition is due to the unsaturated fat content of rice bran. This was supported by the result of Lunsin et al. (2012) that the population of total ruminal bacteria was significantly lower on the rice bran oil supplemented diet. Unsaturated fat is known to be “toxic” for microbial rumen (Maia et al. 2007) causing lower number of microbes and hence reduce the ability to digest feed.

Concentration of Volatile Fatty Acids (VFA) and Ammonia (NH_3)

The results showed that the addition of additives into cassava leaf silage significantly (P<0.05) affected VFA concentration. With the exception of tapioca at 10% (T10), silages with the addition of additives had VFA concentrations higher than that of control group (without additive addition). VFA concentration in the rumen is used as an indicator of feed fermentability. Table 2 shows that, on average, the highest concentration of VFA was with rice bran additive followed by molasses and tapioca, i.e. 173.71, 155.31, and 139.37 mM, respectively. Mean VFA concentration of cassava leaf silage in this experiment ranged from 107.03 to 177.17 mM. This is still in normal range of the VFA concentrations required for optimal growth of rumen microbes that is 80-160 mM. Wang and Song (2001) reported that high carbohydrate level of the feed increased fermentation in the rumen as indicated by higher number of bacteria and consequently increase VFA production. Further, they reported that VFA production was also affected by sources of carbohydrates used.

For all additives, inclusion at the 10% level did not show any benefit to VFA concentration compared to the 5% level (Table 2). Even, with tapioca additives, it was seen that 10% inclusion resulted in lower (P<0.05) VFA concentration compared to that of 5% inclusion. This may be explained that more VFA produced in T10 has been used for more microbial growth. Rumen microbes need carbon dioxide, nitrogen, sodium, and volatile fatty acids to grow (Hungate et al. 1964). Due to the increasing population of rumen microbes in T10 resulted in the higher feed digestibility in T10 than that in T5, as it is shown in Table 2. Other possibility is that the inclusion of 10% additives did not give added benefit compared to 5% inclusion in VFA concentration was due to the addition of 10% resulted in pH of silage to be lower. This is supported by Peters et al. (1989) who reported that total production of VFA was lower at low than at high initial pH of diet.

The inclusion of additives significantly affected (P<0.05) the concentrations of NH_3. Table 2 shows that silages with the addition of molasses and tapioca had NH_3 lower than that of rice bran additive or that of the control (without additive). This indicated a reduction in protein degradation of molasses and tapioca additives. Molasses and tapioca contain high water soluble carbohydrate which is used by lactic acid bacteria (LAB) during ensilage process resulting in rapidly decreasing pH (Mühlbach 2000). Higher lactic acid in silage tended to decrease protein degradation by rumen microbes resulted in lower NH_3 production (Jaakkola and Huhtanen 1989).. The advantage of this is that much more protein escape from rumen to be utilized further by ruminant animal host for production purpose (Kempton et al. 1977). The same results using additive of formic acid or *Lactobacillus plantarum* during ensilaging process of alfalfa have been reported (Nagel and Broderick 1992; Contreras-Govea et al. 2013). On the other hand, due to its higher protein content, silage treated with rice bran (RB5 and RB10) had higher NH_3. The higher protein content of feed will result in higher NH_3 concentration as a result of the increasing proteolytic activity (Haaland *et al*. 1982). In addition, Orden et al. (2000) reported that rice bran supplementation affect the degradation of crude protein. The protein content of each additive were 9.85%, 4.61% and 0.51% for rice bran, molasses, and tapioca, respectively (Table 3).

Table 3. Nutrient composition of the additives

Nutrient	Molasses	Rice bran	Cassava tuber meal
Dry matter	59.8	87.7	87.9
Crude protein	4.61	9.85	0.51
Soluble carbohydrate	72.1	4.12	62.1
NDF	0.00	24.9	20.0
ADF	0.00	12.3	0.16

Source: Rusdy (2015)

High concentrations of NH_3 due to high rate of protein breakdown in the rumen is not beneficial. Ammonia produced will be used by microbes in the rumen for the formation of microbial protein and reduce the protein proportion to be used by animal host. Mean NH_3 concentration in this experiment ranged from 12.01 to 16.71 mM, which were in the optimum range of the rumen NH_3, i.e., 85 - 300 mg/l or equal to 4.99 – 17.61 mM (McDonald *et al*. 2010).

Overall quality assessment

The overall quality assessment of the silages were shown in Table 4. Based on the physical characteristics of the silage, the highest score was obtained by molasses additive, followed then by rice bran and tapioca and control group, i.e., 9, 7, 7, and 6, respectively. Based on the rumen fermentation characteristics, the highest score was achieved by molasses and tapioca, followed by rice bran and control, i.e., 17, 17, 12, and 10 respectively The silage with molasses additive gained the highest overall score, followed by the addition of tapioca flour, rice bran and control, i.e., in average 26, 24, 19, and 16, respectively. This may be due to molasses containing higher water soluble carbohydrate (Table 3) which is easily used by the microbes during ensiling.

Table 4. Overall quality of cassava leaf silage fermented with different additives based on scoring method

Treatment[1]	VFA	NH3	IVDMD	IVOMD	pH	Colour	Odour	Total
C	4	2	2	2	2	2	2	16
M5	6	4	4	4	3	3	3	27
M10	4	4	4	4	3	3	3	25
RB5	6	2	2	2	2	3	2	19
RB10	6	2	2	2	2	3	2	19
T5	6	4	4	2	2	3	2	23
T10	2	4	6	6	2	3	2	25

[1]C (Control) = mixture of cassava leaves, stalk and green stem without additives; M5 = C + 5% molasses; M10 = C + 10% molasses; RB5 = C + 5% rice bran; RB10 = C + 10% rice bran; T5 = C + 5% tapioca flour; and T10 = C + 10% cassava flour.

The same result was reported by Rusdy (2015) who found that applying additive of 5% molasses in making silage of *Chromolaena odourata* gave the best result compared to other additives (cassava tuber flour, maize meal, and rice bran). In vivo study (Sudarman et al. 2016) showed the advantages of feeding 20% cassava leaf silage with 5% molasses additive that greatly improved sheep performance similar to that achieved by feeding concentrate.

CONCLUSIONS

The total scoring method demonstrates that cassava leaf silage with molasses additives produce better quality silage than the other tested additives. The addition of 5% molasses obtained higher score than that of the addition of 10% molasses. Therefore, the addition of 5% molasses makes good quality cassava leaf silage for sheep.

REFERENCES

Contreras-Govea, FE., RE. Muck, GA. Broderick and PJ. Weimer. 2013. *Lactobacillus plantarum* effects on silage fermentation and *in vitro* microbial yield. Anim. Feed Sci. Technol. 179: 61–68.

Conway, EJ. 1962. Microdiffusion Analysis and Volumetric Error, 5th ed. Crosby Lockwood, London.

Eggum, OL. 1970. The protein quality of cassava leaves. British Journal of Nutrition. 24: 761–769.

General Laboratory Procedures. 1966. Department of Dairy Science. University of Wisconsin. Madison.

Gallaher, RN. and WD. Pitman. 2000. Conservation of forages in the tropics and subtropics, pp. 233 – 250. In A. Sotomayor-Rios and W. D. Pitman (Eds). Tropical Forage Plants: Development and Use. CRC Press LLC, Boca Raton.

Haaland, G., HF. Tyrrel, PW. Moe and WE. Wheeler. 1982. Effect of crude protein level and limestone buffer in diets fed at two levels of intake on rumen pH, ammonia-nitrogen, buffering capacity and volatile fatty acid concentration of cattle**.** J. Anim. Sci. 55: 943-950.

Hermiati, E., J. Azuma, D. Mangunwidjaja, TC. Sunarti, O. Suparno and B. Prasetya. 2011. Hydrolysis of carbohydrates in cassava pulp and tapioca flour under microwave irradiation. Indo. J. Chem. 11: 238 – 245.

Hungate, RE., MP. Bryant and RA. Mah. 1964. The rumen bacteria and protozoa. Annual Review of Microbiology. 18: 131-166.

Jaakkola, S. and P. Huhtanen. 1989. The effect of lactic acid on the microbial protein synthesis in the rumen of cattle. AJAS. 2: 398-399.

Kaiser, AG., JW. Piltz, HM. Burns and NW. Griffiths. 2004. Top \Fodder Successful Silage. 2nd Ed. Dairy Australia and New South Wales Department of Primary Industries. 36 p.

Kempton, TJ., JV. Nolan and RA. Leng. 1977. Principles for the use of non-protein nitrogen and by-pass proteins in diets of ruminants. World Anim. Rev. 22: 2-10.

Lunsin, R., M. Wanapat and P. Rowlinson. 2012. Effect of cassava hay and rice bran oil supplementation on rumen fermentation, milk yield and milk composition in lactating dairy cows. Asian-Australas J Anim Sci. 25: 1364–1373. doi: 10.5713/ajas.2012.12051.

Maia, MRG., LC. Chaudhary, L. Figueres and RJ. Wallace. 2007. Metabolism of polyunsaturated fatty acids and their toxicity to the microflora of the rumen. Antonie van Leeuwenhoek. 91:303–314.

Man, NV. and H. Wiktorsson. 2002. Effect of molasses on nutritional quality of cassava and gliricidia tops silage. Asian-Aust. J. Anim. Sci. 15: 1294-1299.

Marjuki, HE. Sulistyo, DW. Rini, I. Artharini, Soebarinoto and R. Howeler. 2008. The use of cassava leaf silage as a feed supplement in diets for ruminants and its introduction to smallholder farmers. *Livestock Research for Rural Development. Volume 20, Article #93.* Retrieved July 1, 2016, from http://www.lrrd.org/lrrd20/6/marj20093.htm.

McDonald, P., RA. Edwards, JFD. Greenhalgh and CA. Morgan, LA Sinclair and RG Wilkinson. 2010. Animal Nutrition. Seventh Ed. Prentice Hall. London. 180 p.

McDonald, P., AR. Henderson and SJE. Heron. 1991. The Biochemistry of Silage. Second Ed. Chalcombe Publications. Marlow. 90-95 pp.

Migwi, PK., BO. Bebe, CK. Gachuiri, I. Godwin and JV. Nolan. 2013. Options for efficient utilisation of high fibre feed resources in low input ruminant production systems in a changing climate: A review. *Livestock Research for Rural Development. Volume 25, Article #87.* Retrieved July 10, 2016, from http://www.lrrd.org/lrrd25/5/migw25087.htm.

Moran, J. 2005. Making quality silage, pp 83-97. In Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmers in the Humid Tropics. Landlink Press. Retrived February 27, 2016, from http://www.publish.csiro.au/?act=view_file&file_id=SA0501083.pdf.

Mühlbach, PRF. 2000**.** Additives to Improve the Silage Making Process of Tropical Forages. FAO Plant Production and Protection Paper No.161. Food and Agriculture Organization (FAO), Rome. 151-164 pp.

Nagel, SA. and GA. Broderick. 1992. Effect of formic acid or formaldehyde treatment of alfalfa silage on nutrient utilization by dairy cows. J. Dairy Sci. 75:140-154.

Nguyen Thi Hoa Ly, Nguyen Thi Lo, Du Thanh Hang and Le Van An. 2000. The use of cassava leaf silage for feeding growing pigs and sows in Central Vietnam. Retrieved February 3, 2016, from http://ciat library.ciat.cgiar.org/articulos_ciat/asia/proceedings_workshop_00/ 517.pdf.

Nguyen Thi Loc, Nguyen Thi Hoa Ly, Vo Thi Kim Thanh and Hoang Ngia Duyet. 2000. Ensiling techniques and evaluation of cassava leaf silage for Mong Cai sows in Central Vietnam. Proceedings National Workshop-Seminar Sustainable Livestock Production on Local Feed Resources. Ho Chi Minh City, Vietnam. Retrieved March 24, 2016, from www.mekarn.org/sarpro/locmay30.htm.

Orden, EA, K. Yammaki, T. Ichinohe and T. Fujihara. 2000. Feeding value of ammoniated rice straw supplemented with rice bran in sheep: II. In situ rumen degradation of untreated and ammonia treated rice straw. Asian-Aus. J. Anim. Sci. 13: 906 – 912.

Peters, JP, JAZ. Leedle and JB. Paulissen. 1989. Factors affecting the *in vitro* production of volatile fatty acids by mixed bacterial populations from the bovine rumen. Journal of Animal Science. 67: 1593-1602.

Rusdy, M. 2015. Effects of additives on fermentation characteristics and chemical composition of ensiled *Chromolaena odourata* leaves. *Livestock Research for Rural Development. Volume 27, Article #60.* Retrieved February 25, 2016, from http://www.lrrd.org/lrrd27/4/rusd27060.html

Skerman, PJ. and F. Riveros. 1990. Tropical Grasses. Plant Production and Protection Series, No. 23. Food and Agriculture Organization (FAO), Rome. 147 p.

Statistics Indonesia. 2014. Agriculture Food Crops Statistics Indonesia. Cassava. Retrieved April 11, 2014, from https://www.bps.go.id/linkTableDinamis/view/id/880.

Steel, RGD. and JH. Torrie. 1980. Principles and Procedures of Statistics: A Biometric Approach. McGraw-Hill Book Co., New York:

Sudarman, A., M. Hayashida, IR. Puspitaning, A. Jayanegara and H. Shiwachi. 2016. The use of cassava leaf silage as a substitute for concentrate feed in sheep. Trop Anim Health Prod. 48: 1509-1512. DOI 10.1007/s11250-016-1107-5

Tilley, JMA., and RA. Terry. 1966. A two Stage Technique for the *In vitro* Digestion of Forage Crop. Journal of British Grassland. 18:104-111.

Wang, JH. and MK. Song. 2001. Effect of sources and levels of carbohydrates on fermentation characteristics and hydrogenation of linoleic acid by rumen bacteria in vitro. Asian-Aust. J. Anim. Sci. 14: 48-53.

Winugroho, M. 1999. Nutritive values of major feed ingredient in tropics: Review. Asian-Aus. J. Anim. Sci. 12: 493-502.

Wobeto, C., AD. Correa, CMP Abreu, CD Santos, JR Abreu. 2006. Nutrients in the cassava (*Manihot esculenta* Crantz) leaf meal at three ages of the plant. Ciênc. Tecnol. Aliment., Campinas, 26(4): 865-869.

Yang, CM. 2002. Response of forage fiber degradation by ruminal microorganisms to branched-chain volatile fatty acids, amino acids, and dipeptides. J Dairy Sci. 85:1183–1190.

Yitbarek, MB. and B. Tamir. 2014. Silage Additives: Review. Open Journal of Applied Sciences, 4, 258-274.

Zhang, HL, Y Chen, XL Xu, and YX Yang. 2013. Effects of branched-chain amino acids on *In vitro* ruminal fermentation of wheat straw. Asian-Aust. J. Anim. Sci. 26: 523-528.

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FARMERS' WILLINGNESS-TO-CHANGE AND ADOPTION OF AROMATIC RICE IN VIETNAM

Trang Tran HoaiThao[1,2] and Orachos Napasintuwong[1,2]
[1]Department of Agricultural and Resource Economics
Faculty of Economics, Kasetsart University, Bangkok 10900 Thailand
[2]Center for Advanced Studies for Agriculture and Food
Kasetsart University Institute for Advanced Studies, Kasetsart University Bangkok 10900 Thailand
(CASAF, NRU-KU, Thailand)
Corresponding author: orachos.n@ku.ac.th

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ABSTRACT

Aromatic rice is one of the highest valued rice in the international market. Despite the fact that Vietnam is the leading rice exporter, its rice price is much lower than other competitors; thus, price is competitive in the aromatic rice market. The Vietnamese government has been trying to promote the adoption of aromatic rice to increase farmer's income and raise export value, but the growth of aromatic rice production is still not as large as expected. The study was conducted from November to December 2013 in the Mekong Delta as it is the main aromatic rice cultivation area mainly for exports, and farmers in this area were influenced by price control measures mentioned above. This study sought to evaluate determinants of aromatic rice's adoption and estimating willingness-to-accept aromatic rice's price premium by applying the Random Utility Theory and Contingent Valuation Method. The results reveal that not only communication with extension officers and knowledge transfer from attending field demonstration but also connections with private companies through contracts and access to seeds positively affect aromatic rice adoption. Furthermore, the mean of willingness-to-accept price premium between aromatic and low quality rice is estimated at 1,085 VND/kg. These findings suggest that a sufficient increase in market price premium of aromatic rice could be one of the ways to create more incentive for the production of aromatic rice and reduce rice areas of low quality in Vietnam.

Key words: price premium, fragrant rice, contingent valuation, choice experiment

INTRODUCTION

Rice is the staple food for half of the world's population. Rice farming is the largest use of land for food production than another crops accounting for 162 million hectares, and also dominates overall food consumption (Global Rice Science Partnership, 2013). Over 90% of the world's rice is produced and consumed in six Asian countries: China, India, Indonesia, Bangladesh, Vietnam and Japan, comprising 80% of the world's production and consumption (Zeigler and Barclay 2008). Although there is a declining trend in per capital consumption of rice in Asia as consumers diversify their diet away from rice to other high value foods including meat and vegetables (Global Rice Science Partnership, 2013), the demand for aromatic rice varieties has increased significantly since the early1990s (von Bruan and Bos 2004). Custodio *et al.* (2016) found that aromatic rice is an important market in Asia. As a result, the demand of aromatic rice in some Asian countries such as Malaysia (Jamal *et al.*, 2013) and Hong Kong as well as the U.S. has been observed (Anonymous, 2014). With the current trend of global rice consumption, rice exporting countries may focus on rice quality rather than quantity as an alternative for exports (Fitzgerald *et al.* 2009).

The aromatic rice market, particularly that of Jasmine rice, has grown in the past several years. Thailand has always dominated in the Jasmine rice market; however, Vietnam and Cambodia became emerging exporters of aromatic rice since 2006. In 2013, Vietnam contributed to about 37.8% of the aromatic rice exports from these three countries, increased from 3.5% in 2008 (The Rice Trader, 2014) attributed to its competitive price. Vietnamese aromatic rice receives a much lower price than that of Thailand and Cambodia as Vietnam quality standards have not been recognized internationally so the export price is not much higher than normal rice (Vietnam Trade Promotion Agency, 2008). In September 2015, the average prices of Jasmine rice from Thailand and Cambodia were 825-835 and 830-840 USD/ton, respectively, while that of Vietnam Jasmine rice was only 455-465 USD/ton (Oryza.com, 2015). In recent years, aromatic rice has increased in the share of total rice exports from Vietnam, accounting for 13.87% in 2013 (Dieu 2014).The main aromatic rice export markets of Vietnam are China, Ghana, the U.S., Hong Kong, Singapore and Malaysia (Dieu 2014). Aromatic rice from Cambodia and Thailand generally refers to "Jasmine rice", which has gained a reputation in international markets due to its preferred aroma and soft texture (Suwannaporn and Linnemann, 2008a, Suwannaporn and Linnemann, 2008b), and both have jointly won the World Best Rice award in 2014. Premium characteristics of Jasmine rice from these two countries are attributable mainly to the varieties of the rice itself. Thailand's Jasmine rice certification is limited to only two varieties: Khao Dawk Mali 105 (KDML105) generally known as Hom Mali, and RD15 (Napasintuwong 2012), and similarly Jasmine rice from Cambodia embraces Phka Rumduol and Phka Malis varieties. Vietnamese aromatic rice, however, contains a group of several varieties of diverse characteristics, including Hai Hau fragrant rice (Vietnam Trade Promotion Agency, 2008), Soc Trang varieties (such as ST5 and ST20), Nang Hoa (high grade local aromatic rice), KDM or Khao Dawk Mali (from the Cambodian border), OM4900 (slightly aromatic and not consider as aromatic rice by some buyers) and Vietnamese Jasmine (The Rice Trader, 2014). Among the aromatic rice varieties for export, Vietnamese Jasmine (Jasmine 85 variety) is the most popular variety, accounting for 80.74% of total aromatic rice export, followed by KDM, Nang Hoa, VD20, and ST varieties (Dieu, 2014).

Vietnamese aromatic rice is price competitive compared to Jasmine rice from Thailand and Cambodia and has gained a significant share in certain export markets such as China. Given the growth in aromatic rice market (Giraud, 2013; von Bruan and Bos, 2004), Vietnam's Ministry of Agriculture and Rural Development (MARD) has attempted to encourage farmers to produce more aromatic rice and less low quality rice (LQR) in the Mekong Delta, the main rice production area producing covering about 7.5 million hectares producing 38 million tonnes of rice annually or about half of national rice production(Smith, 2013)For example, ITARICE company has invested in aromatic rice production covering 12,000 hectares in Long An province that meets Global GAP standard for exports (Vietnam Trade Promotion Agency, 2008). However, the area of aromatic rice remains relatively small at 14.43% of the total rice cultivation area with 2.28% annual growth rate (Tuong, 2010); whereas, the area of LQR in the Mekong Delta is relatively high at more than 30% of total rice area (Nguyen, 2013). Therefore, in order to form a more effective promotion strategy, there is a need to understand what factors influencing farmers' adoption decision of aromatic rice.

The concept and comprehensive reviews of agricultural technology adoption were presented by Rogers (2003) and Feder *et al.* (1985).They revealed that farm, farmers, social and institutional factors, including communication, are complex factors influencing the adoption of agricultural technology. Regarding rice varieties, previous studies indicated the influence of economic condition (Mariano *et al.*, 2012, Saka and Lawal, 2009) and knowledge about varieties (Horna *et al.* 2007) extension programs. Furthermore ,the adoption of new rice varieties would also be influenced by variety's own traits and individual perceptions towards the varieties including yield (Ghimire *et al.* 2015; Li *et al.* 2010; Mottaleb *et al*. 2014; Singh *et al*. 2006), and cooking characteristics (Myint and

Napasintuwong, 2016; Napasintuwong and Pray, 2014). In terms of the adoption of aromatic rice varieties, it is found that climate and soil characteristics and suitability, input requirements, government promotions via extension agents, social and institutional factors such as membership of cooperative and information (Ngokkuen and Grote, 2011; Singh *et al*. 2006), and market factors especially output price(Jamal *et al*. 2013; Myint and Napasintuwong, 2016; Singh *et al*. 2006) affect their adoption. In addition, with higher production risks of aromatic rice, such as vulnerability to diseases and pests and lower yield than ordinary rice, the current price premium of aromatic rice in the Mekong Delta may not significantly be large enough when compared to normal rice to create incentive for adoption among LQR farmers. At present, it is observed that the price of aromatic rice in Vietnam is about 15.91% higher than normal rice. As rice contributes two thirds of the caloric intake of an average Vietnamese household and small price changes have significant welfare implications (Coxhead *et al*. 2012), government interventions particularly trade policy measures to protect domestic rice price have distorted the market (Smith, 2013) and suppressed producer's price especially in the Mekong Delta (Luckmann *et al*. 2015). It is hypothesized in this study that unattractive market price is one important reason of low adoption of aromatic varieties.

Although the influences of socioeconomic factors on varieties adoption have been widely reported, the importance of input and output price in the adoption process as found in Beltran *et al.* (2013)is a research gap. The reason discussed is because the change of output price cannot be observed with studies using a single visit survey (Kaliba *et al.* 2000). Besides, while there are a number of studies about consumer behavior and willingness to pay for quality attributes of rice (Ahmad Hanis *et al.* 2012; Ara, 2003), little research has focused on producer behavior (Ortega *et al.* 2014). This article addresses these research gaps by analyzing rice farmers' adoption decision in Vietnam with two main objectives: the first is determining factors influencing aromatic rice adoption in Vietnam. Because it is hypothesized that market price of aromatic rice is too low for farmers to perceive relative higher profit than growing ordinary rice, the second objective is estimating the premium price difference that farmers are willing to accept and change from LQR to aromatic rice. The study explores the hypotheses that different farm, farmers, and other social factors have different effects on aromatic rice adoption and that premium price of aromatic rice can influence farmers to change from non-aromatic to aromatic varieties.

MATERIAL AND METHODS

Data analysis

Adoption decision model

To access farmers' technology adoption decisions, random utility theory (RUT), which assumes that farmers make their decision by choosing the alternative that maximizes their perceived utility (Fernandez-Cornejo *et al.*, 1994), is adopted in this study. Discrete choice model is applied to assess the influence of farm and farmers characteristics as well as the expected market price on the probability of adopting aromatic rice. The aromatic rice in this study refers to Jasmine 85 and ST20, popular aromatic rice varieties that have good aroma and dominate about 82% of total aromatic rice area in the Mekong Delta (Dieu, 2014). The study was conducted from November and December 2013 in the Mekong Delta as it is the main aromatic rice cultivation area mainly for exports, and farmers in this area were influenced by price control measures mentioned above. In Mekong Delta, rice farmers grow only one variety in one season; as a result, a binary choice model is adopted as farmers are faced with only two choices: adopt or not adopt aromatic rice. Farmer *i* will adopt aromatic rice if the utility of adoption (U_{iA}) exceeds the utility of non-adoption (U_{iNA}); that is $U_{iA} - U_{iNA} > 0$. The output of the decision process can be observed as a binary random variable, Y_i (receiving value one if farmers *i* adopt and zero if farmer *j* not adopt) as follows:

$$\mathrm{Y_i} = \begin{cases} 1 \text{ if } U_{iA} - U_{iNA} > 0 \\ 0 \text{ otherwise} \end{cases} \mathrm{i} = 1, 2, \dots \mathrm{n}$$

RUT presumes that the utility of taking action of adopting (U_{iA}) is composed of a deterministic component, indirect utility *(V_{iA})*, which can be expressed in terms of observed characteristics of farm, farmers, social factors, and attributes of choices *(X_{iA})*, and a stochastic error component (ε_{iA}*)*, which is unobserved. Assuming that V_{iA} is linear parameters, thus

$$U_{iA} = \mathrm{V_{iA}} + \varepsilon_{\mathrm{iA}} = \alpha_{\mathrm{iA}}\mathrm{X_{iA}} + \varepsilon_{\mathrm{iA}}.$$

The probability that a farmer adopts aromatic rice is denoted as:

$$\mathrm{P_A} = \mathrm{P[Y_i} = 1] = \mathrm{P_A} = \mathrm{Prob}\ (\mathrm{U_{iA}} > \mathrm{U_{iNA}}) = \mathrm{Prob}\ (\mathrm{V_{iA}} + \varepsilon_{\mathrm{iA}} > \mathrm{V_{iNA}} + \varepsilon_{\mathrm{iNA}})$$

$$= \mathrm{Prob}(\varepsilon_{\mathrm{iNA}} - \varepsilon_{\mathrm{iA}} < \mathrm{V_{iA}} - \mathrm{V_{iNA}}) = \int_{\varepsilon}^{\infty} \mathrm{I}\ ((\varepsilon_{\mathrm{iNA}} - \varepsilon_{\mathrm{iA}}) < (\mathrm{V_{iA}} - \mathrm{V_{iNA}}))\mathrm{f}(\varepsilon_{\mathrm{i}})\mathrm{d}\varepsilon_{\mathrm{i}}$$

$$= \int_{\varepsilon}^{\infty} \mathrm{I}\ (\varepsilon_{\mathrm{i}} < \beta_{\mathrm{i}}\mathrm{X_i})\mathrm{f}(\varepsilon_{\mathrm{i}})\mathrm{d}\varepsilon_{\mathrm{i}}$$

For *I(.)* being 1 when the expression in parentheses is true and 0 otherwise. The different choices are derived under different specifications of the density of unobserved factors, *f(ε_i.)*. A logit model is chosen over a probit model in this study as unobserved components of utility, *f(ε_i)*, do not expected to have a standard normal distribution since the price coefficient should not be negative, and unobserved factors are hypothesized to be uncorrelated over alternatives(Train, 2009). With the assumptions of error terms *(ε_i)* being independently and identically distributed with a Weibull distribution (Maddala and Lahiri, 1992), the probability of adoption is calculated as:

$$\mathrm{P_A} = \mathrm{P(Y_i} = 1) = \frac{\mathrm{e}^{\beta_{\mathrm{i}}\mathrm{X_i}}}{(1 + \mathrm{e}^{\beta_{\mathrm{i}}\mathrm{X_i}})} \qquad (1)$$

where P_A is the probability of adopting aromatic rice varieties; X_i is the vector of explanatory variables, and β_i is estimated parameters.

The relative odds of adopting aromatic rice are:

$$\frac{\mathrm{P_A}}{\mathrm{P_{NA}}} = \mathrm{e}^{\beta_{\mathrm{i}}\mathrm{X_i}}.$$

Taking the log of each side, the logit model is:

$$\mathrm{Ln}\left(\frac{\mathrm{P_A}}{\mathrm{P_{NA}}}\right) = \beta_{\mathrm{i}}\mathrm{X_i} \qquad (2)$$

The marginal effect of factor X_i on the probability of adoption$P_A$calculated at the mean value is defined as follows:

$$\left.\frac{\Delta\mathrm{P_A}}{\Delta\mathrm{X_i}}\right|_{\text{all other x constant}} = \frac{\partial\mathrm{P_A}}{\partial\overline{\mathrm{X_i}}} = \beta_{\mathrm{i}}\mathrm{P_A}\mathrm{P_{NA}} \qquad (3)$$

Dichotomous contingent valuation method and farmers' willingness-to-change

It is hypothesized that farmers who currently grow LQR will be able to change to aromatic rice if they are compensated by a given amount of money, a difference in income from growing rice aromatic compared to LQR. In this hypothetical situation, the price premium of aromatic rice is assumed to be higher than LQR; this difference reflects the premium money value of income presuming net income (thus utility) of producing two types of rice are being equal without price difference. Contingent Valuation Method (CVM) has been used for measuring the stated preference of willingness-to-accept when an individual forgoes benefits, in other words, costs they suffer. The CVM is a simple, flexible non-market valuation method that is not only widely used in the environmental valuation but also in the consumer demand analysis. In order to estimate farmers' willingness-to-accept a price premium to adopt aromatic rice production among LQR growers, Dichotomous Choice Contingent Valuation Method (DC-CVM) with single bounded, closed-ended format questions is used.

DC-CVM has been one of the most popular techniques to estimate willingness to accept non-market goods due to its simplicity of use in data collection. Hanemann (1984) provided a framework for analyzing closed-ended single bound responses based on RUT. The deterministic part of utility can be expressed in terms of the vector of farmer *j*'s and farm's characteristics, attributes of choices (z_j) and farmer *j*'s discretionary income (y_j). Therefore, the utility function for respondent in state *i* of the change to be valued (*i* = 0 being the base state and *i* = 1 being the final state) can be written as $U_{ij} = U_i(y_j, z_j)$.The indirect utility function is defined as:

$$V_{ij} = \alpha_i z_j + \beta_i y_j$$

Hereα_i denotes an m-dimensional vector of parameters,z_j is an m-dimensional vector of characteristics of the farm and farmer given CV scenario, and y_j is the respondent's discretionary income; $\beta_i$represents the marginal utility of income. Let $t_j$is be the bid price (or monetary value addition), so the deterministic utility for the base state (*i*= 0 = Not Adopt (NA)) and final state (*i* = 1 = Adopt (A)) is$V_{NAj} = \alpha_{NA} z_j + \beta_{NA} y_jandV_{Aj} = \alpha_A z_j + \beta_A(y_j + t_j)$. Assuming that the marginal utility of income is constant, so $\beta_A = \beta_{NA}$. Thus, the change in deterministic utility for respondent *j* can be written as:

$$V_{Aj} - V_{NAj} = (\alpha_A - \alpha_{NA})z_j + \beta_A(y_j + t_j) - \beta_{NA} y_j = \alpha z_j + \beta t_j$$

Willingness-to-accept a change to adopt aromatic rice in this study is defined as the amount of money that makes a farmer indifferent between status quo (not adopting aromatic rice) and the proposed CV scenario (adopting aromatic rice). Thus,

$$V_{Aj} - V_{NAj} = (\alpha z_j + \beta t_j) = 0$$

$$E(t_j) = E(WTA \mid \alpha, \beta, z_j) = -\frac{\alpha z_j}{\beta}. \quad (4)$$

Here *E* is the expectation of farmer's willingness-to-accept the price difference t_j to change to adopt aromatic rice. Using the binominal logit model, the probability of farmer's willingness to accept a change to adoptaromatic rice at each *t* bid price is as follows:

$$P_A = \frac{e^{\alpha z_j + \beta t_j}}{(1+e^{\alpha z_j + \beta t_j})}. \quad (5)$$

Based on the farmers' responses from the pre-survey during the Winter-Spring season in 2013, Jasmine 85 and IR50404 are the most popular aromatic rice and LQR varieties in the Mekong Delta, respectively. From the pre-survey data, Jasmine 85 has a higher yield than IR50404 but also a higher cost of investment; without the price difference, the net income of producing two types of rice are approximately equal. Thus, the difference in prices of the two varieties is a proxy for the difference in farmers' income. The hypothesis is that if the price difference is not significant enough there would be no incentive to grow aromatic rice. LQR growers who did not adopt at the current market price were asked whether they would switch to aromatic rice production at a hypothetical price difference between the two varieties, which varied across farmers. The specific question asked of farmers was "Would you be willing to switch to grow Jasmine 85 instead of IR50404 if the price difference between the two varieties is t_j VND/kg?" $t_j$is the bid price that was selected from pre-test questionnaires ranging from 500, 700, 1000 to 1500 VND/kg. The bid price is randomly selected to ask for the willingness-to-accept the price difference for adopting Jasmine 85 among those who grow

IR50404 in the Winter-Spring season. The answer "yes" or "no" was the independent variable in CV model in response to bid price t_j (500, 700, 1000, 1500 VND/kg). The logit model capturing the willingness-to-accept a change to adopt aromatic rice with bid prices is:

$$\ln\left(\frac{P_A}{P_{NA}}\right) = \beta_0 + \beta_i Z_i + \beta t_j. \tag{6}$$

Table 1 summarizes the variables in equation (2) and (6).

Table 1. Variables used in the aromatic rice adoption logit model.

Variable	Description
Farm size (FSIZE)	Farm size of rice area (hectare).
Rice experience (REXPE)	Year of rice cultivation experience (years).
Age (AGE)	Age (years).
Education (EDU)	Number of formal schooling (years).
Extension (EXTEN)	Number of participations in extension training (times per year).
Family size (FASIZE)	Number of family member (persons).
Winter – Spring crop (WS crop)	Winter – Spring cropping season (1: Yes, 0: Otherwise).
Autumn – Winter crop (AW crop)	Autumn – Winter cropping season (1: Yes, 0: Otherwise).
Salinity soil (SASOIL)	Soil of famer's rice field is salinity soil (1: Yes, 0: Otherwise).
Source of seeds (COMSOURE)	Received, bought seeds from private seed company (1: Yes, 0: Otherwise).
Contract (CONTRACT)	Had sales contract with private company (1: Yes, 0: Otherwise).
Attendance in demonstration (DEMONATEN)	Attendance in demonstration about growing aromatic rice varieties (1: Yes, 0: Otherwise).
Bandwagon importance (BANDIM)	Perception that neighbors' decision on rice varieties is an important factor when choosing rice varieties to grow (1: if 5-point Likert scale ranges from 4 to 5, 0: if 5-point Likert scale ranges from 1 to 3).
Importance of market price (PRICEIM)	Farmer's attitude toward the important of market price on their adoption decision is measured using 5-point Likert scale with: 1 = not at all important; 2 = slightly important; 3 = moderately important; 4 = very important; 5 = extremely important. Farmer who gives a score higher than 3 indicating favorable attitudes (farmer consider price as very important factor influence their adoption decision), and score equal or less than 3 indicating unfavorable attitudes (price is not importantly influence their adoption decision). Therefore (1: if 5-point Likert scale ranges from 4 to 5, 0: if 5-point Likert scale ranges from 1 to 3).
Bid price (t_j)	Price difference between Jasmine 85 and IR50404: 500, 700, 1000, 1500 VND/kg.

Variable	Description
High adoption province (HIADOPPRO)	Highly intensive aromatic rice adoption provinces (adoption rate higher than the average at 14.43%): Can Tho or Soc Trang (1: Yes, 0: Otherwise).
Rice income (RINCOME)	Revenue of rice production per year (million VND)
Commercial rice farmers(COMERFA)	All rice product is sold, none for household consumption (1: Yes, 0: Otherwise)
Member of rice associations (MEM)	Being a member of local rice associations

Data collection

A survey of rice farmers was conducted between November and December 2013 in the Mekong Delta. A three stage stratified sampling technique was adopted. Because the differences in adoption intensity or rate of adoption could have different effects on the levels of extension service and local social activities regarding aromatic rice production, in the first stage, rice producing provinces were categorized into high- and low- adoption (higher and lower than the mean of aromatic rice area of adoption in the Mekong Delta at 14.43%). Three provinces were classified as high-adoption areas and ten provinces were classified as low-adoption areas. In the second stage, both areas were stratified by soil characteristics: soft alluvial and salinity, following the hypothesis that soil characteristics could affect adoption of aromatic rice. In the last stage, from four selected provinces (from the first two stages), two districts from each province were selected randomly. Based on Cochran (2007) assuming a 5% statistical significance level (α) and 25% proportion of aromatic rice farmers in the study area (p), the sample size (n) was identified as 308 farmers from eight selected districts in four provinces of the Mekong Delta (74, 68, 88, 76 farmers in Tien Giang, Soc Trang, Kien Giang, Can Tho accounting for 24%, 22%, 29% and 25% of total sample size, respectively). Dummy variables of location were initially tested in the model but were not significant, these were removed for a better estimation model.

RESULTS AND DISCUSSION

Characteristics of rice cultivation in Mekong Delta

Three hundred and eight farmers were interviewed for 815 rice fields. Among them, 626 fields were LQR, and 189 were aromatic rice. There were 157 out of 306, 27 out of 306, and 5 out of 203 rice fields, accounting for 51.31%, 8.82% and 2.46% adopting aromatic rice in winter-spring, summer-autumn, and autumn-winter season respectively. The average proportion of adopted rice fields of aromatic rice varieties in the study is 23.19%. Table 2 summarizes the characteristics of sampled aromatic rice adopted and non-adopted fields. On average, farmers who cultivate aromatic rice have nearly the same age, education, size of the households, and experience in rice cultivation as those who grow LQR, but the farmers who adopted aromatic rice have more experience in long grain rice cultivation than the non-adopters. The aromatic rice adopters appear to join in extension training programs more than non-adopters, and majority of all farmers are a member of farm associations. On average, aromatic rice growers make significantly higher annual income from rice than LQR growers.

On the market aspects, although both aromatic rice adopters and non-adopters rank above average for the importance of market price on their adoption decision, half of aromatic rice adopters think that the market price is extremely important while only one-third of non-adopters rank highest importance on the market price. The test of differences implies that aromatic rice adopters give different importance to the market price than non-adopters. Similarly, aromatic rice adopters and non-adopters have different attitudes toward the importance of maturity time of varieties. The importance of neighbors' decision on varieties is also difference between aromatic rice adopters and non-adopters. Although this bandwagon effect is important to both groups, but majority, more than half, of LQR growers believe that this effect is extremely important while 46% of aromatic rice growers believe that neighbor's decision is very important and one third believe that it is extremely important revealing that their adoptions are most likely influenced by neighbors adoption decision. However, risk perception is not different among aromatic rice and LQR growers. Both groups believe that risk is not at all important factor on making the variety choice.

On average, aromatic rice fields are 2.64 hectares, about 77% larger than LQR fields. About 14% of aromatic rice fields are contracted with private companies, while most of LQR fields, about 93%, have no contracts with private companies. The cropping pattern and seed procurement are also different among aromatic rice and LQR. More than one-half of aromatic rice cultivation growers cultivate two crops per year while more than 80% of LQR growers cultivate three crops per year. This is due to the longer duration of aromatic rice that makes it possible for fewer crops per year, and implies that the aromatic rice adopters have to tradeoff between high quality produce but fewer crops. However, as mentioned above, annual income generated from rice among aromatic rice adopters is still higher than non-adopters. About one third of LQR uses saved seeds; whereas only 6.35% of aromatic rice farms use seeds saved from previous seasons. The majority of aromatic rice farmers, more than 80%, obtain seeds from private companies.

Table 2. Characteristics of rice farms and farmers in Mekong Delta, 2013.

Variables		**Aromatic rice field**		**LQR field**		**All rice fields**		**t-value/chi^2**
Farmer characteristics		**Mean**	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**	
Age (years)		49.08	11.52	48.20	11.74	48.40	11.69	0.91
Education (years)		6.66	3.52	6.22	3.46	6.32	3.48	1.52
Rice experience (years)		24.69	11.74	25.27	12.01	25.13	11.94	-0.59
Long grain rice experience (years)		7.07	5.24	4.52	6.36	5.11	6.21	5.03***
Family size (persons)		4.74	1.67	4.82	1.67	4.80	1.67	-0.64
Annual income (million VND)		52.56	11.13	34.42	9.52	38.63	12.53	22.05***
		No.	**%**	**No.**	**%**	**No.**	**%**	
Importance level of price[1]	1	4	2.12	51	8.15	55	6.75	21.55***
	2	12	6.35	44	7.03	56	6.87	
	3	15	7.94	73	11.66	88	10.80	
	4	64	33.86	249	39.78	313	38.40	
	5	94	49.74	209	33.39	303	37.18	
	Total	189	100	626	100	815	100	
Importance level of maturing time[1]	1	52	27.51	116	18.53	168	20.61	17.40***
	2	46	24.34	215	34.35	261	32.02	
	3	61	32.28	153	24.44	214	26.26	
	4	18	9.52	73	11.66	91	11.17	
	5	12	6.35	69	11.02	81	9.94	
	Total	189	100	626	100	815	100	

Variables		**Aromatic rice field**		**LQR field**		**All rice fields**		**t-value/chi^2**
Importance level of risk[1]	1	174	92.06	553	88.34	727	89.20	2.56
	2	0	0.00	0	0.00	0	0.00	
	3	0	0.00	0	0.00	0	0.00	
	4	7	3.70	42	6.71	49	6.01	
	5	8	4.23	31	4.95	39	4.79	
	Total	189	100	626	100	815	100	
Importance level of bandwagon effect[1]	1	10	5.29	13	2.08	23	2.82	32.92***
	2	3	1.59	8	1.28	11	1.35	
	3	24	12.70	37	5.91	61	7.48	
	4	88	46.56	220	35.14	308	37.79	
	5	64	33.86	348	55.59	412	50.55	
	Total	189	100	626	100	815	100	
Member of farmers association	Yes	61	32.28	78	12.46	139	17.06	40.29***
	No	128	67.72	548	87.54	676	82.94	
	Total	189	100	626	100	815	100	
Farm characteristics		**Mean**	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**	
Farm size (hectare)		2.64	2.94	1.49	2.82	1.76	2.89	4.85***
		No.	**%**	**No.**	**%**	**No.**	**%**	
Contract with company (%)	Yes	27	14.29	45	7.19	72	8.83	9.08***
	No	162	85.71	581	92.81	743	91.17	
	Total	189	100	626	100	815	100	
Number of crops per year (%)	2 crops/year	101	53.44	105	16.77	206	25.28	103.33***
	3 crop/ year	88	46.56	521	83.33	609	74.72	
	Total	189	100	626	100	815	100	
Source of seed (%)	Private seed company	156	82.54	321	51.28	477	58.53	66.10***
	Local seed group	10	5.29	43	6.87	53	6.50	
	Government institute	8	5.82	29	9.10	37	8.34	
	Saved seed	9	6.35	145	32.75	154	26.63	
	Total	189	100	626	100	815	100	

Note: [1:] 5-point Likert scale with 1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = very important, 5 = extremely important; *, ** and *** indicates 10%, 5% and 1% significant level, respectively.

Adoption of aromatic rice in Mekong Delta

Table 3 shows the coefficient estimates and marginal effects of aromatic rice adoption model. The results from the logit regression analysis show that the generalized McFadden R^2value, a commonly used measure for goodness of fit for binary choice models was 0.4276. This value is within the commonly acquired range of McFaddenR^2 values (0.2-0.5) for logit model (Capps and Kramer, 1985, Supaporn *et al.* 2013). Experience in rice cultivation is found to negatively and significantly influence the adoption of aromatic rice, while age and experience in growing long grain rice varieties increase the probability of adopting aromatic rice. This implies that older farmers and those having more experience in growing long grain rice are those who are more likely to grow aromatic rice than their counterparts, and suggests that promoting aromatic rice to older farmers and those who have longer experience in long grain rice cultivation will increase its adoption. This finding is similar to a study of Li *et al.* (2010), who found that older farmers' increase the willingness to adopt new rice varieties in Sichuan, China, because nowadays elderly farmers make up the main labor force in the countryside and play a leading role in the process of production. Although the average age of both aromatic rice growers and non-growers are about the same at 50 years old, given everything else constant, older farmers tend to adopt aromatic rice than younger ones. Thus, if the new varieties can bring about better impacts, their demand to adopt new varieties will increase. However, the longer time farmers are experienced in general rice cultivation seems to lower the probability of adopting aromatic rice. The reason might be because farmers who are accustomed to normal rice cultivation are more reluctant to adjust to new technology and cultivation practices required for aromatic rice.

Farm size was found to be positively related to probability of adopting aromatic rice, implying that the larger the farm is, the higher the probability to choose aromatic rice to grow. This is probably because rice cultivation is the main occupation in Mekong Delta, and larger farm size implies higher capital and income, and ability to capture economies of scale as found by Pham and La (2014). Since aromatic rice varieties require more investment in terms of seed, fertilizer and labor, richer farmers are more likely to adopt aromatic rice as they can afford the higher cost of production. It was found from the survey that average cost of Jasmine 85 is 745,500 VND/ha higher than IR50404.This finding is similar to what Feder *et al.* (1985) suggested that the adoption of an improved, high yielding variety entails initial set up costs in terms of learning, locating and developing markets, and considering fixed costs, it discourages the adoption by small farms. Moreover, farmers with larger farms will be more willing to devote portions of the land to an untried variety (Mariano *et al.*, 2012), and they are also less vulnerable to failure from trying new technologies compared with those with smaller ones (Langyintuo and Mekuria, 2008). Soil characteristic, neither alluvial nor acidic soil, however, is not found to significantly influence aromatic rice adoption in the Mekong Delta. Jasmine 85 variety was not specific to the soil quality as expected so there are rooms to promote the adoption of this variety in various regions of Mekong Delta.

Farmers' perceptions on price, which represents farmers' considerations about market prospective of aromatic rice, and on the bandwagon effect, which represents their consideration about neighbor's rice varieties adoption, are proved to significantly influence farmers' adoption decision of growing aromatic rice. Farmers who consider their neighbors' choice of rice varieties as important factor are less likely to adopt aromatic rice. On the contrary, those who expect aromatic rice to provide higher price than non-aromatic rice are more likely to adopt aromatic rice than those who have no expectation and do not consider price as an important factor. The positive influence of price factor on aromatic rice adoption decision was showed by Myint and Napasintuwong (2016) and Jamal *et al.* (2013), who studied the adoption of fragrant rice in Myanmar and Malaysia, respectively indicated that higher selling price would encourage farmers to grow aromatic rice varieties. Another previous study about the adoption of technology in farming systems in the Mekong Delta (Chi and Yamada, 2002) also revealed that price has a positive influence, and farmers tend to change from growing normal rice to quality rice, that fetch higher prices in the market.

Extension services and field demonstration are found to significantly influence the adoption of aromatic rice. The results reveal that the probability of aromatic rice adoption increases along with the intensity of the communication with extension agents and the participant in demonstrations. Connections with a private company through contracts and seed supply are also proved to positively influence the adoption decision. Farmers' contracts with processing and export companies significantly increase the probability of adopting aromatic rice. Such a pattern is expected because price certainty encourages farmers to choose rice varieties which bring them the highest profit. This positive influence of the company contract was also indicated in the study of Shumba and Whingwiri (2006)which asserted that contract farming could revive the agriculture sector in Zimbabwe especially in high value crops such as cotton, barley, paprika and tobacco where returns to investment were high.

In addition to this, those who buy seed from a company seem to possess a greater tendency to choose aromatic rice varieties rather than those who buy seed from other sources such as their neighbors. Most of aromatic rice that fetches higher market price is due to its quality. Companies that contracted with farmers also sell aromatic rice seed, and buy the outputs in return. Thus, even with higher seed price, aromatic rice seed from private companies ensures higher seed quality and higher output price. The aromatic rice adopters are willing more to invest in higher quality seed to ensure higher and secure output price. This suggests that the acquisition and availability of seed from private seed company might help encouraging farmers to choose aromatic rice varieties.

Finally, aromatic rice adoptions are different among different seasons. The marginal effect of the Winter-Spring season factor is 0.3531, indicating that farmers in Mekong Delta are 35.31% more likely to adopt aromatic rice in Winter-Spring than during the two other seasons (the Summer-Autumn and Autumn-Winter seasons).The positive influence of the Winter-Spring season is understandable because this is the most fertile season with high-level alluvium, which is recharged annually by a flood that comes from August to October. Thus, with high fertile soil, farmers are more confident to cultivate aromatic rice. In contrast, the underlying reason for the negative influence of Autumn-Winter is the concerns farmers have with the risk from annual floods starting from the end of July. In this third season, shorter maturing duration of non-aromatic rice varieties or LQR varieties are preferred because of their possibility to escape damages from the annual flood.

Table 3. Coefficient estimates of logit model of aromatic rice adoption and marginal effects.

Variables	**Coefficient estimates**		**Marginal effect**	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**
FSIZE	0.0001***	0.0000	0.0000***	0.0000
REXPE	-0.0336**	0.0135	-0.0028**	0.0011
LGREXPE	0.0811***	0.0189	0.0067***	0.0017
AGE	0.0292**	0.0136	0.0024**	0.0011
EDU	-0.0250	0.0348	-0.0021	0.0029
EXTEN	0.0743**	0.0265	0.0062**	0.0023
FASIZE	-0.0838	0.0670	-0.0070	0.0056
WS crop	4.2480***	0.5158	0.3531***	0.0397
AW crop	-1.2293**	0.5279	-0.1022**	0.0399
SASOIL	0.1431	0.2430	1.1539	0.2804
COMSOURE	1.8886***	0.2742	0.1570***	0.0255
CONTRACT	1.2266**	0.3849	0.1020**	0.0335
PRICEIM	0.6280**	0.2947	0.0522**	0.0248
BANDIM	-0.7564**	0.3231	-0.0629**	0.0276
DEMONATEN	1.3550***	0.3982	0.1126***	0.0341

***, **, * Statistically significant at 99%, 95% and 90%, respectively

Note: Number of observations: 815; Log likelihood = -252.82767; Pseudo R^2 = 0.4276

Farmers' willingness-to-accept a change to adopt aromatic rice in Mekong Delta

Out of the 60 LQR farmers, 95% are willing to accept a change from growing IR 50404 to growing Jasmine 85 at some price premium. Only 5% of the respondents would not change to growing aromatic rice variety Jasmine 85 at any bid price offer. Equation (6) was estimated from 60 observations of IR50404 growers to find determinants on their willingness-to-accept a change to adopt aromatic rice. The results shown in Table 4 explain that bid price, contact with extension officers, and farmers located in provinces of high adoption rate are positively and significantly influencing willingness to accept a change to aromatic rice cultivation among LQR growers; whereas income from rice cultivation, being commercial rice farmers (as compared to household consumption producers) and being a member of farmer associations negatively influence it. The marginal effects indicated that if the market price of aromatic rice increases by 100 VND/kg, the probability of farmers' willingness to accept a change to grow aromatic rice will increase by 12% (Table 4).

The coefficient estimates from Equation (4) were used to calculate the mean of willingness-to-accept a change to aromatic rice production of representative LQR growers as followed:

$$\mathrm{E}(\mathrm{t_j}) = \mathrm{E}(\mathrm{WTA} \mid \alpha, \beta, \mathrm{z_j}) = -\frac{\alpha z_j}{\beta} = -\frac{-6.5449}{0.00603} = 1{,}085$$

The results show that the representative LQR growers would require the premium of 1,085 VND/kg or 24.34% price difference between IR 50404 and Jasmine 85 to agree to change to aromatic rice undergoing difficulties, and overcoming perceived risks of aromatic rice production such as vulnerability to diseases and pests, and longer maturity period compared to LQR (Table 2). The significant influence of bid price asserts the hypothesis that farmers require reasonable and higher premium price to adopt higher quality in exchange for fewer crops per year, higher seed price, and other more challenging rice varieties. This finding is in line with the study of Singh *et al.* (2006), which provides evidence that the gradual decline of Basmati aromatic rice area in India was because the existing market price of Basmati aromatic rice and its cost production did not show any favorable incentives for Basmati over non-Basmati rice varieties.

The influence of market price factor on farmers' willingness-to-change to new cultivation practices was explored in previous studies (Beltran *et al.* 2013, Ortega *et al.* 2014). The results of this study are in line and support the findings of Ortega *et al.* (2014) that a small price premium can give farmers the needed incentive to comply with higher quality standards. Based on these findings and considering the potential challenges of aromatic rice production compared to LQR production, the amount of price premium (5.60% or 400 VND increase per kg of Jasmine rice) is reasonable enough to suggest policies to improve the price premium of aromatic rice in Vietnam. This study reveals that marketing strategies to increase the sufficient price premium of aromatic rice could be one important way to increase the adoption rate of aromatic rice in the Mekong Delta.

Table 4. Willingness-to-change to aromatic rice by switching from IR 50404 to Jasmine 85.

Variables	**Coefficient estimates (α)**	**Mean of z_j**	**$\alpha * z_j$**
t_j	0.0060^{***}	925.0000	-
AGE	-0.1060^{**}	46.3833	-4.9185
EXTEN	0.2908^{**}	4.3667	1.2699
HIADOPPRO	6.8992^{***}	0.6500	4.4845
RINCOME	-0.1331	40.0342	-5.3266
COMERFA	-2.4729^{*}	0.7167	-1.7722
MEM	-2.7212^{*}	0.1167	-0.3175
Cons	0.0354	-	-
Mean of WTA	1,085		

Note: ***, **, * Statistically significant at 99%, 95% and 90% respectively

CONCLUSION

While the demand of aromatic rice in the world market is expected to continue growing, particularly among high-income consumers of major rice consuming countries, the aromatic rice exports from Vietnam remains low, compared to their competitors such as Thailand and Cambodia. To promote the adoption and export potential of aromatic rice in Vietnam, this paper explores farmers' behaviors and preferences regarding aromatic rice adoption. The findings from this study show that market price and cropping season are key determinants of the probability of aromatic rice adoption, followed by age, farm size, extension contact and linkage with private company. The results show that the majority of LQR growers are willing accept a change to adopt aromatic rice when a higher price premium of aromatic rice is offered; the mean of willingness-to-accept a change is 1,085 VND/kg or a 24.34% price difference between aromatic rice and LQR compared to 15.91% in present domestic market.

Thus, the findings suggest that in addition to increasing on-farm demonstrations along with strengthening the connection between farmers and private companies, a sufficient increase in market price premium for aromatic rice could be one of the ways to create more incentive for aromatic rice adoption and reduce LQR area in the Mekong Delta. Although this may cause the price competitiveness of aromatic rice exports from Vietnam to decrease, but with current world price of Vietnam's aromatic rice that is nearly 40% cheaper than that of Thailand and Cambodia, this may not be substantial to create a significant impact. Moreover, the issue surrounding this group of farmers is their neighbors' decisions. While farmers are willing to change to higher quality varieties, their neighbors' choice of variety may ultimately affect their decision. Government policies as well as support from the private sector to ensure access to input and confidence in demand for aromatic rice particularly through the price signal would significantly increase the adoption of aromatic rice in Vietnam.

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REFERENCES

Ahmad Hanis, I. A. H., S. Jinap, S. Mad Nasir, R. Alias and A. K. Muhammad Shahrim. 2012. Consumers' demand and willingness to pay for rice attributes in Malaysia. International Food Research Journal. 19 (1): 363-369.

Ara, S. 2003. Consumer willingness to pay for multiple attributes of organic rice: A case study in the Philippines. Contributed paper selected for presentation at the 25th International Conference of Agricultural Economists, August 16-22, 2003, Durban, South Africa.

Beltran, J. C., B. White, M. Burton, G.J. Doole, and D.J. Pannell. 2013. Determinants of herbicide use in rice production in the Philippines. Agricultural Economics, 44 (1), 45-55.

Capps, O. and R. A. Kramer. 1985. Analysis of food stamp participation using qualitative choice models. American Journal of Agricultural Economics. 67 (1): 49-59.

Chi, T. T. N. and R. Yamada. 2002. Factors affecting farmers' adoption of technologies in farming system: A case study in Omon district, Can Tho province, Mekong Delta. Omonrice. 10: 94-100.

Cochran, W. G. 2007. Sampling techniques. 3rd ed., John Wiley and Sons. 428 p.

Coxhead, I., L. Vu Hong, and T. Le Dong. 2012. Global market shocks and poverty in Vietnam: the case of rice. Agricultural Economics.43: 575–592.

Custodio, M. C., M. Demont, A. Laborte and J. Ynion. 2016. Improving food security in Asia through consumer-focused rice breeding. Global Food Security.9:19-28.

Dieu, P. Q. 2014. Vietnam: Cross Border Trades with China, Asian demand and Thai competition: Paper presented at the 6th TRT World Rice Conference. Phnom Penh, Cambodia. 18-20 November 2014.

Doss, C.R., 2006. Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agricultural Economics. 34(3): 207-219.

Feder, G., R. E. Just and D. Zilberman. 1985. Adoption of agricultural innovations in developing countries: A survey. Economic Development and Cultural Change. 33: 255-298.

Fernandez-Cornejo, J., E. D. Beach and W. Y. Huang. 1994. The adoption of IPM techniques by vegetable growers in Florida, Michigan and Texas. Journal of Agricultural and Applied Economics. 26 (1): 158-172.

Fitzgerald, M. A., S. R. McCouch and R. D. Hall. 2009. Not just a grain of rice: the quest for quality. Trends in Plant Science. 14 (3): 133-139.

Ghimire, R., H. Wen-chi and R.B. Shrestha, 2015. Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. Rice Science. 22(1): 35-43.

Giraud, G. 2013. The World Market of Fragrant Rice, Main Issues and Perspectives. 16 (2): 1-20.

Global Rice Science Partnership (GRiSP). 2013. Rice almanac. 4th ed., International Rice Research Institute, Los Banos: Philippines. 283 p.

Hanemann, W. M. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics. 66 (3): 332-341.

Horna, J. D., M. Smale and M. von Oppen. 2007. Farmer willingness to pay for seed-related information: Rice varieties in Nigeria and Benin. Environment and Development Economics. 12 (6): 799-825.

Hossain, M., M.L. Bose and B.A. Mustafi. 2006. Adoption and productivity impact of modern rice varieties in Bangladesh. The Developing Economies. 44(2): 149-166.

Huan, N. H., V. Mai, M. M. Escalada and K. L. Heong. 1999. Changes in rice farmers' pest management in the Mekong Delta, Vietnam. Crop Protection. 18 (9): 557-563.

Jamal, K., N. H. Kamarulzaman, A. M. Abdullah, M. M. Ismail and M. Hashim. 2013a. Farmer's acceptance towards fragrant rice farming: the case of non-granary areas in the East Coast, Malaysia. International Food Research Journal. 20 (5): 2895-2899.

Kaliba, A. R., H. Verkuijl and W. Wwangi. 2000. Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. Journal of Agricultural and Applied Economics. 32 (1): 35-48.

Langyintuo, A. S. and M. Mekuria. 2008. Assessing the influence of neighborhood effects on the adoption of improved agricultural technologies in developing agriculture. African Journal of Agricultural and Resource Economics. 2 (2): 151-169.

Li, D., M. Liu and G. Deng. 2010. Willingness and determinants of farmers' adoption of new rice varieties. China Agricultural Economic Review. 2 (4): 456-471.

Luckmann, J., R. Ihle, U. Kleinwechter, U. and H. Grethe. 2015. World market integration of Vietnamese rice markets during the 2008 food price crisis. Food Security. 7: 143 - 157.

Maddala, G. S. and K. Lahiri. 1992. Introduction to econometrics. 2nd ed., Macmillan New York. 631 p.

Mariano, M. J., R. Villano and E. Fleming. 2012. Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. Agricultural Systems. 110: 41-53.

Mottaleb, K.A., S. Mohanty and A. Nelson. 2014. Factors influencing hybrid rice adoption: a Bangladesh case. Australian Journal of Agricultural and Recourse Economics.59: 258-274.

Myint, P.L. and O. Napasintuwong. 2016. Economic analysis of Paw San rice adoption in Myanmar. Asian Journal of Agricultural Research.10(5): 175-184.

Napasintuwong, O. 2012. Survey of recent innovations in aromatic rice. Paper presented at Agrarian perspectives XXI and 131st European Association of Agricultural Economists Seminar, September 18-19, 2012.Prague, Czech Republic.

Napasintuwong, O. and C. Pray. 2014. Adoption of drought-tolerant rice in Thailand: Participatory varietal selection and implications for breeding programs. Journal of Development and Agricultural Economics. 6 (9): 394-404.

Ngokkuen, C. and U. Grote. 2011. The prediction of household's behavior in adopting geographical indication certification for Jasmine rice from Northeast Thailand. International Journal on GSTF Business Review. 1(1): 173-178.

Nguyen, T. N. 2013. Results of launching the "large-scale field" model of rice production program in summer-autumn season 2011 to winter-spring season 2011-2012, and its future development orientation. (in Vietnamese). 19 p. Retrieved from http://vnclp.gov.vn/uploaded/2013/21/09/2fa9cbba-a082-4e7f-b720-25361767d8a0.doc.

Ortega, D. L., H. H. Wang, N. J. Olynk Widmar and L. Wu. 2014. Chinese producer behavior: Aquaculture farmers in southern China. China Economic Review.28:17-27.

Oryza.com. 2015. Global Rice Quote. Retrieved from http://oryza.com/.

Pham, N. Q. and A. H. La. 2014. Vietnam: Household welfare and pricing of rice: Does the large-scale field model matter for Viet Nam?, pp. 301-335. In Trade Policies, Household Welfare and Poverty Alleviation. Division on Globalization and Development Strategies. Geneva.

Rogers, E. M. 2003. Diffusion of innovations. 5th ed., Simon and Schuster. 551 p.

Saka, J. O. and B. O. Lawal. 2009. Determinants of adoption and productivity of improved rice varieties in southwestern Nigeria. African Journal of Biotechnology. 8 (19): 4923-4932.

Shumba, E. M. and E.E. Whingwiri. 2006. Commercialization of smallholder agriculture. Pp. 577-589. In: Zimbabwe's Agricultural Revolution Revisited. M. Rukuni, P. Tawonezvi, C. Eicher, M. Munyuki-Hungwe, and P. Matondi, (Eds.). University of Zimbabwe Publications, Harare.

Singh, H. N., U. S. Singh, R. K. Singh, V. K. Singh, S. P. Singh and S. C. Mani. 2006. Adoption pattern and constraints analysis of Basmati rice: Implications for enhancing adoption and stabilizing productivity in Uttaranchal, India. Indian Journal of Crop Science. 1 (2): 106-108.

Smith, W. 2013. Agriculture in the central Mekong Delta: Opportunities for donor business engagement. ODI report. December 2013. 13 p. Retrieved from https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9060.pdf.

Supaporn, P., T. Kobayashi and C. Supawadee. 2013. Factors affecting farmers' decisions on utilization of rice straw compost in northeastern Thailand. Journal of Agriculture and Rural Development in the Tropics and Subtropics. 114 (1): 21-27.

Suwannaporn, P. and A. Linnemann. 2008a. Consumer preferences and buying criteria inrice: A study to identify market strategy for Thailand Jasmine rice export. Journal of Food Products Marketing. 14 (4): 33-53.

Suwannaporn, P. and A. Linnemann. 2008b. Rice-eating quality among consumers in different rice grain preference countries. Journal of Sensory Studies. 23 (1): 1-13.

The Rice Trader. 2014. Special Report – Fragrant Rice. October 20, 2014. United States. 15(40): 50-55.

Train, K. 2009. Discrete choice methods with simulation. 2nd ed., Cambridge University Press. 388 p.

Tuong, D. M. 2010. Economic analysis on production of high quality rice in Cuulong Delta, Vietnam. Omonrice, 17: 174-178.

Vietnam Trade Promotion Agency. 2008. Report on Vietnamese rice sector. Export Promotion Center. Hanoi.46 p.

Von Bruan, J. and M.S. Bos. 2004. The changing economics and politics of rice: Implications for food security, globalization, and environmental sustainability in rice is life: Scientific perspectives for the 21st century. Toriyama K, Heong KL, Hardy B. (Eds). Proceedings of the World Rice Research Conference held in Tokyo and Tsukuba, Japan, 4-7 November 2004. Los Banos (Philippines); International Rice Research Institute, and Tsukuba (Japan): Japan International Research Center for Agricultural Sciences. 590 p.

Zeigler, R. S. and A. Barclay. 2008. The relevance of rice. Rice. 1 (1): 3-10.

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ESTIMATING THE MARKET POWER IN THE INDONESIAN GARLIC INDUSTRY

Dea Amanda[1], Yusman Syaukat[2], Muhammad Firdaus[3]
[1] Graduate Study Program of Agricultural Economics, Faculty of Economics and Management, Bogor Agricutural University (Institut Pertanian Bogor), Bogor, Indonesia 16680
[2] Department of Resource and Environmental Economics, Faculty of Economics and Management, Bogor Agricultural University
[3] Department of Economics, Faculty of Economics and Management, Bogor Agricultural University
Corresponding author: ysyaukat@ipb.ac.id

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ABSTRACT

Indonesia is the largest garlic importer country in which its garlic supply is controlled by only a limited number of importers. Issue of oligopolistic market power on Indonesia garlic market arose during 2012-2013 which led to a change in government policy on garlic market, from the previously import tariff policy into non-tariff policy. This study aimed at estimating the degree of market power exercised by garlic suppliers, which are dominated by the importers, and the extent to which the change in regulation policy contributed to the creation of social cost. The Bresnahan-Lau oligopolistic model in static form was used in this study. This model differs from Structure-Conduct-Performance (SCP) paradigm commonly used in market power studies. The Bresnahan-Lau model was able to estimate the degree of market power directly from the structural equations. The main results showed that the degree of market power exercised by garlic supplier was relatively low and there was not enough information for the existence of cartel in garlic market in Indonesia. Instead, the market structure tends to be monopolistic competiton. Nevertheless, the estimated market power parameter is pretty high compared to the other studies that used this model. The results showed that during 2008-2014 the policies on garlic market has created welfare loss and economic rent consecutively as large as Rp 3.3 trillion and Rp 5.6 trillion annually.

Key words: Bresnahan-Lau model, market power, oligopoly, concentration ratio, social cost

INTRODUCTION

Study on market power has been a major focus in industrial economics studies because it was used to measure the competitiveness level of an industry. Analysis on market power has been applied mostly in banking industry. As this sector provides important needs for the community, the industry needs to be as competitive as possible. Shaffer and Disalvo (1994); Zardkoohi and Fraser (1998); and Chang et al. (2012) are few researchers that study on US banking industry with respect to the competition level and the effect of deregulation. Study on banking industry has also been done in Europe (Nathan and Neave, 1989; Suominen, 1994; More and Nagy, 2004). Lubis (2012); Widyastuti and Armanto (2013) applied this study on Indonesian banking industry and found that even though the concentration ratio is pretty high, the credit market is still leaning on the competitive side. However, it was also found that in the long term the level of competitiveness is slowly decreasing. Nowadays, researcher begins to test the theory on agricultural product industries. Study of market power in agricultural sector has been applied for various commodities. Deodhar and Sheldon (1997) found the world market for soymeal exports to be perfectly competitive, while Hatirli et al. (2003) faced the same consequence in regard to banana imports by Turkey. Steen and Salvaness (1999) test the degree of market power of European salmon market and found that it's to be competitive in the long run. Most of these studies were initiated due to some symptoms of market uncompetitiveness, such as high market concentration or the provision of competition act.

Market power study on garlic is important for Indonesia, since high proportion of garlic is imported and its domestic market is controlled only by a few importers. In Indonesia, garlic is mostly consumed by households with per capita consumption about 100 gram per month. Since the domestic production can't meet the domestic demand, its excess demand is filled from imports. Garlic import plays an important role, since domestic production is less than 5 percent of the total garlic consumption. Thus, the government tries to impose a protective policy on imports by implementing import tariff. In 2012, Indonesian government issued a new protective policy to control import of garlic by reducing the number of importers and imposed an import quota. The quota was given based on the prediction of domestic production, previous year consumption and stock.

Even though the import parity price was relatively cheap, the domestic price of garlic rose sharply in 2012-2013 up to Rp 100,000 per kg (note: Rp stands for Rupiah, Indonesian currency, and 1 USD ≈ Rp 13,000). The extreme price hike was predicted due to some factors such as the extreme weather, low domestic production, inefficient supply chain, and issue of stock hoarding by garlic importers (Saputro, 2013). Indication of the existence of supply control by the importers was strengthen by the Indonesian Business Competition Supervisory Board (*Komite Pengawas Persaingan Usaha* or KP PU) decision that punished 19 garlic importers who practicing cartels by controlling 80 percent of national supply. These importers was found to have family relationship among them, same warehouse/storage, etc. These importers allegedly having some degrees of market power, so they can control the domestic price. Market power is a measure of performance that shows how much a firm can increase the price above the marginal cost (Church and Ware, 2000). Associated with market structure, a firm in perfectly competitive market does not have any market power, while a firm in a monopoly market has the strongest degree of market power (Lubis, 2012).

The market structure of garlic tends to be oligopoly, since only a few companies control most of market supply of the product. Some supliers alledgely have higher market power so they can increase the prices above their marginal cost with a relatively high margin. A policy that creates inefficiency will cause a rise of market price and fall in quantity, which then result in welfare loss and economic surplus (rent) transfer from consumer to other parties such as importer, seller and government. This study aims at estimating the degree of market power exercised by garlic supplier, which is dominated by the importers, and the extent to which this re-regulation policy contribute to the creation of social cost.

RESEARCH METHODS

The data used in this research is monthly time series data from 2008 to 2014. This research used quantitative as well as qualitative analysis. The qualitative analysis was used to provide a general overview about Indonesian garlic production. The quantitative analysis was used to estimate the degree of market power and social costs occurred in the market. To analyze the degree of market power, we used a basic econometric model for oligopolistic market developed by Bresnahan and Lau as applied by Steen and Salvanes (1999), Bikker (2003) and Lubis (2012). The model was estimated with Two Stages Least Square (2SLS) method. Then, the estimated parameters from the model were used to estimate the social cost which consisted of economic rent transfers and welfare loss.

Theoretical Model

The demand side of the market can be described by the following function (Bresnahan 1982; Lau 1982):

$$Q = D(P, Z; \alpha) + \varepsilon \quad (1)$$

where Q is quantity, P is price and Z is a vector of exogenous variables affecting demand, e.g. a substitute price and income. Meanwhile, α is the vector of parameters to be estimated and ε is the error term.

The supply side is more complex. When sellers are price takers, price equals marginal costs, and we can write;

$$P = c(Q, W; \beta) + \delta \quad (2)$$

where W are exogenous variables on the supply side, such as factor prices, β is the supply function parameters, and δ is the supply error. Marginal cost is given by c(.) function. When the firms are not price takers, the perceived marginal revenue (and not the price) will be equal to the marginal cost. Instead of a supply curve, we may now write a supply relation;

$$P = c(Q, W; \beta) - \lambda \cdot h(Q, Z; \alpha) + \delta \,; \quad (3)$$

where P + h(.) is marginal revenue, and P + λ h(.) is marginal revenue as perceived by the firm. Hence, λ is a new parameter that may be interpreted as a summary statistic measuring the degree of market power. Under perfect competition, $\lambda = 0$ and price equals marginal cost. When $\lambda = 1$ we face a perfect cartel, and when $0 < \lambda < 1$ various oligopoly regimes apply. Loosely speaking, λ is the percentage of the percieved monopoly marginal revenue (Steen and Salvanes, 1999).

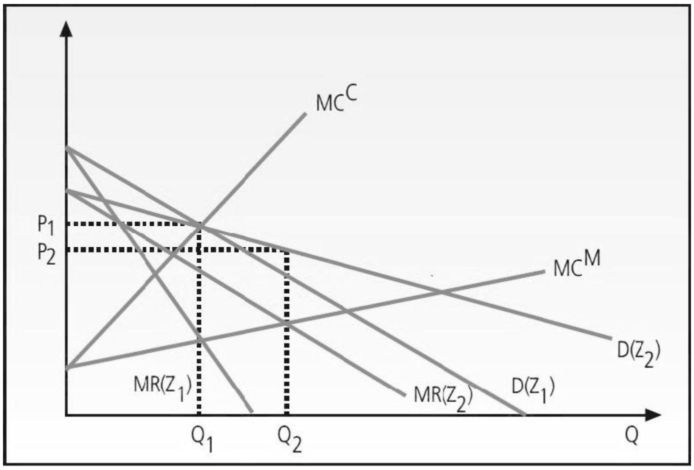
The demand function specification, which used to estimate the market power, was found by determining the exogenous variables (Z). It does not only shift the parallel demand curve, but can also change (rotate) the slope degree of demand curve (Bresnahan, 1982). It can be conducted by inserting an instrumental variable which is the multiplication (cross-term) of price P with exogenous variable Z, as follow:

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 Z + \alpha_3 PZ + \varepsilon \quad (4)$$

Following Bresnahan (1982), the price equation is determined by:

$$P = -\lambda . \frac{Q}{\alpha_1 + \alpha_3 Z} + \beta_0 + \beta_1 Q + \beta_2 W + \eta \quad (5)$$

The logic of this structural model can be described by Figure 1. With the change of exogenous variable Z, the slope degree of the demand curve and intercept will change. If the market behaves competitively, the rotation of the demand curve around the previous equilibrium will not change the equilibrium, so it is fixed at (Q1, P1). However, if the firm has the market power, there will be a change in the equilibrium to be (Q2, P2). Thus, the rotation of the demand curve caused by the exogenous variable Z, gives a different response between competitive markets and monopoly markets (Lubis, 2012).



Source: Lubis 2012

Fig. 1. Response difference between competitive and monopoly market

Model Specification

We will use the above theoretical model to estimate the degree of market power in Indonesia garlic market. Bresnahan-Lau oligopolistic model consist of 2 structural equation from demand side (demand equation) and supply side represented by price equation.

1. Garlic demand

Garlic demand is affected by domestic (consumer) price of garlic, price of shallot as related goods to garlic, import price for garlic, as well as dummy for import re-regulation policies and dummy for Eid Ul-Fitr (Islamic fasting-break festival). Dummy for import re-regulation policy described the conditions where there was a change in import regulation policy during June 2012 to April 2013 so that in this condition value of dummy variable is equal to one and vice versa. Dummy for Eid Ul-Fitr described consumption pattern of Indonesian households which tended to rise around the month of Ramadhan and Eid Ul-Fitr and Eid Ul-Adha festivals. Dummy is equal to 1 during two months before and two months after Eid Ul-Fitr every year, and vice versa. The function of demand can be formulated as follows:

$$QBP_t = \alpha_0 + \alpha_1 PD_t + \alpha_2 PBMK_t + \alpha_3 (PD.PBMK)_t + \alpha_4 PM_t + \alpha_5 (PD.PM)_t + \alpha_6 Dummy\_Pol + \alpha_7 Dummy\_IF + \varepsilon \tag{6}$$

with:

QBP = Domestic demand/consumption for garlic (Kg)

PD = Domestic price of garlic (Rp/Kg)

PBMK = Domestic price for shallot (Rp/US$)

PM = Import price for garlic (Rp/Kg)

DUMMY_Pol = Import policy dummy, i.e when the policy is effective, DUMMY_Pol = 1, otherwise 0

Dummy_IF = Dummy for *Eid* festivals i.e., 2 months before and after the Eid ul-Fitr, the Dummy_IF=1, otherwise 0

On the equation, there are two interaction variables between garlic domestic price and other exogenous variables: shallot domestic price and garlic import price. These variables were used to rotate the demand curve. The expected sign is as follows: α_1, α_2, α_4, $\alpha_6 < 0$ meanwhile α_3, α_5, $\alpha_7 > 0$.

2. Garlic Price

On the supply side, garlic price function is affected by demand (consumption) of garlic, import price for garlic and farmers wage as the price for input of supplied garlic. This relationship can be specified by the following equation:

$$PD_t = \beta_0 + \beta_1 QBP_t + \beta_2 PM_t + \beta_3 WAGE_t + \beta_4 Dummy\_IF + \beta_5 Dummy\_Pol - \lambda.\frac{QBP_t}{\alpha_1 + \alpha_3 PBMK_t} + u \quad (7)$$

In a linear form will become as follows:

$$PD_t = \beta_0 + \beta_1 QBP_t + \beta_2 PM_t + \beta_3 WAGE_t + \beta_4 Dummy_{IF} + \beta_5 Dummy_{Pol} - \lambda.QBP_t^* + u \quad (8)$$

where $QBP_t^* = \frac{QBP_t}{\alpha_1 + \alpha_3 PBMK_t}$

and Wage = monthly wage of farm-worker (Rp)

The expected sign is as follows: $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5 > 0$ and $0 < \lambda < 1$.

Elasticitiy

Value of elasticity describes the response of supply and demand as a result of a change in price. Elasticity can be estimated as follows (Zaini, 2012):

Demand elasticity: $\eta_D = [\alpha_1 + \alpha_3\overline{PBMK} + \alpha_5\overline{PM}].\left[\frac{\overline{PD}}{\overline{QBP}}\right]$ (9)

Supply elasticity: $\eta_s = \left[\frac{\alpha_1 + \alpha_3\overline{PBMK} + \alpha_5\overline{PM}}{\beta_1(\alpha_1 + \alpha_3\overline{PBMK} + \alpha_5\overline{PM}) + \lambda}\right].\left[\frac{\overline{PD}}{\overline{QBP}}\right]$ (10)

Social Cost

Social cost in Indonesian garlic market occurs due to two factors: welfare loss and economic rent transfer. Welfare loss or *Deadweight Loss* (DWL) is counted as the area of Harberger's Triangle and calculated by using the value of elasticity. The welfare loss was estimated for each period of time (monthly). The estimation of welfare loss can be categorized into two: welfare loss because of import tariff (DWL_{TAX}) and welfare loss because of the existence of market power (DWL_{MP}). The following formulas are used to calculate each loss:

$$DWL_{TAX} = \frac{\eta_S \cdot (\Delta P)^2 \cdot \overline{QBP}}{2\bar{P}} + \frac{\eta_D \cdot (\Delta P)^2 \cdot \overline{QBP}}{2\bar{P}} \quad (11)$$

$$DWL_{MP} = \frac{\eta_D \cdot \Delta P \cdot \overline{QBP} \cdot \Delta PD}{2\overline{PD}} = \frac{\eta_D \cdot (\Delta P)^2 \cdot \overline{QBP}}{2\overline{PD}} \quad (12)$$

where ΔP is the difference between garlic domestic price and its import parity price or as much as import tariff. The estimated economic rent transfers are received by four parties: farmer, seller, government and importer. Transfer size received by each party is calculated by applying the following equations:

$$RentTani_t = (PP_t - Pw_t)\ x\ Prod_t \quad (13)$$

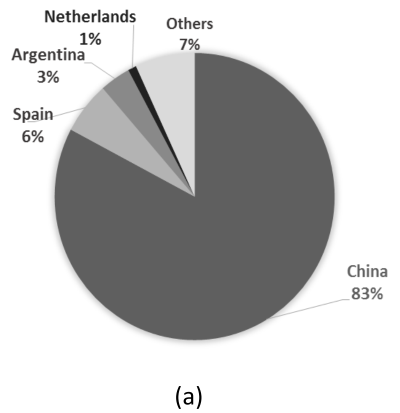
$$RentPdg_t = (PD_t - PS_t)\ x\ Prod_t \quad (14)$$
$$RentImp_t = [PS_t - (Pw_t x(1 + tax))]\ x\ IMbp_t \quad (15)$$
$$RentGov_t = Pw_t\ x\ tax\ x\ IMbp_t \quad (16)$$

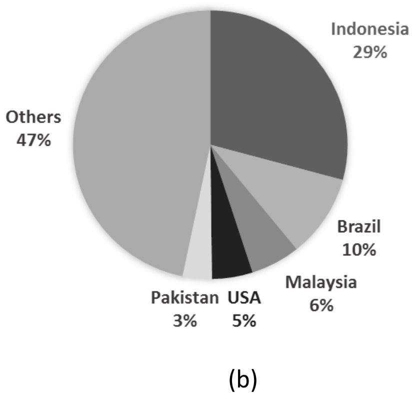
where:

RentTani	: Economic rent transfer received by local farmers (Rp)
RentImp	: Economic rent transfer received by importers (Rp)
RentGov	: Economic rent transfer received by government (Rp)
Prod	: Domestic production (Kg)
tax	: Import tax (%)
IMbp	: Imports (Kg)
PP	: Garlic producer price (Rp/Kg)
PS	: Garlic wholeseller price (Rp/Kg)
Pw	: Import parity price for garlic (Rp/Kg).

OVERVIEW OF GARLIC MARKET

Globally, the trend in garlic use is unique among vegetables, since demand has not only steadily increased over many decades, but it also has grown at an increasing rate. Despite the general growth of vegetable demand, vegetable has experienced stronger growth than garlic demand over the past years. Garlic is a crop which could grow well in cool temperature. Therefore, garlic is best planted on subtropical countries or highland areas. Globally, garlic market was dominated by the Asian. The largest garlic trade balance were dominated by Asia (67 percent) and followed by Europe (20 percent) and the rest is from America, Africa and Oceania (Panzaru and Medelete, 2011). China was the biggest garlic producer, consumer and exporter in Asia and in the world. In 2013, China's garlic export exceeded 1.6 million tons or more than 80 percent world export and the rest was exported by other countries such as Argentina, Spain and Netherlands with relatively low market share. China's high production was supported by large harvested area, high productivity, suitable climate and strong support from China's government on their production. Meanwhile Indonesia was the largest importer in the world and reached more than 30 percent by 2013 with more than 440 thousand tons. Other countries', such as Brazil, Malaysia and Pakistan, import shares were about 20 percent and the rest was imported by other countries. This indicates that world garlic market structure tend to be monopoly with China as the biggest exporter.



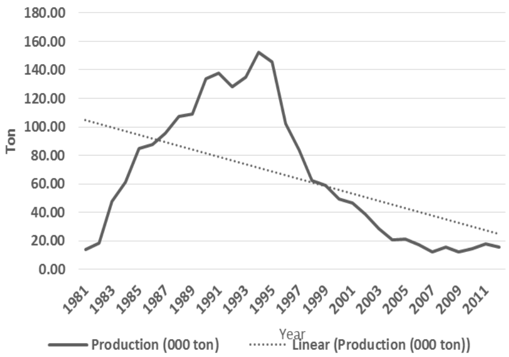


Source: UN Comtrade, 2015

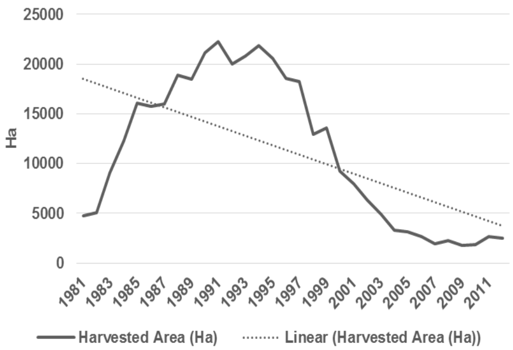
Fig. 2. World largest garlic exporter (a) and importers (b) in 2015

Garlic consumption in Indonesia increases over time. However, its production tended to decline in the last two decades. Figure 2(a) showed that during 1981 to 1995, garlic domestic production gradually increased, and then continuously decreased afterward. Garlic production dropped drastically, especially in the period of 1996-1998, where garlic production declined by more than 50%. This low production was due to small harvested area and low productivity. Garlic average productivity was 66.43 quintal per hectare in the last 10 years. This figure was very low compared to other countries (China 246.5 and South Korea 140.4 quintal per hectare). Some factors had been identified as the reasons for this low productivity i.e., low quality of garlic seeds, plant disease (especially fungus and viruses), and less steady environment (Wibowo, 2006). Harvested area also experienced the same trend as production, as shown in Figure 2(b). This indicated that changes in production mostly due to changes in harvested area of garlic. The biggest changes happened after the peak in 1996-1997. In 1998, Indonesia government signed a letter of intent (LoI) with IMF which requires the removal of import tariffs for food. As a result, agricultural product imports flooded in with lower price compared to that of domestic production and dominate national market. In addition, comparison between garlic price and price of alternative commodities such as potatoes and soybean was rather low, and there was no production facilities and support given for farmers (Kasijadi, 1981).

The LoI between Indonesia and IMF in 1998 required the removal of trade protective policy such as quota and high tariff. After 1998, the imposed import tariff was not able to diminish import, because apart from the relatively small tariff level (5 percent), price gap between the local and imported garlic was very high. The price of imported garlic was only one-third from local price. In 2012, the government predicted that there will be an increase in domestic production in 2013, and put a new policy to protect it by limiting the import level since June 2012. However, in 2013, it turned out that local production could not reach the predicted amount, thus garlic continued to be imported. On the same time, garlic price rose extremely high, up to four times of the previous level. It was predicted that this price increase was due to the intentional supply limit as a result of conspiracy among importers. Consequently, the government removed the policy in April 2013 so the domestic price could back to normal.



(a)



(b)

Source: Ministry of Agriculture 2015

Fig. 3. Indonesia garlic production and harvested area, 1981-2013

RESULTS AND DISCUSSION

Garlic demand function is estimated based on the equation (6) and captures the relationship between demand (QBP) and its explaining factors such as: garlic domestic price (PD), shallot price as a closed related product to garlic (PBMK), interaction variable between the domestic price of garlic with shallot price (PD_PBMK), dummy variables for import re-regulation policy (DUMMY_Pol) –

June 2012 policy, and dummy variable for Eid Ul-Fitri (DUMMY_IF), where garlic demand increased significantly in this period. Garlic import price (PM) was dropped from the equation for the goodness of all parameters. Results are shown in Table 1.

The estimation results in Table 1 shows that the relationship between variables composing Indonesia garlic demand function is in line with economic theory. The main factor determining garlic demand is its domestic price. The influence of garlic price to total demand of garlic works in two ways, direct and indirect. The direct effect is shown by negative PD coefficient (-3120.2) and significant, which means every 1 rupiah increase in garlic price will reduce total garlic demand by 3120.2 kg and vice versa. Meanwhile, the indirect effect is shown by the interaction variable between garlic price and shallot price as a close related good to garlic, namely PD_PBMK which is assumed as non-separable. This interaction coefficient is positive i.e., 0.119. Total effect of garlic price is counted from both effects, counted as *dQBP/dPD* = -3120.2 + 0.123713*PBMK. Using the average value of shallot price, total effect of garlic to its demand is counted as much as -430.6. The effect is negative and in line with hypothesis.

External factors affecting garlic demand is shallot price. Shallot is a commodity with similar characteristics to garlic. Both garlic and shallot are seasoning and are often used together by households. The relationship between shallot price and garlic price is shown by PBMK coefficient by -1537.1, which means every 1 rupiah increase in shallot price will decrease the demand of garlic by 1537 kg. This relationship indicates that shallot and garlic is a great complement to each other as they are often used together. However, from the probability value, this variable didn't affect garlic consumption significantly, showing that consumer have different preference between garlic and shallots.

Table 1. Garlic demand estimation model using Bresnahan-Lau static oligopoly.

Variables	**Parameter**	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	α_0	69116200	38534441	1.793621	0.0767
PD	α_1	-3120.206	1989.475	-1.56836	0.1208**
PBMK	α_2	-1537.124	2344.747	-0.65556	0.5140
PD_PBMK	α_3	0.123713	0.106155	1.165399	0.2474
DUMMY_POL	α_4	-2134784	5409834	-0.39461	0.6942
DUMMY_IF	α_5	14417329	3886351	3.709734	0.0004*.
R-squared		0.150753			
Adjusted R-squared		0.096315			
Own price demand elasticity	η_D	-0.22338			

*Significant at α = 5 percent; ** Significant at α = 15 percent

In this equation there were two dummy variables. Policy dummy variable (DUMMY_Pol) described conditions where there were non tariff policy (between June 2012 and April 2013) and with tariff policy. During the period of non tariff policy, garlic price rose pretty high, thus the government removed this policy on May 2013, leaving no policy regulating garlic import except a relatively low (5%) import tariff. This dummy is equal to one during the period of non-tariff policy, otherwise zero. Considering the main objective of this policy is to protect domestic production which was predicted to increase, the allowable import quota would be smaller than before. Non-tariff policy will decrease imports and supply, and consumption will also decrease. This is in line with the estimated parameters from the equation which is -2,134,784. This means that non-tariff policy will decrease consumption as much as 2,134 tons per month.

Eid_dummy had a role in describing household's consumption pattern. In general, Indonesian food consumption will rise one month before Eid (Ramadhan month), and after Eid Ul-Fitr up to Eid Ul-Adha, which is about 2 months. The value of dummy will equal to one for two months before and after Eid, and zero for the other 10 months. The size of consumption during Eid months makes the sign of parameter positive as expected, and is in line with the estimation results obtained. Compared with other variables in the equation, Eid dummy variable is the variable that has real and most significant effect to Indonesian garlic demand. Its high significance level can be seen from the value of the probability of DUMMY_IF which is smaller than 1 percent.

The parameters of the factors affecting garlic demand (consumption) can be used to calculate the elasticity of garlic demand. The estimated demand elasticity indicates that garlic demand is inelastic to its own price ($\eta_D = -0.22338$). This indicates that increase in price results in relatively small impact on garlic demand. For Indonesian people, garlic is already consumed as main seasoning for meals. Garlic has turned to basic foodstuffs just like rice and sugar, considering that most of the garlic consumed directly by household as basic seasoning for daily meal. Although the sign of price and demand elasticity is negative, the consumption patterns have stronger influence, thus it can be said that garlic are experiencing transition from normal goods to neutral goods. If the price of garlic rises, then the consumer will slightly reduce their garlic consumption or even continue to maintain its level of consumption. In addition to consumption patterns, things that can affect garlic consumption directly is the application of policies to regulate imports by quota. If the government imposed tough restrictions on the number of imports, then this will directly lowered the level of consumption due to inability of domestic production to meet the demand. Though statistically the estimated equation is not very satisfying and yielding a relatively small coefficients of determination (R^2=15% and Adjusted R^2= 9.6%), since the determination of model is based on economic considerations of all parameters, this model is regarded as the best model that can came for the possibilities.

Supply relation function for garlic in Indonesia was represented by price function estimated based on equation (8). This equation captured the relationship between Indonesian garlic price and its influencing factors: Indoneisan garlic demand (consumption) (QBP), import price for garlic (PM), farm-worker's wage (WAGE), dummy variables for import non-tariff policy (DUMMY_Pol), dummy variables for Eid ul-Fitri (DUMMY_IF), and derivative demand equation to price (QBP*). Most of the parameters of garlic supply function were in line with economic theory, although some were not. The estimation results are outlined in Table 2.

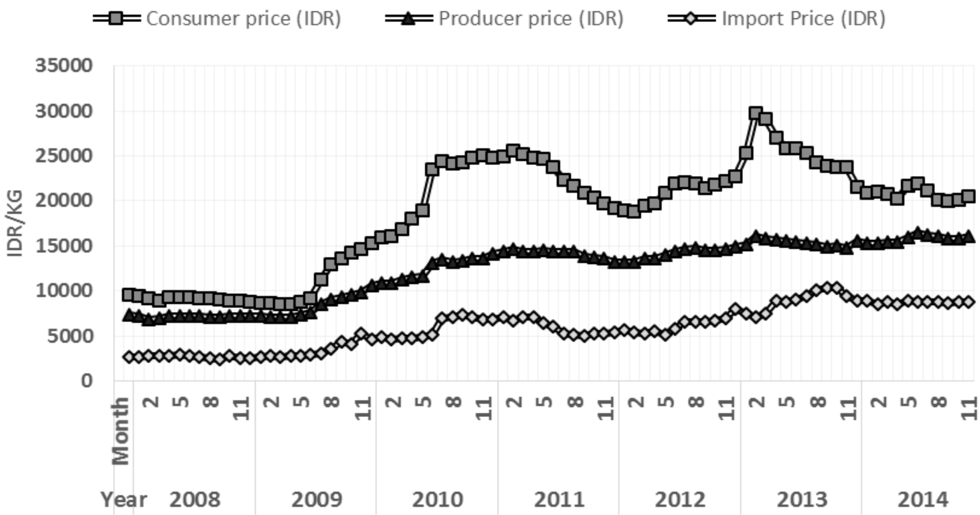
Table 2. Garlic price function estimation model using Bresnahan-Lau static oligopoly.

Variable	Parameter	Coefficient	Std. Error	t-Statistic	Prob.
Constant	β_0	9969.697	5767.61	1.728567	0.0879
QBP	β_1	-0.000625	0.000185	-3.37508	0.0012*
PM	β_2	24100	3220	7.495300	0.0000*
WAGE	β_3	-0.1577	0.160812	-0.98063	0.3298
DUMMY_IF	β_4	400.3026	671.0732	0.596511	0.5526
DUMMY_POL	β_5	4266.866	842.2337	5.066131	0.0000*
QBP*	λ	-0.38411	0.111962	-3.43070	0.0016*
R-squared		0.855939			
Adjusted R-squared		0.844713			
Own price supply elasticity		1.842589			

* Significant at α = 5 person

Garlic consumption negatively affects domestic price. This implies that an increase in garlic consumption will decrease garlic domestic price. The negative relationship is in contrary to the hypothesis where the increase of demand will increase domestic price, since the supplier will try to sell as much as they can. The negative effect of consumption to domestic price allegedly occurs because the equilibrium between supply and demand occurs when the slope of marginal cost is negative. The declining condition of marginal cost indicates that maximum profit condition has not been reached, and additional cost to add more garlic to the market is declining. In this condition, producers (importers) will continue to supply more garlic as long as the demand is increasing. Since most of the supply (95%) was fulfilled from imports, it will encourage import. This situation indicates that existent of higher demand will encourage import and will reduce price, since the cost to supply more garlic is at declining trend.

Garlic import price has a significant positive relationship with domestic price of garlic. This is consistent with our expectation. Since garlic imports hold a very big proportion to the total supply (around 95%), thus domestic price will be significantly affected by the impor price. An increase in import price will result in an increase in domestic price, since import price acts like the main marginal cost of the supply.



Source: BPS 2014

Fig. 4. Garlic price on international level, producer level and consumer level.

Figure 4 illustrates the variability of Indonesian garlic price at consumer, producer and international level (import price) in the period of 2008 to 2014. Price of garlic in all marketing levels have similar trend from time to time. Based on the world market share, Indonesia is the largest importer country and dominating the market for 30% in 2014. Almost all of Indonesian garlic import comes from China, the largest producer and exporter country which haves a share up to 85% in the world export market. Although both China and Indonesia are the largest exporter and importer countries, there are big differences in their market shares i.e., 85% and 30%. This situation shows that China has greatest market power and can influence the garlic prices in Indonesia. Thus, import price level has a big influence on Indonesia domestic price, implying that domestic price will follow the fluctuations in the international prices. If import price increases, domestic price will follow it with a short adjustment time. The lapse of the adjustment time was caused by the loading and unloading process and distribution time to the consumers.

Farmworker wage as the local production input have a negative relationship with domestic price of garlic. The negative relationship is contrary to the hypothesis. The rise on wage will increase the production cost, thus the producer will put a higher garlic price. However, this variable is not significant. It may be caused by low contribution of national production compared to total supply. Indonesia's garlic harvested area is very small, due to the lack of incentive to the farmers to produce garlic. Other competitive commodities such as potatoes or soybean could give better returns to the farmer. Also, these commodities have a relatively low production and marketing risk.

As on the demand equation, the price equation also has two dummy variables, namely Policy dummy and Eid dummy. The estimated parameter shows that import non-tariff policy has significant positive effect on garlic price. The limitation of import will reduce supply, thus the price will increase. Eid dummy has a role in describing household's consumption pattern. In general, Indonesian food consumption will rise one month before Eid (during Ramadhan month) and two months period between Eid ul-Fitr to Eid ul-Adha, so the Eid dummy will equal to one during these periods, otherwise 0. The results indicate that during these periods price will increase or having a positive relationship.

The main objective of this study is to estimate the degree of market power on Indonesian garlic market. Parameter obtained from derivative demand variable (QBP*) is an indicator used to estimate the degree of market power. The results show that the coefficient value is in line with the theory, situated between 0 and -1. The value of λ = 0 means that the suppliers (mostly importers) behave competitively, while if λ = -1 means that supplier behaves as a monopoly or having conspiracy amongst them. Perfect cartel will exploit their market power to gain the highest possible profit. The estimated value of λ is -0.38411, meaning that garlic supplier has low market power to influence the national price and the market structure tends to be loose oligopoly. Though the estimated degree of market power imply that the market structure tends to be loose (weak) oligopoly, the value of λ obtained was pretty high compared to other research using the same Bresnahan-Lau model. Some literature shows that the degree of market power estimated by Bresnahan-Lau model was rather low, such as Steen and Salvaness (1999) with λ=0.019, Zaini (2012) with λ=0.0005, and Busaid (2015) with λ=0.00071. Meanwhile in the banking industry, the estimated degree of market power is even lower such as Lubis (2012) with λ =0.0023 and Chang (2012) with λ =0.0032. In spite of the high value of market concentration and HHI (Herfindahl-Hirschman Index) of these previous studies, the estimated value of λ is not so large. Compared to parameter obtained in this research, although it can be concluded that market structure of Indonesian garlic market is loose oligopoly, but level of competition found is lower than other market. In other word, based on this result can't be used to judge that garlic market in Indonesia is oligopoly.

The social cost of Indonesian garlic trade occurrs due to welfare loss and economic-rent transfers. Welfare loss is due to the import tariffs policy and other policies that raise the market power (non-tariff import policy). Meanwhile, economic rent is transferred from consumers by production and import activities. Economic rent from production activity is received by farmers, while economic rent from import activities is received by importers, sellers and the government. Economic rent received by farmers is due to the difference between producer price and import parity price. Economic rent received by seller is due to the difference between consumer and wholeseller price, while economic rent received by importers is due to the difference between wholeseller and import parity price. Government received income from import tariff as much as 5 percent. The calculation was based on equations (11) to (16).

Table 3 describes the distribution of social costs that arose in Indonesian garlic market in the period of 2008-2014. The biggest social cost was caused by economic rent received by seller and importers, while welfare loss was mostly caused by import tariff policy. Both contributed almost 90 percent of the social cost. More than half of the cost happening in the society was received by marketing agents and importers, while one-third of them were not accepted by anyone. During this period, the average total social cost reached up to Rp 8.9 trillion annually. The highest rise of social cost was during 2009-2010 due to the significant rise in consumption and import. Meanwhile, the highest social cost happened during 2011 to more than Rp 12 trillion. This was caused by large gap between import parity and consumers price.

Table 3. Social cost distribution

Year	Total social cost (billion rupiah)	Economic Rent (%)				Welfare Loss (%)	
		Farmer	Seller	Importer	Government	Tariff Policy	Market Power
2008	4578.91	1.19	53.23	6.63	1.27	33.11	4.57
2009	4935.23	1.50	18.24	41.67	1.36	32.71	4.51
2010	9178.35	0.80	10.53	48.38	1.14	34.40	4.75
2011	12237.40	1.05	38.19	20.14	1.04	34.78	4.80
2012	10311.87	1.39	32.08	26.89	1.21	33.77	4.66
2013	12033.71	0.71	43.43	17.34	1.65	32.40	4.47
2014	9347.39	1.30	44.91	17.90	2.35	29.48	4.07
Mean	8946.12	1.09	34.37	25.23	1.44	33.03	4.56

CONCLUSIONS

Though Indonesia garlic market was controlled by not so many garlic suppliers, the degree of market power exercised by these importers was relatively low, implying that there is not enough evidence for the existance of cartel on garlic market and the market structure tends to be a loose oligopoly. Nevertheless, the estimated market power parameter is pretty high compared to the other market that used the same approach. Indonesia garlic market is characterized by its low price elasticity of demand and relatively high of supply elasticity. This implies that the protective trade policy that leads to the rise of price will not affect the level of garlic consumption. This result suggests that garlic is closer to neutral goods than normal goods, considering that the consumption has no close substitution good.

The social cost of garlic market was pretty high. During 2008-2014 the policy on garlic market has created dead weight loss and economic rent transfer consecutively as large as Rp 3.3 trilion and Rp 5.6 trillion annually. Most of the economic rent was gained by garlic marketing agents and importers, while the dead weight loss was mostly caused by the import tariff applied on garlic.

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REFERENCES

Bikker, J.A. 2003. Testing for imperfect competition on EU deposit and loan markets with Bresnahan's market power model. Research Series De Netherlandsche Bank, Amsterdam.

Bresnahan, T.F. 1982. The oligopoly solution concept is identified. Economics Letters. 10:87-92.

Busaid. 2015. Perburuan Rente Ekonomi dalam Pelaksanaan Program Swasembada Kedelai di Indonesia. Master Thesis, Bogor Agricultural University, Bogor.

Chang SC, Chang JCD and Huang TH. 2012. Assessing market power in the U.S commercial banking industry under deregulation. Economic Modelling. 29: 1558-1565.

Church J. and Ware R. 2000. Industrial Organization: A Strategic Approach. The McGraw-Hill Companies, Inc., The United States of America.

Deodhar, S.Y. and Sheldon, I.M. 1997. Market power in the world market for soymeal exports. Journal of Agricultural and Resource Economics. 22 (1): 78–86.

Hatirli S.A, Jones E, and Aktas A.R. 2003. Measuring market power of the banana import market in Turkey. Turk J Agric. 27:367-373.

Kasijadim F. 1981. Faktor-faktor yang Berpengaruh terhadap Peningkatan Produksi Bawang Putih di Indonesia Timur. Bachelor Thesis, Bogor Agricultural University, Bogor.

Lau L.J. 1982. On identifying the degree of competitiveness from industry price and output data. Economics Letters. 10: 93-99.

Lubis, A. F. 2012. Market power of Indonesian banking. Bulletin of Monetary Economics and Banking 2012. 14(3):226-244.

Ministry of Agriculture database. 2015. Available at http://aplikasi.pertanian.go.id/bdsp/ index.asp [accessible on 13 November 2015]

Móré, C. and Nagy, M. 2004. Competition in the Hungarian banking market. Magyar Nemzeti Bank, Hungary. WP No. 2004/9.

Nathan, E.H. and Neave, A. 1989. Competition and contestability in Canada's financial system: empirical results. Canadian Journal of Economics 22 (3), 576–594.

Panzaru RL and Medelete DM. 2011. International trade with garlic. Scientific Paper Series Management, Economic Engineering in Agriculture and Rural Development, 11(2): 125-128.

Saputro, G.G. 2013. Pemetaan rantai pasokan bawang dan identifikasi penyebab kenaikan harga bawang putih: studi di wilayah Yogyakarta. Master Thesis, Gajah Mada University, Yogyakarta.

Shaffer, S. and Disalvo, J. 1994. Conduct in banking duopoly. Journal of Banking and Finance 18(6): 1063–1082.

Steen F. and Salvanes K.G. 1999. Testing for market power using a dynamic oligopoly model. International Journal of Industrial Organization 17(2):147-177.

Suominen, M. 1994. Measuring competition in banking: a two-product model. Scandinavian Journal of Economics. 96 (1), 95–110

Wibowo, S. 2006. Budidaya bawang putih, bawang merah dan bawang Bombay. Penebar Swadaya, Jakarta.

Widyastuti, R.S. and Armanto B. 2013. Banking industry competition in Indonesia. Bulletin of Monetary Economics and Banking. 15(4):402-434.

Zaini, A. 2011. Analisis ekonomi politik swasembada gula Indonesia: Kombinasi model oligopolistik dinamik dan fungsi preferensi politik. Ph.D Dissertation, Bogor Agricultural University, Bogor.

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Zardkoohi, A. and Fraser, D.R. 1998. Geographical deregulation and competition in U.S. banking markets. Financial Review. 33 (2), 85–98.

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DEVELOPING A LAND SUITABILITY EVALUATION TOOL IN MOBILE ANDROID APPLICATION FOR RUBBER, COCOA AND OIL PALM

Supli Effendi Rahim[1], Ahmad Affandi Supli[2] and Nurhayati Damiri[3]
[1]Agrotechnology Department, Agriculture Faculty, University of Palembang, Palembang Indonesia,.
[2] PhD Program at Faculty of Computer Science, UUM Kedah, Malaysia
[3]Agrotechnology Department, Agriculture Faculty. University of Sriwijaya, Indralaya, Ogan Ilir, South Sumatra Indonesia
Corresponding author: nurhayati@fp.unsri.ac.id

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ABSTRACT

Evaluating land suitability for special purposes e.g. for plantation is a must, to understand important factors to be considered in managing the land successfully. A framework for evaluating the land suitability for purposes in agriculture especially in plantation is first introduced by the Food and Agriculture Organization (FAO) in late 1970s. Using this framework, researchers or land users analyze the suitability of their land, whether it is very suitable or only marginally suitable, or not suitable at all to grow some particular plants. When using the framework manually, it is time consuming and not interesting for land users especially students in agricultural sciences. Available technology in mobile applications nowadays has been suggested in many areas of solving problem. Authors have developed a tool for land suitability evaluation by transforming the FAO framework into smart mobile application. This application is designed by using simple language for each variable (factor) and also by utilizing expert system theory called case base reasoning (CBR) algorithm. The factors that are involved in program are land characteristics such as soil type, depth of soil column, soil fertility, pH, drainage, risk of flood, etc. Suitability in this paper is limited to three plantation crops, namely rubber, cocoa and oil palm. Agro climatic data affecting the suitability of three plantation crops are developed into general and specific criteria for the plants. Computer-based program has been designed and implemented as a means of evaluating the suitability of land for the tree crops. The application is found to be easier to understand and also could automatically determine the suitability of land. Usability testing was also conducted in this study by using usability model, which is designed for mobile application. The results showed from 70 respondents that the usability of the system in this study was in “very good” classification, which is all dimensions are between 3.68 and 4.01. The program is urgently needed by the users, farmers, companies, lecturers, students and government officials to help them more easily manage their land for a better future.

Key words: conformity tool, plantation crops, FAO framework

INTRODUCTION

Indonesia is a vast country. It thereafter requires a tool to evaluate land suitability if one wants to utilize his/her land well. A framework for evaluating land use such as agricultural land and plantations was firstly introduced by FAO (1976). With this framework, land use planners or land users are doing a matching process of their land characteristic data with the standard data for a crop as to evaluate the use of the land whether the land is very suitable for agricultural crop or not (Rahim, 2014).

When using the framework methods for land suitability evaluation manually, it is time-consuming and not at interest of land users including students in agriculture (Rahim, 2014; Rahim *et al*. 2015). Examples of manual evaluation method were research by Hermawan (2011) when the suitability of coal mined lands in PT. Bukit Asam Tanjung Enim was assessed and determined that most of the land in the post-mining land reclamation of coal were suitable for agricultural crops in general. Meanwhile, Rahim (2014) also manually assessed the suitability of the post-mining land for some plantation crops.

The availability of mobile applications for those are most prevalent in the world at present prompted writers to develop more quickly and practical in evaluating of land suitability for a crop. The authors focus on the development of a mobile application as a tool for land suitability evaluation for plantation crops namely rubber, cocoa and oil palm. This application is equipped with a very useful program, especially the students of agricultural sciences. This paper tries to describe the use of mobile applications as a practical and fast tool for land suitability evaluation for several plantation crops, namely rubber, cocoa and oil palm.

This study foresees the need for improvement of the land evaluation making styles among land users as well as among government officers in implementing the tool in evaluating the suitability of lands in general. The tool can offer recommendations which make a clear cut land suitability classification which gives a better classification of the land suitability and list a clear limiting factors which need to be addressed if the land is managed.

THE FAO FRAMEWORK FOR LAND SUITABILITY EVALUATION

A developed tool for land suitability evaluation is made by adapting Land Evaluation framework introduced by FAO (1976 and 2007), with the intention to be useful for land users and land use planners. In this framework for land suitability evaluation as outlined by FAO (1976) and Sys *et al*. (1993) there exist four categories, and four degrees of limiting factors (0-3) i.e. without limiting factor (0), until very severe limiting factor (3), namely:

a. Orders of S and N. Order S indicates that a certain land is suitable for a particular use within a limited time period. Order N indicates that the land is not suitable for a particular use.
b. Classes S_1 - S_3 and N. S_1 Class is a very appropriate for certain use, land that does not have a limiting factor or has only a few minor limiting factor. S_1 is suitable for certain use, land units with light and the limiting factor is not more than one medium divider that can be improved. S_2 is a land with moderate suitability, land units that have more than four light limiting factor and not more than three- limiting medium (moderate) that can be improved. S_3 is less suitable land, land units with more than three limiting factors limiting medium (moderate) and or no more than a severe limiting factor. N is not appropriate potential land, land units that have very severe limiting factors that can be improved.
c. Sub - class declares the type of the limiting factors in each class. In one sub - class can have more than one limiting factors.
d. Units are land suitability unit level is further division of the sub -class based on the magnitude of the limiting factors .

Table 1 presents the criteria for land suitability for plantation crops (rubber, cocoa and oil palm). Criteria in this table cannot be used directly by farmers in order to evaluate the land. Therefore, this table needs to be constructed in a simpler language in the application so it can be easily understood by land use planners or users in general. Such simplification is made in the screen shot section. In fact, variables in the table are transformed into ready-used questions to get an answer from the user. However, not all variables are displayed in the application. This consideration is due to several variables cannot be physically measured, because the number of variables is relatively equal in value between regions or soil types. For example, annual rainfall generally is in the range of more than 2000 mm. The daily air temperature is more than 25 °C.

Table 1. Criteria for land suitability classes of rubber, cocoa and oil palm.

Land characteristics	Limiting factors and land suitability classes			
	S_1	**S_2**	**S_3**	**N1**
Climate condition				
Rainfall	4000-2000	2000-1700	1700-1450	<1250
Temperature (°C)	22-25	20-22	18-20	<18
Topography of slope (%)	0-5	5-8	8-15	15-35
Flood hazard	Fo	F_1	F_1	F_2
Drainage class	Good	Moderate	Poor	Very poor
Texture	ClSL, SClL	SClL	SL,S(f)L	SL,SCl, S(f)
Effective depth (mm)	2000-1500	2000-1000	100-500	<500
Nutrient content:				
- NPK average (kg/ha)	MMM	MLL	LML	-
- CEC (me/10%)	24-16	<16(-)	<16+	-
Base saturation (%)	50-35	60-50	70-60	80-70
C –organic (%)	1,1-1,0	1,0-0,5	<0,5	-
pH	4,5-5,5	5,6-6,5	6,6-7,5	7,6-8,5

Legend: F_O (none), F_1 (light), F_2 (moderate), F_3 (moderate-heavy), CISL (clay sandy loam), SClL (sandy clay loam), SL (sandy loam), S (f)L (sandy (fine) loam), SCl (sandy clay), S (f) (sand, fine). MMM (medium nitrogen - N, medium Phosphor - P, Medium potassium, K), MLL (medium N, low P, low K), LML (low N, medium P, low K), C (carbon), CEC (cation exchange capacity) (Islami and Utomo, 1995; Hermawan *et al*., 2000; Hermawan, 2002; Sitepu, 2007; Rahim, 2014).

Algorithm of expert system - rule based system

Expert system algorithm chosen by Rahim *et al*. (2015) in their paper is a rule-based system (RBS). This is known as an attempt to discern patterns in order to determine the right decisions, so that the suitability of the particular land can be decided correctly. This approach combines the pattern of all the rules meeting that refer to the table as pattern matching and generate conclusions. RBS is an artificial intelligence approach that utilizes the statement "if-then" introduced by Hayes-Roth (1985). The statement "if" here means that certain conditions are resolved, where the statement "it" means when the condition is met the action is stopped or executed.

Every rule has the statement "if-then" was built based review of the literature discussed earlier. Results fired rule is well capable of running other rules related or directly result in the final conclusions (Priti and Rejendra, 2010). Among a group of rules, just some rules are fired which makes the pattern to achieve a particular goal or conclusion. Fired rules are based on the type of facts that are given first, and then reasoning will be processed for the paths to all relevant rules are executed.

Two types of conclusions, which are given by RBS as an expert system, are the forward chaining and backward chaining introduced by Hayes-Roth (1985). Forward chaining is a search method that starts from a group of facts to reach conclusions (Huang, 2009). This method is also known as data-driven, which means that the search of the data that lead to conclusions. Meanwhile, backward chaining is in the opposite way, starting from the goal or conclusion to take the facts in the end. Another name is purpose driven, which means from the destination to data. In this paper, the authors chose forward chaining, because the data coming from the user is requested, then the system will automatically conclude to find the right decision. It is after that, the design forward chaining rules should be depicted in the graph visualization, so what the relevant rules and interpretations can be seen in the algorithm can be done properly. However, it is important to establish all the relevant rules in this paper, so the implication that direction could be lowered further (Rahim *et al*. 2015).

Only a number of variables are displayed in the application. The use of simple language is included in the application. Each of the variables is packaged into a question, which has some details (explanation) so that users can understand the variable and provide an answer. The following screen shots in the next page exhibit the sample of question.

Land suitability of any proposed land is analyzed and measured with three groups dimensions namely (i) land quality identification, (ii) plant requirements, (iii) evaluation process, in selecting land suitability classifications and limiting factors for the proposed crop (Djaenudin, 1995; Rahim, 2003; 2014).

In order to do this, analysis the expert system theory is deployed. Case Base Reasoning (CBR) Theory is chosen as an expert system algorithms in attempting to see the pattern for shaping the calculation issue, so that the suitability towards particular land can be seen. The reason why this theory is selected is due to this approach could see the pattern for each variable and refers to the table as matching value in similarity cases. CBR is an approach which focuses on the role of experience throughout deciphering the future problem (i.e., by reusing from the previous case the problems are solved and also could be from the similarity of the problem that is solved previously) (Leake et al. 1997). Figure 1 displays the concept of the CBR approach.

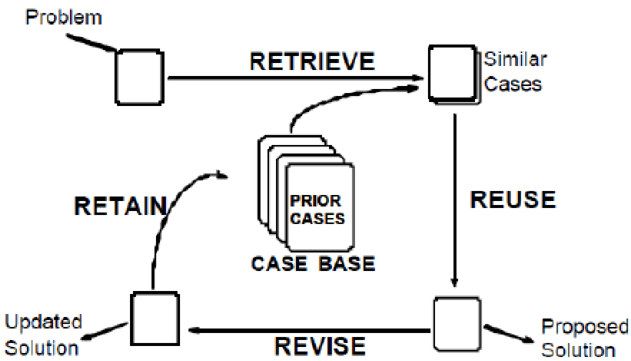

Fig. 1. The process of CBR circle (Aamodt and Plaza, 1994)

Figure 1 shows Aamodt and Plaza (1994) on the model of CBR's cycle. The CBR cycle consists of four main steps: retrieve, reuse, revise, and retain ("4 REs"). This figure explains that first and foremost the data enters as new case problem (retrieve part), and then the flow goes to another phase, which is a comparison case. In this part, the problem value is then compared towards the existing table (FAO theory) that has been stored into the database in order to see the similarity. The similarity here means if the particular problem has biggest similarity toward limiting factors that have been settled in table, then the proposed solution is displayed to the users (reuse part). Lastly, if the proposed solution is suitable, the revision towards new cases could be updated into a new solution that ends up as a retained part in the CBR cycle.

Applications for land suitability evaluation of plantation crops and screenshot

Attempts to use mobile applications for land suitability assessment conducted by Rahim *et al.* (2015) have proven that such a simple and practical means to assess the suitability of the land is possible. Since all land users always find it difficult to do when dealing with large amounts of data coming from the land quality of laboratory analysis of the soil and the availability of data geo-physics and climate throughout Indonesia and in the world. What is important here is that much remains to be done when dealing with agricultural crops. In Rahim *et al*. (2015), a computer program that developed only dealt with general and specific criteria for plantation crops including rubber, cocoa and oil palm. In Indonesia, there are numerous trees that need to be common criteria and especially for crops such as bananas, sugarcane, cashew, coconut, pineapple, rambutan, durian, coffee, pepper, jackfruit, dragon fruit, cloves, breadfruit, sago and others.

Using land suitability assessment methods manually can no longer be recommended. The Indonesian government, in this case, the Department of Agriculture, can no longer be silent without giving a quick solution to provide a tool for land evaluation. The authors, with the help of sponsors, completed a program that is friendly for tablet application and serves as an evaluation tool for the suitability of land for plantation crops in general. This is needed by farmers in remote areas of Indonesia.

Screenshots of results of the application of the program in a tablet are displayed as follows (Fig. 2-6). The application is very straightforward and very easy to run provided the user(s) have appropriate data for the criteria of the land they want to evaluate its suitability. The conclusion for land suitability classes is given promptly.

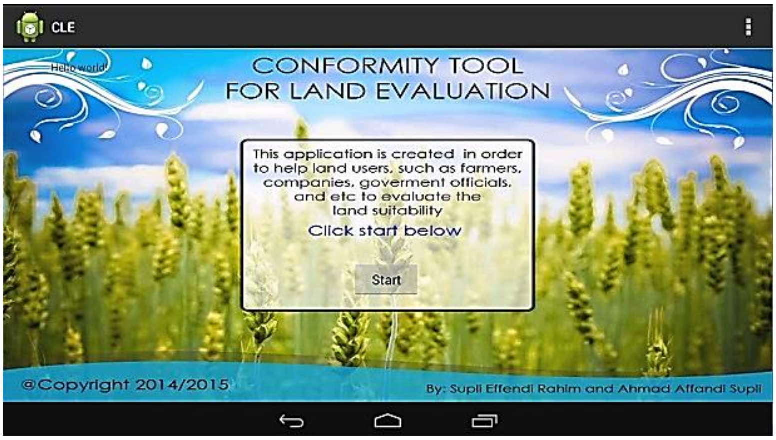

Fig. 2. Main User Interface of Application

Fig. 3. Topography of slopes variable

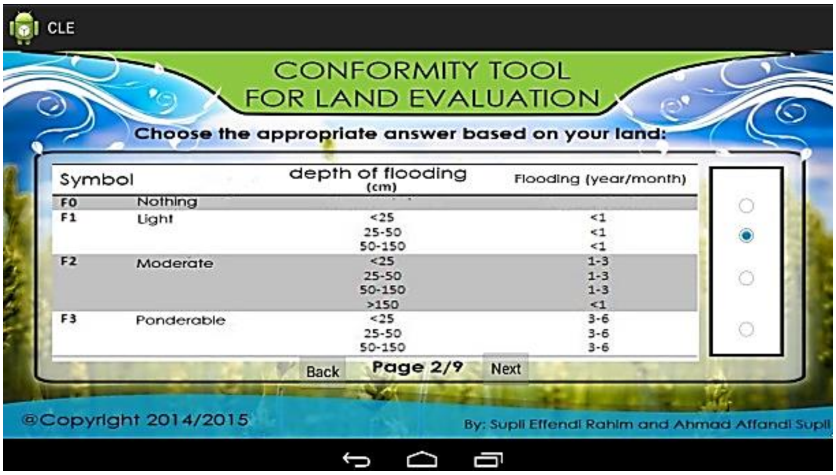

Fig. 4. Flooding variable

Fig. 5. Land texture variable

Fig. 6. Sample of results

Usability of the application

In order to measure the system's usability in this study, the authors adapt a model developed by Hussain *et al*. (2013). This model is chosen due to the usability measurement is specifically designed for mobile application. The usability characteristic in this model consists of three main points, namely effectiveness, efficiency, and satisfaction. In this model, each characteristic is categorized into its own sub-characteristic as well as its guidelines (Table 2). Some types of experiments were conducted in order to measure all of the sub-characteristics. The users have to complete some tasks given. For instance, time taken is about how fast the prototype is after doing a task.

Table 2. Usability characteristic

Quality Characteristic	Sub-Characteristic (Goal)	Guidelines
Effectiveness	**Simplicity**	-Ease to input the data
		-Ease to use output
		-Ease to install
		-Ease to learn
	Accuracy	-Accurate
		-Should be error-free
		-Successful
Efficiency	**Time taken**	-To respond
		-To complete a task
	Features	-Support/help
		-Touch screen facilities
		-Voice guidance
		-System resources info
		-Automatic update
Satisfaction	**Safety**	-While using the application
		-While driving
	Attractiveness	-User interface

Beforehand, convenience sampling was chosen, in which the respondents were obtained from any member of the population who are conveniently available to provide it (Bougie and Sekaran, 2010). Furthermore, Roscoe (1975) stated that in order to determine the sample size, the following rules of thumb could be used:

i. Sample capacities more than 30 and less than 500 are suitable for most research.
ii. For simple experimental research with tight experimental controls, successful research is possible with samples as small as 10 to 20 in size.

Therefore, all in all, this study managed to gather 70 responses to be involved in the experiment. The demography is exhibited in Table 3 below.

All respondents were then required to fill the usability questionnaire that represents all the characteristics mentioned earlier. Prior to this, the users were briefed through slide presentation about the prototype as well as the questionnaire to be filled up at their own pace. They were allowed to ask anything about regarding the questionnaire and how to operate the prototype. The questionnaire used the Likert scale of 5 points (Fig. 7).

Table 3. Demography of respondents' status

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Lecturers	17	24.3	24.3	24.3
	Employees	20	28.6	28.6	52.9
	Students	11	15.7	15.7	68.6
	Farmers	22	31.4	31.4	100.0
	Total	70	100.0	100.0	

In terms of measuring accuracy, respondents are required to fulfill some tasks that are given. After that, they are asked to answer some questions that refer to the following metrics as guidelines, namely:

1. Number of errors
2. Time taken to complete the task
3. Number of tasks successful in given time
4. Number of tasks successful at the first attempt

By using scale of 5 points (Likert scale), they were then directed to give their opinions to measure it.

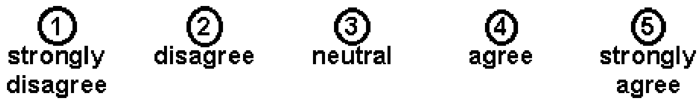

Fig. 7. Linkert Scale 5 Point

All the answers were analyzed by using descriptive analysis frequency in SPSS software. The calculation about mean, minimum, and maximum are analyzed. The results are shown as follows (Table 4 and Table 5):

Table 4. Sub-characteristic statistic results

Statistics							
		Simplicity	**Accuracy**	**Time_Taken**	**Features**	**Safety**	**Attractiveness**
N	Valid	70	70	70	70	70	70
	Missing	0	0	0	0	0	0
Mean		4.0571	3.9381	4.3476	3.1571	3.0524	4.3143
Minimum		2.00	2.00	3.00	2.67	2.67	3.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00

Table 5. Quality characteristic statistic results

Statistics				
		Effectiveness	**Efficiency**	**Satisfaction**
N	Valid	70	70	70
	Missing	0	0	0
Mean		4.0125	3.7523	3.68335
Minimum		2.00	3.00	3.00
Maximum		5.00	5.00	5.00

To interpret the results, the usage of five point scale is used (see table 6).

Table 6. The Five-Point Likert Scale

Gap	**Classification**
1.00 – 1.80	Poor
1.81 – 2.61	Fair
2.62 – 3.41	Good
3.42 – 4.42	Very Good
4.43 – 5.23	Excellent

Based on Table 4, it can be clearly seen that almost all sub-characteristics reached the range of 4.0 and 4.3 points (very good scale) on the average. Meanwhile, the sub-characteristics for feature and safety have lower scores, which is in the range of 3.0 and 3.15 point (good scale) on the average. Nevertheless, the results for the overall average of three main characteristic: effectiveness, efficiency and satisfaction are still included in Very Good scale, which have mean scores of 4.01, 3.75 and 3.68, respectively. It can be concluded that all respondents have very good perspective on the usability of the mobile application.

CONCLUSION

A new solution for land suitability evaluation is simple to run by changing the theory of FAO in smart mobile applications as the appropriate tool in lieu of land evaluation system which is manual. This application is designed with a simple language for each factor and also utilized Based System (RBS), an algorithm rules. Suitability evaluation in this paper is limited to three plantation crops namely rubber, cocoa and oil palm. Agro-climatic data affecting the suitability of three plantation crops are developed into general and specific criteria for the plants. Computer-based program has been designed and implemented as a means of evaluating the suitability of land for the tree crops. In addition, the experimental study was also conducted to test the usability of the system in this study by using a usability model, which is particularly designed for mobile application. The results showed that usability of the system are in the "very good" classification in which the all average means of all characteristic are within the range of 3.68 and 4.01. In the future, this program will be designed accordingly for a tablet as well as for other cross platform technology. The program is urgently needed by the users, farmers, companies, lecturers, students and government officials to help them manage better their land for a better future.

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REFERENCES

Aamodt, A. and Plaza, E. 1994. Case-based reasoning: foundational issues, methodological variations, and system approaches. AI communications, 7(1), 39-59.

Bougie, R. and Sekaran, U. 2010. Research methods for business: A skill building approach. Wiley: London. 421 pp.

Leake, DB, Kinley, A. and Wilson, D. 1997. Learning to integrate multiple knowledge sources for case-based reasoning. Paper presented at the IJCAI (1). pp. 246-251.

Djaenuddin, DF. 1995. Evaluation of land for alternative crop development direction in support of agribusiness activities. Research Center for Soil and Agro-climate. Bogor. 145 pp.

FAO. 1976. A Framework for Land Evaluation. Soil Resources Development and Conservation Service Land and Water Development Division, Food and Agriculture Organization of the United Nations. Published by arrangement with the Food and Agriculture Organization of the United Nations. 72 pp.

FAO. 2007. *State of the World's Forests 2007*. Food and Agriculture Org. Rome, Italy. 151 pp.

Hayes-Roth, F. 1985. Rule-based systems. *Communications of the ACM, 28* (9), 921-932.

Hermawan, B., Hasanuddin, B. Saleh and SSM. Rambe. 2000. Assessment of fertilizer and water requirements specific to the irrigation area in the province of Bengkulu. Cooperation report Installation Agricultural Research and Technology Assessment (IP2TP) Bengkulu with the Research Institute of the University of Bengkulu. 65 pp.

Hermawan, B. 2002. Basic Soil Physics. Lembaga Penelitian UNIB Press, Bengkulu. 104 pp.

Hermawan, B. 2011. Improving the quality of mined land through revegetation and suitability as crop lands. Proceedings of the National Seminar on Agriculture. Urgency and Control Strategy of Agricultural Land Transfer Function. Bengkulu July 7, 2011. ISBN 978-602-19247-0-9.

Huang, H. 2009. Designing a knowledge-based system for strategic planning: A balanced scorecard perspective. *Expert Systems with Applications*, 36(1)209-218.

Hussain, A., Hashim, N. L., Nordin, N. and Tahir, HM. 2013. A metric-based evaluation model for applications on mobile phones. *Journal of ICT*, *12*, 55-71.

Islami, T. and WH. Utomo. 1995. The relationship of soil, water and plants. IKIP Semarang Press. 123 pp.

Rahim, SE. 2003. Soil Erosion Control. Publisher PT. Bumi Aksara. Jakarta. 146 p.

Rahim, SE. 2014. A land suitability classification for post-mining land of PT. Bukit Asam Tanjung Enim South Sumatra Indonesia. Paper presented in Seminar of Post-mining Land in Indonesia. University of Sriwijaya. 11p.

Rahim, SE., A.A. Supli, N. Shiratuddin, Nurhayati and Z.S. Mukti. 2015. A confirmity tool for land evaluation in android mobile application. Paper presented in IJCIMBI 2015, Banda Aceh Indonesia, 27-28 April 2015. 11 pp.

Priti Srinivas, S. and Rajendra, A. 2010. Knowledge-Based Systems for Development. *Advanced Knowledge Based Systems: Models, Applications and Research, S. Priti Srinivas and A. Rajendra, Editors*.

Roscoe, JT. 1975. Fundamental Statistics for the Behavioural Science. *New York: Holt*. 483 pp.

Sitepu, A. 2007. Evaluation of the suitability of land for oil palm plantations (*Elaeis quenensis* Jacq), cacao (*Theobroma cacao*) and rubber (*Hevea brasilensis*) in rural districts Belintang, Sei Bingei Langkat district. Department of Soil Science, Faculty of Agriculture, University of North Sumatra, Medan. 52 pp.

Sys, C. V., Ranst, E., Debaveye, J. and Beenmaert. 1993. Land evaluation part III. Crop requirements. General administration for development cooperation. Placedu Champ de Mars 5 bte 57-1050 Brussels-Belgium. 274 pp.

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A PROTOCOL FOR TRANSPORT OF MANGO PULP WEEVIL, *Sternochetus frigidus* (Fabricius) (COLEOPTERA: CURCULIONIDAE) IN THE PHILIPPINES

Louella Rowena J. Lorenzana[1] and Glenda B. Obra[2]
[1]Department of Agriculture - Regional Field Office MIMAROPA, 3rd Flr. ATI Bldg., Elliptical Road, Diliman 1101, Quezon City
[2]Philippine Nuclear Research Institute - Department of Science and Technology, Commonwealth Ave., Diliman 1101, Quezon City, Philippines
Corresponding author: louelladejesus@yahoo.com

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ABSTRACT

A protocol was developed to send live quarantined pest mango pulp weevil (MPW), *Sternochetus frigidus* (Fabr.) (Coleoptera: Curculionidae) inside mango, *Mangifera indica* L. (Anacardiaceae) fruits for irradiation tests. The insects were reared in the Mango Pulp Weevil Research Laboratory, Brooke's Point, Palawan Island, in western Philippines and sent to the Philippine Nuclear Research Institute (PNRI) in Luzon mainland by plane. The protocol included harvesting, packing and transporting infested mango fruits under guard of a Plant Quarantine Officer until the fruits reached the PNRI. Twelve batches of MPW infested mango fruits were transported following this protocol. A total of 12,199 pieces of MPW infested mango fruits were sent to PNRI of which about 2,500 fruits contained larvae, 2,500 pupae and 7,199 MPW adults. The MPW-infested fruits contained an average of 2.6 adults per fruit and an average of 1.3 immatures.

Key words: quarantine pest, 'carabao' mango

INTRODUCTION

The mango pulp weevil (MPW), *Sternochetus frigidus* (Fabricius) (Coleoptera: Curculionidae), first reported in the south of Palawan Island in 1987, is a quarantined pest that has prevented the export of mangoes from the Philippines to the U.S. except from Guimaras Island which is certified pulp weevil-free. The Palawan Island Group has been placed under quarantine since 1987 to prevent the spread of the pest to other mango growing areas in the country. The life history of this pest has been studied (De Jesus and Gabo, 2000).

The mango fruit industry can be expanded thru the development of quarantine treatments to permit exports. Irradiation is a potential quarantine treatment for mango pulp weevil since this treatment could prevent adult emergence or sterilize mango pulp weevil. If this treatment is effective and approved it will help open U.S. markets to mango exports from the Philippines outside of Guimaras Island. In 2013, the Philippines ranked eleventh in world production of mangoes, mangosteens and guavas with a production of 831,026 tons and a net production value of $497.9 million. Among the ASEAN countries, the Philippines ranked 3rd next to Thailand 3,141,950 tons ($ 1,882.6 million) and Indonesia 2,058,607 tons ($ 1,233.4 million) (FAOSTAT, 2013).

In the Philippines, the only irradiation facility is located at the Philippine Nuclear Research Institute (PNRI) in Quezon City in the Luzon mainland. In order for MPW to be tested for irradiation the supply of a large number of test insects was needed. In this study a protocol for the transport of test insects from an MPW -infested and quarantined area was established and the actual transport of a large number of MPW- infested fruits from the quarantined area (Palawan) to PNRI in Quezon City was completed using the protocol.

Shipments of plant materials have to comply with applicable international and national phytosanitary regulations. It should also not conflict with existing international agreements and legislative regulations. The existing guideline for transport and preparation for shipment covers only live wild animals and plants by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), supported by the United Nations Environment Programme (UNEP) (CITES, 2016). The guideline for plant specimens includes the advance arrangements for transport, packaging, labeling and documentation of live plant specimens.

MATERIALS AND METHODS

A. Approval of protocol for transport of MPW-infested fruits for research

A protocol for harvesting, packing and transport of weevil-infested mango fruits from Brooke's Point, Palawan about 192 km south of the capital, Puerto Princesa City (PPC) to the PNRI is shown in Figure 1. The protocol was based on the MPW life history and field infestation (De Jesus and Cortez 1998; De Jesus and Gabo 2000). The protocol was presented in a seminar at the Bureau of Plant Industry (BPI), Malate, Manila before the BPI Director, Plant Quarantine Chief and Quarantine Heads of all Ports of Entry in the country. The protocol was reviewed, finalized, and approved for implementation by the BPI Director.

B. Mass Rearing of MPW

Adult MPW were periodically collected from infested mango fruits in the field to establish and maintain a 10,000-weevil stock culture in the Mango Pulp Weevil Research Laboratory (MPW Lab) in Brooke's Point, Palawan. Mass rearing of MPW was conducted in the laboratory and on mango trees in the field following the method of Lorenzana and Obra (2013).

Fruit samples were dissected to ascertain weevil development following the method of De Jesus and Gabo (2000).

C. Harvesting, Packing and Transporting of Fruits to PNRI

In the field when the developing mango fruits with weevils reached green mature fruit stage and the desired developmental stage of MPW (adult and immatures [pupae, larvae]) these were harvested, packed then transported to PNRI following the approved protocol (Figs. 1). The harvesting schedule was based on the life history data from the studies of De Jesus and Gabo (2000) and Lorenzana and Obra (2013). Seven batches of adult MPW-infested fruits and 5 batches of immature MPW-infested fruits were sent to PNRI.

Data was gathered on the number of weevils per fruit out of the 10% sample per batch. Weight of boxes of fruits, weight of crates at the MPW lab, PPC airport (Fig. 2 and 3), Ninoy Aquino International Airport (NAIA) Cargo Terminal and PNRI were recorded then validated by the Plant Quarantine Officer (PQO) to ensure that there was no switching of crates during transport of MPW-infested fruits.

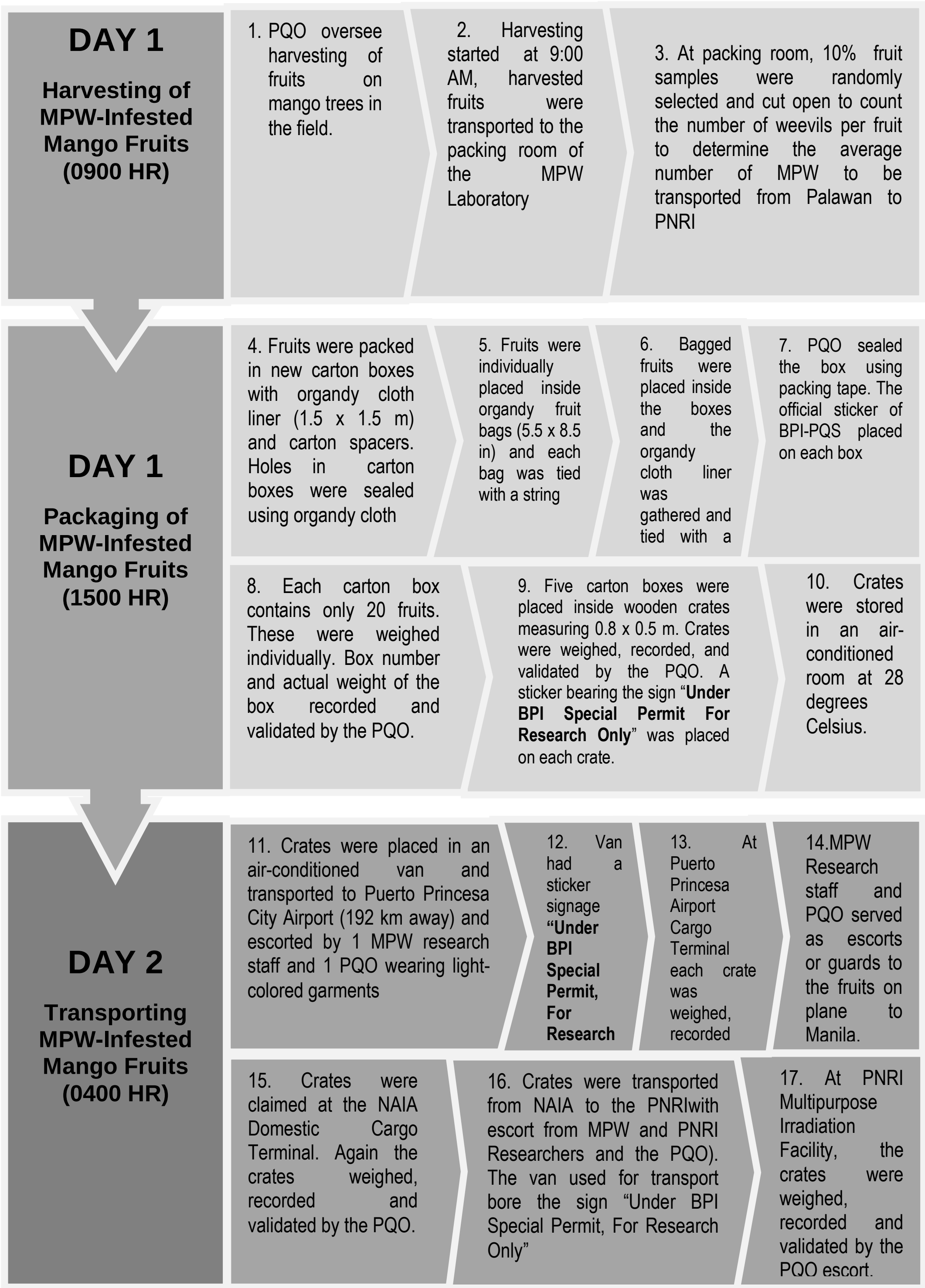

Fig. 1. Protocol for packing and transporting of MPW infested mango fruits to PNRI for irradiation tests.

Fig 2. Packing of MPW infested mango fruits in carton boxes at the Laboratory.

Fig. 3. Weighing of crates containing boxes of MPW infested mango fruits at Puerto Princesa City Airport - Cargo Terminal.

RESULTS AND DISCUSSION

A. Harvesting, Packing and Transporting of Fruits to PNRI

Harvesting, packing and transporting of fruits are shown in Fig. 1 strictly following the approved protocol (Table 1). All activities were under the supervision of a PQO who ensured that no missing or switching of crates full of MPW-infested mango fruits during the transport process until the MPW-infested fruits reached its final destination at the PNRI

A total of 7,199 adult MPW-infested fruits were transported to PNRI in six batches (Table 1). An average of 2.6 adults per fruit were sent to establish the dose for quarantine treatment of *S. frigidus* (Obra *et al*., 2013; 2014).

Table 1. Total number of fruits sent to PNRI and average number of adult weevils per fruit per batch.

Batch No.	No. of Fruits Sent to PNRI	Average No. of Weevils per Fruit*
1	700	2.1
2	700	4.6
3	999	3.7
4	1,100	1.5
5	2,500	1.8
6	1,200	2.1
Total	7,199	2.6

*Data was gathered based on additional 10% fruit samples per batch.

The weight of each crate of mangoes infested with MPW adults packed from the MPW Lab slightly decreased when it reached PNRI in all of six batches (Table 2). This decrease in weight could be due to transpiration or moisture loss from the fruits during the period of transport that took approximately 10 hrs.

Table 2. Average weight of crates containing mangoes infested with MPW adults recorded at MPW Lab, Puerto Princesa Airport, NAIA Domestic Cargo Terminal and PNRI.

Batch No.	Average Wt. of Crates (kg)			
	MPW Lab	Pto Prin Airport Cargo Terminal	NAIA Domestic Cargo Terminal	PNRI
1	25.9	25.1	25.8	25.8
2	26.4	25.9	26.3	26.2
3	26.4	25.6	26.2	26.0
4	32.3	32.1	32.0	32.0
5	28.5	28.3	28.1	28.1
6	29.8	29.3	29.0	28.9

At the NAIA Cargo Terminal the weight of the crates have slightly increased compared to the weight at PPC Cargo Terminal in the first 3 batches. The slight increases in the weight of crates may be due to the different calibration of the weighing scales used in both cargo terminals. This discrepancy was avoided in the subsequent batches when the researchers brought the same weighing scales used at the MPW Lab to the cargo terminals for measuring the weight of crate. The successful transport of mangoes infested with adult MPW led us to proceed with the transport of mangoes infested with immature MPW. A total of 5,000 mangoes infested an average of 1.3 immature MPW per fruit were sent to PNRI in five batches (Table 3).

In the five batches of mangoes infested with immature MPW the average weight of a crate of mangoes (26.5 kg) packed from the MPW Lab also slightly decreased when it reached PNRI (26.1 kg) apparently due to transpiration (Table 4).

This is the first time that quarantined pests in large volume and in several batches from an infested area has been allowed transport to a non-infested area in the country for research purposes and where the entire procedure has been carried out successfully. The key here is the good understanding of the pest biology and behavior so that a sound transport protocol was crafted. Also notable was the good team effort from the MPW and PNRI researchers with the PQO.

Table 3. Total number of fruits sent to PNRI and average number of immature (larvae and pupae) MPW per fruit per batch.

Batch No.*	No. of Fruits Sent to PNRI	Average No. of Weevils per Fruit **
1	900	0.9
2	1,600	1.2
3	800	1.2
4	800	1.6
5	900	1.6
Total	5,000	1.3

* Weevils at larval stage were sent in batches 1 and 2, pupae on batches 3-5.

** Data was gathered based on additional 10% fruit samples per batch.

Table 4. Average weight of crates of mangoes with immature (larvae and pupae) MPW recorded at MPW Lab, Puerto Princesa Airport, NAIA Domestic Cargo Terminal and PNRI.

Batch No.	Average Wt. of Crates (kg)			
	MPW Lab	Puerto Princesa Airport	NAIA Domestic Cargo Terminal	PNRI
1	26.4	26.2	26.0	25.9
2	26.1	26.0	25.8	25.8
3	28.1	28.0	27.9	27.8
4	25.3	25.2	25.1	24.9
5	26.5	26.2	26.1	26.1

CONCLUSION

The protocol for the transport of MPW-infested mango from Palawan that is a quarantined area to PNRI has been established. This made possible the conduct of the research trials for the establishment of radiation dose for quarantine treatment of *S. frigidus*.

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REFERENCES

De Jesus, L.R.A. and F. Cortez. 1998. Field infestation and chemical control of the mango pulp weevil, *Sternochetus frigidus* (Fabr.), in Palawan. Philipp Agric 81: 131-140.

CITES. 2016. Transport guidelines of live specimens. Retrieved from https://cites.org, November 3, 2016.

De Jesus, L.R.A. and R.R. Gabo. 2000. Life history and host range of the mango pulp weevil, *Sternochetus frigidus* (Fabr.) in Palawan, Philippines. Philipp Agric Sci 83 :145-150.

FAOSTAT. 2013. Food and Agricultural commodities production/commodities by regions. Food and Agriculture Organization of the United Nations Statistics Division, Retrieved from http://faostat3.fao.org, September 23, 2016.

Lorenzana, L.R.J. and G.B. Obra. 2013. Mass rearing technique for mango pulp weevil, *Sternochetus frigidus* (Fabr.) (Coleoptera: Curculionidae). J ISSAAS. 19: 75-81.

Obra, G.B., S.S. Resilva and L.R.J. Lorenzana. 2013. Irradiation as a potential phytosanitary treatment for the mango pulp weevil *Sternochetus frigidus* (Fabr.) (Coleoptera: Curculionidae) in Philippine super mango. Philipp. Agric. Sci. 96: 172-178.

Obra, G.B., S.S. Resilva, P.A. Follett and L.R.J. Lorenzana. 2014. Large-scale confirmatory tests of a phytosanitary irradiation treatment against *Sternochetus frigidus* (Coleoptera: Curculionidae) in Philippine mango. J Econ Entomol. 107: 161-165.

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EMISSIONS OF VOLATILE ORGANIC CHEMICALS OF BROWN SEAWEED, *Sargassum cinctum* J. AGARDH (SARGACEAE) IN RELATION TO BEHAVIOR, LARVAL DEVELOPMENT, FECUNDITY AND LONGEVITY OF THE ASIAN CORN BORER, *Ostrinia furnacalis* (GUENEE) (LEPIDOPTERA:CRAMBIDAE)

Marcela M. Navasero*, Susan May F. Calumpang, and Maria Josefina S. Casas
National Crop Protection Center-Crop Protection Cluster, College of Agriculture,
University of the Philippines Los Banos, College, Laguna, 4031, Philippines
*Corresponding author: mmnavasero@up.edu.ph

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ABSTRACT

The behavioral responses of Asian corn borer (ACB) larvae and adult oviposition, effect on development, fecundity, hatchability of eggs and longevity to the brown seaweed, *Sargassum cinctum* J. Agardh, was studied to elucidate the mechanism for reduced ACB populations in corn (*Zea mays* L.) with brown seaweed hanged on the plant as practiced by farmers. The study was conducted from September to December 2015 at the National Crop Protection Center, College of Agriculture, University of the Philippines Los Baños. The methods included rearing pan and Petri plate bioassays to determine possible effects of volatile organic chemicals (VOCs) emitted by brown seaweed. Our results demonstrated that neonates and second instar larvae were apparently repelled by VOCs emitted by *S. cinctum*. VOCs did not affect significantly larval development, post developmental periods, fecundity and longevity of adult male and female *O. furnacalis.* Egg hatchability and larval survival were likewise not significantly affected by VOCs from the brown seaweed.

Key words: rearing pan and Petri plate bioassays, repellency, volatile organic chemicals

INTRODUCTION

Corn (*Zea* *mays* L.) is the second most important cereal crops of the Philippines, next to rice, and is used for food, feed and fodder in the country. It is sown in an area of about 2.5 million ha with a total annual production of 7.5 million metric tons and national average yield of 2.9 tons per ha (Philippine Statistics Authority, 2016).

Like in other crops, pests and diseases cause substantial losses to corn crop. The Asian corn borer (ACB), *Ostrinia furnacalis* (Guenee), is the most prevalent and serious insect pest of corn. Infestation, establishment and survival of the first and second instar larvae occurred during the whorl stage while the older instars (third to the fifth) prefer the leaf sheath (Magsino, 1995). The young larvae injure the young leaves and later instars bore into the stem, tassels, stalks and ears of the corn plant causing tremendous damage resulting in yield reduction ranging from 20 to 80% (Sanchez, 1971).

In rice, farmer observation involved the lower population of green leafhopper (GLH), *Nephotettix virescens* (Distant), an important vector of tungro, a major disease of rice, when stalks of tagbak [*Alpinia elegans* (C. Presl.) K. Schum] are staked into the rice paddies to control rice insect pests. Likewise, kakawate, *Gliricidia sepium* (Jacq.) Walp. along rice paddies, some farmers believe can reduce rice insect pests in the fields. The chemical bases for these phenomena were due to the presence of repellent compounds in headspace emissions by tagbak (Calumpang et al. 2013) and kakawate (Calumpang et al. 2014).

Likewise, the Asian corn borer is repelled by a plant volatile, 1-methyl propyl disulfide, which is emitted by both corn and a weed closely associated with corn, *Ipomoea triloba* L. The emission is increased significantly when corn is entwined by the weed, which provided the chemical basis for the population reduction of corn borer in corn fields with *I. triloba* (Calumpang et al. 2000). And, through farmers' initiatives seaweeds are used in the coastal areas of Bondoc Peninsula to repel ACB (Dr. Romulo Davide, personal communication) to repel ACB and minimize the harm caused by the pest and cut their input costs on the use of expensive insecticides.

Seaweeds are macroscopic algae occurring in the marine and brackish water habitats and considered primary product of marine ecosystems. They are mainly found in the intertidal and the sub-tidal region up to a depth where 0.01% photosynthetic light is available (Dometila et al. 2013). Seaweeds are considered as important marine living resources and are utilized by humans as the only source of phytochemicals, namely: agar-agar, algin and carrageenan, which are extensively used in various industries such as food, confectionary, textiles, pharmaceuticals, dairy and paper industries mostly as gelling, stabilizing and thickening agents (Kaliaperumal et al. 1989). Also, these are used as herbal medicine, fertilizer, fungicides, and herbicides (Aguilera-Morales et al. 2005; Cardozo et al. 2007; Kumar et al. 2014); as food for their vitamin, protein, mineral, fiber, and essential fatty acids contents (Ortiz et al. 2006).

The Philippines, having a coastline of 36,289 km, contains some of the world's richest ecosystems, with extensive coral reefs, sea-grass beds, and dense mangrove forests and high diversity of marine life (http://www.census.gov.ph). In particular, the Bondoc Peninsula in Quezon province, consists of 12 coastal towns, and the Gulf of Ragay provides favorable environments to a wide variety of seaweeds, including *Sargassum cinctum* J. Agardh, a species of brown algae that also abounds in the country (Trono 1992) and used by some farmers to repel ACB in their corn fields.

In other countries like India, its coastline of more than 7,000 km, supports a rich floristic diversity, occurring mainly in coastal areas with rocky substratum or rich with corals (Cheema et al. 2014). In particular, the Gulf of Kutch, possesses a zone of 7,300 km^2 of a system of creeks, marshy tidal flats and rocky coral reefs which provide favorable environments to seaweeds and other marine forms (Guiry 2016 as cited in Guiry and Guiry 2016).

Chemical analysis of the headspace volatiles of corn consisted of C_{21}-C_{27} straight chain hydrocarbons but a drastic reduction in the emissions of these corn volatiles was observed when corn was entwined with *Ipomoea triloba* reducing the inherent attractancy of corn to *O. furnacalis*. The presence of a volatile organic repellent was likewise established (Calumpang et al. 2000). Other reports showed that non-host plant volatiles interfere with orientation to the host plant and affect the olfactory, feeding and oviposition behavior of major insect pests and even natural enemies (Brevault and Quilici 2010; Bruce et al. 2000; Finch and Collier 2000; Forbes and Feder 2006; Koschier et al. 2000; van Tol and Visser 2002). Biologically active plant volatiles maybe used in the development of integrated pest management strategies (Koschier et al. 2002; Calumpang et al. 2013, 2014).

In the present study, we determined the effect of brown seaweed volatile chemicals emitted from fresh leaves of *S. cinctum* on the host-finding behavior of neonate ACB and other larval instars in Petri plate bioassays. Furthermore, we examined the effect of seaweed volatiles on larval development and survival, fecundity and hatchability of eggs as well as lifespan of male and female adult ACB.

MATERIALS AND METHODS

Insects and seaweeds

Eggs, larvae and pupae were collected from the field and brought to the laboratory for sorting, rearing and holding. Larvae were reared until pupation using established diet. Eggs were held in plastic plates lined with moistened filter paper until the black-head stage and when about to hatch these were placed on ACB diet for rearing until pupation. Pupae were kept in emergence cage and allowed to mate and lay eggs. These served as parental stock for mass rearing ACB in the laboratory. The stock culture is the source of insects for various experiments in the laboratory. The initial ACB population used in the study was collected from the Central Experiment Station, College of Agriculture, University of the Philippines Los Baños (UPLB). Larvae and pupae collected in field plots at the National Crop Protection Center, College of Agriculture, UPLB, served as source of additional materials for rearing/ stock culture.

The seaweed samples used in various experiments were obtained from Catanauan, Quezon Province, Philippines. These were used as fresh material or air dried. The seaweed was identified as brown seaweed, *Sargassum cinctum* J. Agardh, by Dr. Garmino C. Trono, Professor Emeritus, Institute of Marine Science, University of the Philippines Diliman, Quezon City, Philippines

Behavioral responses of neonate(1st), 2nd, 3rd and 5th instar ACB to *S. cinctum*

Petri plate bioassay. Behavioral response(s) to seaweed by neonate ACB larvae was monitored. Thirty ACB neonates were placed individually in Petri plate (9cm inside diameter and 2cm in height) with a piece/slice of immature corn fruit (3cm diameter and 3mm thick) at the middle of the plate as larval food. In another set-up, the same number of neonate ACB (30) was likewise placed singly in a Petri plate with a slice of corn fruit embedded with three leaflets of seaweed. In each treatment, the behaviour of the larva from the time of release inside the Petri plate was monitored, whether it settled down and fed on the corn fruit or moved away and wandered about the cover of the plate. The data gathered were as follows: 1. Time spent before settling down on corn, 2. Time spent feeding on the corn fruit, 3.Time spent immobile on corn fruit or walls of the plate.

In another experiment, 30 second instar larvae of ACB, were placed individually in Petri plate with a slice of young corn fruit in the middle (T1). Additional 30 more plates were prepared, each containing a slice of young corn fruit at the middle and three leaves of seaweeds were embedded on the fruit (T2). In each treatment a single larva was released at the side of the plate and the remaining plates were inoculated in the same manner. In both treatments, each released larva was observed or monitored for settling down and feeding on the larval food given. The time spent from the time it was released on the side of the plate until it settled down and feed were observed and recorded. The same set-up and data gathered were also used for the third and fifth instar larvae of ACB.

Effect of *S. cinctum* on larval development

Rearing pan bioassays. Thirty neonate larvae were placed in group in a plastic rearing pan (21.2 cm in length x 14.8 cm in width and 9.4 cm in height with aeration window in the cover**)** lined with tissue paper at the bottom. The bottom of the pan was lined with about 50g of fresh seaweed, after which three pieces of young corn fruit (20cm long and 3cm in diameter) were placed on top and more seaweeds were placed on top of the fruits. During the first day, the behaviour of the neonate was observed and recorded. A similar set-up was prepared, this time, seaweed was not included. Again, thirty neonate larvae were placed inside the pan and observed in the same manner as in the first set-up. Food or corn fruits were replaced with fresh ones when necessary. The experiment was replicated three times. Data gathered were durations, in days, of development periods of larvae and per cent survival until pupation.

In Petri plate bioassays, 30 neonates were placed singly in Petri plate with a piece of young corn fruit at the center as food (T1, without seaweed). Another set of 30 neonates were similarly placed in Petri plates with three leaflets of brown seaweed (T2). Daily thereafter, the set-up was observed twice a day for molting and when food was not sufficient due to rotting and accumulation of feces, this was replaced. Data gathered were durations, in days, of developmental periods of larvae and per cent survival until pupation.

Effect of *S. cinctum* on fecundity and longevity of adult ACB

Fecundity or the number of egg masses and number of eggs per egg mass laid in a lifetime of adult ACB females was monitored. Emerged female ACB in the rearing pan experiment were placed individually in mylar film cages (8.5cm inside diameter x 11cm in height) and paired with a male from the same rearing pan. In the seaweed treatment, the bottom of the cage was lined with 2cm high seaweed before the female adult and its pair was released. Provision for food of the adults consisted of 10% sugar solution in cotton wad suspended inside the cage with a paper clip. The number of egg masses and eggs per egg mass were recorded per female per treatment. Likewise, hatchability of eggs was also taken.

Longevity of male and female adult, on the other hand, was taken as the number of days the adults are alive, reckoned from the time the adult emerged till death.

Sex ratios of emerged adults from seaweed treatment and corn alone were also determined.

Statistical Analysis

The data obtained in the Petri plate and rearing pan bioassays were analyzed statistically and significant differences of means were determined using Independent Sample T-test (SAS Institute 2001).

RESULTS AND DISCUSSION

Comparative responses of neonate (1^{st}), 2^{nd}, 3^{rd}, and 5^{th} larval instars ACB to volatiles from leaves of *S. cinctum* and corn fruit

Time lapse before settling down on corn. The time lapsed for settling down by the neonate, 2^{nd}, 3^{rd} and 5^{th} instar larvae on either corn fruit or corn fruit with detached leaves of brown seaweed showed significant statistical differences for the neonate and second instars larvae but not to the bigger 3^{rd} and 5^{th} instar larvae (Fig. 1). However, the 3rd instar larvae took much shorter time to settle on corn alone than in corn plus brown seaweed while the 5^{th} instar larvae did not appear to be affected by the presence of seaweed on corn. The 3^{rd} and 5^{th} instar larvae were not repelled by the brown seaweed.

In contrast, it took longer time for the neonates to settle on corn with brown seaweed, and 10% did not settle at all and died. The 2^{nd} instar larvae took the longest time to settle with an average of 100 minutes to settle down on corn with seaweed, but all settled down. These results suggest that these early larval instars were repelled by the VOCs emitted by the brown seaweed. Under these conditions, the larvae, could have chosen to feed on whatever food sources away from corn with seaweed.

The reduced feeding damage of ACB larvae in the fields with brown seaweed was possibly due to neonates and 2nd instar larvae ballooning away from corn when repelled by VOCs emitted by the brown seaweed. The same behavior was observed in European corn borer when exposed to synthetic green leaf volatiles which was repellent at high concentrations (Piesik et al. 2013).

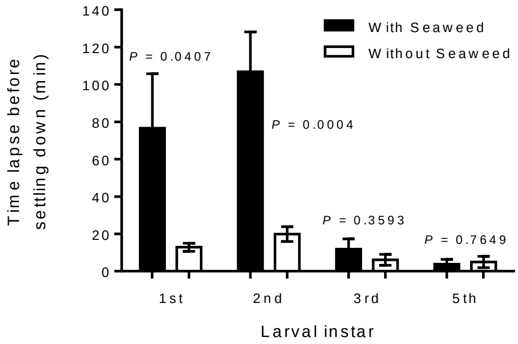

Fig. 1. Mean time lapse (±SE)(min) for settling of *O. furnacalis* on corn and seaweed in no-choice test using corn fruit slices and detached leaves of *S. cinctum* in Petri plate arena (t-test; p-value <0.05 was considered significant).

Feeding responses of larvae on corn and corn plus brown seaweed. Neonates and 2nd instar larvae fed voraciously on any part of the corn fruit without brown seaweed. However, when brown seaweed was embedded on the corn fruit, the larvae fed on the sides and at the bottom, which further showed that the young larvae were repelled by the volatile chemicals emitted by the brown seaweed. Third and 5th instar larvae, however, fed voraciously on corn with or without seaweed and some fed on the brown seaweed which further showed that bigger and mature larvae were not repelled and this may be related to the feeding habit of boring through the stem, tassel and ear shank of corn in the field.

Effect of *S. cinctum* on larval development

Rearing pan/Petri plate experiments. Slight variation in the mean total larval developmental periods, which were 14.8d in the treatment without seaweed and 15.7d with seaweed, in the male ACB was noted in the rearing pan experiment (Fig. 2). In the female, there was also very slight variation in mean total larval periods which was 16.7d in treatment without seaweed and 16.7d with seaweed. However, there was higher mortality of the larvae in the seaweed treatment than in the control treatment (without seaweed). Moreover, there were more males in the seaweed treatment or a sex ratio of 2 males:1 female. Conversely, in the control treatment, there were more females than males or a sex ratio of 1 male:1.3 females. This may indicate the differential effect of seaweed on the female ACB causing their premature death which may have impact on reproduction. This suggests, with fewer female adults, there will be fewer individuals to lay eggs and therefore population build-up will less likely to occur in the field.

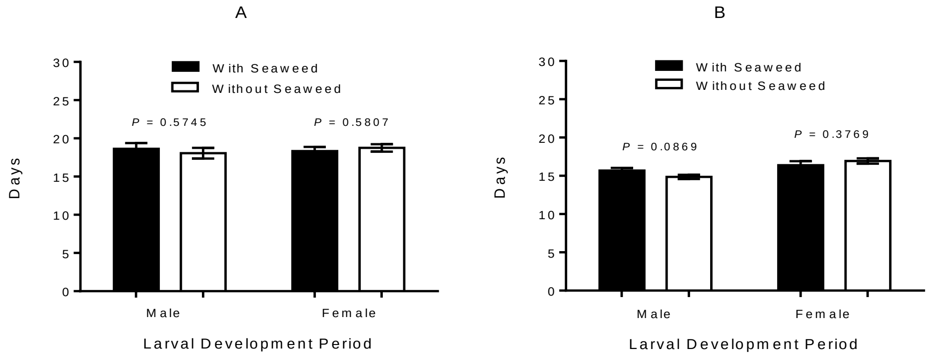

Fig. 2. Mean (±SE) development time of larvae of *O. furnacalis* in rearing pan (A) and Petri plate (B) arena (t-test; p-value<0.05 was considered significant).

Effect of *S. cinctum* on post developmental periods of ACB

In terms of post development of adult female ACB, particularly pre-oviposition, oviposition and post oviposition periods, only slight variation existed between the seaweed treatment and the control in the rearing pan experiment (Fig. 3A). Similar trend was also observed in the Petri plate experiment (Fig. 3B). This means that these traits of the adult female ACB are not easily affected by the seaweed treatment and possibly these traits are inherent to the species.

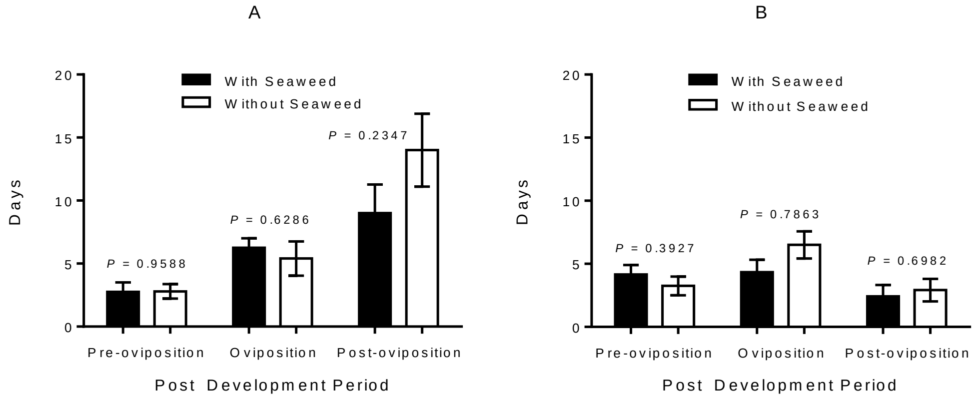

Fig. 3. Mean (±SE) post developmental periods (in days) of *O. furnacalis* in rearing pan (A) and Petri plate (B) arena (t-test; p-value<0.05 was considered significant)

Effect of *S. cinctum* on fecundity and hatchability of eggs of ACB

The fecundity in terms of number of egg masses and number of eggs per egg mass of female ACB reared on corn fruit or corn fruit with detached leaves of brown seaweed showed insignificant statistical differences for those reared in the rearing pan or Petri plate (Fig. 4). However, those reared in the rearing pan with or without the brown seaweed laid more egg masses and eggs per egg mass than those reared in Petri plates. Nevertheless, hatchability of eggs was greater without the brown seaweed in both rearing pan and Petri plate bioassays.

The reduced feeding damage by ACB larvae on corn in the field entwined with brown seaweed can be further explained by reduced hatchability of eggs.

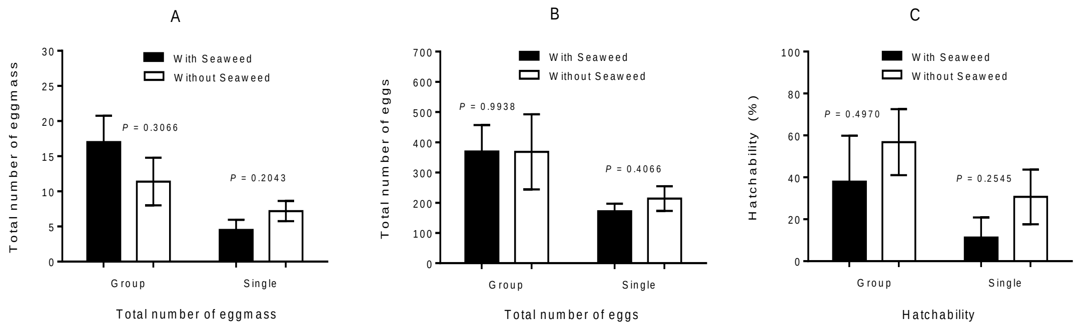

Fig. 4. Mean (±SE) number of egg mass (A), total number of eggs (B) and hatchability of eggs (C) in *O. furnacalis* reared in group (rearing pan) or singly (Petri plate) with and without seaweed, *S. cinctum* (t-test; p-value<0.05 was considered significant).

Effect of *S. cinctum* on longevity of ACB

The lifespan of male and female adult ACB was longer in the rearing pan than in the Petri plate bioassays (Fig. 5). In both bioassays, females lived longer than males. Also, male and female adults in both bioassays without seaweeds lived longer since they feed on the sugar solution. Whereas those in the seaweed treatment did not, as manifested by wetter cotton balls, suggesting that these adults were repelled in the presence of VOCs emitted by brown seaweed. .

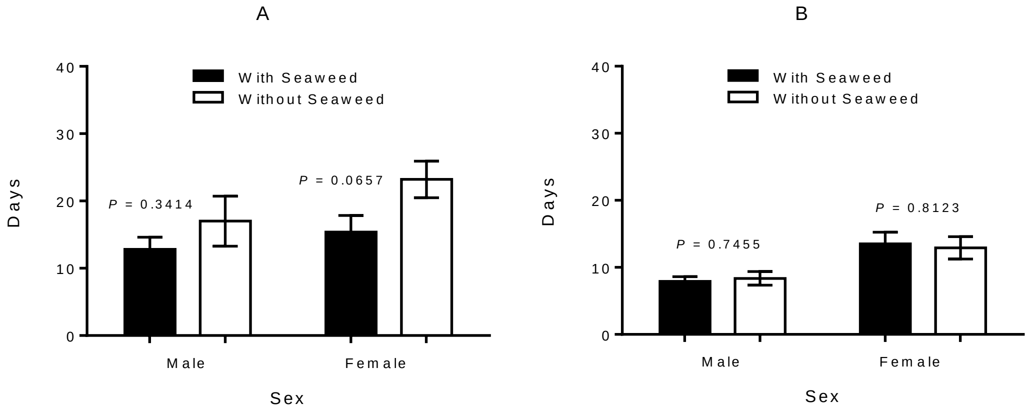

Fig. 5. Mean (±SE) longevity by sex in *O. furnacalis* adults_reared in group (rearing pan) (A) or singly (Petri plate) (B) with and without seaweed, *S. cinctum* (t-test; p-value<0.05 was considered significant).

CONCLUSION

The behavioral response and repellent reaction of the neonates and second instar larvae of *O. furnacalis* to the volatiles from detached leaves of *S. cinctum* provide evidence for an interaction between visual and olfactory stimuli during host finding in this pest. VOCs from brown seaweed repelled neonates and second instar as well as adult female ACB, thus promoting escape through "ballooning" of the larvae and prevent mating and oviposition of repelled adults. The use of the brown seaweed for ACB management in corn can be promoted to reduce dependence on synthetic insecticides and as a useful strategy in organic corn production. This farmer innovation is a pest management option that resource poor corn farmers can utilize in areas where brown seaweeds are accessible.

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REFERENCES

Abou-el-Wafa, GSE, KA. Shaaban, MEE. El-Naggar and M Shaaban. 2011. Bioactive constituents and biochemical composition of the Egyptian brown alga *Sargassum subrepandum* (Forsk). Rev. Latinoamer. Quím: 39(1-2): 62-74

Aguilera-Morales M, Casa-Valdes M, Carillo-Dominguez S, Gonzales-Acosta B. and Perez-Gil F. 2005. Chemical composition and microbial assays of marine algae, *Entomorpha* spp. As a potential food source. Journal of Food Composition and Analysis, 18:79-88.

Brevault T and Quilici S. 2010. Flower and fruit volatiles assist host-plant location in the tomato fruit fly *Neoceratitis cyanescens.* Physiol Entomol 35: 9-18.

Bruce TJA, Wadhams LJ, Woodcock CM 2005. Insect host location: a volatile situation. TRENDS Plant Sci 10(6): 269-274.

Calumpang, SMF, JR Medina, K Ohsawa, T Mitsui and H Honda. 2000. Chemical basis for the population reduction of the Asian corn borer on corn entwined with *Ipomoea triloba* L. J. International Society for Southeast Asian Agricultural Sciences (ISSAAS). 6:28-42.

Calumpang SMF, Burgonio GAS, Navasero MM and Navasero MV. 2013. Behavioral and olfactory responses of rice green leafhopper, *Nephottetix virescens* (Distant) to volatile cues from tagbak (*Alpinia elegans* (C. Presl) K. Schum). Phil J. Sci 142(2): 167-173.

Calumpang SMF, Navasero MM, Burgonio GAS and Navasero MV. 2014. Repellency of volatile organic chemicals of kakawate, *Gliricidia sepium* (Jacq.) Walp., to rice green leafhopper, *Nephotettix virescens* (Distant) (Hemiptera: Cicadellidae). Philipp. Agric. Scientist. 97(2):21-27.

Cardozo KH, Guaratini T, Barros MP, Falcao VR, Tonon AP, Lopes NP, Campos S, Torres MA, Souza AO, Colepicolo P, Pinto E. 2007. Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology. 146(1-2):60-78.

Cheema J, Bhattacharya A, Saini I and Aggarwal A. 2014. Study of seaweeds diversity of port 'Okha' in winter. New York Science Journal 7(9): 21-26. http:/www.sciencepub.net/newyork. Accessed May 6, 2016.

Dometila C. Brintha T, Sakumaran S, Jeeva S. 2013. Diversity and distribution of seaweeds in the Mutton coastal waters, south-west coast of India. Biodiversity Journal 4: 105-110.

Ghada SE, Abou-Elwafa Khaled A, Shaaban Mohamed EE, EL Naga Mohamed Shaaban. 2011. Bioactive constituents and biochemical composition of the Egyptian brown alga *Sargassum subrepandum* (Forsk). Rev. Latinonoamer Quim. 39:1-2.

Finch S. and Collier RH. 2000. Host plant selection by insects- a theory based on 'appropriate/inappropriate landings' by pest insects of cruciferous plants. Entomol Exp Appl 96: 91-102.

Forbes AA and Feder JL. 2006. Divergent preferences of *Rhagoletis pomonella* host races for olfactory and visual fruit cues. Entomol Exp Appl 119: 121-127.

Guiry, MD and Guiry, GM. 2016. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 06 May 2016.

Kaliaperumal N, Chennubhotla VSK and Kalimuthu S. 1987. Seaweed resources of India. CMFRI Buu. 14: 51-99.

Koshier EH, De Kogel WJ and Visser JH. 2000. Assessing the attractiveness of volatile plant compounds to western flower thrips, *Frankliniella occidentalis.* J. Chem Ecol. 26:2643-2655.

Kumar JLN, Barot M, and Kumar RN. 2014. Phytochemical analysis and antifungal activity of selected seaweeds from Okha Coast, Gujarat, India. Life Sciences Leaflets. 57-70.

Magsino GL. 1995. Influence of weed vegetation on the population dynamics of the Asian corn borer, *Ostrinia furnacalis* (Guenee). PhD Dissertation, College of Agriculture, Gregorio Araneta University Foundation, Metro Manila.

Ortiz J, Romero N, Robert P, Arraya J, Lopez-Hernandez J, Bozzo C, Navarrete E, Osorio A. and Rios A. 2006. Dietary fiber, amino acid, fatty acid and tocopherol contents of the edible seaweeds *Ulva lactuca* and *Durvillaea antarctica*. Food Chemistry. 99:04

Philippine Statistic Authority. 2016. Palay and Corn: Volume of Production, 1987-2015 (A00PNVCP). http://countrystat.psa.gov.ph/selection.asp; Accessed on 06June 2016.

Piesik D, Rochat D, Delaney KJ and Marion-Poll F. 2013. Orientation of European corn borer first instar larvae to synthetic green leaf volatiles. J. Appl. Entomol. 234-240.

Sanchez FF. 1971. The economics of corn borer control in the Philippines. In Proceedings of the 7th Inter-Asian corn improvement workshop, University of the Philippines College of Agriculture, College, Laguna, Philippines. 272p.

SAS Institute. 2001. SAS/STAT 9 User's Guide 2001. SAS Institute, Cary, NC.

Thirunavukkarasu R, Pandiyan P, Subaramaniyan K, Balaraman D., Manikkam S., Sadaiyappan B., Jothi GEG. 2014. Screening of marine seaweeds for bioactive compound against fish pathogenic bacteria and active fraction analysed by gas chromatography–mass spectrometry. Journal of Coastal Life Medicine; 2(5): 367-375.

Trono JR., G. 1992. The genus *Sargassum* in the Philippines. In Taxonomy of Economic Seaweeds with reference to some Pacific and Western Atlantic species. (Abbot, I.A. Eds.) Vol. 2, pp 43-94. La Jolla, California: California Sea Grant College.

van Tol RWHM and Visser JH. 2002. Olfactory antennal responses of the vine weevil, *Otiorhynchus sulcatus* to plant volatiles. Entomol Exp Appl. 102: 49-64.

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COST OF ORGANIC CERTIFICATION IN THE PHILIPPINES: BOON OR BANE TO ORGANIC FARMERS?

Ma. Eden S. Piadozo,[1]* Flordeliza A. Lantican[1], Isabelita M. Pabuayon[1] and Nina Nocon-Shimoguchi[2]
[1]Department of Agricultural Economics, College of Economics and Management, University of the Philippines Los Baños, College, Laguna, 4031, Philippines
[2] Department of International Bio-Business Studies, Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture
*Corresponding author: mspiadozo1@up.edu.ph

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ABSTRACT

The enactment of the Organic Agricultural Act of 2010 or RA 10068 in 2010 and its full implementation in 2016 requires all organic produce to be sold in the market to have the organic seal or label. The study determined why organic palay (paddy rice) and vegetable farmers' still have low certification, and are reluctant to have their farm certified. A total of 78 full organic palay and 98 organic vegetable farmers in Region 3 (Central Luzon) and Region 4 (Southern Tagalog), Philippines was included in a survey conducted in 2011. The result of the study showed that small-scale farmers cannot afford to have their farms certified by a 3rd party due to their small volume of production and low farm price received. This will not be viable for farmers who are only in the transition stage and have low yield. Since the Participatory Guarantee System (PGS) has already gained consumer acceptance, the government needs to reconsider the internal control system as a means of certifying organic farms so as not to jeopardize the milestone the organic movement has already attained in the country.

Key words: organic agriculture, 3rd party certification, break-even price, profitability

INTRODUCTION

In the Philippines organic agriculture only emerged in the early 1980s mainly in response to the negative effect of the green revolution. Efforts to promote it were through the initiatives of farmers, private institutions/individuals and academe, who strongly stressed the need for alternative methods to conventional farming. Moreover, it also addressed the consumers' call for alternative lifestyle. It was only in 2010 that Republic Act 10068 or the Organic Agricultural Act of 2010 was enacted into law to promote the organic agriculture in the country. The law defines organic agriculture as "all agricultural systems that promote the ecologically sound, socially acceptable, economically viable and technically feasible production of food and fibers. Organic agriculture dramatically reduces external inputs by refraining from the use of chemical fertilizers, pesticides and pharmaceuticals" as derived from the International Federation of Organic Agricultural Movement (IFOAM) Standards (IFOAM 1998).

Unlike in other countries, there is still limited statistics available on organic agriculture (OA) in the Philippines. In 2010, only 79,992 hectares were organically-managed areas which accounted for only 7% of the total agricultural land while there were 16 processors and 21 exporters (Willer and Lernoud 2012). With regards to certification, there are already two local organic certifiers in the country duly accredited by the Department of Agriculture-Bureau of Agriculture and Fisheries Standards (DA-BAFPS), namely Organic Certification Center of the Philippines (OCCP) and Negros Island Certification Service (NICERT). However, it was found that almost no studies have been made with regard to certified operators. The recent enactment of the Organic Agricultural Act of 2010 specified the guidelines on organic labeling and certification. However, with the well-grounded policies related to conventional farming, the need for organic agriculture training by agricultural extension workers, limited support to existing small organic farmers, high certification cost and other related issues, the organic law seemed to fail in mainstreaming organic agriculture. As a result, the implementation of the organic law was extended to 2016. With this year's full implementation of the law, are organic farmers ready to sell their organic produce with the attendant label? Hence, this paper aims to determine the status of the farmer's organic certification and discuss the reason why organic farmers still have low certification and are reluctant to have their farm certified.

A certification system guarantees the quality and production process of organic products. Since consumers cannot visually distinguish between organic products and chemically-grown products, a certification system is required. This also enables organic producers to penetrate markets.

In the long run, certification enhances market access and stability through longer term contractual arrangements. Farmers are able to establish stable business relationships with their clients with greater bargaining power due to perceived less risk and greater transparency in their negotiations (Dragusanu et al. 2013). In Côte d'Ivoire the good practices applied by cocoa farmers gained the trust of their outlets thereby improving their access to markets (Krain et al. 2011).

A review however of developing countries' efforts in organic agriculture pointed out the weakness of institutional support for nurturing existing knowledge and exchange in organic agriculture (Scialabba and Hattam 2002). Although farmers are aware of some of the basic facts of farming, they were not aware of all the aspects related to certification and standards given by different agencies (Singh and George 2012).

Country report on organic agriculture (Sarmiento 2007); study on organic production practices production and constraints confronting organic agriculture (Piadozo and Quicoy 2009, Piadozo et al. 2014); and documentation of organic vegetables production and supply chain improvement (Conrado 2010, Mojica and Cresino 2010, Sim, Llanes, and Cungihan 2010, and Malab 2011) in the Philippines likewise pointed out these observation. These support the argument that farmers in developing and transition countries still face institutional and economic constraints to reach the stage of being certified organic producers, making it particularly costly for smallholders to participate in this market (Santacoloma 2007). Case studies of organic jasmine rice farms in Thailand showed that due to the high initial costs in the initial set-up phase of two years the benefit of organic certification for both the cooperative and farmers' level are negligible (Vitoon 2007). The increase in costs for developing countries are due to increase in labor costs resulting from more labor-intensive plowing, postharvest handling and processing activities. Moreover, the greater administrative and organization efforts, documentation processes, supporting, monitoring and inspection systems and setting up of farm accounting systems add up to these costs (Santacoloma 2007).

MATERIALS AND METHODS

The study covered selected provinces from Region 3 (Central Luzon), namely: Zambales, Tarlac, Nueva Ecija, Bulacan, Pampanga, and Bataan and Region 4 (Southern Tagalog) with the provinces of Cavite, Laguna, Batangas, Quezon, Rizal, Oriental Mindoro, and Marinduque. The regions are significant production sites for palay (paddy rice) and vegetables. Regions 3 and 4 contribute about one-fourth of the total volume of palay produced and 22.1% of the total area harvested to palay in the Philippines. They have a combined share of 30% and 28% of total production and area harvested for the selected vegetables. Except for a few farmers who were not available during the survey, almost all of the palay and vegetable organic farmers in these two regions were interviewed for the study.

A total of 78 full organic palay and 98 organic vegetable farmers were included in this survey. These farmers have access to organic technology primarily from research institutions and the academe such as the University of the Philippines Los Baños (UPLB) and Central State Luzon State University (CLSU). Farmers' cooperatives and producer groups that could collectively support organic farming are also present in the area. These areas are the production sites of organic agriculture based on previous studies.

The palay farmers were classified into benchmark and typical based on 3.74 metric tons per hectare (mt/ha) palay yield reported for organic farmers who belonged to the *Magsasaka at Siyentista Tungo sa Pag-unlad ng Agrikultura* (MASIPAG). The latter is a farmers' organization whose members were among the pioneers in organic palay farming in the country. Respondents whose yields are at least 3.74 mt/ha were benchmark farmers; those below the said yield were typical farmers. On the other hand, the benchmark for the organic vegetables is as follows: eggplant (7.61mt/ha), string beans (16mt/ha), tomato (8.07mt/ha), lettuce (17mt/ha), cucumber (5.38mt/ha), squash (3.53mt/ha), and okra (10mt/ha) based on the Bureau of Plant Industry (BPI) organic yield. The cost and returns and break-even analyses, and profit-cost ratio were used in determining whether farmers can afford to certify their farms. Information from a certified vegetable farm was also collected to further clarify the effect of certification.

RESULTS AND DISCUSSION

Certification System

A certification system guarantees the quality and production process of OA products. Since consumers cannot visually distinguish between OA products and chemically-grown products, a certification system is required. This also enables OA producers to penetrate markets.

The organic certification systems can be classified as follows: 1st party, 2nd party and 3rd party certification. In the *1st party certification*, the producer with installed internal control system claims that the farm is organic. This system of certification exists in areas or communities where the producer and consumer know each other and the farm or processing activity is open for consumer inspection.

A form of 1st party certification, which is viewed as contentious by other parties is the group-claimed certification or community-based certification system known as *Participatory Guarantee System (PGS)* which is widely practiced in the study areas. This is a system by which the group or its members do certification using their own standards or inspection system. This arrangement is done at the community level or by individual groups of farmers. It is said that self-claimed certification can suffice if the market size is small and concentrated in a local area. According to the International Federation of Organic Agriculture Movements (IFOAM) these participatory systems are perceived as more credible than individual ones, and are able to deliver a higher volume of produce to a wider market.

The *2nd party certification* occurs when the consumer verifies the production system and farmer/processor adheres to the standard set by the consumers. Consumers inspect the farms before a marketing agreement and activity takes place. This type of guarantee system sits in a situation where there is an organized consumer and producer group. In many countries including the Philippines, the 2nd party certification takes place when many NGOs and traders continue to maintain close contacts with farmers by acting as trading agents, and also providing consumers with information about farmers and their production processes to consumers. This is a type of arrangement wherein a trading agent ensures product quality. The degree of effectiveness then depends largely on the trading agent's reputation. Meanwhile, the 3rd *party certification* takes place when a third party without direct interest in the economic relationship between the supplier and the buyer issues the certification. The certification is the formal and documented procedure by which a third party assures that the organic production standards are followed. As the international trade of organic products continued to expand, a more standardized system of certification was developed.

In the Philippines, transaction of organic agricultural products and processed foods is usually done through 1st party or 2nd party certification, indicating that producer-consumer relationship is vital in every transaction. However, the PGS is widely adopted by organic farmers. And there is a clamor among small farmers that this type of certification be adopted in the country even if the Organic Law has already established the 3rd party certification as a way of certifying organic products in the country.

Status of Organic Certification

As shown in Table 1, there are only two (2) local and seven (7) foreign certifying bodies operating in the country. The two local organic certifiers, Organic Certification Center of the Philippines (OCCP) and Negros Island Certification Service (NICERT), were duly accredited by the DA-BAFPS. Although only recognized locally, both certifying bodies are seeking equivalence with other standards in Japan, US and Europe to penetrate other major markets.

For the meantime, OCCP resorted to partnership with international certifying bodies such as CERES CERT (Germany) to assist in exporting organic products. Partnership between local and international certifiers may lessen the cost of certification compared to 100% operation by international certifiers (Sarmiento 2007).

Table 1. List of third-party certifiers in the Philippines

Particulars	Country of Origin	Certification Standard(s)
Local Certifiers		
Organic Certification Center of the Philippines [1]	Philippines	PNSOA
Negros Island Certification Service	Philippines	PNSOA
Foreign Certifiers		
ECO CERT	France	EU Standards, US NOP, JAS Organic
CERES CERT	Germany	EU Standards, US NOP, JAS Organic, Global GAP
Naturland	Germany	EU Standards, US NOP, IFOAM BS
SGS	Switzerland	ISO Guide 65/ EN4501 by Dutch RVA
DoalNara	South Korea	IFOAM Basic Standards
Certification Alliance	Thailand	EU Standards, US NOP, JAS Organic
BCS-OEKO	Germany	EU Standards, US NOP, JAS Organic

Note: [1]OCCP is the local partner of CERES CERT.
Sources: Sarmiento 2007, Cabigas and Morala 2011

Table 2 shows that as of May 2012, OCCP and NICERT had certified only 14 and 12 operators respectively. Most of them were company farms but there were only a few palay and vegetable producers for both certifying bodies. Under OCCP, there were two certified farmer groups namely, a cooperative in Benguet province and another in Bicol region, and were due for renewal. However, the former showed no commitment of renewal. OCCP new applications comprised mainly of organic fertilizer companies. Given this low number of certified farms and the number of suspended/cancelled applications, there is a need to study the issues of certification and potential of Participatory Guarantee

System (PGS) to address also the concerns of small-scale farms which engaged into organic rice and vegetable production.

Table 2. Number of certified operators in the Philippines, May 2012

Certifier	Operators		Number of Farms by Commodity	
	Total	Farms	Rice	Vegetables
OCCP				
Certified	14	8	2	5
Renewal	7	7	1	2
New Application	44	1	1	1
Suspended/Cancelled	12	5	-	3
NICERT				
Certified	12	10	2	6
Renewal	-	-	-	-
New Application	-	-	-	-
Suspended/Cancelled	-	-	-	-

Note: There were multiple answers
Sources: NOAP, 2012

Table 3 shows that not one of the organic palay farmers in Regions 3 and 4 was able to secure a 3rd party certification. Majority (86%) of the palay farmer-respondents interviewed was certified through an Internal Control System (ICS) or Participatory Guarantee System. Only 14% had 2nd party certification. There were more farmers in Region 3 that have this 1st party certification compared to Region 4 where 26% of the farmers are 2nd party certified. However, the distribution of respondents by type of certification is more or less similar for both benchmark and typical farmers.

Table 3. Distribution of organic palay farmer-respondents by type of certification by farm classification in Regions 3 and 4, Philippines, 2012 (n=78)

Certification	Benchmark		Typical		All	
	No.	%	No.	%	No.	%
Region 3						
1st Party	19	95	22	96	41	95
2nd Party	1	5	1	4	2	5
Total	20	100	23	100	43	100
Region 4						
1st Party	15	75	11	73	26	74
2nd Party	5	25	4	27	9	26
Total	20	100	15	100	35	100
Both						
1st Party	34	85	33	87	67	86
2nd Party	6	15	5	13	11	14
Total	40	100	38	100	78	100

Source: Survey data, 2011.
Note: Benchmark and typical palay farmers refer to those have at least 3.74 mt/ha yield or below 3.74 mt/ ha yield, respectively.

On the other hand, only 2% of the 98 organic vegetable farmers identified for this study acquired 3rd party certification (Table 4). Eighty six percent have 1st party certification, majority through an Internal Guarantee System (IGS) or PGS while the rest, are 2nd party certified. There are more farmers in Region 4 who have PGS certification compared to Region 3. Both regions have one benchmark farmer each who has a 3rd party certification from the OCCP. No typical farmer has obtained any 3rd party certification. Tarlac province has the highest 2nd party certified members while the following provinces have a modest proportion of OA farmers with PGS certification: Marinduque (37%), Quezon (35%) and Batangas (23%). Baras, Rizal, the recipient of OA support and training in the past spearheaded by a UPLB team, has 27% 1st party certified farmers.

Table 4. Distribution of organic vegetable farmer respondents by farm classification and by type of certification in Regions 3 and 4, Philippines, 2012

Certification	Benchmark		Typical		All	
	No.	%	No.	%	No.	%
Region 3						
1st Party	4	57	10	56	14	56
2nd Party	2	29	8	44	10	40
3rd Party	1	14	-	-	1	4
Total	7	100	18	100	25	100
Region 4						
1st Party	17	94	53	96	70	96
2nd Party	-	-	2	4	2	3
3rd Party	1	6	-	-	1	1
Total	18	100	55	100	73	100
Both						
1st Party	21	84	63	86	84	86
2nd Party	2	8	10	14	12	12
3rd Party	2	8	-	-	2	2
Total	25	100	73	100	98	100

Source: Survey data, 2011.

Note: Benchmark vegetable farmers refer to those who have yield of 7.61mt/ha for eggplant, 16mt/ha for string beans, 8.07mt/ha for tomato, 17mt/ha for lettuce, 5.38mt/ha for cucumber, 3.53mt/ha for squash, and 10mt/ha for okra. Typical farmers have yield lower than those mentioned.

Cost of Certification

In the Philippines, the organic agriculture industry is largely comprised of small farmers thus organic certification is viewed as a potential barrier to entry to these farmers. This will burden them with increased costs of certification. With the enactment of RA 10068 in 2010 and to be fully operational in 2016, farmers fear that they cannot market their produce anymore as organic without the organic seal. Thus it is inevitable that they have to pay the costs associated with certification. OCCP offers certification for producers (farm, livestock and poultry), processors and group certification. Since the application fee and inspection fee are fixed at PhP 2,000 and PhP 5,000, respectively, the minimum fees that OCCP charges are PhP 27,000 for producers and processors, while PhP 32,000 for group certification (Table 5). Certification is only valid for 12 months and subject for renewal. For group certification, additional inspection fee of PhP 1,000 per farm is charged. It should be noted that other incidental expenses (e.g. travel and accommodation of inspectors) are still not included. It may take six months to have a farm certified.

Table 5. Payment fees for OCCP certified farms/activities (valid for 12 months subject for renewal)

Fee	Amount (PhP)			
	Producer	Processor	Production and Processing	Group Certification
Application fee	2,000	2,000	2,000	2,000
Certification fee	20,000	20,000	40,000	25,000
Inspection fee	5,000	5,000	5,000	5,000

Source: OCCP, 2011

The question is, can organic farmers cope with the high cost of certification? Can they pay it? For this purpose, the effect of certification on the farm's profitability was undertaken for this study. This was done for uncertified benchmark and typical farms, and an OCCP certified farm. Typical farms represent farms operated by small-scale farmers i.e. farmers with lower yield vis-à-vis benchmark farmers. For vegetables, those included in the analysis were common to all farms: eggplant, string beans, tomato, lettuce, ampalaya, cucumber, squash, and okra. The fixed and variable costs incurred in the vegetable production were determined. On the cost of certification, the application fee of PhP 2,000 and certification cost of PhP 20,000, were apportioned to the total farm area while the inspection fee of PhP 5,000 was charged for every vegetable planted in 1,000 m^2. This is the same method applied to palay farmers. Since there are no certified farms for palay, the certification cost was added to their production cost. The break-even analysis was used to determine if their selling price and volume produced are below or above the break-even price and quantity. Price and quantity have a bearing on the farmers' total revenue and how can these cover the farmers' expenses.

As shown in Table 6, the 3rd party certification has generally brought down the profit of both the palay benchmark (large scale) and typical (small-scale) farmers. The increase in cost due to certification reduced the benchmark farmers' profit for every peso invested in farming from 0.57 to 0.19 or a decrease in their net returns from PhP 19,330/ha to only PhP 8,865/ha. On the other hand, the typical farmers' losses further increased with the cost of certification from PhP 860/ha to PhP 14,056/ha. The result of the study shows that small-scale farmers are the ones who cannot comply with the high cost of certification as borne out by literature (Vitoon 2007, Santacoloma 2007, Dragusanu et al. 2013). This will not be viable for farmers who are only in the transition stage and therefore will be hard pushed in coping up with the added cost of certification. As borne out by this study, these palay farmers to break even, have to increase their production by almost 5 times which is quite impossible to attain in the very short run.

Palay farmers largely sell their produce in paddy form. Second, they usually sell their produce in their localities or conventional markets. Benchmark farmers, because of the larger volume sold, are paid an additional PhP 1.00/kg while typical farmers, PhP 0.50/kg. If they wish to receive higher prices for their produce, palay farmers need to adopt value addition services (drying, milling and transporting) and tap niche markets which offer high prices for milled organic rice instead of selling in conventional markets.

Table 6. Break-even analysis for a benchmark and typical organic palay farm, with and without certification in Region 4, Philippines, 2011.

Item	Without Certification		With Certification	
	Benchmark	Typical	Benchmark	Typical
N	20	15	20	15
Gross Returns (PhP/ha)	53,025	22,335	56,560	23,139
Fixed Cost	20,844	16,726	34,844	30,726
Variable Cost	12,851	6,469	12,851	6,469
Total Cost (PhP/ha)	33,695	23,195	47,695	37,195
Net Returns (PhP/ha)	19,330	-860	8,865	-14,056
Profit-Cost Ratio	0.57	-0.04	0.19	-0.38
Ave. Production (kg/ha)	3,535	1,608	3,535	1,608
Selling Price (PhP/kg)	15.00	13.89	16.00	14.39
BEQ[a] (kg)	1,834	1,695	2,819	2,215
BEP[b] (PhP/kg)	9.54	14.42	13.50	23.13

[a] Break-even quantity
[b] Break-even price
Source: Survey data (2011)

Tables 7 and 8 compare the profitability of growing organic vegetables by uncertified benchmark and typical vegetable farmers and an OCCP certified farm. The result shows that the cost of 3rd certification had indeed increased their cost of operation. Despite the high cost incurred, the certified farmer was able to obtain higher net returns for string beans (PhP 84,689/m^2), okra (PhP 32,376/m^2), lettuce (PhP 27,261/m^2), ampalaya, (PhP 16,687/m^2), and cucumber (PhP 12,009/m^2) due to high prices received for these vegetables which were sold in an organic market. The increase in cost, however, had adversely affected his profit cost ratio: string beans (0.72), okra (0.42), lettuce (0.34), ampalaya (0.24), and cucumber (0.20). In fact, the certified farmer incurred losses from his eggplant, squash and tomato production. He has to maintain his high level of production, in fact increase eggplant, squash and tomato production, to be able to maintain his positive net returns from growing organic vegetables.

There is great possibility, however, for benchmark farms to get certified and bear the additional cost of certification given their positive net returns and higher profit cost ratio as exemplified in string beans (4.62), tomato (3.10), squash (1.39) and eggplant (1.32) than typical farms. This is brought about by their higher volume of production vis-à-vis typical farmers. On the other hand, uncertified typical farms generally had lower profitability and profit cost ratios for all vegetables grown. The small volume of production, the generally low farm price received and lack of access to niche markets offering high prices for organic products are deterrents for certification of typical farms. It would be difficult for these farms to afford the high cost of certification.

Table 7. Break-even analysis for a benchmark and typical organic vegetable farm without certification by type of vegetable in Regions 3 and 4, Philippines, 2011

Item	Eggplant		String Beans		Tomato		Lettuce	
	Benchmark	Typical	Benchmark	Typical	Benchmark	Typical	Benchmark	Typical
Gross Returns (PhP/1,000 m^2)	28,536	9,929	70,797	13,185	66,623	16,064	-	78,018
Fixed Cost (PhP/1,000 m2)	932	520	922	3,876	1,487	1,554	-	1,991
Variable Cost (PhP/1,000 m2)	11,385	4821	11,672	4,531	14771	7,218	-	15,002
Total Cost (PhP/1,000 m^2)	12,317	5,341	12,594	8,407	16,258	8,772	-	16,993
Net Returns (PhP/1,000 m^2)	16,219	4,588	58,203	4,778	50,364	7,293	-	61,025
Profit-Cost Ratio	1.32	0.86	4.62	0.57	3.10	0.83	-	3.59
Ave. Production(kg/1,000 m^2)	984	273	1,699	393	1,269	387	-	917
Selling price (PhP/kg)	29.00	36.37	41.67	33.55	52.50	41.51	-	85.08
BEQ[a] (kg)	53.5	27.8	26.5	176.0	36.4	68.0	-	29.0
BEP[b](PhP/kg)	12.52	19.56	7.41	21.39	12.81	22.67	-	18.53

Item	Cucumber		Ampalaya		Squash		Okra	
	Benchmark	Typical	Benchmark	Typical	Benchmark	Typical	Benchmark	Typical
Gross Returns (PhP/1,000 m^2)	31,826	3,291	-	24,376	12,225	1,846	33,340	6,328
Fixed Cost (PhP/1,000 m2)	3,234	596	-	1,290	752	628	3,473	304
Variable Cost (PhP/1,000 m2)	17,747	3,045	-	9,505	4,362	1,026	6,418	3.45
Total Cost (PhP/1,000 m^2)	20,981	3,641	-	10,795	5,114	1,654	9,891	1,035
Net Returns (PhP/1,000 m^2)	10,845	-350	-	13,581	7,111	193	23,449	5,293
Profit-Cost Ratio	0.52	-0.10	-	1.26	1.39	0.12	2.37	5.11
Ave. Production(kg/1,000m^2)	943	158	-	632	571	80	1,667	212
Selling price (PhP/kg)	33.75	20.83	-	38.57	21.41	23.08	20.00	29.85
BEQ[a] (kg)	216.6	382.1	-	54.8	54.6	61.2	215.0	11.5
BEP[b] (PhP/kg)	22.25	23.04	-	17.08	8.96	20.67	5.93	4.88

[a] Break-even quantity
[b] Break-even price
Source: Survey data (2011)

Table 8. Break-even analysis for an OCCP certified farm in Nueva Ecija, Region 3, Philippines, 2011.

Item	Type of Vegetable							
	Eggplant	**String Beans**	**Tomato**	**Lettuce**	**Ampalaya**	**Cucumber**	**Squash**	**Okra**
Gross Returns (PhP / 1,000m^2)	38,016	201,771	46,296	106,425	84,902	73,440	48,110	110,079
Fixed Cost (PhP/1,000 m^2)[a]	12,471	12,460	12,471	12,471	12,471	12,471	12,471	12,471
Variable Cost (PhP/1,000 m^2)	34,080	104,622	36,651	66,693	55,744	48,960	37,008	48
Total Cost (PhP /1,000m^2)	46,551	117,082	49,122	79,164	68,215	61,431	49,479	77,703
Net Returns (PhP/ 1,000m^2)	-8,535	84,689	-2,826	27,261	16,687	12,009	-1,369	32,376
Profit-Cost Ratio	-0.18	0.72	-0.06	0.34	0.24	0.20	-0.03	0.42
Ave. Production (kg/1,000m^2)	480	2,491	643	473	1,072	1,360	1,028	1,359
Selling price (PhP/kg)	79.2	81	72	225	79.2	54	46.8	81
BEQ[b] (kg)	1,520.9	319.5	831.4	148.5	458.5	692.8	1,154.7	377.9
BEP[c] (PhP/kg)	96.98	47.00	76.40	167.37	63.63	45.17	48.13	57.18

[a]Fixed cost includes cost of certification* (PhP48.00/1,000m^2) and inspection fee (PhP10,000/1,000m^2)
*Cost of certification was computed by dividing PhP 20,000 and application fee PhP 2,000 by the total farm area.
[b] Break-even quantity
[c] Break even price
Source: Survey data, 2011.

CONCLUSION

Aside from the high cost of certification, it has been widely reported in various studies the long and tedious process of having a farm certified as organic. This will be a disincentive to small-scale farmers to pursue certification. Furthermore, typical farmers do not have the financial capability to pay the high cost of certification and will thus be unable to sell their produce in the market with the organic seal and label. This becomes doubly difficult for small farmers who are in the transition phase as their soil has still to adjust before ample harvest can be realized for their farms.

Currently farmers are already selling their PGS certified produce in the market and have already gained consumer acceptance. Buyers continue to patronize the PGS certified vegetables as they know these are safe. Farmers too have already shifted to organic agriculture and this economic burden may discourage other farmers in going into organic farming thus having inimical effect to the efforts already gained in propagating organic agriculture in the country. Thus there is a need to amend the Organic Agriculture Law to allow the Internal Control or Participatory Guarantee System as a means of certifying agricultural products for the market. However, for medium and large farmers who have the capacity to supply institutional buyers in the domestic market with big volumes and who can penetrate the international market need to have their products certified by the 3rd party system.

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REFERENCES

Cabigas, R. and R. Morala. 2011. Enhancing labeling, standards and certification for sustainable, organic and ecological agriculture in the Philippines, Paper presented at the Workshop on Development of Standard and Certification System for Organic Agricultural Products by Asian Productivity Association (APO) and the India National Productivity Council. New Delhi, India.

Canono, J. 2000. Philippine organic products: Organics market brief. A Global Agric.Info, Network Rep. No. RP0015, USDA-FAS.

Conrado, V.D.l. 2010. Documentation of organic vegetable production in Region 2. PCAARRD. Research Terminal Report. 65 p.

Dragusanu, R. D. Giovannucci and W. Nunn. 2013. The economics of fair trade. 41pp. (Accessed at scholar.harvard.edu/files/rdragusanu/files/jep_firstdraft_sept10_2013.pdf on 1 October 2015).

International Federation of Organic Agriculture Movements [IFOAM]. 1998. *Basic Standards for Organic Production and Processing.* Tholey-Theley, Germany.

Krain, E., E. Millard, E. Koran and E. Servat. 2011. Trade and pro-trade growth: Introducing rainforest alliance certification for cocoa production in Cote d'Ivoire. GIZ. 9 pp.

Malab, B.S. 2011. Documentation of organic vegetable production in Region 1. PCAARRD. Research Terminal Report, 65 pp.

Mojica, M.C. and N.C. Cresino, 2010. Documentation of organic vegetables production and supply chain improvement for commercially grown organic vegetables in Region 4. PCAARRD. Research Terminal Report. 67pp.

National Organic Agriculture Program [NOAP]. 2012. List of Certified Organic Farms/Producers/Processors as of May 2012. (Accessed at http://organic.da.gov.ph/new/ on 28 May 2012).

Organic Certification Center of the Philippines [OCCP]. 2011. *((*Accessed at *occpphils.org* on April 15, 2011*).*

Piadozo, M.E.S., F.A. Lantican, I.M. Pabuayon, A.R. Quicoy, A.M. Suyat and P.K.B. Maghirang. 2014. Rice farmers' concept and awareness of organic agriculture: Implications for sustainability of Philippine agricultural program. Journal of International Society for Southeast Asian Agricultural Sciences (ISSAAS) 20 (2): 142-156.

Piadozo, M.E.S. and A.R. Quicoy. 2009. Assessment of the requirements to enhance organic agriculture in the Philippines. FAO-PCAARRD. Research Terminal Report. 65 pp.

Santacoloma, P. (Ed.). 2007. Organic certification schemes: managerial skills and associated costs — Synthesis report from case studies in the rice and vegetable sectors, Food and Agriculture Organization (Rural Infrastructure and Agroindustries Division), Rome. 155p. (Accessed at http://ftp.fao.org/docrep/fao/010/a1227e/a1227e01.pdf on 1 October 2015).

Sarmiento, G. 2007. Country paper: Philippines. Paper presented at the Regional Conference on Organic Agriculture in Asia. Bangkok, Thailand.

Scialabba, N. and C. Hattam (Eds.). 2002. *Organic Agriculture, Environment and Food Security, Environment and Natural Resources Series No. 4*, Food and Agriculture Organization, Rome.

Scotfield, A.M. 1986. "Organic Farming – The Origin of the Name", *Biological Agriculture and Horticulture,* 4:1-5.

Sim, J.M, Llanes, C.D., and Cungihan, E.B. 2010. Documentation of organic vegetables production and supply chain improvement for commercially grown organic vegetables in Cordillera Administrative Regions. PCAARD. Research Terminal Report. 62 p.

Singh, S. and R.l George. 2012. Organic farming awareness and beliefs of farmers in Uttarakhand, India. Journal Hum Ecol, 37(2): 139-149.

Vitoon, G. 2007. Organic jasmine rice farmers in the northeast of Thailand, *In* Santacoloma, P. (Ed.). Organic certification schemes: Managerial skills and associated costs — Synthesis Report from Case studies in the rice and vegetable sectors, Food and Agriculture Organization (Rural Infrastructure and Agroindustries Division), Rome. pp. 1-49 (Accessed on ftp://ftp.fao.org/docrep/fao/010/a1227e/a1227e01.pdf on 1 October 2015).

Willer, H. and J. Lernoud. 2012. Current statistics on organic agriculture worldwide, *In* Willer, Helga and Lukas Klicher (Eds.), The world of organic agriculture: Statistics and emerging trends 2012, International Federation of Organic Agriculture Movements (IFOAM), Bonn, Germany and Research Institute of Organic Agriculture FiBL, Frick, Switzerland, pp. 35-12.

The International Society for Southeast Asian Agricultural Sciences