Research article

Effect of Different Dietary Nutritional Compositions on Clark's Anemonefish (*Amphiprion clarkii*) Growth

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Received 12 February 2015 Accepted 1 April 2015 (*Corresponding Author)

Abstract Clark's Anemonefish (*Amphiprion clarkii*) is one of marine ornamental fish. The nutritional requirements of *A. clarkii* are important for their growth. This study aimed to assess the effect of different diets on *A. clarkii* growth performance. The experiments comprised of three treatments including (1) grinding pacific white shrimp (*Litopenaeus vannamei*), (2) grinding white perch fish (*Lates calcarifer*), and (3) grinding surf clam (*Paphia undulata*). Growth rate, survival rate, and other growth parameters were studied within 30 days after starting of the experiments. Results indicated that growth rate of *A. clarkii* based on weight and length was highly significant on grinding white perch fish treatment. Average daily growth was also the best on grinding white perch fish treatment (0.46±0.09 g), followed by ground pacific white shrimp (0.37±0.04 g) and grinding surf clam fish (0.35±0.03 g), respectively. Survival rate showed significant difference on grinding surf clam (97.78±3.85%), followed by grinding pacific white shrimp (75.57±8.38%) and grinding white perch fish (64.44±5.09%), respectively. Food conversion ratio tended to be better on grinding white perch fish. This finding indicates that grinding white perch fish could be used as dietary source of *A. clarkii*.

Keywords Clark's Anemonefish, marine ornamental fish, nutritional requirement, nutritional composition

INTRODUCTION

Marine ornamental fish are one of the most popular attractions world-wide due to adaptability to live in confinement. The tropical ornamental fish has increased trust among aquarists due to their multitudinous color and gorgeousness (Ghosh et al., 2011). Thus, marine ornamental aquaculture has become economically feasible, and much interest has been generated for inland (Watson and Hill, 2006). Feed composition and water management in containing tank are important. Dietary

sources are important to fish growth (Koedprang ,2006), especially fish are rare in high density indoor systems or confined in cage and cannot forage freely on natural feeds. They must provide complete diet (Craig and Helfrich, 2009). The protein requirements of fish seem to be higher than terrestrial animals (Lovell, 1988). The commercial fish feed was designed to complete nutritional intake for the marine ornamental fish growth, which has an impact to the high price. The enriched live feed, the rotifers and artemia had to prepare by using microalgae for feeding the fish (Madhu et. al., 2013). Artemia could be a good alternative live feed to be used in the hatchery of ornamental fish but lack of the facilitated supplies (Lim et. al., 2003). Limited supply and high cost of fish meal have forced fish nutritionists to search for alternative protein sources (Silva et al., 2010). The application of live feeds in marine ornamental fish culture has been hampered by the lack live feed information for feeding the fish. Live feeds of nutritional composition were the alternative diets with comparable nutritional quality that needed to maintain the cost competitiveness of marine ornamental fish and remained healthy in suitable diet, which could be contributed to enhancing growth of Clark's Anemonefish culture.

OBJECTIVE

This study aimed to assess the growth rate, survival rate, and other growth parameters of Clark's Anemonefish fed by three different nutritional compositions.

METHODOLOGY

Fish source

Two hundred and seventy larvae of Clark's Anemonefish (*Amphiprion clarkii*) were obtained from the ornamental fish culture at Krabi Coastal Fisheries Research and Development Center, Krabi province and transported to the hatchery at Division of Fisheries, Rajamangala University of Technology Thanyaburi, Pathum Thani province. The total of *A.clarkii* all between 1.5-3 cm in length was acclimatized in a conditioning tank for three days by using natural seawater with salinity maintained at 30 psu after passing through a sandy filter. Then, fish were distributed into nine 100-liter tanks (100 L capacity; 30 individuals per tank). The experiments were assigned for 30 days study period.

Experimental design

The experiments followed a completely randomized design (CRD) comprising three feed treatments of grinding pacific white shrimp (*Litopenaeus vannamei*) (T1), grinding white perch fish (*Lates calcarifer*) (T2), and grinding surf clam (*Paphia undulata*) (T3). The larvae were fed on the three different diets twice a day, 08:30 and 16:00 h, at a rate of 3–4% of their body weight per day. After one hour of each feeding, uneaten diet and fecal matter were siphoned out of the tanks.

The proximate nutritional compositions (protein, lipid, fiber, ash, moisture, and dry matter) in the experimental diets were analyzed according to Association of Analytical Chemists (AOAC, 2000). The number of dead fish was recorded during the experiments. Length and weight data were recorded at the 30^{th} day after the start of the experiment to determine the growth performance. Average daily growth (ADG) as in Eq. (1) , survival rate (SR) as in Eq. (2), and food conversion ratio (FCR) as in Eq. (3) were calculated using the equations,

$$ADG = (W_e - W_s)/t \quad (1)$$

where W_e was the weight at the end of the experiment, W_s was the weight at the start of the experiment, and t was the number of days.

$$SR = ((N_e - N_s)/N_s) \times 100 \quad (2)$$

where N_e was the number of fish alive at the end of the experiment, and N_s was the number of fish alive at the start of the experiment.

$$FCR = W_f/W_t \quad (3)$$

where W_f was the feed intake, and W_t was the total weight of fish at the end of the experiment.
The general water quality factors, namely temperature, salinity, and pHwere measuredwith a multi-parameter probe (YSI-6600 Sonde instrument, USA).

Data analysis

Analysis of variance (ANOVA) was used to consider the growth factors for each treatment. The significance between the means was compared by using Duncan's new multiple range test (DMRT) at a probability level of 0.05 ($p<0.05$).

RESULTS AND DISCUSSION

Average weight of *A. clarkii* at the end of the experiment (W_e) was significantly affected by different types of diets ($p<0.05$), the highest average weight was on grinding white perch fish treatment (0.46±0.09 g), followed by ground pacific white shrimp (0.37±0.04 g), and grinding surf clam fish (0.35±0.03 g), respectively. The final length of fish varied between 2.49±0.13 cm, as found in T3 to 2.86±0.15 cm, as found in T2 ($p<0.05$). The results indicated that growth rate of *A. clarkii*, in terms of weight and length,were better in grinding white perch fish treatment (T2) (Table 2). According to Chambel et al. (2015), it was reported that Percula Clownfish (*Amphiprion percula*) averaging 1.92±0.01 cm size was treated byusing commercial marine fish diets with different crude protein levels, 52.5, 48, 41, and 38%. Results showed the final length of *A. percula* varied between 2.865±0.066 to 3.108±0.066 cm.

Different types of diets also significantly affected on average daily weight (ADG) and survival rate ($p<0.05$), the highest ADG were recorded on grinding white perch fish (0.008±0.001 g/day), and the lowest one in those fed on grinding surf clam (0.004±0.000 g/day). Survival rate (SR) values showed the highest significant in T3 (97.78±3.85%). No statistically significant difference was found on food conversion ratio (FCR) fed on different diets. However, T2 tended to reveal the highest value (10.92±2.47) as shown in Table 2. This study indicated that the diets effected to *A. clarkii* growth performance.

Water quality during culture period showed that water temperature, pH, and salinity varied from 21.0-26.0 ^{o}C, and 7.0-8.0, and 30-32 psu, respectively. Those parameters had no significant difference by different diets ($p>0.05$). In this study, the water quality factors were similar to results obtained by Chambel et al. (2015) in the *A. percula* culture.

Table 1 Growth parameters (mean±SD) of Clark's Anemonefish fed on the three diet treatments

Parameters	Diets		
	Treatment 1	Treatment 2	Treatment 3
W_s (g)	0.19±0.06a	0.19±0.05a	0.20±0.06a
W_e (g)	0.37±0.04b	0.46±0.09a	0.35±0.03b
L_s (cm)	1.94±0.25a	1.93±0.16a	1.98±0.21a
L_e (cm)	2.69±0.13b	2.86±0.15a	2.49±0.13c
ADG (g/day)	0.005±0.000b	0.008±0.001a	0.004±0.000b
SR (%)	75.57±8.38b	64.44±5.09b	97.78±3.85a
FCR	12.55±4.36a	10.92±2.47a	14.80±3.85a

Weight at the start (W_s) and the end (W_e) of the experiment, length at the start (L_s) and the end (L_e) of the experiment, average daily growth (ADG), survival rate (SR), and food conversion ratio (FR). The values in each row followed by the same letter are not significantly different ($p<0.05$).

Growth performance of fish could be assessed from protein requirement depended on the dietary feed intake of fish. The nutritional composition of the three diets is shown in Table 2. Protein and lipid composition showed high level in T2 (19.81% and 0.03%) followed by T1, and T3, respectively (Table 2). The optimal protein level in dietary feed played the key role to produce maximum weight gain in the least time (Martínez et al., 2004). Chuapoehuk (1999) reported that the kinds of aquatic animal that had the high level of protein and energy were fish (20.4% and 111 calories/100g), shrimp (19.7% and 94 calories/100 g) and clam (12.3% and 63 calories/100 g), respectively. The optimal protein level in the diet of fish raised in captivity and most fish farmers used complete diets containing required protein 18-50% (Craig and Helfrich, 2009). In addition, Chambel et al. (2015) indicated that the compound diet of 40% protein would provide nutrients that would ensure optimal growth of *A. percula*.

Table 2 Composition of the feeds (%) in each treatment

Parameters	Diets		
	Treatment 1	Treatment 2	Treatment 3
Protein	18.31	19.81	14.25
Lipid	0.01	0.03	0.02
Fiber	0.04	0.08	0.12
Ash	1.09	1.11	1.32
Moisture	77.35	79.54	79.91
Dry matter	22.65	20.46	20.09

CONCLUSION

This study indicated that grinding white perch fish had significant effect on Clark's Anemonefish growth in terms of weight, length, and average daily growth. Based on this study, grinding white perch fish had the optimal protein levels for growth performance and could be included in diet for Clark's Anemonefish culture.

ACKNOWLEDGEMENTS

The authors would like to express deep gratitude to all the staff members of the Division of Fisheries, Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, for all supports and assistance.

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Research article

Effect of Nitrous Oxide on Physiological and Biochemical Changes during Fruit Drop of Longkong Postharvest

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Abstract Longkong (*Aglaia dookkoo* Griff) is a popular tropical fruit which currently has about 99.37% consumer demand. In the case of exporting, the main problem is that longkong fruit drops from its bunch after harvesting. Therefore, the objective of this research is to study the effect of nitrous oxide on physiological and biochemical changes during fruit drop of longkong postharvest. The addition of 90% nitrous oxide (at times 1, 3, 6, 12 and 24 h) induced the reduction of loosening of longkong fruit after harvest. Exposure to nitrous oxide delayed the onset of fruit drop of the longkong bunches with the most effective treatment being fumigation with 90% nitrous oxide for 6 h. Longkong fruit exposed to 90% nitrous oxide for 24 h, showed an increased respiration rate and ethylene production. While Longkong fruit exposed to 90% nitrous oxide, there was no significant effect on the activity of enzymes polygalacturonase (PG), pectinesterase (PE), cellulase (Cx) and peroxidase (POD) during storage.

Keywords longkong, fruit drop, nitrous oxide

INTRODUCTION

Longkong (*Aglaia dookkoo* Griff.) is a subtropical fruit which can be grown in various parts of Thailand. The quality deterioration of longkong leads to consumer rejection that makes the product cannot be sold. Besides, there is a loss of economic value for both producers and consumers. Senescence of longkong can be seen as browning, disease, and fruit drop, which is a critical problem that results in a lower sales price. The study of morphology shows change in abscission zone (AZ) area which has cell wall degradation in the middle lamella (Oberholster et al., 1991; Sexton et al., 1983) as well as microfibril expansion and disorganization in the primary cell wall in the AZ (Sexton and Robert, 1982). Enzymes associated with degradation of the cell wall are pectin esterase (PE), endo-polygalacturonidase (PG), exopolygalacturonase, rhamnogalacturonase, ∞-galactosidase and cellulase (Downs et al, 1992). In grapes, the stem of the fruit becomes detached from the fruit in the area which gradually extends from the sides of the phloem until the middle of the tissue and causes fruit drop. The fruit drop of grapes is related to an increase of the cellulose enzymes hydrolases and polygalacturanase in AZ (Deng et al., 2007). Nitrous oxide (N_2O) is a natural occurrence of atmospheric gas principally produced by aerobic denitrifying bacteria in soil, which has been demonstrated to inhibit ethylene action and synthesis in higher plants (Frontiera et

al., 1994; Gouble et al., 1995; Leshem and Wills, 1998). N_2O, like CO_2, has an isosteric linear structure that confers similar physical properties such as relative stability and high solubility to both molecules (Leshem and Wills, 1998; Benkeblia and Varoquaux, 2003). This biophysical similarity of N_2O to CO_2 might be pertinent to the control of ethylene in the controlled atmosphere storage of postharvest climacteric fruit (Leshem andWills, 1998). In addition, N_2O is not toxic. It is used in medical practice as an anaesthetic (Gouble et al., 1995), and it is a permitted additive for food (Benkeblia and Varoquaux, 2003). Other studies report the inhibition of postharvest decay of fruit by N_2O, which have also been carried out in the non-climacteric strawberry and mandarin, and in the climacteric fruit apple, persimmon and tomato (Qadir and Hashinaga, 2001). Therefore, in this study, we determined the effects of N_2O gas on the reduction of fruit drop of longkong after harvest.

OBJECTIVES

The objective of this study was to determine effects of N_2O gas on the reduction of fruit drop of longkong after harvest.

METHODOLOGY

Freshly harvested bunches of longkong with full yellow fruits were procured from a commercial orchard. Each bunch longkong was separated into individual bunches, which were placed into sealed plastic chambers with 90% N_2O with 20% O_2 for 0, 1, 3, 6, 12 or 24 hours at 20°C. After treatment, the fruits were stored at 13°C with 90$\pm$5% relative humidity. The treatments were replicated three times with 25 fruit bunches per replication. Standard procedures were followed in measuring fruit drop, weight loss, respiration rate (Gemma et al., 1994), ethylene production (Gemma et al., 1994), PG (Lohani et al., 2004; Pathak and Sanwal, 1998), PME (Abu-Goukh and Bashir, 2003; Nagel and Patterson, 1967), Cx and POD activities (Lohani et al., 2004).

RESULTS AND DISCUSSION

Longkong fruit was fumigated with 90% nitrous oxide (N_2O) for 0, 3, 6, 12 and 24 hours followed by storage at 13 °C. The result showed that the longkong fumigated with 90% N_2O for 0, 6 and 24 hours delayed the fruit drop for 6 days. At hour 6, the fruit drop of longkong was 11.69%, whereas longkong fumigated with 90% N_2O for 12 hours had the highest occurrence of fruit drop with 84.21% on day 12 of storage (Fig. 1A). Weight loss of longkong fumigated with N_2O increased over the duration of storage, which averaged 4% weight loss (Fig. 1B).

There was no statistical comparison of the relative effect of weight loss and nitrous oxide because the low temperature storage delayed the weight loss and reduced deterioration of the longkong.The respiration rate of longkong fumigated and non-fumigated with N_2O slowly increased during storage time, the control fruit had a lower respiration rate than the longkong fumigated with N_2O, especially with fumigation for 24 hours which had the highest rate of respiration in day 12 of storage (76.77 mL $CO_2.kg^{-1}.h^{-1}$) (Fig. 2C).

Fruit fumigated with N_2O for long time may result in an increase in respiration and ethylene production rates (Oszmianski et al., 1985: Macheix et al., 1990). Ethylene production of longkong fumigated with N_2O for 24 hours rapidly increased more than that of other fumigations on day 3 and day 6 of storage. However, longkong fumigated with N_2O less than 3 hours had lower the ethylene production on day 3. It is possible that N_2O may delay deterioration through two mechanical formulas (Gouble et al, 1995; Bemish et al, 1996). In the first form, N_2O bonded with ethylene. In the second form, N_2O inhibited ACC Oxidase (ACO) and synthesis ACC synthase (ACS) with N_2O and CO_2, which both forms had similar functions. However, the effect of N_2O and CO_2 maintained the quality of strawberry (Qadir et al., 2000). If N_2O bonded with ethylene, then ethylene could not bond with itself. It was resulting in delay of the senescence for a short time,

which ripening or senescence occurred. At day 12, there was no significant difference for the ethylene production in all treatments (Fig. 2D).

Research in other fruit species indicates that hydrolytic enzymes, including endo-beta-1, 4-glucanase (cellulose), polygalacturonase (PG), pectinmethylesterase (PME), play a significant role in the abscission stage by affecting middle lamella dissolution and cell-wall degradation and stimulating with exogenous ethylene (Tucker et al., 1984; Taylor et al., 2001), as well as with high activity when there was fruit drop such as with grapes (Deng et al, 2007). As a result, pectin methylesterase (PME) activity in the first day was equal to 0.040 unit/mg protein, after that the activity decreased in the longkong fumigated with N_2O for 3 hours on day 3 and 6 of the storage. Subsequently, activity of enzymes increased at first and then decreased in the end of storage, while longkong fumigated with N_2O for 12 and 24 hours maintained the activity of PME during storage (Fig. 2E). Polygalacturonase activity increased after storage until day 6 and reduced over the storage. Longkong fumigated with N_2O for 6 and 12 hours had lower polygalacturonase activity than the control fruit on 3 day of storage. (Fig. 2F). Cellulase activities increased until the maximum on day 6 and then reduced after that. On day 3, Longkong fumigated with N_2O for each time period had higher cellulase activity than the control fruit (Fig. 2G). Peroxidase enzymes activities of fumigation and control fruit showed no statistical difference in the peroxidase activity on 3 days of storage, reduced the activity on day 6, and increased on day 9 of storage. Longkong fumigated with N_2O for 3 and 6 hours had the peroxidase enzyme activity equal to 0.280 and 0.353 unit/mg protein, while longkong fumigated with N_2O for 0, 1, 12 and 24 hours had the activity equal to 0.570, 0.507, 0.570 and 0.597 unit/mg protein, respectively (Fig. 2H).

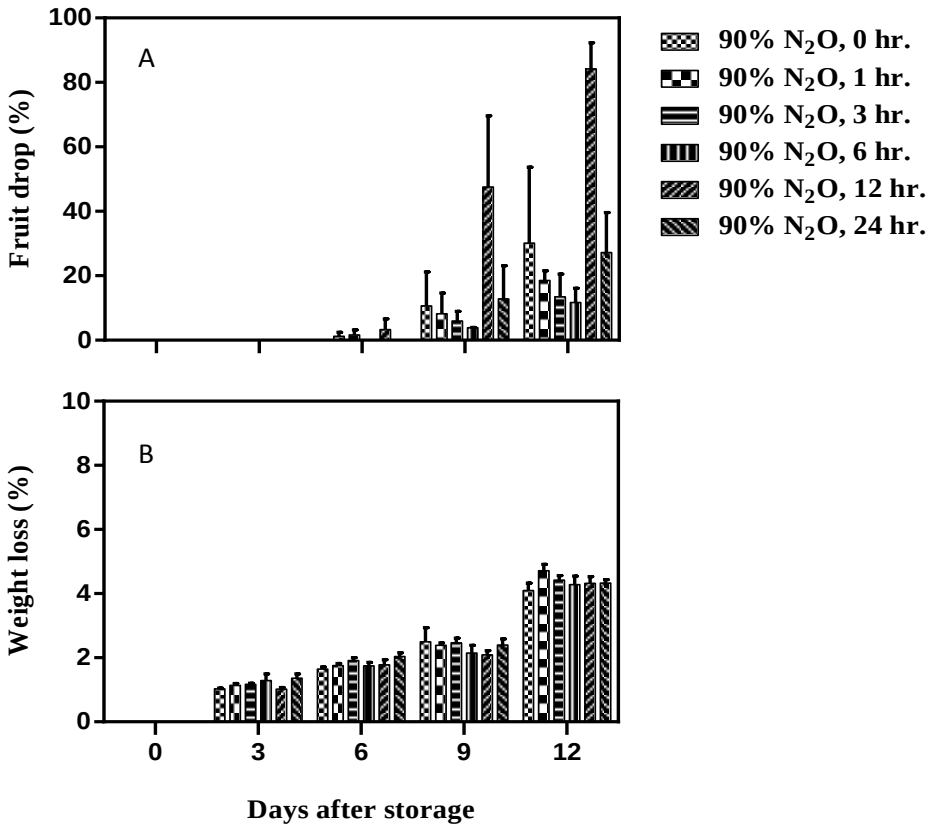

Fig. 1 Change in fruit drop (A), weight loss (B) in abscission zone of longkong exposed to 90% nitrous oxide for 0, 1, 3, 6, 12 or 24 h and then stored at 13 °C

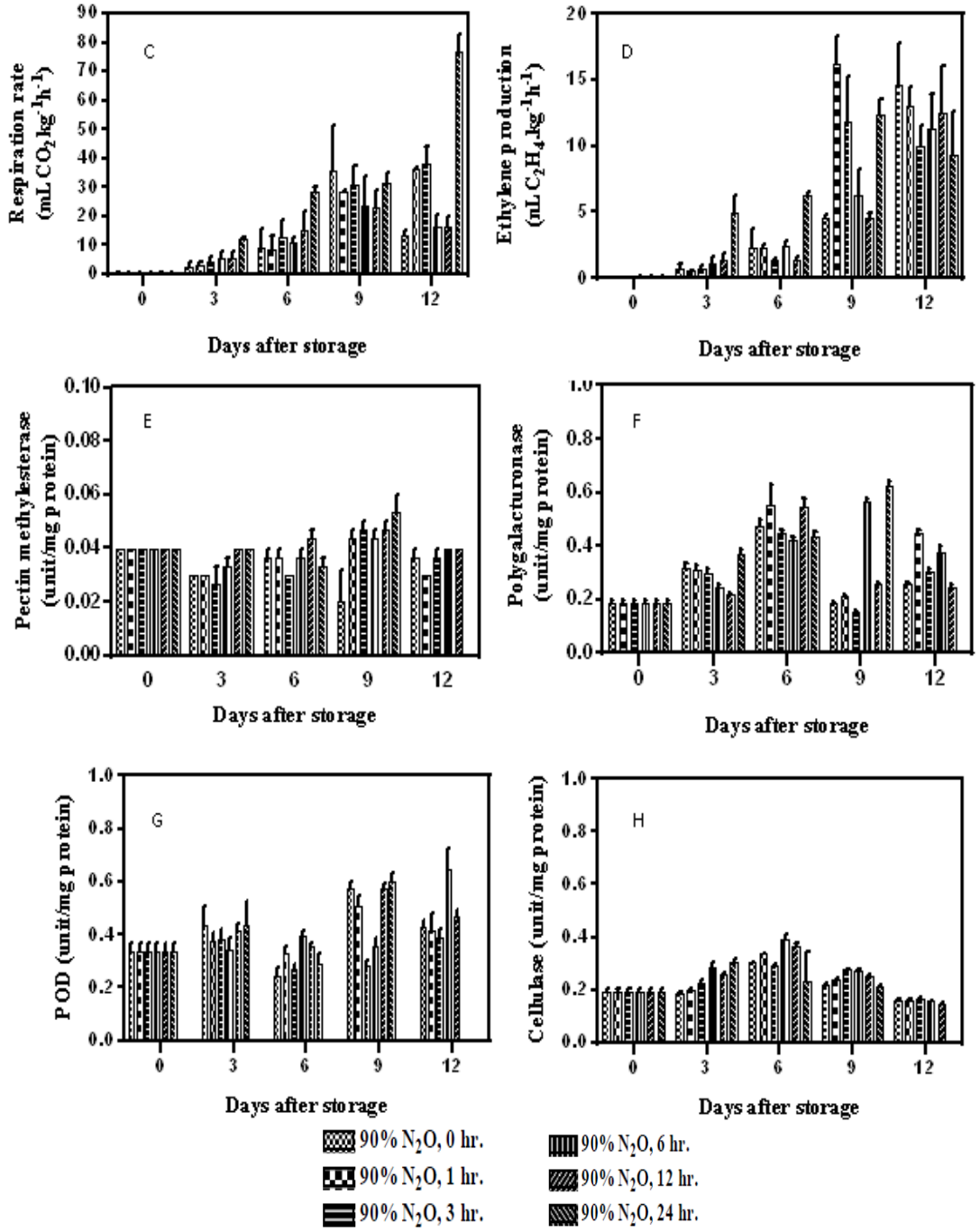

Fig. 2 Change in respiration rate (C), ethylene production (D), pectin methylesterase (E), polygalacturonase (F), peroxidase (G), cellulose (H) in abscission zone of longkong exposed to 90% nitrous oxide for 0, 1, 3, 6, 12 or 24 h and then stored at 13 °C

CONCLUSION

Longkong fumigated with 90% N_2O for 6 hours, delayed the fruit drop but showed no effect on activities of PG, PME, Cx and POD during storage.

ACKNOWLEDGEMENTS

This work was supported by Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT) and Thailand Toray Science Foundation (TTSF).

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Research article

Characterization of Potential Molave (*Vitex parviflora* Juss.) Mother Trees in Lila, Bohol, Philippines

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Abstract Molave (*Vitex parviflora* Juss.) is a timber species which naturally grows in the province of Bohol and is considered as the province' flagship timber species. Molave is generally used for furniture, hand tools, and is known for its durability as beams on bridges and as railroad ties without artificial preservatives. Molave is also a recommended afforestation species in the marginal uplands. The lack of information about the location and distribution of superior Molave mother trees is a major constraint in scaling up the production of high quality seedlings of native timber trees in Bohol. The study aimed to phenotypically characterize the potential mother trees in Municipality of Lila, Bohol using the standard selection criteria (stem straightness, stem forking, branch angle, stem circularity, tree health, branch thickness, and branch persistence), which were developed by the Department of Environmental and Natural Resources (DENR). Specifically, to know the number of potential, Molave is a mother tree with its merchantable height, diameter and elevation. Molave trees with at least 28 cm in diameter and at least 3 meters in height were considered as potential mother trees. Out of 242 potential mother trees, only 160 trees satisfied the DENR Administrative Order 2010-11. The average height and Diameter at Breast Height (DBH) were 5.91 meters and 40.47 cm, respectively. The biggest DBH recorded is 110 centimeters while the highest merchantable is 12 meters. On the other hand, the average elevation was 120.9 meters above sea level. Many good Molave mother trees in Lila, Bohol, Philippines are qualified to provide seed for tree propagation and to produce quality seedlings for reforestation of the Bohol upland areas especially on the National Greening Program (NGP) of the Philippine government.

Keywords Molave tree, mother tree, phenotype, afforestation species

INTRODUCTION

In the Philippines, there is a scarcity of information on the distribution and phenology of premium indigenous timber species because of limited research and development effort (Gregorio et al., 2006), except for dipterocarps. Most research activities focus on a few exotics that have been used in large-scale industrial tree plantations, reforestation projects and smallholder tree plantings. The limited knowledge about the distribution and phenology of mother trees constrains seedling producers from diversifying their seedling production and has led to the use of wildlings, which often results in the production of seedlings of low physical quality (Gregorio, 2006). Because of these reasons, the scaling up of the domestication of native timber trees is constrained by the limited availability of planting materials and low quality germ plasm.

There is an increasing interest in planting premium indigenous timber species in tree farming, agroforestry, and reforestation in the Bohol, for ecological and economic reasons. Milan and Margraf (1994) argue that the planting of indigenous trees promotes biological diversity. Generally, the timber quality of native timber trees (including Molave) is superior to that of the common exotics, leading to a higher market value.

Molave is a flagship timber species in Bohol generally used for furniture, hand tools, and known for its durability as beams on bridges and as railroad ties without artificial preservatives. Molave is a medium to large tree attaining a diameter of 100 to 150 cm and a height from 25 to 30 m. In exceptional cases, it reaches a height of 35 m or more and a diameter up to 200 cm with a bole from 16 to 20 cm. It is a tree that grows irregularly too far with a clear bole of 2 m or less in length (Dichoso, 2000). Fortunately, Molave stands in Lila, Bohol attain a clear bole height of more than 3 m to a maximum of 8 m, which is sufficient enough to initially qualify as potential mother trees.

A mother tree is a tree selected from the forest stands, which gather seeds for propagation purposes (DAO 09, s. 1995). A mother tree should provide a sustained supply of forest tree seeds and other planting stock for the country's collection, distribution and use of forest tree seeds and other forms of plating materials.

The government, through Department of Environment and Natural Resources, promotes the use of high quality planting materials in its afforestation and other afforestation activities to promote biodiversity conservation in marginal uplands/watershed areas (Lomosbog, 2013), and to ensure sustainable production and supply of wood and other forest products in the country. In most recent government and non-government greening endeavor in the province of Bohol, they are using low quality planting stocks because of the limited access to phenotypically and genotypically – superior mother trees as a source of planting stocks especially Molave. To increase the possibility of collecting good quality seed, mother trees should be selected in stands that consist of good quality trees (Mulawarman et al., 2003).

Therefore, the intention of this study is to assess the possible potential mother trees of Molave in Lila, Bohol as future sources of seeds in the production of quality planting materials in support of the National Greening Program (NGP) and other related government and non-government reforestation endeavor.

OBJECTIVE

The study aimed to phenotypically characterize the potential Molave mother trees in municipality of Lila Bohol by using the standard DENR selection criteria. Specifically, it sought to know the number of potential Molave mother trees and its merchantable height, diameter, and elevation within each barangay[1].

METHODOLOGY

The study was conducted in all barangays of Lila, Bohol, namely: Taug, La Fortuna, Tiguis, Calvario, Lumanoy, Catugasan, Cayupo, Candulang, Poblacion, Macalingan, Cogon, Nagsulay, Malinao East, Malinao West, Bonkokan Ilaya, Bonkokan Ubos, Janbawan, and Banban. Lila is a town on the southern coast of Bohol, twenty-eight and a half km from Tagbilaran City. It lies between Loay and Dimiao. Sometimes it was a part of the latter municipality. The climate is type four characterized by even distribution of rainfall with dry season in January to May and wet season in June to December (BAMP 2006). The classification of land is karst and limestone areas with a vegetation of grassland and forest areas.

Selection Criteria of the Potential Mother Trees

Potential mother trees were determined based on its: (a) diameter measurement ≥28 cm; (b) merchantable height ≥3 m; (c) stem straightness; (d) stem forking; (e) branch angle; (f) stem circularity; (g) tree health; (h) branch thickness; and (i) branch persistence (DAO, 2010-11). The candidate mother trees were rated from 1-6 as shown in Table 1.

[1] A *barangay* (Brgy. or Bgy.; Filipino: baranggay, [baraŋˈgaj]), formerly called barrio, is the smallest administrative division in the Philippines and is the native Filipino term for a village, district or ward.

Table 1 Selection criteria for potential mother trees and their corresponding ratings

Criteria	Rating Scales			
	6	5	4-3	2-1
Stem straightness	Perfectly straight	Slight bending	Bending	Over bending
Stem forking	Forking above 6m	Forking between 6m and 3m	Forking below 3m	Multi-stem forking
Branch angle	Branches forming 90˚	Branches forming between 90˚ and 75˚	Branches forming between 75˚ and 60˚	Branches forming between 60˚ and 45˚
Stem circularity	Stem is round	Not perfectly round	Oblong shape	No shape
Tree health	Green-lush vigorous crown	Intermediate	Thin yellow crown	
Branch thickness	Thin branches relative to tree size		Intermediate	Thick coarse branches relative to tree size
Branch persistence	Dry branches shed relatively fast after canopy closure		Intermediate	Dry branches remain on the stem for several years after canopy closure

Source: DAO (2010) (1 as very unacceptable; 2 as unacceptable; 3 for relatively acceptable; 4 as fair; 5 as good; and 6 as highly acceptable)

Data Collection and Analysis

Diameter at breast height of each potential Molave mother tree was measured using improvised Molave tree caliper. The tree caliper was placed at the right angle to the trunk at a point 1.3 m above the ground. For trees growing on slopes, it was recommended that DBH be measured from the uphill side of the tree.

Merchantable heights of potential mother trees of Molave were determined using simple ocular estimation. Merchantable height was estimated from the first big branch of the Molave tree.

After determining the diameter and height of the potential mother trees, the trees were marked with yellow enamel paint to serve as permanent marker or a guide mark during the determination of elevation and coordinates.

Assessment of the potential mother trees of Molave was limited only on the stem straightness, stem branching, stem circularity, tree health, branch angle, branch thickness, and branch persistence as physical tree attributes.

Global Positioning System (GPS) units were used to determine the locations (elevation) of each potential Molave mother tree per barangay. Each mother tree was given its own unique code for future mapping purposes.

The study used frequency counts and simple percentage functions of Microsoft Office Excel 2007 Data Analysis as statistical analysis.

RESULTS AND DISCUSSION

Number of Potential Mother Trees

The potential mother trees of Molave in Lila, Bohol were evaluated using the DENR assessment criteria. Out of 242 potential mother trees of Molave, only 160 (66.12%) trees obtained a rating of "good"; on the other hand, 82 (33.88%) trees garnered a rating of "fair". Of the 160 Molave mother trees rated as "good", barangay Bongkokan Ubos had the most number of mother trees with 22 (68.75%), followed by barangay Catugasan with 21 (80.77%). On the other hand, barangays Cayupo, Candulang and Macalingan had the same number of good Molave mother trees with 16, while barangay Calvario had the least number of good mother tree with only one (Table 2).

Table 2 Number of Molave mother trees per barangay

Name of Barangays	Number of trees				
	Good	%	Fair	%	Total
1. Bongkokan Ubos	22	68.75	10	31.25	32
2. Catugasan	21	80.77	5	19.23	26
3. Candulang	16	64.00	5	36.00	21
4. Cayupo	16	76.19	9	23.81	25
5. Macalingan	16	94.12	1	5.88	17
6. Lumanoy	11	40.74	16	59.26	27
7. Cogon	8	88.89	1	11.11	9
8. Taug	7	46.67	8	53.33	15
9. Tiguis	7	70.00	3	30.00	10
10. Malinao West	6	66.67	3	33.33	9
11. Jambawan	6	54.55	5	45.45	11
12. Bongkokan Ilaya	4	80.00	0	20.00	4
13. Malinao East	4	80.00	4	20.00	8
14. La Fortuna	4	50.00	1	50.00	5
15. Banban	4	100.00	1	0.00	5
16. Nagsulay	4	80.00	1	20.00	5
17. Poblacion	3	33.33	6	66.67	9
18. Calvario	1	25.00	3	75.00	4
Total	160	66.12	82	33.88	242

%=percentage

Merchantable Height

Table 3 presents the average merchantable height (m) of potential mother trees of Molave per barangay in Lila, Bohol. A total of 242 potential mother trees was identified in the study. Potential Molave mother trees in barangay Bongkokan Ilaya had the highest average height of 8.75 m, followed by barangays Lomanoy, Malinao East, Malinao West, and Jambawan with 7.33 m, 6.65 m, 6.56 m, and 6.18 m, respectively. The said barangays were the first five barangays in Lila, Bohol having the most abundant potential Molave trees, which at least 3 meter height were found (Fig. 1b). On the other hand, barangay Poblacion of Lila, Bohol had the lowest average height of potential Molave mother trees with 4.11m.

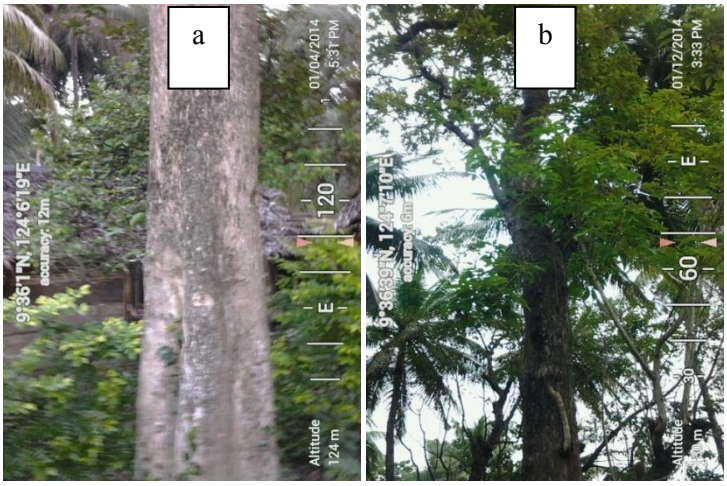

Fig. 1 Molave mother tree assessed based on stem growth such as (a) diameter measurement and (b) merchantable height

Diameter at Breast Height (DBH)

Among the 242 potential mother trees of Molave in Lila Bohol, barangay Catugasan had the biggest average Diameter at Breast Height of 55.85 cm, followed by barangays Bongkokan Ubos,

Macalingan, Tiguis and La Fortuna with average DBH of 46.69 cm, 45.53 cm, 44.50 cm and 43.80 cm, respectively. Moreover, barangay Jambawan had the smallest average DBH of 33.82 cm (Table 3).

Elevation

Table 3 illustrates the average elevation in meters above sea level (masl) of potential mother trees of Molave per barangay in Lila, Bohol. The table further shows that barangay Jambawan had the highest elevation of 221.6 masl, followed by barangay Calvario with 220 masl. On the other hand, barangays Malinao West, Malinao East and La Fortuna had the next top elevations of 132.2, 126.4, and 123.2 masl, respectively.

Table 3 Merchantable height, diameter at breast height and elevation of Molave mother trees per barangay

	Name of Barangays	Merchantable Height (m)	Diameter at Breast Height (cm)	Average Elevation (masl)
1.	Bongkokan Ubos	5.61	46.69	80.10
2.	Catugasan	5.12	55.85	112.40
3.	Candulang	6.00	36.00	113.80
4.	Cayupo	5.68	40.68	117.90
5.	Macalingan	5.29	45.53	119.70
6.	Lumanoy	7.33	39.37	120.50
7.	Cogon	5.56	39.00	123.00
8.	Taug	5.40	39.33	100.10
9.	Tiguis	5.40	44.50	115.70
10.	Malinao West	6.56	34.89	132.20
11.	Jambawan	6.18	33.82	221.60
12.	Bongkokan Ilaya	8.75	41.25	109.20
13.	Malinao East	6.75	35.67	126.40
14.	La Fortuna	6.00	43.80	123.20
15.	Banban	5.60	36.25	75.60
16.	Nagsulay	5.00	36.80	73.20
17.	Poblacion	4.11	42.89	92.00
18.	Calvario	6.00	36.20	220.00
	Average	5.91	40.47	120.92

masl (meters above sea level)

CONCLUSION

A lot of good Molave mother trees in Lila, Bohol, Philippines met the requirements to provide quality seed and seedlings based on DAO 2010-11 for reforestation of the Bohol upland areas, especially on the National Greening Program (NGP) of the Philippine government. A total of 160 Molave trees was considered as good mother trees sporadically distributed in five barangays of Lila, Bohol namely Bongkokan Ubos, Catugasan, Cayupo, Candulang and Macalingan. The height measurements of the good mother trees ranged from 6.18 m to 8.75 m while its diameter ranged from 43.80 cm to as big as 55.85 cm.

It is recommended to conduct Geo Tagging of the identified good Molave mothers for seed documentation and exact location of seed sources. Furthermore, it is needed to provide financial benefits and technical assistance to land owners who continuously protect the growing Molave mother trees.

ACKNOWLEDGEMENTS

1. Bohol Island State University - for the support in the conduct of the Study
2. Local Government Units of Lila, Bohol - for allowing the researchers to conduct this Study
3. The Punong Barangay (Captains) of the 18 barangays of Lila, Bohol - for the assistance during the actual field data gatherings
4. DENR Extension Officer assigned in Lila, Bohol – for the company in the initial field location of the potential mother tree of Molave

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Research article

Efficiency of Crude Extract from Pummelo Peel on Controlling the Growth of *Colletotrichum gloeosporioides* (Penz.)

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Received 15 December 2014 Accepted 1 April 2015 (*Corresponding Author)

Abstract The objective of this research was to investigate the antifungal efficiency of pummelo peel extracted with different solvents on *Colletotrichum gloeosporioides*. Crude extracts from pummelo peels were eluted with four solvents, such as ethanol, hexane, dichloromethane and ethyl acetate. Chemical compounds of the crude extracts were analyzed by GC-MS and HPLC and inhibition the growth of *C.gloeosporioides* was tested by PDA culture. The result showed that limonene was the major compound in all extracts (79.55-89.91%). α-Phellandrene and 2, 6-octadien-1-ol, 3, 7-dimethyl were found only in crude extracts using ethyl acetate as a solvent. In addition, the extract was eluted with ethyl acetate also had the amount of flavonoids: nobiletin and 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone, higher than those eluted with other solvents. Inhibition the growth of *C.gloeosporioides* of pummelo peel extracted with dichloromethane, ethanol, hexane and ethyl acetate were 19.16, 52.81, 65.58, and 95.61%, respectively. Therefore, pummelo peel extracted with ethyl acetate was the highest efficiency on controlling *C.gloeosporioides* ($p \leq 0.05$).

Keywords Crude extract, pummelo, *C.gloeosporioides*

INTRODUCTION

Mango is one of the most popular and best known tropical fruits (MacLeod and Troconis, 1982; MacLeod and Pieris, 1984). It is a highly priced fruit due to its attractive color, delicious taste, and high nutritional values (Mitra and Baldwin, 1997; Lalel et al., 2003). Traditionally, the major mango exporting countries are the Philippines, Thailand, Mexico, and India (Jacobi et al., 2001). Many different ripening conditions, postharvest treatments, and processing methods are used to prepare mangoes for marketing to consumers (Moore, 2003). Its short shelf life limits the commercialization at long distances. It is also highly susceptible to damages caused by fungi, bacteria and fruit fly larvae (Diaz-Sobac et al., 1996).

Anthracnose is a major pre- and post-harvest disease on mangoes, causing direct yield loss in the field and packing plant, and quality and marketing issues (Ploetz, n.d.).Mango anthracnose is

caused by the fungus *Colletotrichum gloeosporioides* (Pitkethley and Conde, 2007). Ripe fruits affected by anthracnose develop sunken, prominent, dark brown to black decay spots before or after picking. The fruit spots can usually do coalesce and can eventually penetrate deep into the fruit, resulting in extensive fruit rotting. Most green fruit infections remain latent and largely invisible until ripening (Nelson, 2008). Post-harvest treatments are available for control of anthracnose in mango fruits. Prochloraz is used as a cold nonrecirculating spray. Hot water dips, used to control fruit flies, will also control anthracnose and stem end rots. Hot benomyl dips will control anthracnose and are useful where stem end rots are a problem (Pitkethley and Conde, 2007). However, there are many studies using plant extracts such as essential oils and pure compounds against plant pathogenic fungi, which have been conducted. Antifungal compounds have been found in plants, derived from secondary metabolites such as tannins, terpenoids, alkaloids and flavonoids (Arif et al., 2009).

Pummelo (*Citrus grandis* or *Citrus maxima*) is an original citrus fruit, with the look of a big grapefruit, native to South and Southeast Asia. Citrus fruits contain several bioactive compounds such as flavonoids, limonoids, and organic acid. Polymethoxyflavones are group of flavonoids that present mainly in the fruit peel. There are some reports that show polymethoxyflavones, which are important components of plant defensive mechanism against various diseases causing pathogens such as phytophthora and *Colletotrichum gloeosporioides* (Del Rio et al., 1998; Ortuño et al., 2006; Uckoo et al., 2011). Thus, this research aimed to investigate the major volatile compounds, flavonoids and polymethoxyflavones as well as the antifungal efficiency of crude extract from pummelo peel on *C. gloeosporioides*.

OBJECTIVES

The study was conducted with the following objectives:

1. To determine the major volatile compounds and flavonoids of crude extract from pummelo peel; and
2. To investigate the effect of crude extracts from pummelo peel on inhibition the growth of *Colletotrichum gloeosporioides*.

METHODOLOGY

Pummelo was purchased from a commercial market in Phathumtani province, Thailand. The flavedo of the fruit was cut into small pieces and then immersed with a solvent for 24 hours and the ratio of peel and solvent was 1:3. The four solvents were ethanol, dichloromethane, hexane and ethyl acetate which were used in this experiment. The extracts were pooled and evaporated at 40 ^{o}C using a rotary evaporator. Then the extracts were stored at freezer until used. Volatile compounds and polymethoxyflavones in the extracts were analyzed by GC-MS and HPLC. Each sample was analyzed in triplicate.

C. gloeosporioides was isolated from infected mango fruits with typical symptoms and maintained on potato dextrose agar (PDA) at 25 ^{o}C for seven days. The pathogen was inoculated into mango and re-isolated on PDA before the experiment.

The effect of extracts from pummelo peel on mycelial growth of *C. Gloeosporioides* was assayed by modifying the method of Liu et al. (2007). Mycelial disks (5 mm in diameter) from one-week-old culture of *C. gloeosporioides* were placed in the center of Petri dishes containing 20 ml of PDA with the 10,000 ppm extracts eluted with different solvents, and then incubated at 25^{o}C. The plate without the extract served as the control. Mycelial growth was determined by measuring colony diameter (mm) each day after inoculation. Each treatment was five times replicated, and the experiment was repeated thrice. The inhibition rate on mycelial growth was calculated according to the following formula: Inhibitory rate (%) = 100 x (colony diameter of the control − colony diameter of the treatment) / (colony diameter of the control).

RESULTS AND DISCUSSION

Pummelo peel in this study had the color L* a* and b*, which the values were between 62.8-67.6, 3.1-8.7 and 47.3-48.7, respectively. Chemical compounds of the crude extracts were analyzed by GC-MS (Table 1) and HPLC (Table 2). The result showed that the extract from pummelo peel was eluted with ethyl acetate that could identify volatile components and flavonoids better than those extracted with dichloromethane, hexane and ethanol (Table 1). Terpenes were the major components in extracts of pummelo peel. Volatile compounds were always found in citrus such as pinene, sabinene, myrcene, phellandrene, limonene, ociemene, linalool, terineol, carvone, caryophyllene, and geraniol. Ester such as geranyl acetate was also found in the extracts. Limonene was the major compound in all extracts (79.55 - 89.91%) and the result was consistent with Hosni et al. (2010). However, this research could identify the compounds of the extracts less than another research. This might be due to the difference of solvents and extraction methods. Hosni et al. (2010) used both of pummelo flavedos and leaves in their research as well. Linalool was also found in all extracts; however, it was presented in very small amounts (0.20 - 2.22% peak area). Jabalpurwala et al. (2009) found that linalool was the main compound in pummelo blossom. α-Phellandrene and 2, 6-octadien-1-ol, 3, 7-dimethyl were found only in crude extracts using ethyl acetate as a solvent.

Table1 Volatile compounds (% peak area) of extracts from pummelo peel eluted with four solvents

Volatile Compounds	Solvent			
	Ethanol	Hexane	Dichloromethane	Ethyl acetate
α-Pinene	nd	0.42	nd	0.72
Sabinene	nd	0.98	nd	nd
β-Pinene	nd	nd	1.52	2.26
β-Myrcene	0.35	1.49	nd	2.54
α-Phellandrene	nd	nd	nd	0.20
Limonene	79.55	81.52	84.62	89.91
β-Ociemene	nd	0.19	0.167	0.15
Linalool	2.22	0.20	0.63	0.28
α-Terpineol	nd	nd	0.76	nd
2-Cyclohexen-1-ol, 2-methyl-5-(1-methylethene)-cis	nd	nd	0.21	nd
D-Carvone	nd	nd	0.28	nd
2,6-Octadien-1-ol, 3,7-dimethyl	nd	nd	nd	0.58
Geraniol	nd	nd	0.44	0.30
Geranyl acetate	0.47	nd	nd	0.12
Caryophyllene	0.55	0.25	nd	0.10
1,6-Cyclodecadiene, 1-methyl-5-methylene-8-(1-methylethyl)	0.73	1.17	nd	0.71

nd: Not detected

Citrus peel was rich in flavanones and polymethoxlated flavones (Ortuño et al., 2006). Nobiletin in the extracts were eluted with ethanol, dichloromethane, hexane, and ethyl acetate were 4.87, 0.20, 0.24 and 0.68%, respectively. Tangeretin of pummelo peel extracted with ethanol, dichloromethane, hexane and ethyl acetate were 7.39, 4.36, 0.10 and 7.80%, respectively. Polymethoxyflavones were groups of flavonoids that presented mainly in the fruit peel. These compounds had two or more methoxyl's on their basic flavonoid structure (Uckoo et al., 2011). Pummelo peel extracted with ethanol had very small amount of 3, 6, 3', 4'-tetramethoxyflavone (0.66%), when compared to other solvent extractions. And 3-hydroxy-7,3',4',5'-tetramethoxyflavonein the extract were eluted with hexane, and dichloromethane were found only 0.34 and 0.47%, respectively. Whereas extraction pummelo peel with ethanol and ethyl acetate had 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone higher than 7.00% (Table 2).

Table2 Flavonoids and polymethoxyflavones (% peak area) of extracts from pummelo peel eluted with four solvents

Flavonoids and Polymethoxyflavones	Solvent			
	Ethanol	Hexane	Dichloromethane	Ethyl acetate
Nobiletin	4.87	0.20	0.24	0.68
3, 6, 3', 4'-Tetramethoxyflavone	0.66	77.44	70.59	75.72
3-Hydroxy-7, 3', 4', 5'- tetramethoxyflavone	8.35	0.34	0.47	7.67
Tangeretin	7.39	4.36	0.10	7.80

Figure 1 showed that mycelial growth of *C. gloeosporioides* on PDA plate without the extract served as the control. Antifungal efficiency of crude extract from pummelo peel on *C. gloeosporioides* was showed in table 3 and figure 2. Inhibition the growth of *C. gloeosporioides* of pummelo peel extracted with dichloromethane, ethanol, hexane and ethyl acetate were 19.16, 52.81, 65.58 and 95.61%, respectively. Thus, pummelo peel extracted with ethyl acetate was the highest efficiency on controlling *C. gloeosporioides* ($p \leq 0.05$). Polymethoxyflavones are important component of plant defensive mechanism against various disease causing pathogens such as *Phytophthora* and *C. gloeosporioides* (Del Rio et al., 1998). The present study found two compounds of polymethoxyflavones; 3, 6, 3', 4'-tetramethoxyflavone and 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone. Extraction of pummelo peel with hexane and dichloromethane had the high peak area of 3, 6, 3', 4'-tetramethoxyflavone (more than 70%), while 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone were only 0.34 and 0.47%, respectively. On the contrary, the extract eluted with ethanol had a higher 3-hydroxy-7, 3', 4', 5'- tetramethoxyflavone (8.35%), whereas 3, 6, 3', 4'-tetramethoxyflavone was very low. Extraction of pummelo peel with ethyl acetate had the high peak area of both 3, 6, 3', 4'-tetramethoxyflavone and 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone were 75.72 and 7.67%, respectively, which was different from the extracts eluted with other solvents. Therefore, this might be the cause of effectiveness in inhibiting the growth of *C. gloeosporioides*.

Table 3 Effect of crude extracts from pummelo peel eluted with four solvents on the growth of *C. gloeosporioides*

Solvent	Inhibitory rate (%)
Ethanol	52.81^{b}
Hexane	65.58^{b}
Dichloromethane	19.16^{c}
Ethyl acetate	95.61^{a}

Mean of the same column with different superscripts indicating significantly differences ($p \leq 0.05$)

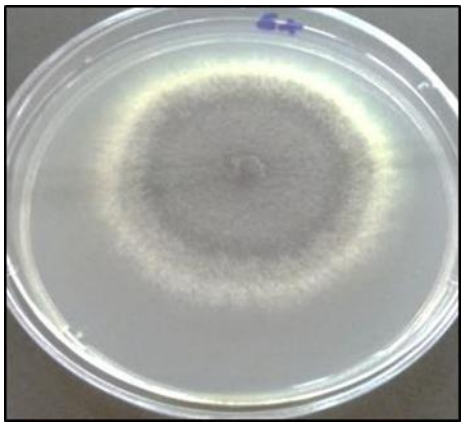

Fig. 1 Mycelial growth of *C. gloeosporioides* (on plate without crude extract from pummelo; control) after incubated at 25°C for 7 days

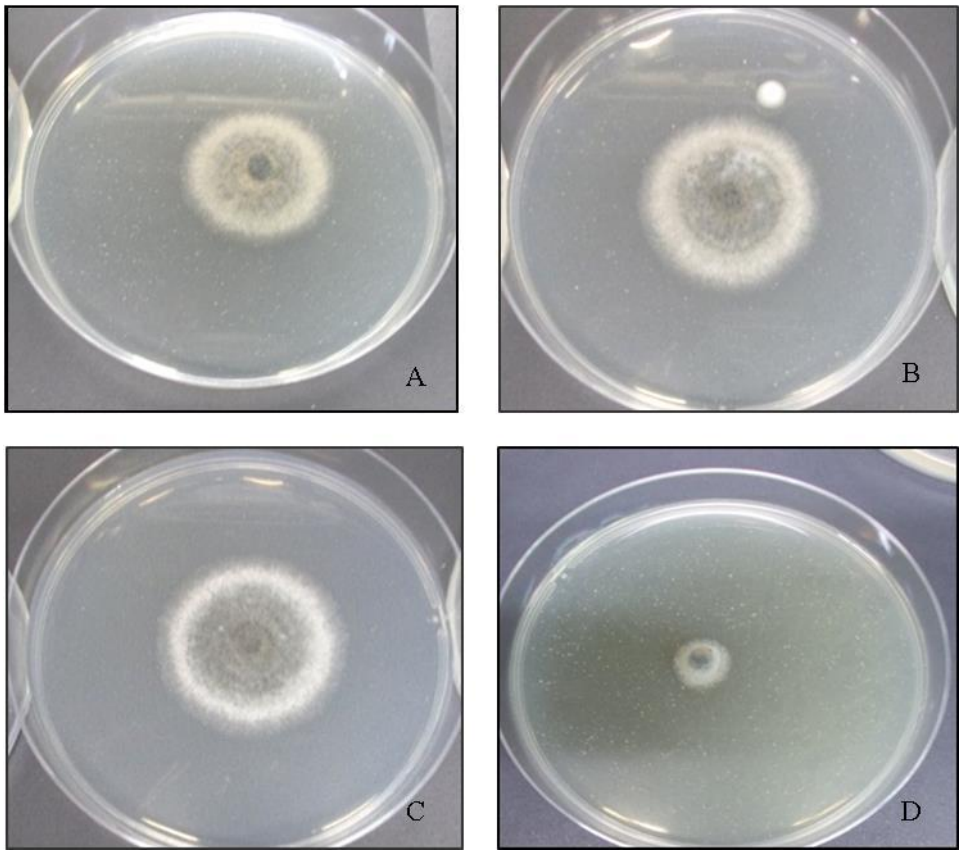

Fig. 2 Effect of extracts from pummelo peel eluted with ethanol (A), hexane (B), dichloromethane (C) and ethyl acetate (D) on mycelial growth of *C. gloeosporioides* after incubated at 25°C for 7 days

CONCLUSION

The major volatile compound of crude extract from pummelo peel was limonene. The extract eluted with ethyl acetate had the most volatile components, followed by the extraction with dichloromethane, hexane, and ethanol, respectively. Flavonoids (nobiletin and tangeretin) and polymethoxyflavones (3, 6, 3', 4'-tetramethoxyflavone and 3-hydroxy-7, 3', 4', 5'-tetramethoxyflavone) were found in all solvent extractions. However, the extract eluted with ethyl acetate had the amount of nobiletin and 3-hydroxy-7, 3', 4', 5'- tetramethoxyflavone, which were higher than those eluted with other solvents.

Inhibition the growth of *C. gloeosporioides* of pummelo peel extracted with dichloromethane, ethanol, hexane and ethyl acetate were 19.16, 52.81, 65.58, and 95.61%, respectively. The crude extract of pummelo peel eluted with ethyl acetate was the highest efficiency on controlling mycelial growth of *C. gloeosporioides*.

ACKNOWLEDGEMENTS

This work was supported by National Research Council of Thailand (NRCT) and Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT).

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Research article

Utilization of Coconut Fronds for Weed and Insect Pest Management in Tomato Production

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Abstract The study assessed the effectiveness of coconut frond or cocofrond mulch in managing weed and insect pest population in tomato crops. Specifically, it aimed to determine if cocofrond mulch reduced weed infestation in tomato; to evaluate its influence in minimizing insect pest population affecting the crop; and to find out the yield performance of tomato mulched with cocofronds. Randomized Complete Block Design with four treatments and four replicates was employed in a 139.50 m^2 experimental lot using the Diamante Max variety. The woven and unwoven cocofronds, polyethylene plastic mulches, and control plots with hand weeding were compared. Weed and insect pest species, its population counts, and yield data were taken and analyzed statistically through analysis of variance and Tukey's HSD Test. The findings revealed that either woven or unwoven coconut frond used as bed mulch was as effective as black plastic mulch in suppressing the dominant broadleaf, the Button weed (*Borreria laevis)* but had no effect on the populations of the other 17 minor weed species observed. Bed mulch reduced the numbers and damage caused by the 12-spotted ladybird beetle (*Epilachnaphilipinensis remota*) larvae but had no effect on its adult population nor on the damage caused by other pests like the green looper (*Chrysodeixis chalcites)* and fruitworm (*Helicoverpa armigera)* larvae. Neither coconut frond nor black plastic bed mulch had any significant effect on tomato crop's yield. These findings are an ample basis for a wider exploration on the potential use of coconut fronds as a low-cost weed and pest management techniques for organic vegetable production.

Keywords coconut frond, weed management, insect pest management, mulch, broadleaf weed

INTRODUCTION

In the Philippines context, tomato ranks second in the top horticultural crops being produced by a production industry, which dominated by small scale farmers. Although it is grown widely, the average yield in the Philippines is relatively low with 9.79 mt posted in 2005 (PCAARRD, 2007).

Low production in small scale farming is due to high incidence of diseases, insect pests, and high logistics costs. Other farmers encounter problems on nutrient deficiency diseases, insect pest infestation, and weed competition. Weeds reduce yields by competing for space, light, water, and nutrients, weakening crop stand, and by reducing harvest efficiency. Weed infestation throughout the crop life cycle results in about 40 to 60% reduction in potential tomato fruit yield (Adigun, 2005). Some weeds increase pest problems by serving as hosts for insects and pathogens. Weeds are most competitive if they emerge prior to or at planting until about 6 to 8 weeks after crop emergence (University of California, 2014). Despite the high costs in insect pest, disease and weed management measures, the problems result to low income due to low yield. Thus, farmers grope for a safe and economically productive technology to counter weed and insect pest problems in tomato culture, and mulching is believed to be one.

Studies on mulching frequently present straw mulch, plastic mulch and live-mulch cowpea. This is tested in pepper and shown that cowpea mulch is more effective in suppressing pest populations of pepper but straw mulch provide a better refuge for the natural enemies (Mochiah, M., Baidoo, P. and Acheampong, G., 2012). Mulching trials on plant growth, yield, and pest control in organic yellow zucchini production reveal that paper, rye straw, black plastic, and rye straw plus paper greatly reduce weeds as compared with the bare soil control and are not significantly different in their weed suppression effect (Hulsey, 2013). Black plastic mulch results in significantly higher early and total yields as compared to all other treatments and the bare soil control. Black plastic also has significantly greater densities of squash bugs and stink bugs as compared to other treatments and the control. None has ever tried mulching coconut leaves and fronds in tomato or other vegetables but this experiment.

OBJECTIVE

The main purpose of this study was to assess the usefulness and applicability of coconut fronds as mulch for weed and insect pest management in tomato production. Specifically, the purpose was to determine the influence of cocofrond mulch on weed population, pest incidence and yield of tomato.

METHODOLOGY

The experiment was conducted at the Bohol Island State University, Zamora, Bilar, Bohol with a reddish soil that had 2.27% organic matter content, 3.5 ppm Phosphorus, 10 ppm K, and a pH of 4.88. The area had previously been abundantly occupied by Humidicula grass apart from *Paspalum conjugatum, Euphorbia hirta, Digitaria ciliaris, Dactyloctinium aegyptium, Ehinochloa colona* and *Panicum repens.* A randomized complete block design was used with four treatments and four replicates. All cultural practices in tomato production were followed, except on weed and insect pest management after transplanting. Diamante Max variety of tomato seedlings were transplanted on December 6, 2013. Vermicompost and carbonized rice hull combination at the rate of 5 tons per hectare was applied as basal fertilizer. The study compared coconut fronds and the commonly recommended black plastic mulch. Fig. 1 presents the treatments.

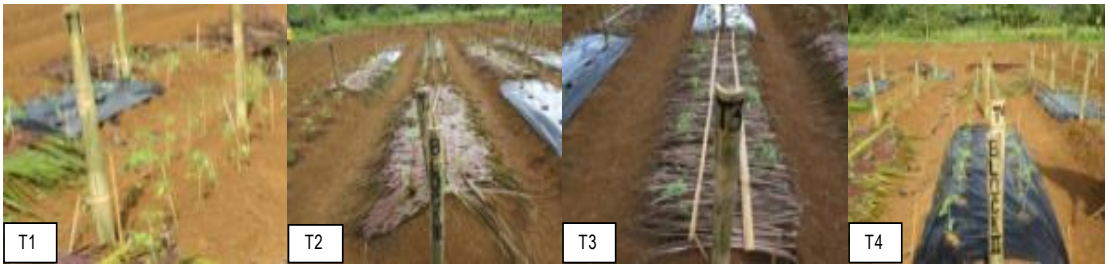

Fig.1 Treatments: T1- control-hand weeding, T2- woven cocofrond mulch, T3- unwoven cocofrond mulch, T4- plastic mulch

Data collected were weed species, population per species at 30 and 60 days from transplanting; insect pest population per species taken fortnightly in ten sample plants per treatment per block; and yield of five harvests per treatment per block computed in tons/ha. Analysis of variance and Tukey's HSD Test were applied.

RESULTS AND DISCUSSION

Influence of Coconut Fronds and Plastic Mulches on Weed Infestation

Table 1 presents the 18 weed species found in the experimental plots where majority were broadleaf weeds, no grass weeds identified, and only one sedge species the *Cyperus kyllingia*. All were dominated by a broadleaf *Borreria laevis.*

Table 1 Mean population weeds per species per treatment

Morphological Classification	Scientific Name	Mulch / Mean Population*			
		Control	Parallel Cocofrond	Woven Cocofrond	Plastic Mulch
Broadleaf	*Calpogonium mucunoides*	0.8	1.8	0.8	0.8
Broadleaf	*Ageratum conyzoides*	16.3	10.5	8.0	20.0
Broadleaf	*Mimosa pudica*	16.8	25.8	34.5	9.5
Broadleaf	*Phyllanthus.amarus*	9.3	1.3	9.3	2.5
Broadleaf	*Cassia tora*	0	0.8	0	1.0
Broadleaf	*Ipomea triloba*	6.8	5.3	7.8	1.5
Broadleaf	*Borreria laevis*	255.0	75.0	119.0	31.5
Broadleaf	*Borreria ocymoides*	2	0	0	0
Broadleaf	*Commelina diffusa*	1.8	0.3	0.3	1.5
Broadleaf	*Phyllathus niruri*	3.5	4.5	1.3	2.5
Broadleaf	*Desmodium triflorum*	1.3	1.8	0.8	0.5
Broadleaf	*Chromolaena odorata*	0	0	0	0.3
Broadleaf	*Cleome rutidosperma*	1.5	2.0	6.0	0.3
Broadleaf	*Corchorus olitorious*	8.5	7.3	11.3	0.5
Broadleaf	*Euphobia hirta*	0	0	0.3	0
Broadleaf	*Stachytapheta jamaicensis*	1.0	1.0	1.0	0
Broadleaf	*Bidens pilosa*	0	0	0.5	0
Sedge	*Cyperus kyllingia*	3.3	0.3	1.5	0

**Average from 3 replicates*

Multivariate analysis showed that only the population of *Borreria laevis* significantly differed among treatments. Tukey's HSD Test in Table 2 reveals that all kinds of mulch significantly reduced the population of *B. laevis* compared to hand weeding. The test also illustrates that all mulches have similar suppressive effects on the *B. laevis*. This initial finding encourages further studies to prove its potential in weed management in tomato as well as in other vegetables.

Table 2 Comparison of treatment means of *B. laevis* using Tukey's HSD test

Treatment	N	Subset*	
		1	2
T4 - PE plastic mulch	4	31.50	
T3 - Parallel cocofrond	4	75.00	
T2 - Woven cocofrond	4	119.00	
T1 – Control/Hand Weeding	4		255.00
	P-value	0.149	1.00

**means in the same subset are not significantly different to each other*

Effects of Coconut Fronds and Plastic Mulches on Insect Pest Incidence

The population of the three insect pest species found the most damaging to the experimental tomato crops: 12-spotted ladybird beetle, *Epilachna philipinensis remota;* tomato fruitworm, *Helicoverpa armigera*and the green looper, *Chrysodeixis chalcites* differed in terms of time and the mulch used. Figure 2 reveals that plastic mulch reduced their population for a number of weeks. This was followed by cocofrond mulches while tomatoes with hand weeding had higher pest population in most of the time.

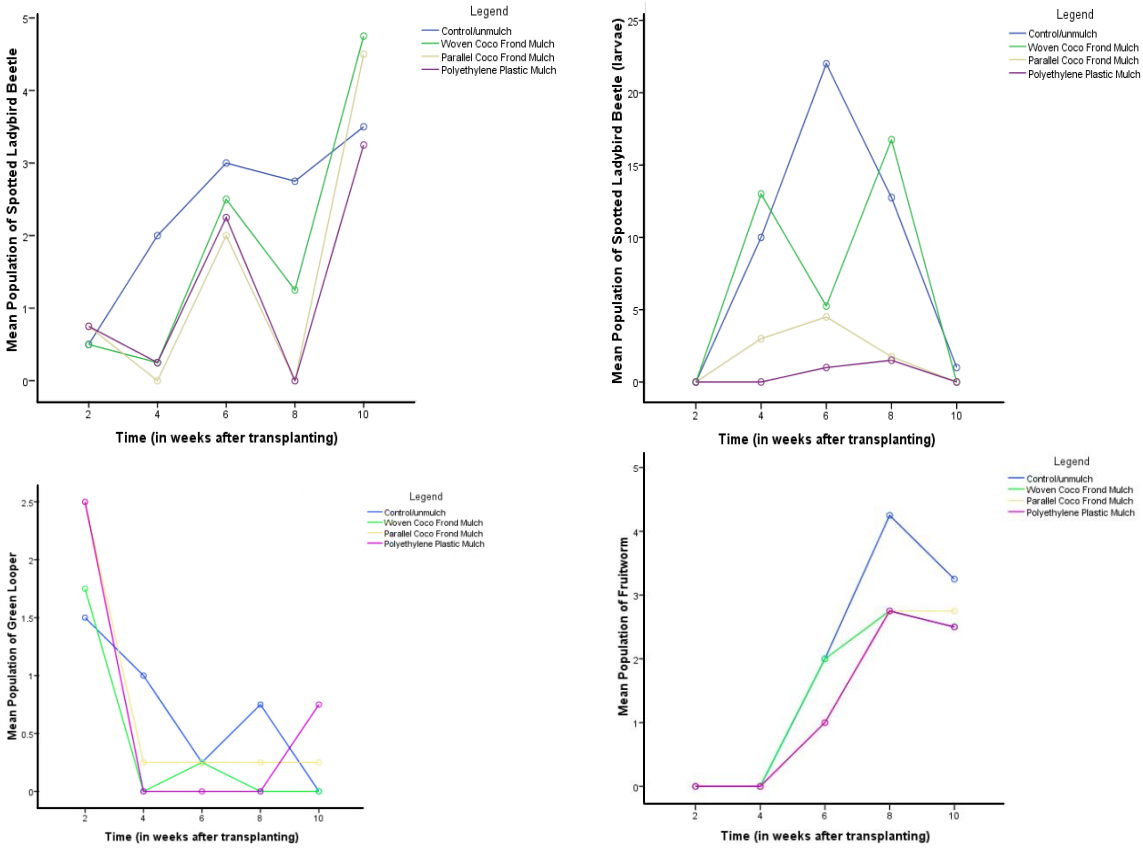

Fig. 2 Population of 12-spotted ladybird beetle adults (above left), its larvae (above right); greenlooper larvae (lower left), and tomato fruitworm larvae (lower right) infesting tomato crops per time

Analysis on the population of 12-spotted ladybird beetle adults, fruitworm larvae, and green looper larvae presented in Table 3 shows highly significant difference between time/weeks, while the beetle larvae had significant result. This implies a similar effectiveness of the mulches on the pest though time element or crop stage had significant effect on the pest irrespective of the mulching materials. However, pest population was not significantly affected by the treatments except for 12-spotted ladybirds beetle larvae which had been significantly affected by the mulches. Time and treatment interaction was not significantly denoting the independent influence of time and mulches on the pest population. The same analysis illustrated that *Epilachna* larvae was influenced by mulch while the adults were not affected. This suggests that there be a difference in egg lay and survival of the eggs or of the hatching larvae in mulched plots versus the control.

Tukey's HSD test results on the 12-spotted ladybird beetle larval population presented in Table 4 reveals that plastic mulch had a significantly lower number compared to the rests of the mulches. The unwoven and the woven cocofrond mulches had intermediate populations which were not significantly different from either the black plastic mulch or the control plots.

Table 3 Analysis of variance on the insect pest population infesting the tomato crops

Pests	Source of Variations					
	Within-Subjects				Between Subjects	
	Time		Time x Treatment		Treatment	
	F-Statistic	P value	F-Statistic	P value	F-Statistic	P-Value
Spotted ladybird beetle adults	15.085**	0.000	0.966ns	0.494	1.745ns	0.211
Spotted l. beetle larvae	3.988*	0.043	1.438ns	0.256	4.949*	0.018
Fruitworm larvae	9.181**	0.000	0.304ns	0.986	0.165ns	0.918
Green looper	17.878**	0.000	1.070ns	0.406	0.389ns	0.763

Note: Tested at 95% level of confidence

Table 4 Comparison of means on spotted ladybird beetle larval population using Tukey's HSD test

Treatment		Subset* 1	Subset* 2
4 – Plastic Mulch	4	0.0415	
3 – Parallel/Unwoven Cocofrond	4	0.1545	0.1545
2– Woven Cocofrond Mulch	4	0.5810	0.5810
1– Control/Hand weeding	4		0.7605
P-value		0.114	0.068

**means in the same subset are not significant to each other at 95% level of confidence*

The damage counts based on infested leaves by the 12-spotted ladybird beetles and the fruitwormbored tomato fruits are shown in Fig. 3. The figure illustrates that there was lesser damage on the crops that were mulched with cocofronds, compared to the ones that planted with hand weeding and with plastic mulch.

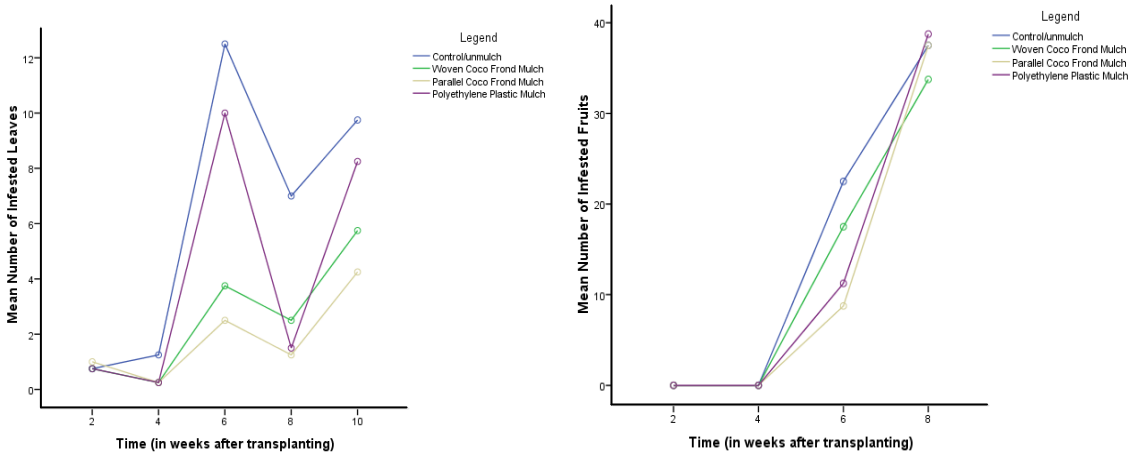

Fig. 3 Number of *Epilachna* beetle-infested leaves (left) and the fruitworm-infested fruits tomato (right)

Table 5 Analysis of variance on the 12-spotted ladybird beetle and fruitworm infestation on tomato crops

Pests	Source of Variations					
	Within-Subject				Between-Subjects	
	Time		Time x Treatment		Treatment	
	F-Statistic	P value	F-Statistic	P value	F-Statistic	P-Value
12-spotted l. beetle infestation	2.258ns	0.130	0.385ns	0.873	4.540*	0.024
Fruitworm infestation	32.395**	0.000	0.307ns	0.968*	0.254ns	0.857

Note: Tested at 95% level of confidence

Analysis of the *Epilachna* beetle infested leaves in Table 5 indicates no significant interaction between time and treatments, but main effects between treatments differed significantly. This means that the beetle-infested tomato leaves were significantly reduced with the use of mulching materials. Tukey's HSD test on infested leaves showed that plants with hand weeding had significantly higher infested leaves compared to mulched plants, particularly to unwoven cocofronds. Analysis also showed that fruitworm damage was not significantly different among treatments indicating that mulching had no influence on the number of infested fruits. A significant difference between times indicated that fruitworm-infested fruits irrespectively increased with crop age applied with mulching materials.

Influence of Coconut Fronds and Plastic Mulch on Yield of Tomato

Yield of tomato with and without mulch did not differ significantly from each other as shown in table 6. This implies the lack of influence of the mulch on the crop's yield. There could have been a treatment difference if the control plots had not been hand weeded.

Table 6 Yield analysis of tomato in tons/ha as influenced by cocofrond mulch

Source of Variation	Sum of Squares	df	Mean Square	F	P-value
Treatment	0.183	3	0.061	1.086^{ns}	0.392
Error	0.675	12	0.056		
Total	0.858	15			

Note: Tested at 95% level of confidence

CONCLUSION

Mulching is useful in suppressing the dominant weed, *B. laevis* in tomato production. The three bed mulches, woven and parallel arranged coconut fronds, and black plastic similarly suppressed the population of *B. laevis.* The black plastic mulch was highly effective in reducing spotted ladybird beetle [SLB] (*Epilachna* sp.) larval population, while both woven and unwoven/parallel arranged cocofronds had slightly suppressed the pest. The mulches reduced the SLB larval damage on tomato, although in this case the woven cocofronds was highly effective while, the non-woven/parallel cocofrond mulch and plastic mulch were slightly effective in minimizing the damage. Despite the effectiveness of the mulches on weeds and insect pest management, they did not influence crop yield, implying additional tests.

ACKNOWLEDGEMENTS

Indebtedness is hereby conveyed to the Australian Center for International Agricultural Research (ACIAR) for the financial support provided, likewise the ACIAR and the Visayas State University Research Teams for their technical assistance.

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Research article

Working with Ethnic Group: A Case Study of Introducing Pig Fattening to Garay Ethnicity in Ouyadav District, Ratanakiri Province

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Received 15 December 2014 Accepted 8 April 2015 (*Corresponding Author)

Absract Ratanakiri is remotely located in northeast of Cambodia about 600 km from Phnom Penh. Pig production of Garay ethnicity was challenged with poor feeding and high risk of mortality. The study aimed to compare the effect of feed supplement, estimate the economic efficiency, and study the adoption of target group to the demonstrated experiment pig fattening. A group discussion was launched to select 5 volunteer farmers from each village who met the criteria. The chosen farmers were trained on pig fattening process. Each of them had been subsidized two piglets; hand in hand pen construction, and feed supplements for 4 months. Some information was informally interviewed to understand the current feeding and management; and determine the suitable interventions. Farmers were then randomly allocated into two treatments, *viz.* T0 (Control group – free range feeding) and T1 (Supplement group – 40% concentrates, 30% rice bran, 30% cassava chip).The growth rate was recorded every 2 weeks for 4 months. After a 7-month period, all adopted farmers were interviewed by using questionnaire for impact study. The results have shown significant 3-fold improvement in daily average weight gain of improved diet group although the economic efficiency of the two groups did not differ. After seven months of interventions on the ground, some changes were observed. For example, 80% of the selected farmers kept pigs in pens regularly and started to utilized local available feeds. Thirty percent was willing to buy commercial feeds. All management tasks were done 50%, 40%, 10% by wives, husbands, and children, respectively. Vaccination was not totally implemented by them. We concluded that our interventions have changed some behaviors of focused famers and neighbors on the production in terms of management practices and feeding for pig fattening. More feeding options need to be assessed for better economic efficiencies.

Keywords fattening pig production, productivity, intervention, Garay ethnicity

INTRODUCTION

Ratanakiri province is located in the northeast of Cambodia. It borders with Laos PDR to the west and Vietnam to the east. The province is located about 600 km from Phnom Penh and the average annual temperature is in the range of 26-31 ^{o}C. Ethnic Group was the main target of the study; there is Garay ethnicity contributing totally 98% of population in Ka Te and Samkaninh villages of Lumchor and Soam Thom communities, respectively belonging to Ouyadav district selected as studied area. The main jobs of villagers are cassava and rice cropping, animal husbandry (more

noted as local breeds), as well as forestry such as hunter and labor work (RPDA, 2010). In Cambodia, pig raising is one of the sources of income for farmers through selling of pigs, pork, and processed pork, which are good sources of protein (Sorn, 2011). 92.81% of Pig production was conducted by smallholder in 2010 and this percentage decreased to 84.87% in 2013 due to rising of disease outbreak and low profit when selling to the market (DAHP, 2013). In general, small scale animal production depends on locally available feed resources such as rice bran, broken rice, sugar cane tops, sweet potato vines, cassava roots, and kitchen waste; while commercial feeds are rarely used due to high cost. The proportion of commercial feed used is about 20 % of pig smallholder, while the remaining 80 % depends on mainly crop residues and farm by-products, which are often poor quality and low nutritional value (Khieu et al., 1996). Biosecurity is defined as the implementation of creation the barrier to prevent most contamination and infection by segregation, cleaning, and disinfectant; the practices depend on production system concerned, the local geographic and socio-economic (FAO & OIE, 2010). However in Ratanakiri, the pigs of the ethnic group are freely raised, challenging poor feeding, no deworming and vaccination programs; resulting to high risk of diseases and mortality. In addition, due to land converting from forestry-covered to agro-industry land such as rubber farm, cassava, and so on; less scavenging areas are available. This leads farmers to hesitate to increase number of pigs, or even continue their raising. The introduction of pig fattening by concentrating diet supplemented to local basal diet, and proper management and bio-security (pig housing, deworming, and vaccination) by farmers would be a solution to overcome the constraints; while pig production performance and farmers' income would be improved. The farmtrials in this paper employ hypothesis testing and lessonlearn methods to study the adoption of new techniques of participating famers and neighboring ones.

OBJECTIVES

The study aimed to compare the effect of feed supplements, estimate the economic efficiency, and study the adoption of the target ethnic group to new techniques of the demonstrated experiment of pig fattening.

METHODOLOGY

There are 2 steps in this study: the first is to select the focused group and set up a trial of pig fattening, and the second is evaluation of farmer adoption.

Farmer Selection

Ka Te and Samkaninh villages were selected as the studied areas based on the ethnic resident that is 98% of Garay group. The discussions were conducted with local authority about farmers' situation in the selected villages. Farmer meetings were set up to introduce the project purposes and activities in each village. The selection of volunteer farmers to join the project was done during the meetings. Then, all willing farmers' houses were visited to observe their resources. The criteria of selecting the farmers were as follows: be ethnic group, willing to work, have available labors and house-area for constructing the pig pen, and grow some vegetables for the pigs. The household heads that were women, widows, and disable people were also encouraged to participate. After all criteria were met, the selected farmers were trained on fattening pig production, breed and breed selection, feed and feeding, housing, and bio-security.

Experimental Design

The selected farmers were assigned into 2 treatments as shown in Table 2, with five replications (farmers), and two piglets were distributed to each farmer. The two treatments were: T0: control group by supplementing rice bran and T1: supplement group: supplementing concentrates at 40% with cassava chip 30%, and rice bran 30%, mixed with farmer's basal diet.

Table 1 Feed supplementation

Group	T0 (Control)		T1 (Supplement)	
Duration	Jul-Aug	Sep-Oct	Jul-Aug	Sep-Oct
Quantity for 2 piglets (kg/day)	0.4	0.5	0.8	1.0
Piglets (heads)	10		10	
Crude Protein (%)	9.5 %		20.5 %	

Piglet Housing and Distribution

After completed the training course, pig pens were constructed by full participation from farmers to improve their understanding about pig pen. The method was learning by doing as they had no experience to construct the pen before. The pen size was 2 meters in width and 3.5 meters in length with concrete floor, iron sheet roof, and wooden barred to protect the piglets out. Twenty local breed piglets of three months old were bought from nearby villages, and then they were randomly distributed to volunteer farmers. The initial piglet-weigh in both groups was non-significant as: T0 was 6.39 ± 0.38 kg and T1 was 6.41 ± 0.36 kg.

Feed and Feeding for Pig Fattening

Concentrate feed was used as a part of supplement diet to show farmers how much feed rich-protein could improve the growth performance of their pigs. The basal diet of both groups was based on locally available feed resources such as taro stem, banana stalk, sweet potato vines, pumpkin, papaya and vegetables. Feeds for supplement of both groups were packed for 1-time feeding to be mixed with basal diet.

Management and Bio-security

In order to introduce the farmers, some parts of bio-security were implemented; the pens were disinfectant by applying commercial calcium bicarbonate, cleaned by boiled water 100 ^{0}C after 1-day period, and piglets were kept in individual pens with drinking nipples. All the pigs were vaccinated against hog cholera disease, treated with an anti-parasitic drug (Ivomic given by injection) at the first week of keeping and beyond after one month next. Pigs were fed 2-3 times per day depending on available time of the farmers.

Table 2 Vaccination

Date	Piglet Age	Vacine name	Disease	Usage
27/07/2013	3 months	Pest Porcine	Hog Colera	Muscle injection
27/08/2013	4 months	Pest Porcine	Hog Colera	Muscle injection

Data Collection and Analysis

The piglets were weighed every two weeks in the morning before feeding. Feed supplementary and feed refusals were daily recorded. All data were recorded using Microsoft Office excel 2010. The study of farmers' adoption was conducted by questionnaire 3 months after the experiment finished. In every 2 weeks, growth performance deviation was analyzed by using Independent Sample T-test Statistics of SPSS version 18. The adoption data from the questionnaire was analyzed by Microsoft Excel to calculate the descriptive statistics and to design graphic.

Chemical Analysis

Samples of feed supplement—concentrated feed, rice bran, cassava chips, were collected from the area of study and analyzed for Dry matter (DM) and Nitrogen (N), according to Undersander et al. (1993) and AOAC (1990), respectively.

RESULTS AND DISCUSSION

Table 3 Average daily gain of pig (Gram/day/head)

No.	Group	N	Mean	Std. Deviation	P. value
1	Control	10	86.25	16.36	0.00
2	Supplement	10	277.59	26.05	

The supplementation group had higher daily weight gain than control group, piglets in supplementation group had ADG at 277.59 ± 26.05 gram per day (P<0.001) as shown in Table 3. Comparing to the study of Phengsavanh et al. (2013), as providing the concentrated feed containing CP 20 % on Growing Local Breed gave an average daily gain at 263.5 gram/day. Yin (2008) showed that cross breed of local and exotic breed fed by normal food of famers (rice bran and kitchen waste), provides growth performance at 82.00 ± 9.36 gram/day; and another group supplemented commercial concentrated feed 15% of live body weight (LBW) provided up to 313.00 ± 18.00 gram/day.

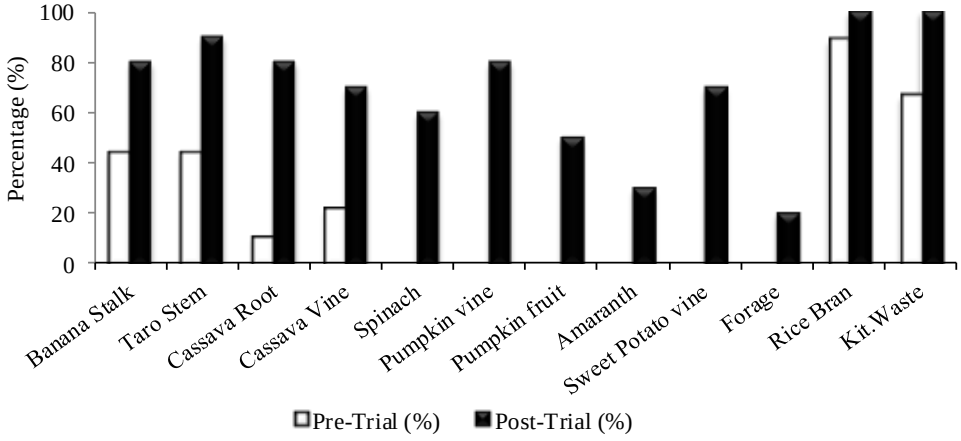

Fig. 1 Feed used as Pig's food pre-intervention and post-intervention

Before starting this study, the Garay ethnicity has raised their pigs by letting them freely scavenge with poor feeding. Pigs were fed irregularly depending on the convenience of owners. After 7 months of participatory with the study, the focused farmers have been utilizing some available local materials to feed their pigs such as banana stalk, taro stem, cassava root, cassava vine, spinach, pumpkin vine, pumpkin fruit, amaranth, sweet potato, and forages (Stylo 184), rice bran, kitchen waste, and other local vegetables as shown in Fig. 1.

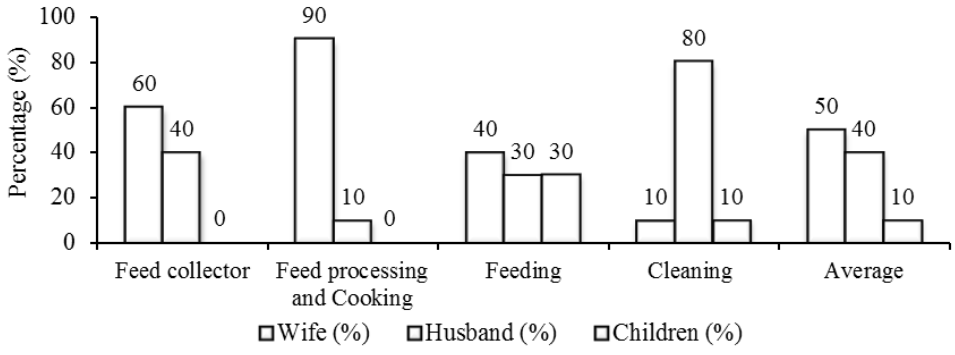

Fig. 2 Family participation in pig production

The Garay live traditionally, as men work on farm. All housework and taking care children are done by women. Normally, women are not allowed to make any decision. During the training, women were encouraged to work for pig fattening program and actively contact with the researchers to increase their social rights in terms of gender equality. Figure 2 shows that most of pig raising processes were done by women 50 %, men 40 %, and children 10 %.

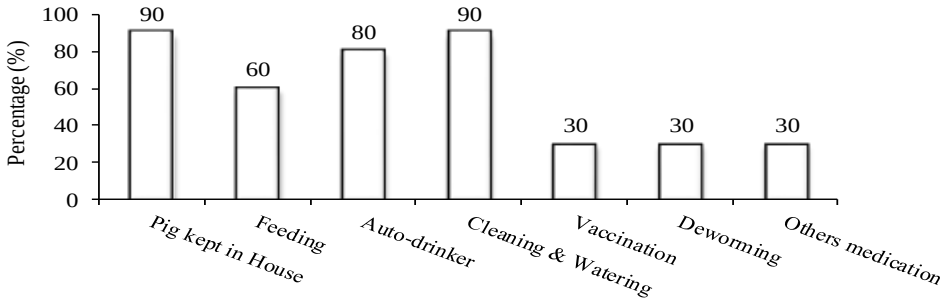

Fig. 3 Farmer adoption to component intervention

During the study, farmers kept their pigs in pens, and regularly fed 2-3 times a day. Two auto-drinking machines were broken by pig biting, whereas the rest 80 % could be used. Every morning, farmers cleaned the pens and pigs. These tasks were handled by children when the farmers were not available. Some farmer houses had a machine, which eased cleaning process. However, the vaccination and deworming process were complained by farmers, as it was expected to be done by a national program.

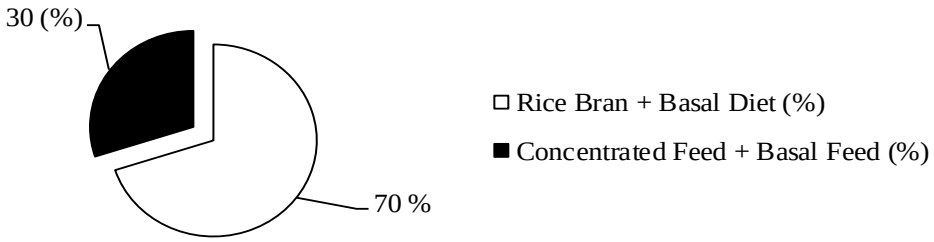

Fig. 4 Feed used during adoption study

The commercial feed is too expensive and the market is far from the village, causing farmers burdens to travel or buy as pig diet. As shown in Fig. 4., most of the farmers have used the rice bran mixed with vegetables, whereas there were three farmers who have bought the commercial feed for their pigs.

Estimated Economic Efficiency

The economic efficiency between two groups was not much different. For Group T1, supplementing by the concentrate feed was less economic than the result of using expensive commercial concentrate feed. The commercial feed was not recommended to use as pig food because feed conversion ratio (FCR) of local pig is a limitation.

CONCLUSION

The use of commercial feed supplement for pig production improved the growth performance but its expensive price caused non-economic production. On-farm experiment would help farmers to understand the real condition.

Table 4 Economic efficiency of control and supplement group

Items	Unit	T0 (Control)			T1 (Supplement)		
		Price/unit (USD)	Number	Price	Price/unit (USD)	Number	Price
Piglets	heads	15.00	10	150	15	10	150
Food	Kg	0.23	500	112.5	0.54	1000	540
Medication	per cycle	0.50	10	5	0.5	10	5
Housing	per cycle	2.65	10	26.5	2.65	10	26.5
Drinker	per cycle	0.38	10	3.75	0.38	10	3.75
Grand expense	USD			297.75			725.25
Gross Income	USD	2.13	160.5	341.06	2.13	375	796.88
Economic efficiency	(%)			**1.15**			**1.10**

Knowledge that they gained could be more effective for making decision with consideration of process that was applicable for their areas. Some techniques and complicated process such as vaccination made farmers hesitate to follow; hence, they always thought the government would support it. Moreover, the information from this on-farm practice was rare to be done for smallholder farmers. Otherwise, further study should focus more on on-farm experiment with farmers, who have less understanding of how to involve their livestock production to new technology.

ACKNOWLEDGEMENTS

Much grateful to CIAT and IFIAD for fund support, and all professors and lecturers of Animal Science Faculty and all staff at Center for Livestock Development Studies for critical comment and document support, senior researcher from Department of Animal Health and Production and Ratanakiri Provincial Department of Agriculture for suggestion and physical contribution into the study.

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Research article

Tube Stamp for Mechanical Intra Row, Close to Crop Weed Control of Carrots (*Daucus carota*) in Organic Farming

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Received 25 March 2015 Accepted 29 April 2015 (*Corresponding Author)

Abstract Weeds are competitors against crop plants for resources such as water, light, and nutrients. Consequently, weeds are responsible for a decrease in yield. In organic farming, only non-chemical weed reduction is possible. Many practicable techniques for mechanical inter-row weed treatment are available, however, options for intra-row treatment are more limited. In particular, there is no method for individual plant weed control for dense row crops such as carrots, due to the high risk of damaging the culture plant. Therefore, in organic farming of dense row crops, this task is still conducted manually which leads to high labour costs. As part of the research project RemoteFarming.1 "web-based interactive crop farming at the example of robotic weed control in vegetables", a new tool for intra-row individual plant weed control was developed as component of an autonomous field robot. The field robot possesses all devices, which are necessary for mechanical individual plant weed treatment - cameras, a manipulator arm and a weeding tool (tube stamp), as well as mobile network capabilities. The detection/identification of weeds, which is used a web-based approach, is remotely assisted by a human remote worker. In the initial studies, the tube stamp was tested regarding its efficiency in the field and its efficiency on various weed species under defined conditions. Weed plants treated with the novel tube stamp show none or very few remaining vegetation in BBCH-scales (Bundessortenamt, Biological Federal Institute, Chemical Industry). It is up to 12 weed plants allow the crops to be advanced. Furthermore, this weed treatment technique niether introduce cuts in the soil nor causes broad soil loosening, which would stimulate the germination of new weed plants. Consequently, its very low impact zone of 11 mm of diameter allows reducing weeds in dense row crops and close to crop successfully.

Keywords intra-row, weed-control, carrots, field robot

INTRODUCTION

In agricultural cultivation, weeds are competitors against crop plants for resources such as water, light, and nutrients. Consequently, weeds cause low yield. Weeds grow between the lines (inter-row), within the lines (intra-row), and nearby the crop (close-to-crop). In conventional crop production, there are no differences between weed control techniques for different growing areas due to the allowance of chemical plant protection. One aim in organic crop production is to avoid the introduction of chemical plant protection products to the environment. Thus, in organicfarming, only non-chemical weed reduction is allowed. Beyond thermal and biological treatments, many practicable techniques for mechanical inter-row weed treatment are available, while options for

intra-row treatment are extremely limited. Mechanical intra-row weed control is usually carried out by methods and mechanisms such as weeding harrows, torsion weeders, rotary hoes, finger weeders, or vertical brush hoes (Mohler, 2001; Bond and Grundy, 2001; Upadhyaya and Blackshaw, 2007; van der Weide et al., 2008). In a very limited number of studies, selective mechanical methods were also developed. The systems differentiate between crop and weed and regulate the weed in the intra-row area without damaging the crop plant. For example the "Cycloid hoe", tested in maize (Wißerodt et al., 1999; Kielhorn et al., 2000), the "Mobile robot" (Åstrand and Baerveldt, 2002), the "Rotating disc" (Tillett et al., 2008), a "Weeding machine" also tested in maize (Cordill and Grift, 2011) or a concept of a special "Rotary hoe" (Müter et al., 2013).

Furthermore, at the time being, there is no practicable method for close-to-crop mechanical weed control, in particular in dense row crops like carrots (*Daucus carota*) and onions (*Allium cepa*), due to the high risk of damaging the culture plant. Thus far, this process is performed in dense row crops by hand-weeding. This method requires exhaustive and not ergonomic manual labour and is very time-consuming, which results in high cost and intensive labour management (van der Weide et al., 2008).

The new tool for intra-row individual plant weed control (tube stamp) is developed as part of the collaborative research project RemoteFarming.1 "web-based interactive crop farming at the example of robotic weed control in vegetables". The project RemoteFarming.1 combines field robotics, sensors, and actuators, as well as web-based interactive communication technology, in one system (Sellmann et al., 2014). Within the project an autonomous, multipurpose field robot platform, called "BoniRob", is built (Fig. 1, left). It can autonomously navigate along crop rows and ridges using a 3D laser scanner or freely using GPS data. The BoniRob is designed as a carrier, supplier, and base for multiple BoniRob-Apps; which can be integrated into the platform using defined mechanical, electrical, and logical interfaces (Bangert et al., 2013). One of these BoniRob-Apps is a mechanical weed control App developed as part of RemoteFarming.1. It includes the tube stamp presented in this paper.

Fig. 1 Autonomous field robot platform "BoniRob" with and without Remote Farming.1 application for intra-row individual plant weed control (left). Manipulator and tube stamp actuator for single plant treatment (right)

The mechanical weed control App has a camera set up, supplemented by a wavelength adapted lighting system for recording high-resolution image data. The tube stamp is connected to a delta robot with a parallel kinematic structure (Veltru D8). It positions the tube stamp with Visual Servoing. Details on the vision based manipulation can be seen in Michaels et al. (2013).

In the first step of the project, called "RemoteFarming.1a", the detection of weeds is solely performed by a remote worker using "human image processing". The person marks the weeds in the image data acquired by the robot on the field.The positions of weeds are then transferred back to the BoniRob via mobile networks (Sellmann et al., 2014). The delta robot moves the actuator (Fig. 1, right) according to the previously selected position and eliminates the weed.

In the next step, called "RemoteFarming.1b", the automatic detection of weeds based on an automatic plant classification system without segmentation (Haug et al., 2014) is included. Based

on this automatic image processing, the remote worker gets suggestions for weeds to be removed. Then the remote worker can confirm, modify, or delete these target positions before the respective weed will be treated.

METHODOLOGY

The tube stamp essentially consists of a tube housing (Fig. 2, g), a high-helix lead screw (Fig. 2, a), a lead screw nut (Fig. 2, b), a special tube (Fig. 2, e), two springs with different spring constants (Fig. 2, d and f) and the stamp (Fig. 2, c) (diameter 11 mm) which is forced through the channel of the tube. It is powered by a 70 Watt BLCD motor (Fig. 2, h).

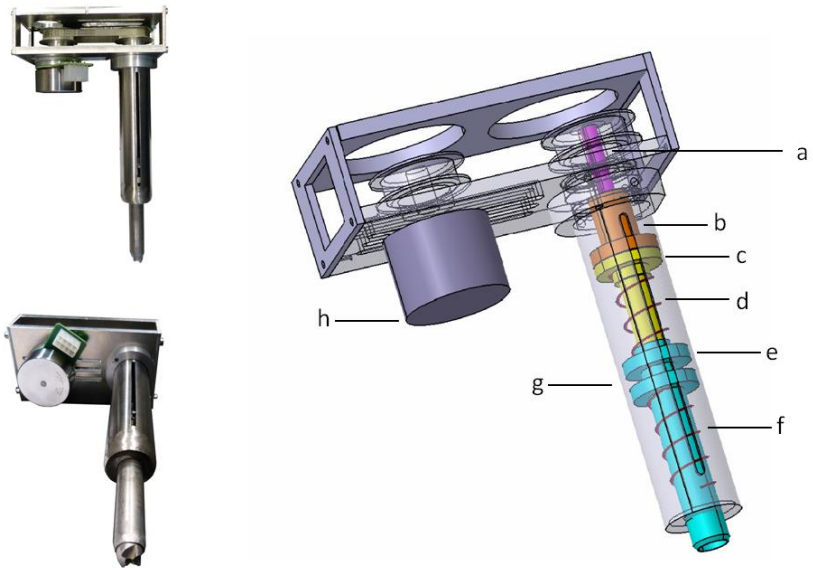

Fig. 2 Tube stamp for single plant weed control in detail

Stamp and tube are connected using a combination of two springs. In phase 1, the system is at rest (Fig. 3) with all elements in starting position. The tube and the stamp are completely inside the tube housing. In the second step, phase 2 – the stamp is moved downward to penetrate the soil approximately 47 mm. The rotary motion of the motor is converted into a vertical movement using the high-helix lead screw/lead screw nut combination. The spring constant (c_2) of the spring connecting the tube housing with the tube is lower than the constant (c_1) of the spring connecting the tube and stamp. Accordingly, the motion of the stamp is initially fixed along with the motion of the tube. The tube touches the ground first and fixes the weed and holds it for the execution of weed termination. The tube and stamp are forced downward together until the spring (c_2) is completely compressed. In the last step of the stamp movement, phase 3 – stamping, the stamp advances downward through the tube until spring (c_1) is completely compressed. The stamp then makes contact with the weed and pushes it into the ground. It then proceeds to damage the weed with its sharpened head. The electric-motor then inverts the direction and removes the stamp from the soil. The tube is moved by the spring (c_2) back to its initial position. The process duration is less than 600 milliseconds.

For tests, the tube stamp has been decoupled from the RemoteFarming.1 system and integrated into specially designed devices: a fixed device for greenhouse experiments and a mobile device for field trials.

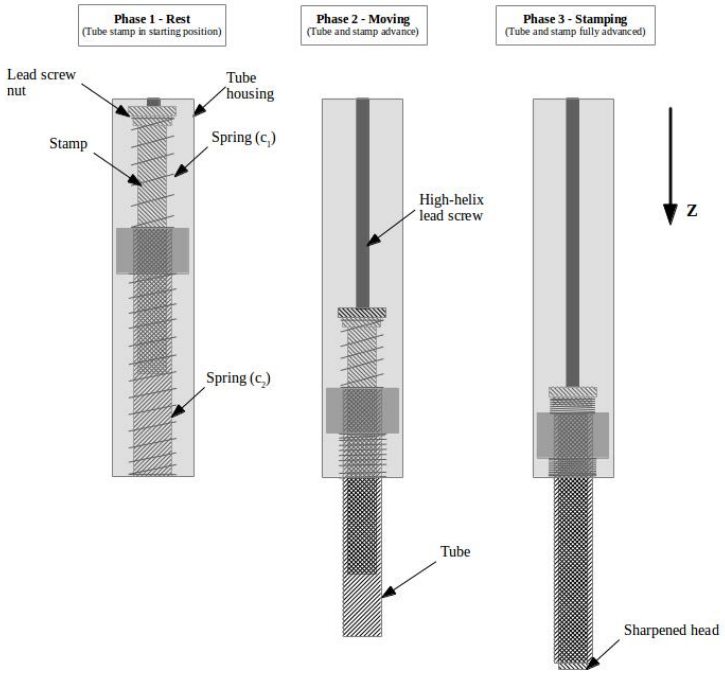

Fig. 3 Basic structure of weeding process with the tube stamp

RESULTS

Experiment 1: Test under Greenhouse Conditions

Setup

In experiment 1, the effectiveness of the actuator in relation to different weed species was tested. The experiment took place under greenhouse conditions with controlled temperature, artificial lighting, and species-appropriate irrigation. For this purpose, the species *Stellaria media*, *Capsella bursa pastoris*, *Daucus carota*, *Vivia cracca*, *Poa annua*, *Setaria viridis* were seeded in isolated flower pots. This was based on a substrate with the soil type lS (loamy sand). To eliminate the germination of species out of the substrate seed pool, the substrate was heated up to 80° C for four days. Ninety specimen of each species were seeded. The germination rate of each species differed. Consequently, there were different amounts of plant samples per type for the test. All plants were treated in BBCH-scale 10 to 11.

In order to perform the experiment in a greenhouse, the actuator was mounted on a stationary test bench, which also carried the system control and user interface. Thereby, the plants could be placed precisely below the actuator.The mechanism was manually activated. The actuator treatment took place and the flower pots were removed from the test bench. After regulation, the phenotyping of the regulated weed plants followed. This was done according to the following classification (in dependence on rules of agriculture value analysis of the German Federal Plant Variety Office (Bundessortenamt, 2000)):

Level 1 = no weed plant damage
Level 3 = low weed plant damage
Level 5 = moderate weed plant damage
Level 7 = high weed plant damage
Level 9 = weed plant dieback

Outcome

Figure 4 shows the result of experiment 1. The y-axis represents the percentage number of actuator treatments. The x-axis shows different plant species. Thus, the bar-chart demonstrates the percentage number of actuator treatments with the particular phenotyping level of each species. The absolute number of actuator treatments at the species *Stellaria media* is n = 28. One-hundred percent of this species is classified with the phenotyping level 9 (weed plant dieback). The results of *Capsella bursa pastoris* are similarly. One-hundred percent of this species is classified with phenotyping level 9 by an absolute number of actuator treatments n = 19. Any other species depend a lower influence of the actuator treatment (*Daucus carota* n = 51, 64.71% of them were classified with level 9, 1.96% with level 7 (high weed plant damage), 7.84% with level 5 (moderate weed plant damage), 7.84% with level 3 (low weed plant damage), 17.65 % with level 1 (no weed plant damage); *Vivia cracca*, n = 21, 57.14% with level 9, 4.76% with level 7, 0% with level 5, 4.76% with level 3, 33.33% with level 1; *Poa annua*, n = 86; 56.98% with level 9, 8.41% with level 7, 6.98% with level 5, 3.49% with level 3, 24.42% with level 1). With a result of 43.48% plant dieback (10.87% with level 7, 6.52% with level 5, 0% with level 3, 39.13% with level 1) by *Setaria viridis* (n = 46), the tube stamp has the lowest influence. The experiment reveals that weeds tend to show different reactions to the actuator treatment.

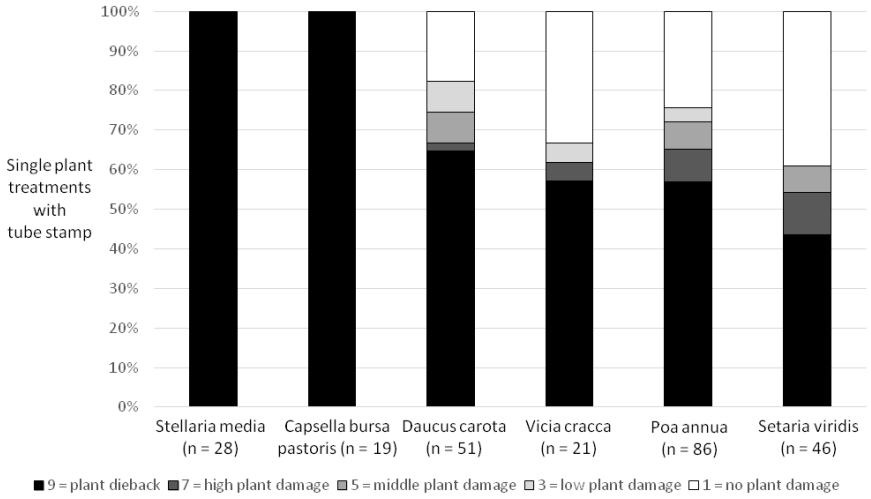

Fig. 4 Effect of single plant treatments with tube stamp at different weed species under greenhouse conditions

Experiment 2: Field Trial

Setup

To test the efficiency of the tube stamp, a field trial was performed. The Basis for the test section was a parcel with soil type sL (sandy loam). The field contained ridges with a peak-to-peak width of 750 mm and a height of 220 mm. Carrots of the variety *Nantaise* were seeded in the middle of the ridge. At the time of the field test, the weeds were in the BBCH-scale of less than 12. The diversity of the weed species was limited to *Stellaria media*, *Matricaria recutica*, *Viola arvensis*, *Convolvulus arvensis* and *Chenopodium album*. During the 7 day period from regulation to phenotyping, there was an average temperature of 13° C with a maximum of 22° C and minimum of 8 °C. The accumulated precipitation was 14 mm. Plots were marked on the ridge crown with dimensions 30 cm long by 10 cm wide. In total there were 10 plots.

For this experiment, the actuator was installed on the mobile platform, which also carried the system control and user interface. The actuator can be moved along two axes using two linear bearings. Thus, it was possible to position the actuator directly on top of the weed. The positioning and the activation of the tube stamp were done manually. Seven days after procedure, the

phenotyping of the individual plants took place. This was similarly performed with the procedure of experiment 1.

Outcome

Figure 5 shows the result of the experiment 2: field trial. The y-axis represents the percentage of actuator treatments. The x-axis shows the distribution of phenotyping classification. One-hundred and thirty plants were treated. One-hundred and ten plants were rated as classification number 9 (weed plant dieback, 84.62%), 6 plants as classification number 7 (high weed plant damage, 4.62%), 6 plants as classification number 5 (moderate weed plant damage, 4.62%), 4 plants as classification number 3 (low weed plant damage, 3.08%) and 4 plants were rated as classification number 1 (no weed plant damage, 3.08%).

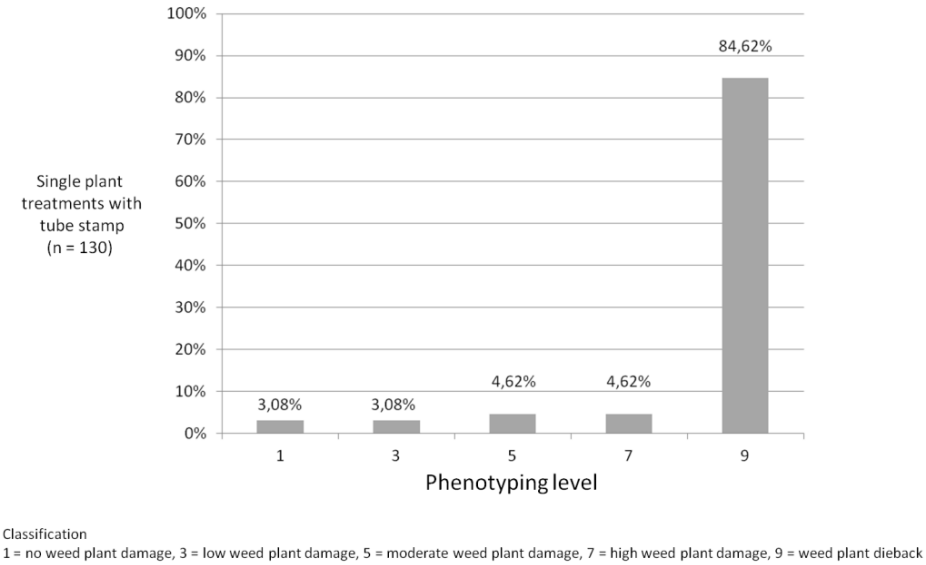

Fig. 5 Results of single plant treatment in experiment 2: field trial Osnabrueck

Fig. 6 Plot with tube stamp treatment compared to control plot without tube stamp treatment. The tube stamp treatment was realized 13 days ago

Figure 6 shows an example of actuator treatment (Fig. 6, top) compared with a control plot without tube stamp treatment (Fig. 6, bottom). The tube stamp treatment was realized on the ridge

crown 13 days before. The ridge sides were formed by a hoe. This two variants showed significant differences.

DISCUSSION

The first experiment demonstrates the potential of the stamping mechanism. The results of experiment 2 show a significant effect of the tube stamp on weeds (Fig. 5 and Fig. 6). Eighty-four point sixty-two percent of weeds was fatally damaged. In each case, 4.62% were moderately to highly damaged. In addition these plants (plants with phenotyping note 5, 7 and 9) were damaged to a great extent. Therefore, there was none or very little remaining growth of the weed plant. Consequently, the culture plant could overtake the weed plant. Thus, a successful individual weed control rate of 93.86% was achieved. By comparison, the studies show a weed reduction of 63% to 82% per usual practice hand weeding in organic carrot production. This comparison demonstrates the high efficiency of the tube stamp process. Figure 6 which show a plot with tube stamp treatment compare to a control plot without tube stamp treatment, support this statement.

In experiment 1, the effectiveness of the tube stamp in relation to different weed species has been tested. All treaded plants were in BBCH-scale 10 to 11. All plant samples of species *Stellaria media* and *Capsella bursa pastoris*could be destroyed by the tube stamp. However, some samples of the species *Daucus carota*, *Vicia craca*, *Poa annua* and *Setaria viridis* persisted after the treatment by the actuator. In parts, these species showed a remaining growth. The experiment shows that weeds tend to differently react to the tube stamp treatment. However, for all tested species, the treatment at the mentioned growth stage significantly damaged the majority of samples. It is noticeable for the results of distribution of the tube stamp treatment. Mainly, there is an irreversible mortally damage. High, moderate, and low damage are very low. On the other hand, the level "no damage of the weed plant" increases. Consequently, in this study specific species have been damaged mortally or have shown no effect. Moreover, it is the high percentage of low or not damaged grasses *Poa annua* and *Setaria viridis*.

Further, this experiment was realized under highly controlled conditions. Thus, there were ideal conditions for plant growth. Vice versa, there could be different and suboptimal conditions in the field. Especially, suboptimal environmental conditions, like high temperature, high/low rainfall etc., could weaken the weed plant. There was also no competition for resources between the culture plant and weed plant, which could further degrade the weed plant. Therefore, the results are different under field conditions. A negative aspect is the different germination rate of weeds. Therefore there is no significant statistic, only a tendency.

Consequently, in addition with the RemoteFarming.1 system, it is possible to control weed growth in the close-to-crop area and less spaced culture plants. All previously known selective-mechanical operating systems were designed for row crops with wide row spacing (Åstrand and Baerveldt, 2002; Cordill and Grift, 2011; Müter et al., 2013; Wißerodt et al., 1999; Kielhorn et al., 2000) e.g., maize (*Zea mays*) and sugar beets (*Beta vulgaris*). These systems work on the whole intra-row area between the culture plants for example with rotating disc (Tillett et al., 2008) or special tines (Kielhorn et al., 2000; Gobor et al., 2013; Cordill and Grift, 2011). The novel tube stamp concept enables single plant treatment in crops with small in-row space; particularly weed treatment in the close-to-crop area.

CONCLUSION

Intra-row and close-to-crop weeding in dense row crops is cost intensive and time consuming. As part of the project RemoteFamring.1 a new tool for intra-row individual plant weed control was developed, called tube stamp. In the initial studies, the tube stamp was tested regarding its efficiency in the field and its efficiency on different weed species under defined conditions. The result of the field trial showed significant weed reduction. Thus, a successful individual weed control rate of 93.86% was achieved.

There is still a continued improvement of the tube stamp and the RemotFarming.1 system. Further studies are necessary to compare the RemoteFarming.1 system with other strategies, as well as research for the potential influences of the tube stamp on culture plant yields. Consequently, the tube stamp works with high effectiveness under practical conditions in close-to-crop area. With the integration of the tube stamp in the RemoteFarming.1 module, the complete system could replace other existing, cost intensive systems for intra-row weed control.

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Research article

Problems in Rural Areas of Bosnia, Montenegro and Serbia: A Comparative Analysis

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Received 13 February 2015 Accepted 30 April 2015 (*Corresponding Author)

Abstract: Bosnia, Montenegro, and Serbia (BMS) are in a phase of consolidation, which implies rising of economic growth, agricultural productivity, and fostering rural development. Therefore, it is crucial to have a clear idea about problems faced by rural population in order to design effective rural development policies. The paper aims at highlighting the main problems in rural areas of BMS with a particular focus on those hampering good governance and increased diversification of their rural economies. For each country, significance of the problems was identified; and a critical analysis was performed to highlight causes, implications in terms of rural governance and policy, and potential solutions. Problems were identified in the framework of surveys dealing with agricultural and rural development governance that involved representatives of public, civil society, and international organizations: 120 in Bosnia (winter 2011), 50 in Montenegro (winter 2012), and 120 in Serbia (summer 2013). Economic problems include difficult access to financial resources, low level of investments, rural economy diversification, limited employment opportunities, small and uncompetitive farms, and rural enterprises. Remoteness and isolation, bad local natural resources management, and increased pollutions were the main environmental and geographic problems mentioned by the interviewees. Socio-cultural and demographic problems encompass rural poverty, low quality of life, gender inequity, low human capital of the rural population, unpopularity of agriculture and alarming negative demographic trends. Focus of local development strategies mainly on agriculture and lack of local spatial plans are some of the political and regulatory problems. There are also problems related to the poor physical infrastructure and services, and lack of processing facilities and local markets. For smooth accession to the European Union (EU), BMS should address these problems urgently in a systemic and holistic way to unlock the growth potential of rural areas, taking stock of the current EU's rural development policy.

Keywords rural areas, agriculture, problems, Bosnia, Montenegro, Serbia

INTRODUCTION

The three countries of the Western Balkan (WB), namely Bosnia, Montenegro and Serbia (BMS), are in a phase of consolidation, which implies rising of economic growth, agricultural productivity, and fostering rural development. Therefore, it is crucial to have a clear idea about problems faced by rural population in order to design effective rural development policies.

Around 61% of the Bosnian population can be classified as rural (UNDP, 2013). The share of Montenegrin population living in the countryside accounts for 38% of the total population (Arcotrass-consortium, 2006). Approximately 43% of the Serbian population lives in rural areas (RDNS, 2010). The rural areas of BMS lag behind in terms of socio-economic development and still face many problems such as low quality of life and limited employment opportunities. In such context, agriculture plays an important socio-economic role for employment and poverty reduction. Moreover, since a large share of population lives in rural areas, there can be no balanced development of BMS without devoting more attention to rural population and combating rural poverty. For the development of agriculture and rural areas, evidence from other countries such as those of the EU, show that agriculture is not sufficient to ensure the sustainable development of rural areas. It is the core reason why rural economy should be diversified (OECD, 2006). Participation of local actors in rural development processes is particularly important; especially there is a transition to adopt people-centred approaches and policies. It is clear nowadays that achieving sustainable and inclusive development of rural areas means long-term effective and efficient policy measures. It is important that these policy measures and instruments have real impact on rural population livelihood and quality of life. Hereinafter, they should create an enable environment for investments, improve household assets, and service delivery in rural areas.

The paper aims at highlighting the main problems in rural areas of BMS with a particular focus on those hampering good governance and increased diversification of the rural economy.

METHODOLOGY

The applied methodology comprised both primary and secondary sources of information. Many literature sources were consulted and primary data were collected by a questionnaire survey that was sent via email to different key stakeholders in BMS.

BMS share similar traditional, cultural, and historical background as ex-republics of the former Yugoslavia. The spoken language is the same, which made easier communication for online questionnaire dissemination and the overall survey. Problems were identified in the framework of surveys dealing with agricultural and rural development (ARD) governance that involved representatives of public, civil society, and international organizations; 120 in Bosnia (winter 2011), 50 in Montenegro (winter 2012) and 120 in Serbia (summer 2013). Unit of data collection was individuals, one representative per eligible organisation, while unit of data analysis was organizations. Only institutions that are involved in ARD were considered in the surveys. The selection of eligible institutions was mainly based on internet search and literature review as well as authors' personal and professional networks. Questions were open ended to say that no list of problems was previously prepared and respondents were left at their own to identify problems. The questionnaire was pre-tested in all target countries with representatives of public, civil society, and private sector. Feedback gained was useful for making improvements, especially in terms of used terminology and question wordings. For each country, the significance of each identified problem was identified and a critical analysis was performed to highlight causes, implications in terms of rural governance and policy, and potential solutions.

RESULTS AND DISCUSSION

Problems in rural areas mentioned by the respondents can be divided in several categories: economic problems; environmental and geographic problems; institutional, political and regulatory

problems; social, demographic and cultural problems; and infrastructure- and service-related problems (Table 1).

Economic Problems

Lack of financial resources is one of the main indicators used for assessing poverty. This problem is more expressed in those rural areas in which employment opportunities are limited and where many people suffered due to loss of jobs. This is particularly true in the Bosnian case where many companies were totally devastated or partially during the civil war. However, overall unstable political and economic situation in whole WB also negatively affected the quality of life in the rural areas of Montenegro and Serbia. In addition, the lack of financial resources is connected to *difficult access to credits due to lack of collaterals*. Therefore, rural population hardly has access to credits and does not have savings that allow to live with dignity and to make investments for future. Financing agriculture and agribusiness has always been difficult due to the risky nature of the business. Traditional forms of collateral are often not available, and not acceptable when they are available. Thus, limiting access needs funding for the sector (Winn et al., 2009).

Rural economy diversification is still a challenge in many rural areas of BMS, both in terms of off-farm and non-farm income-generating activities. Despite its declining gross value added, agriculture continues to have an important influence on the rural economies of these countries. Farm activities diversification in BMS is hampered by the lack of financial resources, willingness, initiatives, and knowledge and skills of rural households to start new endeavours. Diversification endeavours can allow, among others, to add value to products through some on-farm processing and packaging activities, as well as to make products widely recognized by developing products with geographic indications and regional quality labels. Rural economy is still highly dependent on agricultural sector, not only because of reluctance and resistance of rural households to start new activities in the non-farm sector but also the focus of national rural development strategies and local development plans on agriculture.

As for *small fragmented uncompetitive farms*, there is lack of farmers' organization, which is coupled with the dispersed farm settlements, hinders the participation of farmers in ARD. This hinders also the supply of extension services, farm credit, and other vital inputs to farmers and infrastructure. All these factors negatively impact competitiveness of single farms but also the overall agricultural sector of whole countries.

Environmental and Geographic Problems

Long distance to urban areas is often mentioned especially in Montenegro. This is related to uneven regional development and lack of urban nuclei that aggregate economic activities near to rural areas. This problem is further aggravated by poor road infrastructure, which makes mobility more difficult. Another problem is *bad management of local resources and increased pollution due to uncontrolled use of chemicals.* The excessive exploitation of forests and the irrational use of land caused a change in land use structure (Nyssen *et al.,* 2014), and the quality of vegetation cover. In these cases, it is necessary to adopt conservation agriculture techniques and practices. Bosnian agriculture is rather traditional and the use of chemicals is low (Stanojcic-Eminagic, 2010). Fertilizers and chemicals application should be under control especially in Serbia (*cf.* Vojvodina).

Although many scholars and practitioners highlight the potential of *organic agriculture* as a sustainable development opportunity for the developing and transition countries, it is still at the early developmental stage in BMS. In fact, less than 0.01% of the products consumed in Serbia is organic (GAIN, 2009), while in Bosnia organic area represents less than 0.1% of the total agricultural area (Driouech *et al*., 2013). The main obstacles for organic production development in BMS region are the lack of adequate government support (Vittuari, 2011), the undeveloped market, the small range of organic products, and the underdeveloped processing infrastructure.

Unused natural resources and mined agricultural land is mainly a legacy of the civil war in Bosnia that compelled many people to migrate from rural areas. *Limited arable land* in Montenegro

is predominantly due to geomorphology as quite a large part of the country is mountainous and karst.

Institutional, Political and Regulatory Problems

The main problem is lack of a stable ARD policy. ARD policy-making in the WB region in general and in BMS in particular has often been dictated by ad-hoc considerations. Agricultural policy is still mostly implemented based on annual programs of budget allocation, which are not stable in terms of funds, support measures, and eligibility criteria. Rural development policy is generally subordinate to production support. Funds aimed at supporting rural development are much lower (Volk, 2010). One characteristic specific to Bosnia is state administration complexity, which complicates the implementation of its agricultural policy. Montenegro has already undergone major changes in the process of reforming agricultural policy but many challenges remain (Marković and Marković, 2010). In Serbia, the implementation of agricultural policy has been permanently changing. Programs and regulations were changed and/or abolished several times during the year. The agricultural policy in Serbia is only partly designed on a strategic basis. In recent years, it has been characterized by the increasing estrangement from the EU model of support. Frequent changes in administrative structures bring radical changes in the support system (Bogdanov and Bozić, 2010).

Social, Demographic and Cultural Problems

Rural poverty is a serious problem faced in many rural areas in BMS. Poverty is a complicated issue that is influenced by endowments and capital of rural households; and also by general social environment, especially in terms of presence or absence of social programs and safety nets.

Gender inequity is still an issue in the rural areas in BMS. This should be broadly understood not only in terms of equity between men and women but also in terms of different socio-economic and ethnic groups. Female rural population has very limited participation in the decision-making processes (FAO-Bosnia, 2012). The truth is also regarding their share in the most important positions within ministries and other public institutions. Rural youth are also among the most disadvantage groups. They sometimes have limited access to educational programmes. Very often, rural young women are not given the same opportunities comparing with young men. Young people are not enough involved in rural policy cycle. Unfavourable environment "push" youngsters to migrate and rural areas remain without human capital and cannot achieve development. Youth's knowledge and skills are of vital importance for the implementation of sustainable ARD programmes (FAO, 1991).

Prejudices of youngsters about staying in the countryside and unpopularity of agriculture are related to their mind-sets. The education that they receive in rural areas is very often urban oriented and makes them believe that their future perspectives will be better in the urban areas. Living in cities is perceived as prestigious and fashionable especially in *rural mentality*; and it can happen that rural people, especially the young, prefer to move even when they find less paid jobs in comparison with the ones they can get in rural areas. Bad services quality influences *negative demographic trends* in rural areas because it fosters out-migration. In addition, poor services are among the consequences for intensified urban drift.

As for the *use of traditional technologies*, despite effort made for modernizing the agricultural sector in the three countries, agriculture is still mainly traditional except in some fertile areas such as Vojvodina (Serbia) and Semberija (Bosnia). In fact, the use of traditional methods and techniques calls into question about the efficiency of agricultural extension services. Most of farm managers are old and not open to modern technologies. Difficult access to plots makes mechanization difficult. Agricultural production is predominantly in the hands of a multitude of small-scale and unorganized farmers. State level interventions are needed to address the issue of land fragmentation through land consolidation.

Infrastructure and Service Problems

Dispersion of rural settlements is a big problem as it influences the availability and quality of a range of services. Adequate access of all rural people to services and structures (including infrastructure) necessary to engage in diversification endeavours is far from optimal. It has to be linked to costs related to service provision in rural areas especially in times of financial and economic crisis. Low population density in rural areas exponentially increases the cost of services delivery per rural citizen. Even when some services exist in small rural communities, they are very often of lower quality with respect to urban centres. However, the quality of rural services and the performance of service delivery structures are a problem in most of rural areas in BMS, especially in remote rural areas.

What is alarming is the general observation that the situation is getting worse regarding human capital in the rural areas of BMS because of the out-migration of its well-educated youth. This undermines one of the most important endogenous assets and resources that can speed up the diversification journey. In fact, it is well-known that non-farm activities require a range of new managerial and soft skills. This highlights the importance of the role of extension and advisory services as well as of other institutions and international development agencies dealing with capacity building, business skills development, and human capital strengthening in rural areas. These actors should work together and coordinate their activities in order to address this challenge.

CONCLUSION

It is essential to analyse the problems in the rural areas as these not only influence the impact of policies but also the different phases of the policy cycle. Appropriate diagnosis of problems is crucial for designing effective ARD strategies and policies. One of the common problems faced in rural areas of BMS is related to low human capital. This has implications in terms of policy implementation as well as policy monitoring and evaluation. For implementation phase, it is necessary to have at disposal competent and endogenous human capital with high education level. Furthermore, skills and education level influences quality of data that are collected on the field which directly impacts evaluation. Sustainable development of rural areas cannot be based only on agriculture, as rural economies should also be diversified. In general, rural regions face many problems that reduce the critical mass needed for effective public services, infrastructure, and business development. Rural enterprises face many disadvantages compared to urban-based counterparts due to small size of local markets, sparse distribution of potential customers in rural areas, and more difficult access to credits. Better coordination and governance of ARD can help solving most of the identified problems.

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Table 1 Major problems in rural areas of Bosnia, Montenegro and Serbia

INDENTIFIED PROBLEM	COUNTRY			INDENTIFIED PROBLEM	COUNTRY		
	BO	MO	SE		BO	MO	SE
Economic problems				*Social, demographic and cultural problems*			
Lack of financial resources and of investments	A	A	A	Rural poverty	A	A	A
Lack of labour force and undeveloped rural labour market	C		C	Low quality of life	A	A	A
Low level of SMEs and new businesses development	B	C	B	Lack of qualified human resources	A	A	A
Limited use of machinery		C		Lack of knowledge and information	A	A	A
Extensive agriculture	B		B	Low educational level and use of ICT	A	A	A
Difficult access to credit due to lack of collateral		C		Lack of vision, initiatives and willingness			C
Limited employment opportunities	A	A	A	Lack of training activities for farmers		C	
Low prices of agricultural products	B		C	Use of traditional methods and technologies	B		B
Difficult procurement of agricultural inputs and high costs	C	C		Poor social and cultural life	C		C
Low productivity and low remuneration for workers	C	C		Disorganization of farmers	B		C
Undeveloped rural tourism	C			Gender inequity	C	C	C
No added value to agricultural products	C	C		Lack of cooperation between producers and scientists	C	C	
Low level of rural economy diversification and high dependence on the agricultural sector	C		C	Disappearance of common interest and emerging individualistic mentality of rural population			C
Obsolete farm machinery and equipment	B		B	Unpopularity of agriculture	A	B	B
Small and uncompetitive farms	A	B	B	Obsolete educational and cultural facilities	C		
Environmental and geographic problems				Territorial dispersion of rural settlements and low density	C	C	
Long distance to urban areas	C	A		Prejudices of youngsters about staying in the countryside	A	B	B
Bad management of local resources and increased pollution due to uncontrolled use of chemicals			C	Negative demographic trends (low birth rate, depopulation, migration, ageing, single men, etc.)	A	A	A
Insufficient development of organic production		C		*Infrastructure- and service-related problems*			
Unused natural resources	C	C		Difficult access to rural areas (*i.e.* bad roads)	B		C
Mined agricultural land from the war	C			Poor physical infrastructure and communal services (*e.g.* sewage, garbage, ambulance, transport, etc.)	A	A	A
Limited arable land		C					
Institutional, political and regulatory problems				Lack of processing capacities, equipment and resources	B		B
Non-stimulating tax policy and existence of "grey economy"	C	C		Lack of tourist accommodation facilities and services	A	A	A
Local strategies mainly focus on agriculture activities	A	B	A	Instability of electrical power supply		C	
Small and irregular economic incentives	C	C	C	Lack of collection centres for rural products	B		C
Lack of spatial plans at the local level	B	B	B	Lack of local markets	A	C	C

Source Authors' elaboration based on survey results. Legend: BO=Bosnia; MO=Montenegro; SE=Serbia; A=Significant (problems mentioned by >50% of respondents); B=Average (25-50%); C=Poor (>25%).

Research article

Reuse of Wastewater from Cassava Industry for Napier Grass Production

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Abstract Cassava industry plays an important socio-economic role in Thailand economy. The growth of the cassava processing industry has resulted in extensive water pollution, as it generates large amounts of wastewater with extremely high concentrations of organic pollutants from washing and extraction. The need for wastewater management from cassava processing was apparent and fit with green technology for reuse of wastewater for agriculture. Napier grass (*Pennisetum purpueum*), a perennial species, has become a priority source of biomass for alternative energy production in Thailand, as the National Energy Policy Council has raised the target of power production from Napier Grass to 3,000 MW under the 10-year alternative energy development plan (2012-2021) for Thailand. This study aimed to investigate the feasibility of using Napier Grass cultivation from cassava industry wastewater. Wastewater quality (effluent and influent) from cassava industry and its impact on soil chemical properties were studied at a site in Kalasin province, northeast Thailand to observe the effects of different concentrations (0%, 25, 50%, 75% and 100%) on germination test and Napier Grass biomass production. The wastewater characteristics were: pH of 7.2, EC 4 dSm^{-1}, BOD 119 mgL^{-1}, COD 1070 mgL^{-1}, TS 3230 mg L^{-1}, TKN 207 mg L^{-1}, TP 226 mgL^{-1} and water soluble K 1490 mgL^{-1}. The soil exposed to wastewater gave higher EC, more organic matter accumulation, higher total N, and available P when compared to soil without being exposed to cassava wastewater. The results showed that the wastewater concentrations significantly increased the Napier grass biomass. Therefore, wastewater from cassava industry can be used in Napier grass production as an example of application of green technology.

Keywords cassava production, wastewater quality, soil property, Napier grass biomass production

INTRODUCTION

Reuse wastewater in agriculture is gaining wider acceptance worldwide. It represents an agronomic option that is increasingly being investigated and taken up in regions with water scarcity, growing urban populations, and rising demand for irrigation water (Gatta et al., 2014; Meli et al., 2002; FAO, 2011). Many irrigated areas around the world are experiencing water shortages due to several factors, including climate change, and surface and groundwater pollution. Water scarcity poses serious economic, social, and even political concerns in all of its aspects. Under these

circumstances, reuse of wastewater can help to mitigate the damaging effects of local water deficits (Gatta et al., 2014; FAO, 2010). Treated wastewater not only offers an alternative irrigation source, but also the opportunity to recycle plant nutrients (Chen et al., 2008). Its application might ensure the transfer of fertilizing elements, such as nitrogen (N), phosphorous (P), potassium (K^+), organic matter, and nutrients, into agricultural soil (Gatta et al., 2014). The cassava processing industry is considered to be one of the largest food processing industries in Thailand. However, the growth of the cassava industry has resulted in serious environmental pollution as it generates large amount of solid waste and wastewater with high organic content (Chavalparit and Ongwandee, 2008).

Together with the rice and sugarcane industries, the tapioca starch-processing industry has played an important role in Thailand's agricultural economy. Known as the world's largest producer and exporter of tapioca starch, Thailand produced over seven million tons of starch in 2004. Approximate annual revenue from tapioca starch export was 38,805 million baht or 1,060 million dollars (DOA, 2005). Tapioca is produced from treated and dried cassava (manioc) root and used in the food, paper, and toothpaste industries. Only 20% of the cassava root harvested in Thailand is delivered to starch-processing plants while the rest is used in the production of pellets and chips. Currently, Thailand has 92 tapioca processing plants with a total production capacity of native and modified starch at about 16,910 and 4350 ton/day, respectively (DOA, 2005). Normally, these tapioca-processing plants operate 24 hours per day from September to May each year.

The production of native starch from cassava root involves seven major stages. These are root washing, chopping and grinding, fibrous residue separation, dewatering and protein separation, dehydration, drying, and packaging. The production facilities experience a number of environmental problems such as the consumption of large volumes of water and energy, and the generation of high organic-loaded wastewater and solid waste. The starch extraction process requires a vast volume of water, which in turn produces large amount of wastewater. According to the study of Tanticharoen and Bhumiratanatries (1995), the production of one ton of starch from cassava generates an average of 20 m^3 of wastewater. Hien et al. (1999) reported the characteristics of wastewater from Vietnamese tapioca starch plants with values of 11,000-13,500 mg $CODL^{-1}$, 4200-7600 mg SSL^{-1}, and pH of 4.5-5.0. The approximate generation of wastewater and solid waste (fibrous residue and peel) from one ton of starch was 12 m^3 and 3 kg, respectively (Hien et al., 1999).

Thus appropriate wastewater management from cassava starch industry is needed. Reuse of such wastewater and its nutrients for agriculture fits with green technology. An appropriate class to consider for nutrient uptake is grass with high biomass. *Pennisetum purpureum* (Napier grass) is also known as elephant grass or Ugandan grass and is a species of perennial tropical grass native to the African grasslands and is cultivated extensively. Napier grass (*P. purpueum*) is a perennial plant that is also a priority source of biomass for alternative energy production in Thailand. The National Energy Policy Council, in its 10-year alternative energy development plan (2012-2021), has set a target to produce 3,000 MW of electricity from Napier grass. Napier grass has low water and nutrient requirements, therefore it can make use of uncultivated lands. Historically, this species has been used primarily for grazing. Recently, however, it has been incorporated into a pest management strategy. In addition to this role, Napier grass improves soil fertilityand protect arid land from soil erosion. They are also utilized for firebreaks, windbreaks, in paper pulp production and most recently to produce bio-oil, biogas and charcoal.

The perennial *Pennisetum purpureum* Schumach (Napier or elephant grass) readily crosses with the annual *Pennisetum americanum* (L.) Leeke (pearl millet) and the resultant interspecific hybrids are more vigorous than the parent species. Hence, several hybrid Napier grass cultivars (*P. purpureum* and *P. americanum*) have been developed (Premaratne and Premalal, 2006). Because of the high biomass production and very high forage quality for livestock, growth of these hybrids is widely promoted in subtropical and tropical countries including Thailand (Tudsri et al., 2002; Premaratne and Premalal, 2006). Recently, a very productive cultivar (Pakchong1) of this hybrid grass has been developed and marketed by Thailand's Department of Livestock Development. The

Pakchong1 cultivar is claimed to have several advantages over other Napier grass cultivars, as it grows taller, has a higher content of crude protein, has an annual yield exceeding 500 ty^{-1}, and can be harvested 5-6 times per year (Jampeethong et al., 2014).

The nutrients wastewater from the cassava industry has the potential to contribute to crop production, including that of Napier grass. Nevertheless, there is a need for periodic monitoring, to avoid any imbalance in the nutrient supplies, which might cause an imbalance; such wastewater can also be a source of pathogenic organisms, enteric bacteria and viruses and potentially hazardous chemical substances such as salts, heavy metals, and surfactants. Hence, there is the need for further studies to investigate the feasibility of using wastewater from cassava industry for Napier grass production.

OBJECTIVES

The objectives of the study were: (i) to evaluate the effects of nutrients in the wastewater from cassava industry on qualitative and quantitative aspects of Napier grass production; and (ii) to assess the impact of the wastewaters on the soil properties.

METHODOLOGY

Water and Soil Sampling

Three samples of the wastewater from influent and effluent from biogas system at cassava industry were collected in sterile 1000-mL glass bottles, and transported to the laboratory in refrigerated bags. The samples collected were kept in a refrigerator at $+4^{\circ}C$, and examined within 24 hours of their collection. Soil samples were collected in triplicate from each of 5 treatments before and after. All of the soil samples were taken from a 15-cm layer in each plot, from under the drippers, and they were air-dried, crushed, and passed through a 2 mm sieve before the chemical analysis.

Water Quality Analysis

The water samples were analyzed in triplicate, according to the international standard methods (APHA-AWWA-EF, 2005). The analysis included the physico-chemical parameters of pH, electrical conductivity (ECw; dSm^{-1}), total solids (TS; mgL^{-1}), biological oxygen demand over 5 days (BOD5; mgL^{-1}), chemical oxygen demand (COD; mgL^{-1}), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP; mg L^{-1}) and potassium (K^{+}; mgL^{-1}),

Soil Chemical Analysis

The soil electrical conductivity and pH were measured ion 1:2 (w/v) and 1:2.5 (w/v) aqueous soil extracts, respectively. The pH and EC were measured using a digital pH meter in 1/2.5 (w/v) deionized water. Total N (total nitrogen) was measured by the micro Kjeldahl method (Jackson, 1973; Bremner and Mlvaney, 1982). Exchangeable phosphorous (Exch. P) was determined by using the Bray II extraction method (Schroth et al., 2003) and Exchangeable Potassium (Exch. K) was determined by 1 N Ammonium acetate and Flame photometry method.

Plant Growth Test

An experiment was carried out to investigate the effects of wastewater from cassava industry on germination and plant growth under greenhouse conditions at Khon Kaen University, Thailand, at (latitude of 16° 28' N and longitude of 102° 48' E) during the rainy season of 2014.

Napier grass plants were used in this experiment. The experiment was laid out in a completely randomized design (CRD) with three replications for each crop. Five-wastewater concentration treatments were used (T_1: tap water only, T_2: 25% wastewater concentration, T_3: 50% wastewater concentration, T_4: 75% wastewater concentration, and T_5: 100% wastewater concentration) were used. For five kilograms of 2 mm sieved air-dried of each soil sample were placed in each black plastic pots of 30 cm height and 25 cm diameter for each treatment. Wastewater was applied before planting in every three days until termination. Bud per stem, height, fresh weight, dry weight, yield of stem and root were recorded.

Statistical Analysis

The data obtained from different experiments were analyzed by using the one-way analysis of variance (ANOVA) function of Statistica 8 software (Version 8, USA) to test for variations ($p<0.05$) that were deemed significant between treatment groups and controls.

RESULTS AND DISCUSSION

The wastewater released from cassava industry characteristics were pH of 3.9, 7.2, EC of 1.5, 4.0 mS/cm, BOD of 633, 119 mg/l, COD of 4267, 1067 mg/l, TS of 4853, 3227 mg/l, TKN of 28, 207 mg/l, TP of 120, 226 mg/l and water soluble K of 1833, 4900 mg/l, respectively (Table 1). The result suggests that nutrients were high in wastewater. Therefore, it could be use for grass nutrient uptake.

Table 2 shows the effects of wastewater from cassava industry on soil properties. In the soil exposed to wastewater, the pH of the soil increased compared to the soil without exposure to wastewater. Similarly, the application of wastewater resulted in higher EC, N, P, K than the soil without exposed to wastewater. The exposed soil contained more organic matter accumulation and higher exchangeable K than the soil without exposure to wastewater. The noticeable increase of exchangeable K in the soil exposed to wastewater might be explained by the presence of high levels of organic matter in it. The soil exposed to wastewater had the higher total N content, whereas the soil without being exposed to wastewater had low value. The high total N content in soil by exposing to wastewater might be due to the fact that wastewater might enhance salt uptake and immobilization of N. The application of wastewater resulted in higher available P than the soil without exposed to wastewater. It might be due to the fact that the wastewater resulted in increasing available P in the surface layer. The soil exposed to wastewater gave higher exchangeable K^+ when compared to the soil without being exposed to wastewater. This might be the initial high content of these elements in the wastewater. Therefore, the results of this study show that soil chemical properties after being treated wastewater from cassava were better than the ones without application of wastewater.

Plant Growth Experiment

The biomass yields of the Napier grass plants grown on the amended soils have been determined using their height and weight data for plant stem and root biomass. The biomass of the Napier grass plants increased in the treatment using wastewater for all the samples. The highest yields were recorded for wastewater at 25% concentration (Tables 3 and 4)

Table 1 The wastewater from cassava industry characteristics

Wastewater Parameter (unit)	Influent	Effluent	Water quality standard for effluent discharge (MOST, 1996)
pH	3.9	7.2	5.5-9.0
EC (dSm^{-1})	1.5	4.0	-
BOD (mgL^{-1})	633	119	60
COD (mg L^{-1})	4270	1070	400
TS (mg L^{-1})	4850	3230	-
Total N (mg L^{-1})	28	210	100-200
Total P (mg L^{-1})	120	226	-
Total K (mg L^{-1})	1830	4900	-

Table 2 Soil quality after apply wastewater from cassava industry

	Soil quality				
	pH	EC (dSm^{-1})	TN (%)	Exchangeable P (ppm)	Exchangeable K (ppm)
Before	6.12b	0.038c	0.008c	34b	44c
After	6.01c	0.091a	0.021b	48a	64b
(influent)	6.44a	0.065b	0.028a	43a	92a
After (effluent)					
F-test	**	**	**	*	**
CV (%)	0.45	3.12	8.04	5.18	2.79

Note: Mean (n=3) in the same column followed by the same lower case letters are not significantly different at p≤0.05

Table 3 The effects of wastewater from cassava industry (influent) on Napier grass production

Treatment wastewater concentration	Buds/ stem	Height (cm)	Stem fresh biomass(g)	Stem dry biomass (g)	Root fresh biomass (g)	Root dry biomass (g)
0 %)Control(	2.67	64.33	19.86^{b}	2.35^{b}	2.71^{c}	0.31^{b}
25%	3.67	72.68	43.30^{ab}	3.67^{ab}	7.09^{b}	0.50^{ab}
50%	4.33	77.00	50.87^{ab}	4.09^{ab}	8.02^{ab}	0.72^{ab}
75%	4.33	76.33	43.70^{ab}	2.22^{b}	7.00^{b}	0.28^{b}
100%	3.33	78.667	71.67^{a}	4.75^{a}	11.58^{a}	0.76^{a}
F-test	ns	ns	**	**	*	**
C.V. (%)	26.35	13.02	26.87	21.40	30.72	22.23

Note: Mean (n=3) in the same column followed by the same lower case letters are not significantly different at p≤0.05

Table 4 The effects of wastewater from cassava industry (effluent) on Napier grass production

Treatment wastewater concentration	No. Bud/ stem	Height (cm)	Stem fresh biomass (g)	Stem dry biomass (g)	Root fresh biomass (g)	Root dry biomass (g)
0 %)Control(	2.67	4.33	19.86	2.35	2.71	0.31
25%	3.67	76.33	35.26	2.87	5.47	0.38
50%	3.00	70.68	37.11	3.19	5.70	0.51
75%	2.67	72.33	33.39	2.60	5.44	0.39
100%	2.67	64.68	23.06	1.60	3.04	0.14
F-test	ns	ns	ns	ns	ns	ns
C.V.)%(	35.21	12.46	41.93	35.62	44.49	62.27

Note: Mean (n=3) in the same column followed by the same lower case letters are not significantly different at p≤0.05

CONCLUSION

Every wastewater application significantly produced maximum Napier grass biomass based on measured data. Therefore, wastewater from cassava industry natural can be reused to give enhanced Napier grass biomass production. The reuse of wastewater from cassava industry for Napier grass production considered the aspects of water reuse, nutrient reuse, and biomass production. The high biomass yield of Napier grass also makes it a possible potential feedstock in producing cellulosic ethanol, with the added benefit of water quality improvement and sustainable energy. This study suggests that through the cultivation of highly productive, low input, perennial and valuable plant species, benefits can be realized in the form of water quality improvement, water reuse, nutrient reuse, biomass production, and sustainable energy.

ACKNOWLEDGEMENTS

This research project was supported by Integrated Water Resource Management Research and Development Center in Northeast Thailand, Khon Kaen University, Thailand. We would like to thank Kalasin cassava industry, Miss Matanee Polsuwan, Miss Arpaporn Mudnawed, and Mr.Thongchai Seangchad for research assistance.

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Research article

The Study of Greenhouse Gas Emissions of Ethanol Production from Agro-industrial Fruit Residues

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Received 3 March 2015 Accepted 15 May 2015 (*Corresponding Author)

Abstract Nowadays, bio-ethanol is playing an important role as an alternative fuel for passenger cars in Thailand. The use of biofuel can reduce greenhouse gas (GHG) emissions because it is derived from plant materials. This study aimed to analyze greenhouse gas (GHG) emissions of ethanol production from agro-industrial fruit residues based on a life cycle approach. The results showed that the life cycle GHG emissions of ethanol production were found to be 123.10 kg CO_2-eq/kg of anhydrous ethanol. The main source of GHG emission was the electricity used in the process stage (97.83%) and the second was materials and reagents used in the stage (2.64%). It showed major energy consumption came from the conversion process to produce ethanol. Another encouraging result is that 1 kg non-pretreated pineapple peel waste inputs could produce 525 g of ethanol fuel; or it is was estimated to be 52-53% of ethanol production. Therefore, agro-industrial fruit residues can be feedstock for ethanol production in Tropical countries.

Keywords LCA, GHG, ethanol, pineapple peel waste

INTRODUCTION

Biofuels are important because they replace petroleum fuels. The emissions of greenhouse gases (GHGs), in particular carbon dioxide (CO_2), are expected to reduce when fossil fuels are replaced with biofuels; because the latter are derived from plant materials. Bioethanol is by far the most widely used biofuel for transportation worldwide. Ethanol utilization for sustainable energy in this decade is desired especially ethanol produced from agricultural waste. The reason is, in the sense of economy and environmental prevention, it can reduce greenhouse effects. There are studies on ethanol production from agricultural waste such as sweet sorghum bagasse, cassava waste, rice straws, and pineapple peel waste, which are renewable and interesting resources (Itelima et al., 2013; Nigam, 1999; Siwarasak et al., 2006; Siwarasak et al., 2012; and Wang et al., 2012). Ethanol production is an alternative energy that can solve environmental impact and a value added form of solid-waste for agricultural industries, particularly in Thailand. The bioconversion of cellulose and hemicelluloses to monomeric sugars, for example, carbohydrates with 5 and 6 carbons are harder to accomplish than the conversion of starch, presently used for bioethanol production (Ohgren et al., 2006). There are several options for a lignocelluloses-to-bioethanol process, which is chosen. However, a few data on an environmental analysis of bioethanol production from agro-industrial fruit residues have been reported. The cassava waste and rice straws are high potential raw materials to produce ethanol from fermentation. Moreover, pineapple peel is a potential raw material to produce ethanol due to its containing an appreciable amount of insoluble fiber-rich fraction, which primary consists of cellulose, pectin substances, hemicelluloses, and notable proportions of lignin (Huang et al., 2011). According to Thai Office of Agricultural Economics,

Thai pineapple products in 2011 were increased by 25.41% compared to the previous year (OIE, 2012). The products mostly included fresh pineapples and processed pineapple products. Canned pineapple processing industry is one of the highest potential industries in Thailand, due to its geography of locating in monsoon region. The skins, cores, and ends of a pineapple are not discarded in pineapple canneries but instead used to make a number of products such as vinegar, alcohol, and animal food. Thailand is ranked as the top of the pineapple exporting countries with a market share of 40-50% (Eapsirimetee et al., 2013). Table 1 shows the 2015 forecasting of farm crop perennial trees and fruit trees in the whole kingdom including harvested areas, productions, and yield of pineapple (OAE, 2015). Furthermore, an analysis of supply or productivity of pineapple in Thailand is also reported in the table. Pineapple peel, a by-product of the pineapple processing industry, account for 29-40% (w/w) of total pineapple weight (Choonut et al., 2014). From Table 1, this implies a high potential of using pineapple peel for ethanol production.

Table 1 Forecasting of farm crop perennial trees, fruit trees and pineapple productivity in Thailand

Pineapples	Year			Quantity	Percent
	2013	2014	2015	±	±
Harvested areas (rais)	532,947	479,072	476,433	-2,639	-0.55
Productions (tons)	2,067,908	1,748,222	1,702,735	-45,487	-2.60
Yield (kgs/rai)	3,880	3,649	3,574	-75	-2.06

OBJECTIVES

The aim of this study was to investigate the impact of bioethanol production by fermentation from agro-industrial fruit residues with *Trichoderma reesei* RT-P1 and *Saccharomyces cerevisiae* RT-P2 to the environment and to promote the use of indigenous and renewable sources for transportation fuels. Life cycle assessment (LCA) was carried out to determine the GHG emissions performance. Bioethanol from pineapple peel wastes in Thailand was considered in the analysis.

METHODOLOGY

Life cycle assessment (LCA) was used as an environmental assessment tool to identify and evaluate the GHG emissions of bioethanol production from agro-industrial fruit residues (pineapple peel wastes). LCA methodology used in this study was based on ISO 14040 framework, which consisted of four steps: goal and scope definition, inventory analysis, impact assessment, and interpretation (Lee and Inaba, 2004). The life cycle inventory analysis and impact assessment were carried out based on ISO 14040 for all stages involved in the production of 1 kg of 99.5% ethanol (anhydrous ethanol) from pineapple peel wastes which included transportation and bioethanol conversion, but not cultivation and harvesting. The functional unit (FU) of this study was 1 kg of 99.5% ethanol production. The system boundary is shown in Fig. 1. Most of input-output data were collected as primary data at the actual sites in Thailand. These collected data included raw materials used, energy consumption, utilities, and waste generated within the system boundary. The secondary data were used in this study as necessary from literatures, calculation, etc. The analyses focused on the three most important GHGs of bioenergy systems including i.e. carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), with the global warming potential factors of 1, 25, 298 kg CO_2-eq/kg substance, respectively (IPCC, 2007).

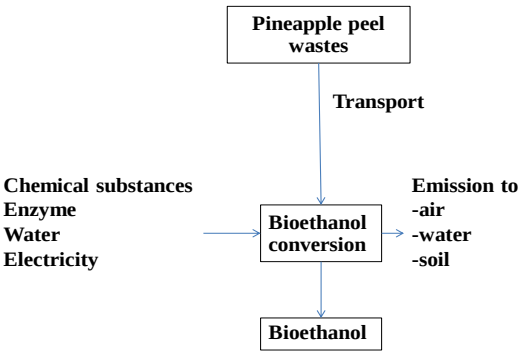

Fig.1 Product system boundary of this study

Preparation of Raw Materials and Transportation

In this study, pineapple peel waste was tendered by United Winery and Distillery Company limited, Nakhon Chai Si, Nakhon Pathom province, Thailand. Pickup Trucks with load 560 kg transported pineapple peel wastes from the factory to Chemical Engineering Laboratory. The laboratory is located in Rajamangala University of Technology Thanyaburi, Pathumthani province, Thailand. The transport distance was 200 km (round trip). The data were collected at the sites. Diesel fuel consumption was 24.5 L per 200 km (Table 2). The samples were dried before performing the experiment.

Bioethanol Conversion

Based on the optimal fermentation conditions obtained from analysis results of orthogonal experiment, the verification of ethanol conversion was obtained from fermentation by using crude enzyme powder. Crude enzyme powder was produced from co-culture of *Trichoderma reesei* RT-P1 and *Saccharomyces cerevisiae* RT-P2. The ethanol fermentation was carried out in 250 mL shaking flasks at 120 rpm, by using 8% dried weight of pineapple peels in 100 mL liquid medium for 1 to 5 days cultivation at initial pH 5 at room temperature (30 ^{o}C). Samples were collected daily for analysis of ethanol and reduced sugar concentration. Ethanol concentrations were estimated by the dichromate colorimetric method (Williams and Reese, 1950), and the reduced sugar concentrations were estimated to be 3, 5-dinitrosalicyclic acid (Miller, 1959). Three replications were done in this experiment.

RESULTS AND DISCUSSION

Ethanol batch fermentation from pineapple peels wastes with the crude enzyme powder was analyzed. The results of batch fermentation are shown in Fig. 2. From the figure, ethanol concentration was initially around 8 g/L for batch fermentation. Ethanol values increased to 42 g/L on day 4. Then Ethanol concentration decreased to about 18 g/L on day 5. The more increasing ethanol led the more decrease of sugar due to the enzyme hydrolysis done by cellulose of the crude enzyme powder during its exponential growth and the decrease of sugar converted to ethanol (Lever et al., 2010; Mamma et al., 1996). In addition, direct energy and material inputs in the ethanol production system are summarized in Table 2, which the GHG emissions per kg of 99.5% ethanol production were calculated. The calculated emission results are presented in Fig.3,

representing 123.10 kg CO_2-eq/kg ethanol. The assessment reveals that there were wide ranges of GHG emissions depending on the production environment such as type of fuel used in transportation, water consumption, materials and reagents and electricity used in the ethanol production.

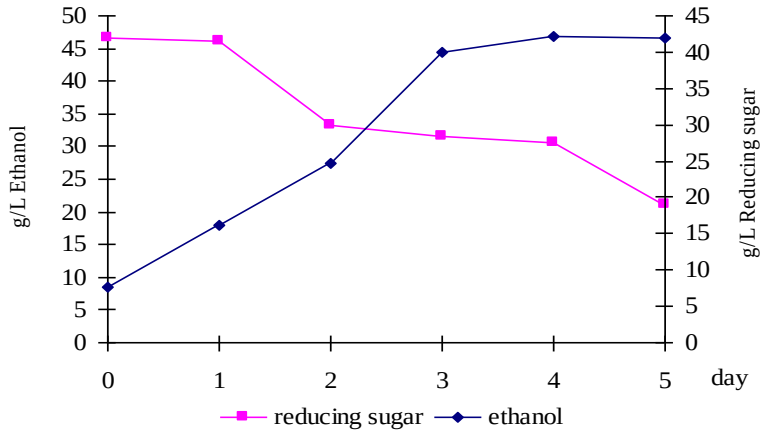

Fig. 2 Ethanol and reducing sugar in batch fermentation (SD 3%)

Table 2 Direct material and energy-related input/output associated with ethanol production system

Segment	Unit	Input	Output
Ethanol conversion			
pineapple peel waste	g	1000.00	
Enzyme	g	750.00	
$CaHPO_4$	g	12.50	
$MgSO_4$	g	12.50	
Urea	g	100.00	
K_2PO_4	g	187.50	
Sugar	g	375.00	
Water	L	12.50	
Electricity	kWh	112.70	
Transportation			
Diesel used for transport	km/L	8.16	
Ethanol product			525.00

The results of this study showed higher ethanol yield than other studies. For example, the maximum yield of bioethanol (9.69g/L) with no hydrogen production by S.cerevisiae with 36 % of cellulose was achieved from pineapple peel after pretreatment with water and heat at 100 0C for 4 h. (Choonut et al., 2014). The fermented broth using S. cerevisiae TISTR 5048 with 20.44 % of cellulose gave the highest percentage of bioethanol yield which was 65 % (Niwaswong et al., 2014). Other studies, lignocellulosic ethanol production could alternatively be done from agricultural wastes such as corn stover, sugarcane bagasse and rice straw (Kadam and McMilland, 2003; Kadam et al., 2000; and Kim and Dale, 2004). Lignocellulosic materials represented a promising option as a feedstock for ethanol production by considering output/input energy ratios, great availability both in tropical and temperate climate countries, low cost (primary related to their transport), and ethanol yields (Sánchez and Cardona, 2008). Furthermore, it was found pineapple peel waste is quite simple, uncomplicated, and low cost as it can be applicable in the ethanol production industries.

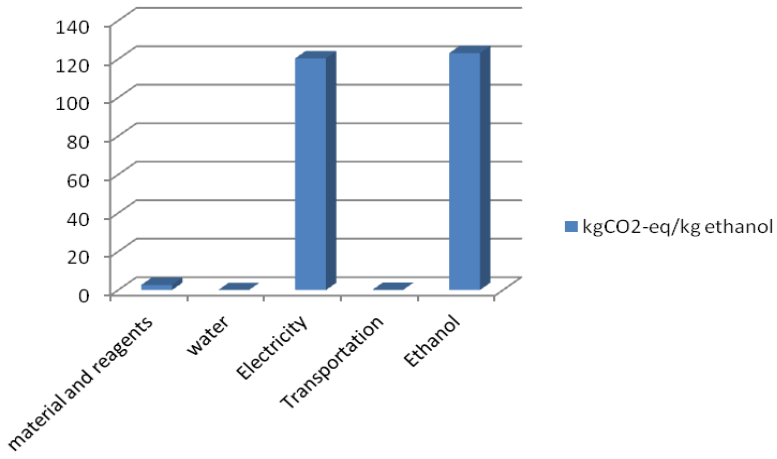

Fig. 3 GHG emissions from ethanol production

In Thailand, with its agriculture-based economy, employs 20% of available agricultural residues through agricultural wastes and by-products. Moreover, there is potential to produce 3.1-8.6 million liters/day of ethanol (Kumar et al., 2013). However, the great production of ethanol from industrial fruit residues can entail serious economic and environmental consequences. The greenhouse gas reduction of ethanol with respect to conventional gasoline, on a well to wheel basis, is about 13% when ethanol is derived from grain; and up to 90% for sugarcane-based ethanol (Quadrelli and Peterson, 2007).

CONCLUSION

The maximum ethanol production was obtained from fermentation crude enzyme powder, which was produced from co-culture of *Trichoderma reesei* RT-P1 and *Saccharomyces cerevisiae* RT-P2. Ethanol values increased on day 4 with the use of 8% dried weight of pineapple peels in 100 mL liquid medium for cultivation at initial pH 5 at room temperature (30^{o}C). Among all processes in the ethanol production system, ethanol conversion created the highest amount of GHG emissions (electricity used), up to 97.8% of the total emissions. Materials and reagents used created 2.1% of the total GHG emissions. The other processes, which were transportation (diesel used) and water consumption created less than 1% of the total GHG emissions. Another encouraging result was 1 kg of non-pretreated pineapple peel waste input could produce 525 g of ethanol fuel, or it is estimated to be 52-53% of ethanol production. In this study, pineapple peel was proved as one of the potential raw materials for bioethanol production. Therefore, agro-industrial fruit residues can be used as feedstock for ethanol production in tropical countries.

ACKNOWLEDGEMENTS

Financial support by the Thailand Research Fund under the Faculty of Science and Technology, Rajamangala University of Technology Thanyaburi (Grant annual/2011)is gratefully acknowledged.

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Research article

Evaluation on Agro-forestry System in Salt Affected and Non-salt Affected Areas

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Received 22 December 2014 Accepted 20 May 2015 (*Corresponding Author)

Abstract Low economical return is the main constraint that makes farmers not grow more trees in salt affected areas. So, the research interest was paid to the applicable agro-forestry system combining advantages of trees and crops for rehabilitating salt affected soils and increasing local farmers' income. Accordingly, existing agro-forestry systems in salt affected and non-salt affected areas in Khon Kaen province were investigated and evaluated. For the evaluation, the plant profile of each system was described in the investigation plot at 20m x 20m. In addition, Simpson and Shannon indexes were used to evaluate plant diversity of each investigation plot. Agro-forestry systems on salt affected areas could be categorized into five types: patch forests in farmlands, trees on paddy bunds, tree plantations associated with animal husbandry, home gardens, and trees in vegetable gardens. On the other hand, agro-forestry systems in non-salt affected areas could be categorized into seven types: trees in farm boundaries, trees on paddy bunds, tree plantations associated with animal husbandry, trees in home gardens, trees in vegetable gardens, trees in fruit orchards, and trees and aquaculture. The results of the two indexes revealed that the diversity of plants in agro-forestry systems in non-salt affected areas was higher than that in salt affected areas, except in the systems of tree plantations associated with animal husbandry and of trees in home gardens. It was considered that as the plant diversity in salt affected areas was lower than that in non-salt affected areas due to soil salinity; local people in salt affected areas kept higher plant diversity in the systems of tree plantations associated with animal husbandry and of trees in home gardens for their livelihoods.

Keywords agro-forestry system, salt affected and non-salt affected areas, Simpson diversity index, Shannon diversity index

INTRODUCTION

Reforestation by fast growing trees for lowering saline groundwater level is one of practices that can be applied by local people for rehabilitating salt affected soil in northeast, Thailand (Yamklee et al, 1995; Wada, 1998; Yuwaniyama, 2011). Several organizations in Thailand and overseas introduced the utilization of salt-tolerant trees and plants to solve or to mitigate salinization problem. However, local farmers have not adapted planting trees, as it takes long time to gain the profit (Vittayakorn et al., 1994). Thus, the applicable practice that combines the advantage of growing trees for mitigating salt affected soils along with generating income should be considered to introduce to local people.

Agro-forestry is an interface between agriculture and forestry and encompassed mixed land use practices. Agro-forestry practices are ranging from simple forms of shifting cultivation to complex hedgerow intercropping systems. All agro-forestry systems have the purposeful growing

trees with crops and/or animals for multiple products or benefits from the same management unit. Agro-forestry also has three attributes: productivity, sustainability, and adoptability (Nair, 1993).

Agro-forestry systems for rehabilitating salt affected soils are widely applied in several countries such as Australia, Bangladesh, and China, and India (Singh et al., 2002; Zang et al., 2004; Ahmed, 1991; Eastham et al., 1993).

Agro-forestry in Thailand has been practiced for a long time since the Forest Village Scheme was introduced by the Forest Industries Organisation of Thailand (FIO) in 1967 as an attempt to stop further spreading of the fast shifting cultivation and deforestation in the country (Boonkird et al., 1984). In Nakorn Ratchasima province, Im-Erb et al. (2004) reported that an agro-forestry system being promoted in recharge area of the province for mitigating salt affected soils was well accepted by farmers according to their additional income. In 2007, Ruaysoongern studied about agro-forestry systems in the northeast of Thailand and categorized into 25 systems.

While there were some researches regarding agro-forestry systems in Thailand, there were a few investigations focusing on agro-forestry practices in salt affected areas. The objectives of this study were to categorize and evaluate the existing agro-forestry systems in salt affected and non-salt affected areas in Khon Kaen province.

Salt affected and non-salt affected areas are defined by the salinity level of soils. Salinity level in Thailand is defined by percentage of salt crust on soil surface in dry season. The area that salt crust covers more than 50% is defined as very severely affected class, and the salt crust covers 10-50% is defined as severely affected class, and for the 1-10% as moderately affected class and non-salt crust is defined as non-salt affected area (Arunin, 1998).

METHODOLOGY

Field investigation on existing agro-forestry practices in salt affected areas and non-salt affected area were conducted in September, 2009 and March 2013 in Khon Kaen province, Thailand. Aerial maps were used for identifying the land utilization. After the land utilization was identified, agro-forestry practices were categorized based on the studies of Ruaysoonngern (2007) and Nair (1993). The sampling plots of 20m x 20m were made for observing plant profiles of each practice. For the comparison of agro-forestry in salt affected and non-salt affected areas, Simpson diversity index and Shannon diversity index were employed in this research. The Simpson diversity index is the probability of any two individuals drawn at random from an infinitely large community belonging to same species. The Shannon diversity index assumes that individuals are randomly sampled from an indefinitely large population and also assumes that all species are represented in the sample.

Simpson diversity index (1949)

$$D = \sum_{i=1}^{s} (Pi^2) \quad (1)$$

where D = Value of Simpson's diversity index
Pi = proportion of individuals in the ith species
s = number of species

and Shannon's index (1949)

$$H' = -\sum_{i=1}^{s} \{(\frac{n_i}{N}) \cdot \ln(\frac{n_i}{N})\} \quad (2)$$

where H' = Value of Shannon's diversity index
Pi = proportion of individuals in the i^{th} species
ln = natural logarithm
s = number of species in community

The indexes were used for calculating diversity index of each sampling plot. Moreover, hearing survey to farmers regarding their land utilization were also conducted.

Research Sites

Salt affected areas: Phra Yun district is one of the salt affected areas of Khon Kaen province. According to Regional Environment Office 10, Khon Kaen reported that salt affected areas cover 6,095 hectare or around 35 percent of the district area (REO 10, 2003). Agriculture is the main occupation of people in the district while paddy rice and sugarcane are the main agricultural products (Phra Yun Community Development Office, 2012).
Non-salt affected areas: Nong Rue district is one of the non-salt affected areas of Khon Kaen province. Agriculture is the main occupation of the people in the district while paddy rice, cassava, vegetable, and sugarcane are main agricultural products (Nong Rue Community Development Offic e, 2012).

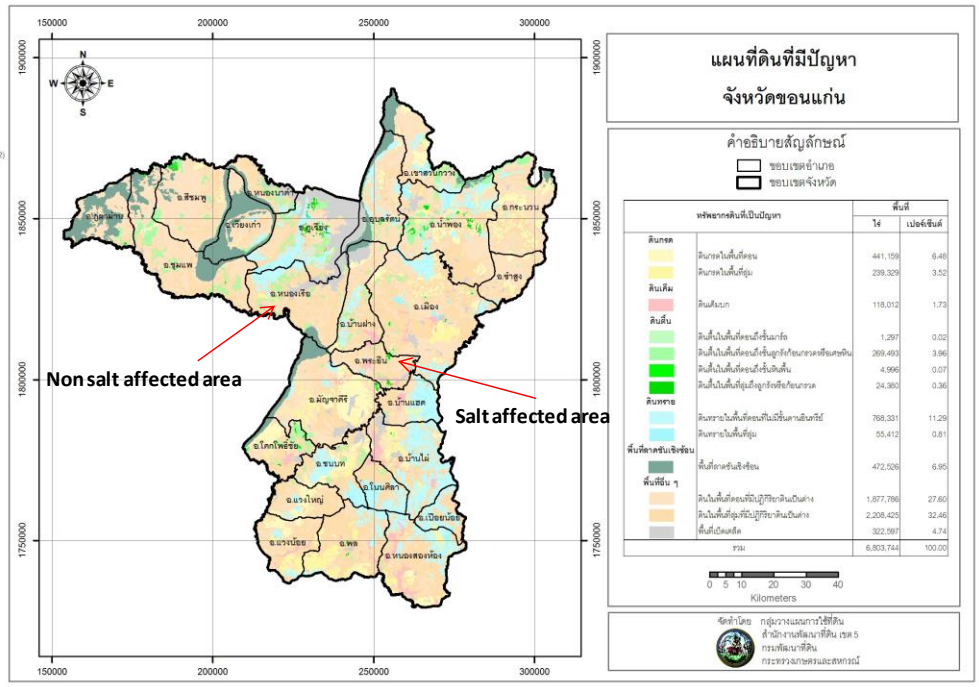

Fig. 1 Study areas

RESULTS AND DISCUSSION

Salt Affected Areas

Land uses in the salt affected areas were classified into paddy field, upland field, patch forest along the stream, settlement area, and bare area. Five agro-forestry systems were found in salt affected areas. Patch forest in farmland was a small area of natural forest surrounded by naked land or farmland, as the natural Dipterocarp trees were kept in farmland for collecting fuelwood and being source of timber, as well as food such as leaves, flowers, shoots, and mushrooms. The samples of tree from patch forests were *Sindora siamensis*, *Dipterocarpus obtusifolius*, *Xylia xylocarpa*, and *Lannea coromandelica*.

Farmers in the northeast of Thailand preferred to keep trees in their paddy bunds for multipurposes. Trees found in the paddy bunds were considered important due to their commercial value. *Shorea obtusa* was the dominant tree found in the paddy bunds. Farmers with large areas planted trees and let their cows graze in the plantation for weed control. The cows also provided natural fertilizer for trees in the plantations. The samples of trees from the plantation were *Eucalyptus camaldulensis, Tectona grandis*, and *Pterocarpus macrocarpus*.

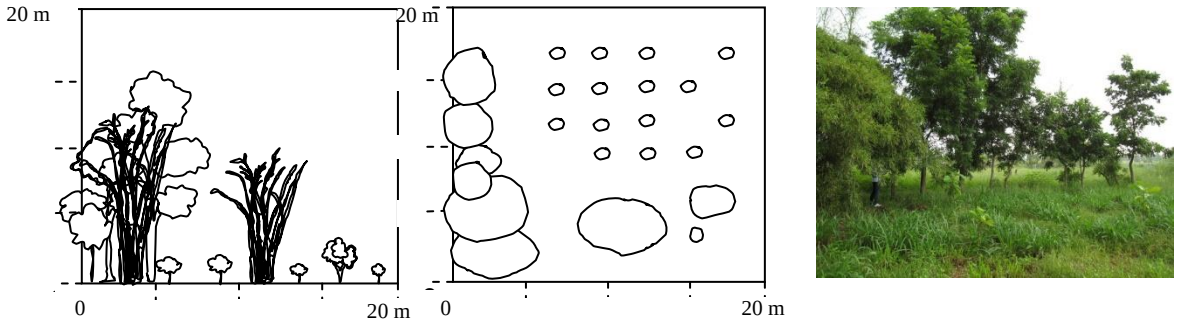

Fig. 2 Trees in home gardens

As shown in Fig. 3, farmers planted several kinds of tree in their home garden. The examples of tree in the home gardens were *Bambusa bambos*, and *Thyrsostachys siamensis*, *S. siamensis* and *Azadirachta indica*. Fast-growing *Anthocephalus chinensis* was found to be used for temporary construction materials and *Pennisetum purpureum* for fodder. In vegetable gardens, farmers planted several kinds of tree together with vegetables. The trees of *Mangifera indica, Cocos nucifera, Musa sapientum,*and *Anthocephalus chinensis* were used as edible fruits and temporary construction materials.

Non-salt Affected Areas

Land uses in the non-salt affected areas were classified into paddy field, upland field, trees plantation, water bodies, fruit orchards, and settlement area. Agro-forestry systems in non-salt affected area could be categorized into seven types.

Farmers often grew trees for indicating farm boundary because it was cheaper than construct farm fence. Trees that mainly grew for indicating farm boundary were valuable trees or fast growing ones such as *E. camaldulensis*, *A. indica*, and *Bambusa* sp. In the sampling plot, *P. marcrocarpus* were grown for indicating boundary of sugarcane farm.

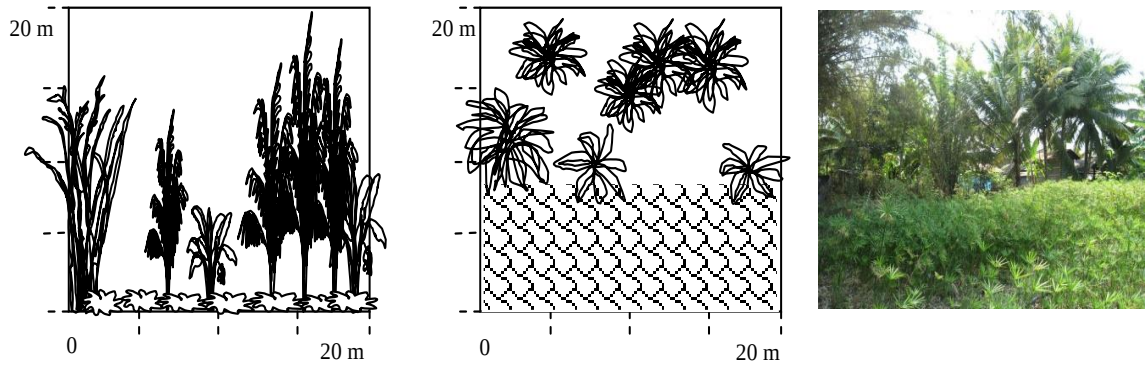

Fig. 3 Trees in home garden

Trees on paddy bunds were kept for several purposes. Aside from natural trees, in non-salt affected area farmers also grew fast growing trees for economical purpose. In the sampling plot, *E. camaldulensis* and *A. indica* were grown on the paddy bund for economical purpose. Farmers who had enough farmland grew commercial trees in large area and let their cows graze in the plantation for weed control. Besides weed control, cows also provided natural fertilizer for the trees in the plantations. The sample of the tree from the plantation was *E. camaldulensis*.

As shown in Fig. 3, home gardens consisted of various kinds of tree for foods, construction materials, fuel wood, and material for handicraft. The samples of trees in the home gardens were *B. bambos* for construction and handicraft, garden fences; *Cocos nuciferus* and *Musa sapientum* for food; and *Cyperus alternifolius* for weaving mat. In vegetable gardens, several kinds of trees were planted together with vegetables. For this agro-forestry practice, 18 species of plants were found included trees such as fruits trees and timber trees for construction materials.

Farmers grew trees and mixed them with fruit trees for several purposes. In fruit orchard, trees were grown and resulted in multi-storey pattern, the highest tree *P. macrocarpus* and *Tamarindus indica* provided shade to *Annona squamosa* and *Dimocarpus longan* while *B. bambos* was the middle storey. Two of agro-forestry practices that commonly applied in non-salt affected areas were trees and aquaculture. In this practice, several kinds of trees were grown around fish pond for fruit, construction material, and shadow. Moreover, trees around fish pond also provided shade that decreased evaporation. Trees found in this practice included; *P. macrocarpus, Mangifera indica, A. indica, Borassus flabellifer, Leucaena leucocephala* and *Erythophleum succirubrum*.

Trees found on the paddy bund in salt affected areas were the trees surviving from the forest while trees found on paddy bund in non-salt affected area were domesticated or new introduced trees. The result was similar to Vityakon (1993) finding that surviving trees were once a part of dry Dipterocarp forest while the domesticated or new introduced trees were grown intentionally.

Comparison of Agro-forestry System in Salt Affected and Non-salt Affected Areas

The results of the field investigation of agro-forestry systems in salt affected and non-salt affected areas in Khon Kaen province indicated that the agro-forestry systems as well as plant varieties in salt affected areas had a lower variety than that in non-salt affected areas.

Table 1 Simpson and Shannon diversity indexes of plant species found in each agro-forestry system in salt affected and non-salt affected area

Salt affected area			Non-salt affected area		
Practice	**1/D**	**Shannon Diversity index**	**Practice**	**1/D**	**Shannon Diversity index**
1. Patch forests in farmland	2.666	1.165	1. Patch forests in farmland	non observed	non observed
2. Trees on farm boundary	non observed	non observed	2. Trees on farm boundary	1.04	0.097
3. Trees on paddy bunds	1.001	0.004	3. Trees on paddy bund	1.002	0.01
4. Tree plantation associated with animal husbandry	1.134	0.279	4. Tree plantation associated with animal husbandry	1	0
5. Trees in home garden	2.909	1.098	5. Trees in home garden	1.006	0.024
6. Trees in vegetable garden	3.111	1.174	6. Trees in vegetable garden	34.735	0.512
7. Trees in fruit orchard	non observed	non observed	7. Trees in fruit orchard	3.459	1.284
8. Trees and aquarculture	non observed	non observed	8. Trees and aquarculture	9.142	1.126

Moreover, total plant species, as well as plant numbers that were found in agro-forestry systems in salt affected area were lower than that in non-salt affected area. The results of Simpson diversity index and Shannon's index revealed that the diversity of plants in agro-forestry systems in non-salt affected area were higher than that of in salt affected area except in the practices of tree plantation associate with animal husbandry and trees in home garden (Tables 1).

CONCLUSION

The agro-forestry systems found in salt affected areas consisted of five practices while in non-salt affected areas consisted of seven practices. Simpson diversity index and Shannon's index revealed that the diversity of plants in agro-forestry systems in non-salt affected area were higher than that of in salt affected area except in the systems of tree plantation associate with animal husbandry and trees in home garden. Based on the investigated results, it was suggested that the suitable agro-forestry system with higher varieties of plant be introduced in salt affected area.

It was suggested that farmers in salt affected area increase the diversity of tree species especially salt tolerant tree together with salt tolerant or halophyte vegetable or field crop in each agro-forestry practice in salt affected areas for increasing plants diversity and income, as well as rehabilitating salt affected soil.

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Research article

Pollen Food Source Diversity of Stingless Bee (*Tetragonula pegdeni)* and *Lepidotrigona terminata* in Cultivated Area

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Received 23 February 2015 Accepted 31 May 2015 (*Corresponding Author)

Abstract Stingless bees play an important role in pollination of local economic crops. During rainy season, numbers of stingless bee population decline because of lack of food plants. It can lead to colony collapse situation. The main purpose of the first study was to survey the pollen food source of stingless bees in the beginning of rainy season (June) to dry season (December) in the rambutan orchard plantation area in Chantaburi province. The result revealed that 11 species of blooming flowers in observation area were visited by stingless bees in June, five species in October, and four species in December. The second study aimed to identify species of pollen food source from pollen load collected from stingless bees (*Tetragonula pegdeni* and *Lepidotrigona terminate)* colonies in vegetable planting area. It was found that the most favorite plants that stingless bees collected as their pollen food source were amaranth *(Amaranthus lividus*) and corn (*Zea mays*. Linn).

Keywords pollen food source, diversity, stingless bee

INTRODUCTION

Pollination for fruit and seed set is very important for most crop plants. It has been estimated that about 30% of human food is derived from bee-pollinated crops (Kearns and Inouye, 1997). Stingless bee is a kind of bees considered as an important pollinator of the native flora in tropical and subtropical parts of the world. Stingless bees have been used as insect pollinators of many crops (Heard, 1999). In eastern part of Thailand, stingless bees have been kept and used as insect pollinators especially for rambutan for decades (Sawatthum, 2004). In Chantaburi province, several stingless beekeepers sell or rent out stingless bee hives. To be able to use stingless bees for commercial pollination purpose, proper management of colonies in hives is very important. As this type of bees can form perennial colonies from which they forage for food all year-round. Nectar and pollen are food of adult bees as they feed their larvae with pollen. For the bees, an understanding of their main pollen sources allow us to establish plantations providing them with pollen and consequently leading to the stability of the colonies (Kerr et al., 1986). There are a few plants blooming during rainy season in Thailand. Moreover, it is hard for stingless bee workers to fly out when it rains. These cause lack of storage food situation for all members in the colonies, especially pollen for the larvae. These conditions weaken the colonies and have an affect on the survival of the colonies due to the scarcity of pollens. To reduce these problems, the stingless beekeepers need to know the pollen sources in rambutan plantation (Meliponiary) and in vegetable farms in order to plant them to support pollen for the bees. Pollens from viable sources are vital inputs that stingless beekeepers should sustainably manage so that the stingless bee colonies can be protected and promoted for economic and ecologicalpurposes.

OBJECTIVES

This research was implemented with the following objectives:

1. Observation on flower visited by stingless bees in rambutan plantation
2. Studies of pollen sources of 2 stingless bees in vegetable farm

METHODOLOGY

Plant and Pollen Specimens Collection

Pollen specimens collection: Pollen was collected during the period of greatest pollen scarcity (fewer species in the flowering phase). The collecting expedition took place from June to December 2010. The collection locations were Meliponiary of stingless beekeeping in Wang-Pla sub-district, Thamai district, Chantaburi province and stingless bee nests were kept in vegetable farm nursery of Crop Production Department, Faculty of Agricultural Technology, Rajamagala University of Technology. Pollen was collected from bloom flowers around 300 meters far from Meliponiary rambutan plantation in the beginning of rainy season (June), beginning of dry season (October), during dry season (December), and blooming flowers 300 meters around vegetable farm nursery all year round to be used as reference pollens. Another pollen samples were collected from bee pollen loading from worker bees in front of the nests. Two species of stingless bees were chosen, namely: *Tetragonula pegdeni* (8 colonies) and *Lepidotrigona terminate* (4 colonies). The pollen samples were chemically processed via acetolysis (applied from Erdtman, 1952 and Brown, 1960). The samples were then mounted in glycerin jelly and sealed with paraffin. Three slides were prepared for each sample. Pollen types were determined by comparing each slide to reference slides (known flowers) and by consulting the specialized literature in this field.
Plant specimens collection: Flowering plant specimens were collected from both sites at the same time as collected pollen samples. Five specimens per plant were collected and preserved as herbarium specimens and identified with the help of specialized literature.

Pollen Sources of Stingless Bees Analysis

Data on flowering plants, types of pollen from pollen loads were matched to the analyzed pollen sources of both stingless bees.

RESULTS AND DISCUSSION

Flowering plants around Meliponiary in rambutan plantation in Wang-Pla sub-district, Thamai district, Chantaburi province, visited by stingless bees were observed and sample were collected in June, October, and December; 2010. The small numbers of blooming flowers visited by stingless bees was shown in those three observations. Eleven species were found in June, five species in October, and four species in December (Table 1).

The Pollen Source Analysis

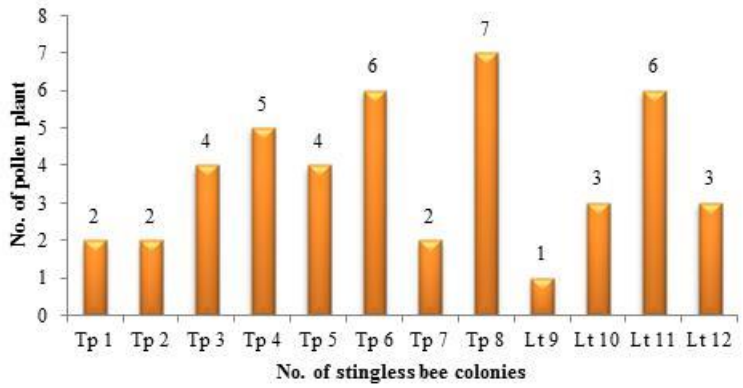
The pollen load collected in front of 12 colonies from two species of stingless bee (*T. pegdeni* and *L. terminata*) in vegetable farm showed that pollen of 17 plant species was found in pollen load species and colonies of stingless bees showed individual character of collecting the various species of pollen plants.

Table 1 Blooming flowers visited by stingless bee

Month of observation	Plant		
	Common name	Scientific name	Family
June	Sulfur Cosmos	*Cosmos spp.*	Asteraceae
	Goat Weed	*Ageratum conyzoides Linn.*	Asteraceae
	Bird Chilli	*Capsicum annuum*	Solanaceae
	Hairy Basil.	*Ocimum basilicum* L.f. *var. citratum Back.*	Labiatae
	Holy basil, Sacred Basil	*Ocimum sanctum* L.	Labiatae
	Java Tea, Kidney tea, Cat' s Whiskers	*Orthosiphon aristatus* (Blume) Miq. Bolding	Labiatae
	white gourd, wax gourd	*Benincasa hispida*	Cucurbitaceae
	White Popinac, Lead Tree, Wild Tamarind	*Leucaena leucocephala* (Lamk.) de Wit.	Leguminosae
	Angel face pin	*Cynoglossum lanceolatum* Forssk	Boraginaceae
	Common Purslane,Verdolaga, Pigweed, Little Hogweed, Pusley	*Portulaca oleracea* L.	Portulacaceae
	Unknow		
October	White Popinac, Lead Tree, Wild Tamarind	*Leucaena leucocephala* (Lamk.) de Wit.	Leguminosae
	Rose	*Rosa hybrids*	Rosaceae
	Hairy Basil	*Ocimum basilicum* L.f. var. citratum Back.	Labiatae
	Purslane, Pussley, Rose mose, Sun plant, Eleven-o'clock	*Portulaca oleracea* L.	Portulacaceae
	Unknown		
December	Water lily	*Nymphaea lotus* L.	Nymphaeaceae
	Coral Vine, Pink Vine	*Antigonon leptopus*. Hook. & Arn	Polygonaceae
	white gourd, wax gourd	*Benincasa hispida*	Cucurbitaceae
	banana blossom	*Musa sapientum* L.	Musaceae

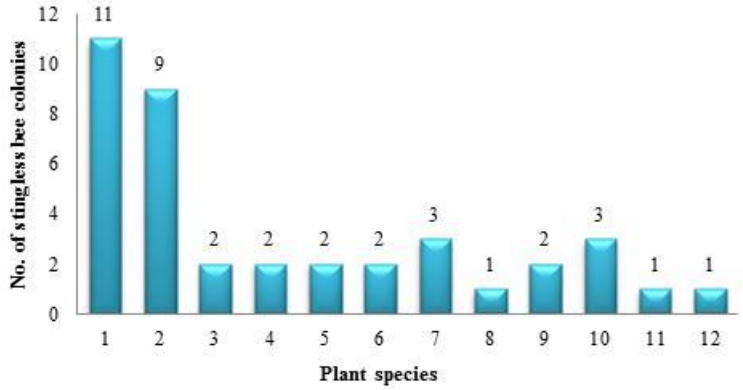
Tetragonula pegdeni colony number 8 collected the highest variety of pollen plants (seven species) while *L. terminata* colony number 11 collected six species of pollen plants (Fig. 1). Figure 2 shows the most favorite plants found in pollen load in yellow flame. (*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne) and Corn (*Zea mays*. Linn), respectively. The observation in the field showed that amaranth (*Amaranthus lividus* Linn.) was the favorite place of visiting of the stingless bees.

In southeastern Brazilian Atlantic Forest, stingless bees *Tetragonisca angustula* preferred to visit Asteraceae and Anacardiamore than others (Braga J. A., et.al., 2012) while in manmade plantation in Thailand, the two stingless bee species preferred Leguminosae (*Peltophorum pterocarpum*), Poaceae (*Zea mays*), and Amaranthaceae (*Amaranthus lividus*). Therefore, corn and amaranth could be pollen plants providing pollen food sources for bees during pollen-scared season, as both of them were easy to grow in almost every kind of environment.



[1]* Tp = *Tetragonula pegdeni*
Lt = Lepidotrigona terminata

Fig. 1 Number of plants found in pollen loads collected from worker stingless bees in front of the stingless bee colonies



* 1 = *Peltophorum pterocarpum* (DC.) K. Heyne
2 = *Zea mays* Linn.
3 = POACEAE
4 = NYMPHAEACEAE
5 = *Vaccinium sprengelii* (G.Don) Sleumer
6 = Unknow 1
7 = Unknow 2
8 = *Luffa acutangula* (Linn.) Roxb.
9 = *Antigonon leptopus* Hook. & Arn.
10 = SOLANACEAE
11 = *Pterocarpus indicus* Willd.
12 = *Maoutia puya* (Wall. ex Hook.) Wedd.
13 = AMARYLLIDACEAE
14 = *Solanum torvum* Sw.
15 = Unknow 3
16 = Unknow 4
17 = *Mikania micrantha* H.B.K.

Fig. 2 Numbers of stingless bee colonies collected pollen from each pollen plant

CONCLUSION

Results of floral diversity using as pollen source of two stingless bees *T. pegdeni* and *L. terminata* showed a small number floral plants visited by stingless bees during observation. There were eleven species in June, five species in October, and four species in December. The most common pollen types found in stingless bee pollen loads were *Peltophorum pterocarpum* (DC.) and K. Heyne and *Zea mays* but the most popular plant visited by stingless bees found in vegetable farm was amaranth.

ACKNOWLEDGEMENTS

This work was supported by Rajamangala University of Technology research fund. The author would like to thank Assoc. Prof. Danai Vannavanich for his comments.

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Research article

Analysis of Urban Ecosystem Services Considering Conservation Priority

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Received 16 December 2014 Accepted 31 May 2015 (*Corresponding Author)

Abstract Many cities lose their green space and ecosystem services, especially in developing countries, which represent a problem as serious as an environmental pollution. Japan has also experienced the problem as a result of rapid economic growth. A system to assess ecosystem services and to create conservation maps in urban area was developed for use as a policy suggestion for urban planning. Nine ecosystem services were calculated by proxy variables in the studied area, Nagoya city, Japan. After selecting a subset of relatively and highly independent proxy variables, five ecosystem services significantly decreased before and after a period of strong economic growth (1955 and 1997). Distributions of the ecosystem services had trends of fragmentation indicated by a cluster analysis. Conservation priority maps created by using the conservation planning software called Zonation were presented. In the eastern and western areas, ecosystem services decreased with the loss of green space indicated by the authors in a previous study. The conservation priority level of the central area was relatively high due to the loss of green space. The results of this study are helpful planning for green space and offset-evaluating system.

Keywords Geographical Information System, green space, landuse, Nagoya, zonation

INTRODUCTION

Many cities lose their green space (parks, agricultural fields, and secondary forests) and related ecosystems due to an increase in population, industry, and business, especially in developing countries. This loss represents a problem as serious as an environmental pollution. Japan has also experienced the problem as a result of rapid economic growth. Currently, the green space in many Japanese cities is still over 10% of the land area. However, it appears that the quality of this green space, as measured by characteristics such as continuousness and ecological complexity, has not remained high.

Ecosystem services (e.g., Costanza et al., 1997; Millennium Ecosystem Assessment, 2005), defined as goods and services provided by ecosystems to human society, are essential for a sustainable society. Green space in urban areas, including grass, agricultural, and forest ecosystems, provides ecosystem services such as biodiversity conservation, air and water purification, climate mitigation, disaster control, and cultural services (recreation, landscape, etc.). However, ecosystem services from these ecosystems decrease with urban development.

From a socioeconomic point of view, setting ecosystem conservation priorities is an effective way to maximize ecosystem services and/or biodiversity under economic constraints. Many software programs have been applied to conservation planning for biodiversity, including C-Plan, Marxan, and Zonation. Moilanen et al. (2011) researched competing land uses (in terms of their biodiversity, carbon storage, agricultural production, and urban area) in Great Britain using Zonation software. Fan and Shibata (2014) applied Zonation to the evaluation of ecosystem services in a river basin and found that forest ecosystems should be prioritized, especially for the water supply service that they provide, for Hokkaido, Japan.

In a previous study (Ooba and Hayashi, 2014), the authors indicated that land use in Nagoya, Japan differed before and after a period of strong economic growth, with the green space in Nagoya, including agricultural fields and forests, decreasing drastically. Those results mentioned that the provisioning of ecosystem services also decreased drastically; however, quantitative evaluation was not performed. In addition, conservation policy suggestions would be useful for the remaining green space, especially information on the areas that are the most important for maintaining or enhancing ecosystem services based on detailed geographical and quantitative research.

OBJECTIVE

The aim of this study is the development of a system to assess ecosystem services in urban areas and create maps of ecosystem conservation priorities for use as a policy suggestion for urban planning.

METHODOLOGY

Study Area and Data Set

The study area (the city of Nagoya) is the same area as the previous study (Ooba and Hayashi, 2014). The annual average temperature and precipitation are 15.8°C and 1,535.3 mm, respectively. With a population of approximately 2,260,000, metro Nagoya (ca. 32,600 ha) is Japan's fourth largest city and is representative of urban Japan.

Digital maps of land use in 1955 and 1997 at a 10 m resolution were developed in the previous study. The maps categorized 5 types of land use: water surface, built-up urban (residential and industrial) areas, roads, agricultural fields, and forest. In this study, green space was defined as the agricultural field and forest land uses. A digital elevation map (10-m resolution) was also used to estimate prevention of soil erosion. The following geographical processing and calculations were performed using ArcGIS 10.2.

Evaluation of Ecosystem Services

Several variables were calculated as proxies for supply of ecosystem services from the studied area (Table 1) at the resolution of the Japanese standard mesh defined by the Japan Industrial Standard, corresponding to approximately 1 km. The following variables were calculated using an area-based primary unit for each land use: carbon sequestration, prevention of eutrophication, food supply, air purification, climate mitigation (contribution to increase of air temperature), infiltration rate, and prevention of soil erosion. The detailed calculations used to generate these values are indicated in Table 1. For cultural services, a proxy variable was estimated from the distance to the nearest relatively large green space (recreation index), defined as an area larger than 1 ha. A proxy for biodiversity conservation was estimated from the continuousness of green space (biodiversity index) by using Focal Statistics in ArcGIS and setting the proximity radius to 2 km. For the 1997

data set, these 9 variables were converted to normalize values due to difference of units by subtracting the mean and dividing by the standard deviation. Some variables (prevention of eutrophication, climate mitigation, prevention of soil erosion, and distance to a large green space) were of the opposite scale to the other variables. These variables were reversed by multiplying by −1. For comparison to 1997, the variables for 1955 were normalized by the statistics of 1997.

A matrix of correlation coefficients among all proxy variables was generated to identify linear relationships. After selecting a subset of relatively highly independent proxy variables, a cluster analysis was performed using the k-mean method for the 1997 data set to clarify the characteristics of ecosystem services at each mesh cell in the city. For the 1955 data set, each mesh cell was reclassified and compared to the result for 1997 to obtain the differences between the two years. These calculations were performed using statistical software (Excel statistics, Social Survey Research Information, Japan) in Microsoft Excel 2013.

Table 1 Proxy variables of ecosystem services in urban area

Name	Cat*	Estimation Method	Values or Details	Unit	Ref.
Carbon sequestration	S	Primary unit	3.09(F)	t/y	1
Prevention of eutrophication**	S		16.5(U), 42(A), 3.8(F)	kg-N/y	2
Food supply	P		2.98(A)	t/y	3
Air purification	R		0.00615(A), 0.011(F)	t-NO_2/y	1
Climate mitigation**	R		6(U), −2.9(A), −1.3(F), 2(W)	°C	4
Rain infiltration	R		12.7(U), 89.3(A), 258.2(F)	mm/h	5
Prevention of soil erosion**	R	S and C coefficient in RUSLE [6]	$S = 65.41\sin^2\theta + 4.56\sin\theta + 0.065$ C = 1 (U), 0.33(A), 0.0085(F)	-	6 7(A) 8(F)
Recreation **	C	Distance of relatively large green space	Enquired distance for large green space (A and F) polygon (> 1ha)	m	9
Biodiversity	S	continuousness of green space	Focal statistics (proximity radius 2 km) (ArcGIS spatial tools)	-	9

Abbreviation: U: Urban area and road, A: Agricultural area, F: Forest area, W: Water surface
** Category of ecosystem services: Supporting (S), Provisioning (P), Regulating (R), Cultural (C)*
*** Opposite scale. High value of the variable indicated negative effect about the concerned ecosystem service.*
1. Ogawa et al. (2003)
2. Japan Sewage Works Association (1997)
3. Aichi prefecture (2012)
4. Yokoo et al. (2003)
5. Murai and Iwasaki (1975)
6. Renard et al. (1997), RUSLE: Revised Universal Soil Loss Equation.
7. Ogawa et al. (2005)
8 Kitahara et al. (2000)
9 Li (2014)

Algorithm of Calculating Conservation Priority

The conservation planning software Zonation provides several algorithms to determine conservation priorities (e.g., core-area zonation). The authors chose the simplest algorithm, the additive benefit function, which calculated the sum of all calculated values of ecosystem services for each mesh cell and produced a mesh-map of the sums. In this study, the input values were the proxy values of ecosystem services. The weight and cost for each proxy variable were assumed to be 1.0 (the default). For a technical reason, the raster data for Zonation were created at a 500-m mesh converted from the above mentioned approximately 1-km mesh.

RESULTS AND DISCUSSION

Ecosystem Services Evaluated by Proxy Variables

Nine ecosystem services were estimated at a 1-km mesh for 1955 and 1997 for Nagoya city (data not shown). The matrix of correlation coefficients among all proxy variables was also calculated. The variables calculated from the digital maps of land use type using the primary units exhibited high correlations with the other variables calculated by the same method. On the other hand, the variables calculated using ArcGIS had low correlations with the former variables. For further analysis, the following five variables of which correlation coefficients were less than 0.6 were selected: carbon sequestration, food supply, prevention of soil erosion, recreation index, and biodiversity index. The food supply variable was the only proxy of a provisioning service that was selected; it was chosen over prevention of eutrophication, which displayed a high correlation with food supply.

The values of all of the selected variables decreased from 1955 to 1997, which was related to a decrease in green space from 55% of the total city area to 16% (Ooba and Hayashi, 2014). The distribution of the supply of ecosystem services also changed, becoming sparse and isolated in 1997.

Classification of Supply of Ecosystem Services

The distribution of classified mesh cells from the selected 5 proxies is indicated in Fig. 1. Because the number of classes is arbitrary in the k-mean method, the authors chose 5, which was the same as the number of classified types in the original land use maps. The following labels were used in referring to the land use maps: core urban area, urban area, agricultural area, forested area, and green area. Between the dates of the two land use maps, urban areas expanded and agricultural and forested areas contracted complementarily. In 1997, green areas (mixture of urban area and green space area) appeared as a result of the fragmentation of green space.

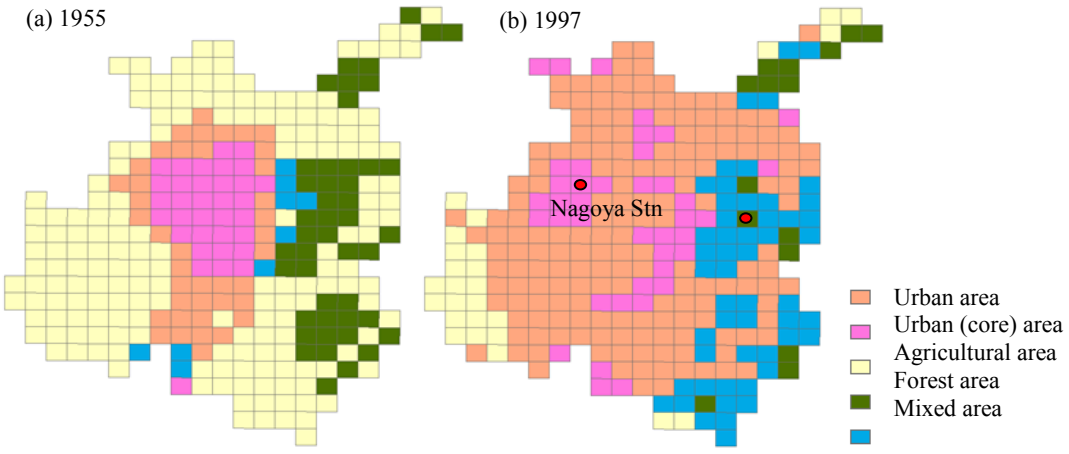

Fig. 1 Classification from the proxy variables of ecosystem services

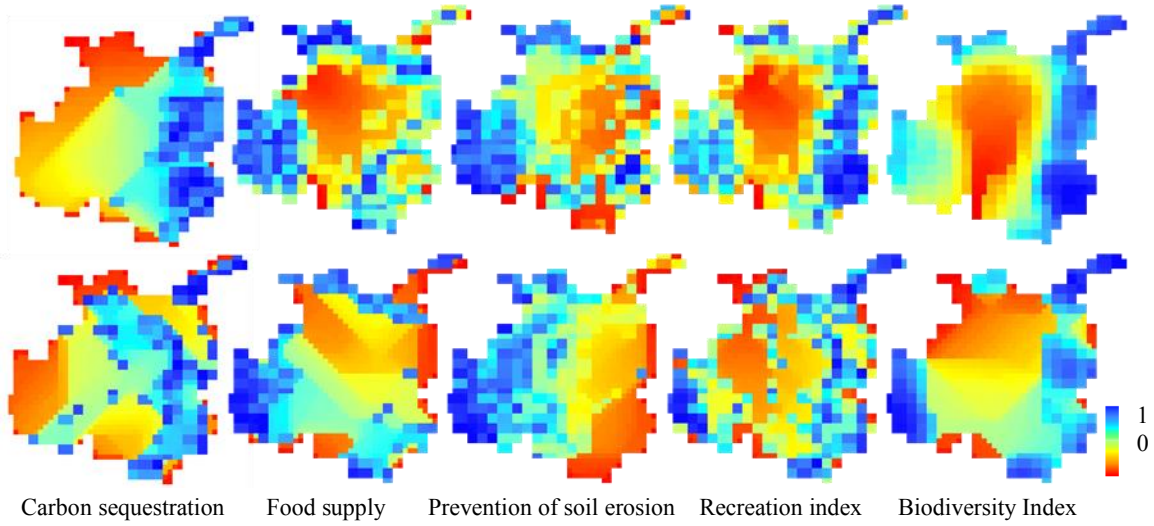

Fig. 2 Relative priority ranks (0-1) of the selected ecosystem services

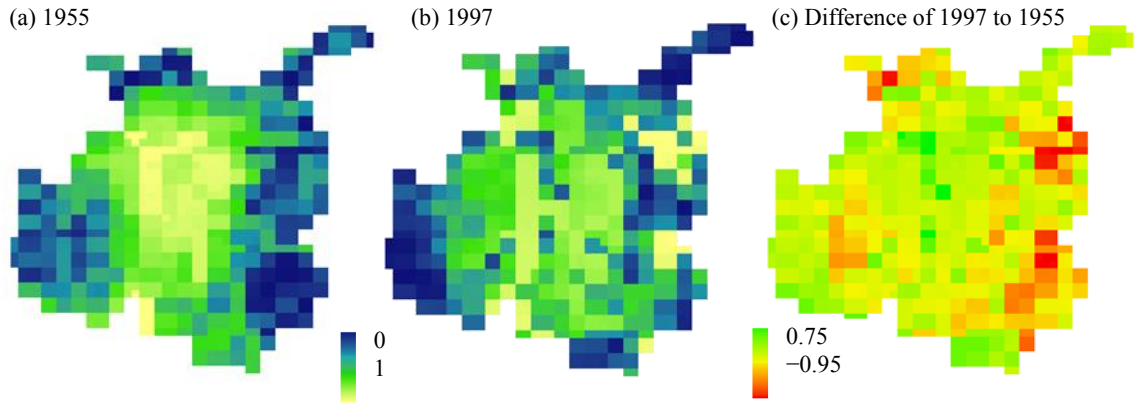

Fig. 3 Relative priority ranks and difference of integrated ecosystem services

Conservation Priorities

Priority maps for each of the 5 selected proxies were calculated using Zonation and are presented as Fig. 2. The maps represent the conservation priority order of each mesh cell for each proxy variable (the blue colored cells supply the most ecosystem services). In 1955, the mesh cells on the east and west sides in the city had relatively high values in the all ecosystem services, whereas almost half the cells in those areas had low values in 1997.

Integrated priority maps, presented as Fig. 3, were also calculated from the 5 variables using Zonation. The conservation priority level of the marginal area of the city is high levels in 1955 provided from both agricultural and forest ecosystems. This east, especially east-south and east-north, high priority area almost disappeared by 1997. The west area remained a high priority. Compared to the east area, the west and northeast areas were also assigned high priority. Fig. 3(c) presents the differences between the two years. This indicates an overall loss of ecosystem services, which is consistent with the pattern observed above for each individual ecosystem service. It is

notable that the conservation priority level of the central area is relatively high due to the loss of green space in the marginal area.

Outlook

A relatively simple method (primary units) was applied to estimate the supply of ecosystem services. Derived variables such as carbon sequestration and prevention of eutrophication were highly correlated with the other variables derived by the same method. For each estimate of supply of ecosystem services, more appropriate methods may be developed that depends not only on land use but also on other geographic, statistical, or process-based methods. For several services, especially those related to culture and biodiversity, innovative proxy variables and estimation methods are needed.

The default settings of the Zonation software program (weight and cost) were used in this study. For widespread applicability, these values must be determined by suitable methods: Cost may be estimated by building up the management costs of conserving an ecosystem. Weight may be estimated by social investigation, such as an economic survey or questionnaire about the value of the ecosystem.

In a more practical context, discussions about an offset system for development have begun, and many studies related to the design of such an offset system have been performed. Offset systems focused on conserving natural land uses or biodiversity have already been introduced in the United States, Australia, and many European countries. The authors place a special focus on offset systems based on assessing ecosystem services because the methodology for such a system provides not only on-site offset (offset sites located near the development site) but also off-site offset because the similarity of ecosystems is assessed by the supply of ecosystem services from the target ecosystems.

CONCLUSION

The authors' previous work revealed a drastic change in green space in Nagoya city from 1955 to 1997 (Ooba and Hayashi, 2014). This study included not only a quantitative evaluation of ecosystem services but also an integrated assessment of ecosystem services in this area. The supply of ecosystem services decreased along with the decreased area of green space. A high supply of ecosystem services present in the marginal area of Nagoya city in 1955 disappeared, while in the eastern area, loss of ecosystem services was relatively low. Conservation priority maps created using Zonation software were presented, which is helpful planning for green space and offset-evaluating system in the studied area.

ACKNOWLEDGEMENTS

This study was supported by the funding program for next generation world-leading researchers (MEXT, Japan) and the Environment Research and Technology Development Fund (1-1401, 2-1404, MOE, Japan). The authors thank H. Shibata, M. Fan, and Y. Inagaki.

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Research article

Micro Hydroelectricity Using Irrigation Ponds for Better Water Management

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Received 22 January 2015 Accepted 15 July 2015 (*Corresponding Author)

Abstract This paper discusses estimates of hydroelectricity potential using irrigation ponds in mountainous areas. Hydroelectric power output is calculated from hydrological observations such as discharge from the ponds and water level at two irrigation ponds. Although these ponds have almost the same water storage capacity, water discharge patterns differ due to differences in the command areas. Results show that water management influences the pattern of hydroelectric power generation. The use of electricity is also important to consider since irrigation ponds in mountainous areas are distant from villages, which have no electricity infrastructure. In most cases, the irrigation ponds in mountainous areas are difficult to access. In addition, most of the water managers are aging and are having difficulty maintaining irrigation ponds and its water management. Therefore, using hydroelectric power to support the operation and maintenance of irrigation ponds would be one of the best ways to use the hydroelectric power generated at irrigation ponds. Finally, a field experiment of a micro-hydroelectricity system is conducted at an irrigation pond and the pond monitoring system is installed.

Keywords renewable energy, siphon intake, automatic control, monitoring system

INTRODUCTION

Irrigation ponds are used as supplemental irrigation for paddy rice fields in Japan. Recently, the generation of micro hydroelectricity using irrigation facilities as a form of renewable energy has received much attention due to encouragement by the Japanese government and the significant price increases in electric power. Irrigation ponds, especially those located in mountainous areas, can easily generate the gravitational drop, which is necessary for hydroelectricity generation and gives advantage to ponds in these areas more than the ones in flat areas.

Lots of investigations have been conducted by the government and local governments so the governments can estimate hydroelectricity potential in mountainous areas in Japan. However, most of them were calculated only by using topographic information and rainfall data without considering actual water management. Ueda et al. (2013) have reviewed small-scale hydropower generation using irrigation water in Japan. Ueda et al. (2015) had conducted a scenario analysis to propose a water management scheme to balance two objectives, irrigation and hydropower. There is no research on hydropower generation using small irrigation ponds, as there are many in mountainous areas especially in western part of Japan.

Therefore, this paper discussed and estimated hydroelectricity potential using Nanatani pond and Matsutani irrigation ponds in Tottori, Japan and the use of electricity by considering current

water management practices. Moreover, field experiment of hydroelectricity was conducted at Yanaka pond in Tottori.

METHODOLOGY

Irrigation ponds are categorized into two groups, including ponds in mountainous areas and in flat areas. In this paper, siphon intake is assumed to estimate the hydroelectricity potential using irrigation ponds in mountainous areas. There are advantages of employing siphon intake, such as preventing dust entering, making use of water head for hydroelectricity, reducing initial investment for hydroelectricity, and easier water management than conventional practices.

Study Areas

Two irrigation ponds, Nanatani and Matsutani, were selected in this study. Both of them are located in mountainous areas of Tottori Prefecture, Japan. Storage capacities of the two ponds are more than 200,000 m^3 and the height of both ponds are over 12 m. Considering more than 50% of irrigation ponds in Tottori, the ponds have less than 10,000 m^3 of water storage capacity, which are relatively big ponds. Besides, there were significant differences in beneficiary areas and catchment areas. Catchment areas of Nanatani pond were about half of the Matsutani's one while beneficiary areas of Nanatani were more than 3 times of the Matsutani's one. Water was collected from runoff of each catchment area only and there was no water supply from river water. General descriptions of the selected irrigation ponds are summarized in Table 1.

Table 1 General information about observed ponds

Name of Pond	Nanatani	Matsutani
Storage capacity (10,000 m^3)	210.0	259.2
Dam height (m)	12.0	16.5
Catchment area (ha)	30.0	62.0
Beneficiary area (ha)	44.5	13.0
Water resource	Runoff	Runoff

Hydrological Observation and Estimation of Hydroelectricity

Siphon intake was assumed in this study instead of conventional operation. The opening and closing bulbs on inclined inlet pipe were employed to make use of advantages of siphon for hydroelectricity such as avoiding trash intake, easier operation of open and close gate, and getting water head and lower cost. The outlines of hydroelectric system are illustrated in Fig. 1.

Also, hydroelectric power output (kW) is calculated as following Eq. 1.

$$P = \rho g H_e \, Q \, \eta \quad (1)$$

Where, P is electric output (kW), ρ is density of water (1,000kg/m^3), g is gravity acceleration (9.8 m/s^2), He is effective head (m), Q is discharge (m^3/s), η is efficiency (0.601).

Water levels of irrigation ponds and canals were monitored in every 10 minutes during irrigation season in 2010 and 2011. A level survey was conducted to determine the head and for hydrological observations such as discharge from the ponds and water level. Height-volume curves of irrigations ponds and height- discharge curves of irrigation canals were also prepared for the two ponds based on the field survey.

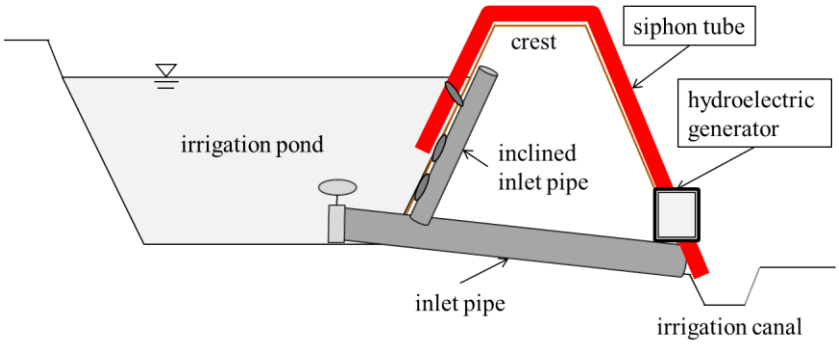


Fig. 1 Outlines of hydroelectric system

Field Experiment

Field experiment of siphon intake and hydroelectricity was conducted at Yanaka pond in Tottori during non-irrigation period. Usage of generated electricity was also demonstrated such as installing electric bulb for easier water management and or monitoring system to inform water managers for the water level of the ponds.

RESULTS AND DISCUSSION

Estimated Hydroelectricity

Fig. 2 (a) shows the estimated power output of Nanatani pond in 2010. Irrigation period is 106 days from May 30 to September 12. Water discharge varied daily because water managers conventionally opened the gate at 6 a.m. and close at 6 p.m. Water manager also adjusted the discharge according to rainfall events. If it rained at 6 a.m., the water manager would not discharge water. If it rained at daytime, the manager would go to the pond to decrease and/or stop discharge.

Fig. 2 (b) shows estimated power output of Matsutani pond in 2010. Irrigation period is 104 days from June 1 to September 12. Compared with Natanani pond, Water level and discharge at Matsutani pond were more stable. Irrigation water was released 24 hours and water discharge was adjusted every 3-4 days at Matsutani pond.

Table 2 Summary of the estimated output, 2011

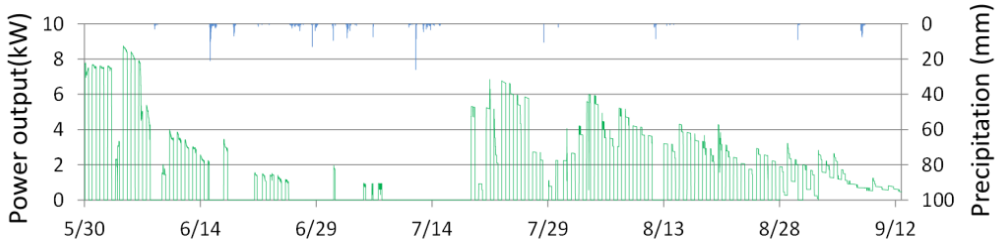
Pond	Nanatani	Matsutani
Gross generation (kWh)	1,821.0	3,443.0
Total discharge (10^3 m^3)	199.7	265.2
Maximum output (kW)	5.0	3.6
Average output (kW)	1.7	1.3
Monitoring time (h)	2,538.0	2,610.0
Discharge time (h)	1,080.0	2,610.0
Generating time (h)	1,080.0	2,610.0
CO_2 conversion ($kgCO_2$)	1,011.0	1,911.0
Oil conversion (L)	462.6	874.5

Table 2 shows the results of estimated hydroelectricity of two ponds for the year of 2011. The maximum electric power output and electric power were 4.92 kW and 1,420 kWh at Nanatani pond and 3.57 kW and 3,000 kWh at Matsutani pond. Although these ponds had almost the same water storage capacity, water discharge patterns differed due to differences in the command areas. Nanatani pond had larger command area than Matsutani pond; therefore, strict water management

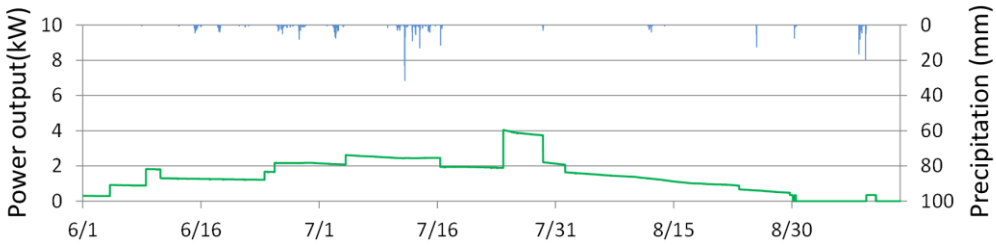
was practiced at Nanatani pond. The water manager at Nanatani pond usually opened the gate at 6 a.m. and closed at 6 p.m., and the water gate was closed when it rained. On the other hands, the water manager at Matsutani pond usually kept the gate opened and the discharge was controlled twice a week during the irrigation period. Therefore, the water level of the pond decreased continuously at Matsutani pond while the water level of the pond slowly decreased at Nanatani pond due to its strict water management. As a result, hydroelectric power was continuously generated at Matsutani pond compared with Nanatani pond. It shows that water management influences the pattern of hydroelectric power generation.

Result of Field Experiment

A field experiment of a micro-hydroelectricity system was conducted at Yanaka irrigation pond in Tottori, Japan. Electricity output was also continuously monitored in two weeks to examine the stability of output. Fig. 3 shows the results of field experiment. Stable output about 1.2 kW was observed during the first 10 days from February 1 to 10. Then the output decreased according to the lowering of water level in the pond.

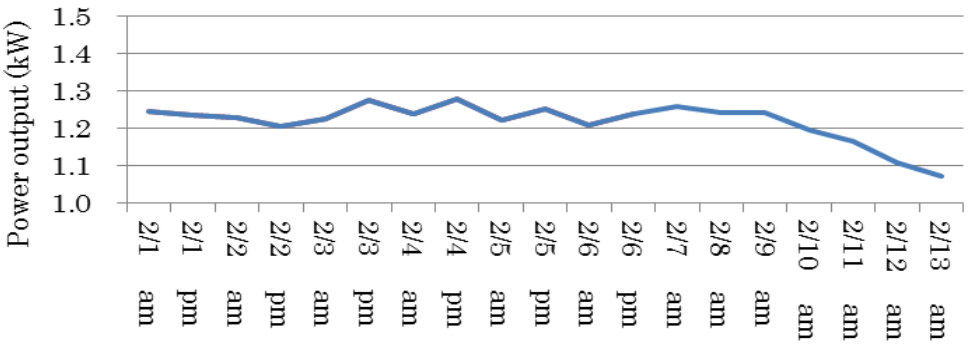


(a) Nanatani pond



(b) Matsutani pond

Fig. 2 Estimated power output at observed ponds, 2010 (Kusaka et al., 2011)



(*Discharge: 52 L/s, Generating efficiency: 45~50%*)

Fig. 3 Power output of the field experiment

Usage of Generated Electricity

The usageof the electricity was also important since irrigation ponds in mountainous areas were distant from villages and had no electricity infrastructure. Consequently, the electricity generated at ponds could not be readily used by villagers and farmers. In most cases, it was observed that the farm ponds in mountainous areas were difficult to access. In addition, most of the water managers were aging, over 65 years old, and were having difficulty in maintaining farm ponds and their water management (Taniguchi et al., 2011). Using hydroelectric power to support the operation and maintenance an irrigation pond, replacing manpower, and fuel with electricity would be one of the best ways to to generate electricity at a farm pond. Moreover, some water managers havd problems with illegal disposal of cabbages into the ponds and illegal fishing by fishermen who deliberately discharged water to lower the water level in the ponds for easier fishing. However, since the location of irrigation ponds were far from the villages, water managers could not check the ponds often.

Pic. 1 Installation of an electric bulb
(*Left: outlines of hydroelectric system*)

Pic. 2 Outlines of the monitoring system

Pic. 3 View of a live camera through smartphone

Considering those conditions, an electric bulb and monitoring system with water level sensor and live view camera was installed. Through the monitoring system, water managers could check the water level of their irrigation ponds and also watch the conditions of water intake and its surroundings through a computer or smart phone if the internet connection was available. A monitoring system was installed at Yanaka irrigation pond, which had a water level sensor and live view camera. Users could check the water level and view of the irrigation pond through the internet connection. The system required 200W for its operation.

Pictures 1, 2, and 3, show the electric bulb, monitoring system, and the view of irrigation pond through smart phone, respectively.

CONCLUSION

Hydropower potential using irrigation pond was estimated. Estimated electric power output and electric power were different at the ponds with similar storage capacity due to different water management. Field experiment of siphon intake generation was also conducted and constant power output was generated. Using hydroelectric power to support the operation and maintenance of a farm pond, replacing manpower and fuel with electricity, would be one of the best ways to generate electricity at a farm pond.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge financial support from “Community Contribution Support Activities”, Tottori University and technical supports from Tottori Institute of Industrial Technology and Asahi Organic Chemical Industry Co. Ltd.

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Research article

Analysis of Fiscal Gap and Financing of Cambodia's Protected Areas

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Received 16 December 2014 Accepted 15 July 2015 (*Corresponding Author)

Abstract The Analysis of Fiscal Gap and Financing of Cambodia's Protected Area (PA) conducted by the Department of International Conventions & Biodiversity, Ministry of Environment (MoE), aimed to identify resource gaps in the management of 23 PAs of Cambodia. The pressure & response indicators were used to analyze resource gaps. Pressure indicators were population, number of visitors of each PA, roads, and hiking trails within PAs; while response indicators included the number of full time staff and operational expenditure. To examine resource gaps for PAs management, all PAs were classified into three clusters according to the area size. The comparisons between pressure and response demonstrated trends of existing resources for the management of PAs, therefore they were analyzed by pairing pressure and response indicator. To calculate resource gaps, two benchmarks were set for each cluster: the average and the highest. Each PA resource gap was identified based on two rules: 1) bringing the number of fulltime staff and operational expenditure that was below average to the "average benchmark"; 2) bringing the number of fulltime staff and operational expenditure that was higher than the average to the "highest benchmark". As a result, the total gap of full time staff in 2009 was 449 personals, equal to 1/3 of existing staff. However, the gap of full time staff in this context did not take into account of their capacity to fulfill PA management tasks. The total operational expenditure gap in 2009 was 1,221,405 USD, equal to 25% of the benchmark estimation of 2,462,881 USD. In conclusion, for better management of 23 PAs, the budget for PAs operation should be doubled; therefore it should be increased up to 2.5 million USD per year.

Keywords fiscal gap, Cambodia, protected area, financing

INTRODUCTION

A 1993 degree of the Royal Government of Cambodia designated 23 Protected Areas (PA) comprising approximately 18% of the total land areas of the country. Following IUCN (2004) categorization, these PAs can be classified into National Park (7), Wildlife Sanctuary (10), Multiple-use Areas (3), and Protected Landscape (3). Through Royal decree (2001) and Declaration N.4010 (1999), one Biosphere Reserve has been established and three Ramsar sites have been identified in addition to the 23 PAs. Those PAs are managed by the General Department of Administration for Nature Conservation and Protection (GDANCP) of the Ministry of Environment by Law on Protected Areas 2008.

In addition, the Royal Government of Cambodia has designated 6 Protected Forests (PF), which are managed by the Ministry of Agriculture Forestry and Fisheries (MAFF). The management of Protected Forests is regulated under the Forestry law and relevant Royal Decree, Sub-Decree and Declaration of the MAFF.

Each type of PA has a specific inclusion definition and a management objective. The management of PAs has complied with the Royal Decree on the Creation and Designation of Protected Areas (1993), the Law on Environmental Protection & Natural Resource Management (1996), the Law on Protected Areas (2008), which define a framework of PA management,

biodiversity conservation, and sustainable use of natural resources within PA. Other PA related legislations and regulations include the Environmental Impact Assessment (EIA) sub-decree (1999), Biosafety reserve (2008), Forestry Law (2002), Fisheries Law (2002), Royal Decree, Sub-Decree and Declaration, and other relevant laws. Protected Areas is the main approach to biodiversity conservation in Cambodia. Data collection and interview in 2012 by Department of International Convention and Biodiversity, it showed that 23 Protected Areas had residents within or around them; tourism activities, unsustainable use of natural resources, illegal logging, wildlife trade, and insufficient resources, which were main challenges for PA management. The resources for PA management are generally considered to be insufficient while updated information and practical evaluation are lack to support the argument. This research finding and recommendation options are expected for use by PA responsible institutions to increase budget and sustain finance for effective management of PA System in Cambodia.

OBJECTIVES

This paper aimed to identify the fiscal gap and financing needs for Cambodia's Protected Area management. The overall objective was to analyze the resource gaps in PA management. The research was targeted for 23 Cambodian PAs under administration and management of the Ministry of Environment (MoE). The data were analyzed based on setting internal and external indicators and relevant criteria as appropriate. The findings of resources gaps and recommendations in filling the gapes by either increase national budgets and recruit more rangers or full time staffs are expected to be used by PA responsible institutions for effective management of PAs in Cambodia.

METHODOLOGY

Research was conducted using both primary and secondary data/information collected from 23 Protected Areas established by Royal Decree in 1993. The data were collected directly from each PA's manager, key experts, relevant institutions, partners, stakeholders, and any available sources. Analysis of data collection, cluster classification, and benchmark identification were based on the following methodologies:

Primary Data Collection and Surveys

A research questionnaire was designed in Khmer language for data collection from 23 PAs. It was divided into four parts: part one focused on background information of PA including name, date of establishment, land area, location, IUCN's classification, and its purpose; part two related to the physical characteristics of PA such as access to PA, inhabitants of PA, travelling within PA, and facilities available within PA; part three aimed to gather information on visitor characteristics such as the number of visitors to PA, visitors entry fee, visitor accommodation fee, and activity fee; and part four captured information on staffing revenues and costs, number of staff, staff capacity, operation expenditure; fee collection, and annual revenues for an individual PA.

Secondary Data Collection

Some data could not be collected from the field. The research team directly communicated with relevant institutions, local authorities, and international agencies through available contact persons before sending official letters to request for cooperation in providing data. Data and information from research projects, annual reports, census, materials from workshops and seminars were also collected.

Data Analysis

To analyze the Fiscal Gap for each PA, pressure and response indicators were identified. The pressure indicators included population within 5 km radius, visitors, road, and hiking trail; while the number of full time staff and operational expenditures were identified as respond indicators. The analysis of population focused on total population in the 5 most populated villages within a 5 km radius of the boundary; the less population caused less pressure on natural resources. The total operational expenditure from government budget and other external sources supported some PAs' activities.

The following methods were used to identify resource gaps: analysis pressures and respond, and set benchmark.

Response: This study selected the number of full time staff, and operational expenditures in 2009 as response variable to assess the response to the pressure factors including: population, visitors, road, and hiking trail.

Benchmarking: According to size variance of PA and to maximize the accuracy of gap analysis, 23 PAs were classified into three clusters as follows:

- Cluster 1: PA with total land areas of 0 ≤5,000 ha; 2 Pas
- Cluster 2: PA with total land areas of> 5,000 ha ≤50,000 ha; 6 Pas
- Cluster 3: PA with total land areas of> 50,000 ha ≤402,500 ha; 15 PAs

A benchmark of response indicators was identified for each cluster to analyze resource gaps, which was carried out for full time staff (FTS) per 1,000 ha and operational expenditure (OpEx) per ha. The *average* and *highest* indicators of FTS/1,000 ha and OpEX/ha within each cluster were used as benchmarking tools to estimate gaps.

Resource GAPs: According to the method introduced by the Economy and Environmental Program for Southeast Asia (EEPSEA, 2012), the following rules were applied for calculation resource gaps.

1. If the Number of Full-Time Staff & Operational Expenditure is lower than the average, bring the value of Full Time Staff & Operational Expenditure to the Cluster *Average (Avr)*.
2. If the Number of Full-Time Staff & Operational Expenditure is higher than average in Cluster, bring the value of Full Time Staff & Operational Expenditure to the *Highest* (*Hst*) value in Cluster.

The resource gap analysis was carried out by comparing existing resource allocation for PAs management with averages & highest of individual clusters. The comparisons scenarios presented for looking at how PAs were currently managed, and should stimulate discussion as any action was to be taken for further improvement.

RESULTS AND DISCUSSION

The Cambodia Protected Areas were divided into three clusters based on size: Cluster 1 was for PA that had total land areas from 0 ≤5,000 ha; Cluster 2 was for PA with total land area from between 5,000 ha and ≤ 50,000 ha; while Cluster 3 was classified for any PA having land area more than 50,000 ha but less than or equal 402,500 ha (Table 1). Cluster 3 represented highest number of PA in the amount of 15 PAs out of 23 PAs. According to the data in Table 1, the average total land area in cluster 1 is 3,898 ha, cluster 2 is 28,004 ha, cluster 3 is 209,919, and Kulen-Promtep wildlife sanctuary has highest total land area of 402,500 ha.

In 2009, 204,117 Cambodians visited 9 PAs: three national parks, three wildlife sanctuaries, one protected landscape, and two multiple use areas. In the same year, 339,199 foreigners visited 10 PAs. Therefore, the total number of tourists recorded in 2009 was 543,316 people. However, Bokor National & Phnom Kulen National Parks, and Ankor Multiple Use Area were not included in this analysis as the information on the number of visitors as these PAs could not be obtained as these were managed by other agencies and private companies.

Table 1 Cluster and benchmark for full time staff and operational expenditure

PA total area clustering			Full time staff (FTS)			Operation expend (OpEx)		
Cluster Interval (ha)	No. PA in Cluster	Avr.Total Area (ha)	Avr. No. FTS	Avr. No. FTS per 1000 ha	Hst No. FTS per 1000 ha	Avr. OpEx (USD)	Avr OpEx/ha (USD)	Hst OpEx per ha (USD)
Total = 23		**Highest = 402,500 ha**				**Lowest = 2795 ha**		
$0 \leq 5{,}000$	2	3,898	10.50	2.97	3.94	7,570	2.10	2.67
$> 5{,}000 \leq 50{,}000$	6	28,004	30.17	1.03	1.77	17,576	0.60	0.94
$> 50{,}000 \leq 402{,}500$	15	209,919	45.93	0.25	0.52	74,725	0.30	1.24

According to interview information received from PA's directors, deputy directors, rangers, and commune chiefs, the revenue of each PA were through entry fees (0.25 - 0.75 for local visitors & USD 5 for foreigner), accommodation, and facilities such as boat rental, car park, guide fee, etc. Tourist facilities and accommodation rates varied from PA to PA depending on customer demand. As the road condition of PA was not so good and far from the town, entry fees were lower, e.g. $0.12 per person. Some PAs had additional charges for visitors to see rare species.

Response Indicators

Number of full time staff in 2009: The Ministry of Environment set up 32 offices and 78 sub-offices around and within 23 PAs. For daily operations 891 full-time staff were employed by government to work in 23 PAs.
Operational expenditures in 2009: The operational expenditure for each PA including staff salary, uniforms, and medicine were covered under the government budget. Other operational costs such as project based activities supported by other donors. The total operation expenditures in 2009 for 23 PAs was USD 1,241,476.

Pressure Indicators

Population of five largest villages within 5 km radius in 2009: The total population in the 5 largest villages in a radius of 5 km from border of each PA was 347,625 people.
Roads and hiking trails: Roads & trails in each PA were constructed for filed monitoring recreation and ecotourism. Phnom Prich wildlife Sanctuary had the longest road (380 km), while Botum Sakor National Park had more trails (1,750 km) compared to other PAs. On the other hand, for Roniem Daun Sam Wildlife Sancturay, no road has been constructed and Preah Vihear Protected Landscape only has a 4 km trail.

Response vs Pressure

This research has compared pressure with response in pairs of: Population vs Full Time Staff; Population vs Operational Expenditure; Visitor vs Full Time Staff; Visitor vs Operational Expenditure; Road vs Full Time Staff; and Hiking Trail vs Full Time Staff. Road and Hiking Trail identified as pressures factors have elaborated in follow paragraph.
Population vs full time staff: According to data collection from all PAs (2009) the distribution of population and full time staff in 1000 ha tended to have a positive association in general because the more population was the more full time staff were employed. In this regard, the high pressure by population within 5 km radius in PAs had a response of higher number of full time staff, except Angkor Protected Land Scape which had less full time staff (0.93/1,000 ha) in proportion to population of 4,212.50 per 1000 ha compared to other PAs.

Population vs operational expenditure: The same source of data from directors and rangers in 23 PAs (2009) on the distribution of population and operational expenditure for 23 PAs resulted in positive conditions. The results indicated that the greater the population was, the more staff were employed for management. However, distribution of both factors in Prea Vihar Protected Landscape, Phnom Samkos Wildlife Sanctuary, and Kirorom National Park had more response and less pressure, especially Prea Vihea with operational expenditures of 1,533 USD per 1000 ha in 2009 with no population within this PA. Besides, Angkor Protected Landscape had less resources in term of operational expenditures (470.09 USD/1,000 ha) to response with a high population of 4,212.50 per 1,000 ha.

Visitors vs full time staff: Only nine PAs recorded the number of visitors. The distribution of pressures and response factors for visitors and full time staff was the focus for nine PAs that had data available. The trend of Visitors vs Full Time Staff moved to a positive relationship although three PAs (Preah Vihea Protected Land Scape, Kirirom National Park, and Peam Krosop Wildlife Sanctuary) had high pressure because of the number of full time staff did not fully respond to the number of visitors, so it led to limited human resources for effective management in those PAs.

Visitors vs operational expenditure: The distribution of the number of visitors per 1,000 ha and total operational expenditure per 1,000 ha in 23 PAs also had a positive trend. Distribution of visitors ranged from 0 to 3,589 per 1000 ha, while operational expenditure had a distribution range from 82.27 USD per 1,000 ha in Roniem Daun Sam Wildlife Sanctuary to 2,674.06 USD per 1,000 ha in Kep National Park. In general, many distributions of both factors showed less pressure.

Roads v full time staff: Length of road per 1,000 ha had been considered as pressure factor for PA management due to it was potential and easy for poacher to conduct illegal activities within PA. Besides, it could be considered also as respond factor for PA manager or ranger to control other activities. Nevertheless, this study deliberated existing road, which PA was a pressure factor, but its distribution tended to be positive respond. According to data in this study, there was two contrast outliers at Angkor Protected Land Scape trended to have high pressure with road distribution in 13.80 km per 1,000 ha, and Kep National Park had high response within 4 full time staffs per 1,000 ha.

Hiking trails vs full time staff: Moreover, the length of hiking trails was also considered as pressure factor. The results showed that almost of PAs had enough staff to patrol illegal activities if poachers used only hiking trail.

Benchmarking

This study set benchmarks of *full time staff/1,000ha* and *operational expenditure/ha* at *average* and *highest* points for each cluster, to estimate and calculate resource gaps with the above rules and methodology. However, resource gaps of PAs management did not refer to the quality of full time staff and sufficient financial resources for *effective* PAs management.

Resource GAPs

To estimate resource gaps, the number of full time staff/1,000 ha and operational expenditure/ha had been identified as shown in Table 1. The serial number on horizontal axis in Figs. 1, 2, 3, and 4 represent each PA. The 7 National Parks are: 1- Kirirom, 2- Bokor, 3- Kep, 4- Ream, 5- Botum Sakor, 6- Phnom Kulen, and 7-Virachey; 10 Wildlife Sanctuaries are: 8- Phnom Aural, 9- Peam Krasop, 10- Phnom Samkos, 11- Roniem Daun Sam, 12- Kulen Promtep, 13- Beng Per, 14- Lomphat, 15- Phnom Prich, 16- Phnom Nam Lyr, and 17- Snoul; 3 Protected Landscapes are: 18- Angkor, 19- Banteay Chmar, and 20- Preah Vihear; and 3 Multiple Use Areas are: 21- Dong Peng; 22- Samlaut; and 23- Tonle Sap.

Full time staff GAP: According to the *average* and *highest* benchmark of Full Time Staff (Table 1) and data shown in Fig. 1, cluster 1 had only one PA below *average* and cluster 2 had four PAs below and one PA above its *average*, while cluster 3 had eight PAs below and six PAs over *average.* Therefore, Cluster 1 had 0.97/1,000 ha or approximately 5 (4.8) full time staff gap, cluster 2 had 1.47/1,000 ha or 42 full time staff gap and cluster 3 had 1.85/1,000 ha of 402 full time staff gap. The calculation of full time staff gap in each PA was shown in Fig. 2. Among 23 PAs, only Tonle Sap multiple use area and Phnom Aural wildlife sanctuary had high full time staff gap: 82 staff gap were for Tonle Sap and 66 staff gap for Phnom Aural. For other PAs, the gap was between 0 to 45 staff. The result of full time staff gap assessment indicated that an additional 448.55 staff needed to be employed to the existing 891 staff to meet the benchmark of 1,339.55 staff. That means 1/3 of existing staff is required to recruit in addition.

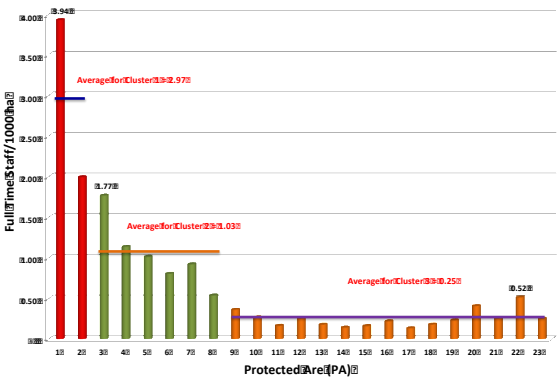

Fig. 1 Full time staff / 1000 ha

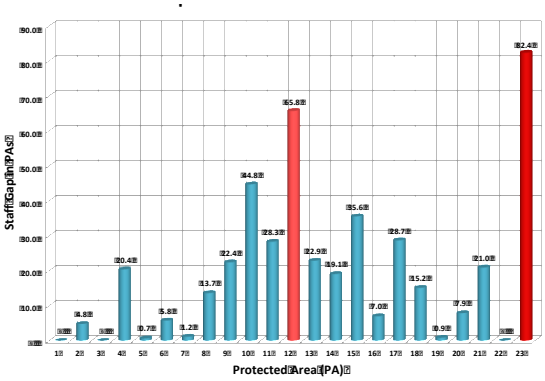

Fig. 2 Full time staff gap in each PA

Operational expenditure GAP: The assessment of the financial gap was based on the annual budget (2009) for PA management of the Ministry of Environment. The funding for supporting PA management received from Government was 40 person (equivalent to USD 499,515) and from other external sources was 60 person (equivalent to USD 741,964). This amount of external sources pertained to only nine PAs. There was not any donor's funding included, as some portion was undisclosed due to the confidential policy of the management. Therefore, this paper focused only donor's funding that worked with government or had a joint project through the Ministry of Environment.

The operational expenditure for each PA included salary for full time staff, expenditure for uniform, medicine and conservation projects. The *average* and *highest* of operational expenditure for each cluster are presented in Table 1. Figure 3 shows that cluster 1 had an *average* expenditure of USD 2.10/ha and the *highest* expenditure USD 2.67/ha, so the total gap was USD 2,853. In cluster 2, operational expenditure in six PAs was not very diverse and was below the *average*, only Dong Peng multiple use area was spending above the *average*. Therefore, the total gap for this cluster was USD 16,886. Besides, cluster 3 operational expenditure in 15 PAs was variance from one PA to another; and 10 PAs were below the *average*, while 4 PAs were above the *average*. The total operational expenditure for cluster 3 was USD 1,201,666. Total gap for each PA is shown in Fig 4. It articulated that Kelen Promtep wildlife sanctuary had highest gap (347,092.7 USD) while Tonle Sap multiple use was the second highest gap of operation expenditure in 2009. Phnom Prich wildlife sanctuary and Botum Sakor national park also presented high gaps.

Total gap of operational expenditure in 2009 for 23 PAs was USD 1,221,405 approximate 50 percent of benchmark estimation at USD 2,462,881. For better management of PA system in Cambodia, operational fund should be increased to double of 2009 budget.

As the results of assessment, the resource gaps for full time staff & operational expenditure for 23 PAs are shown in Table 2.

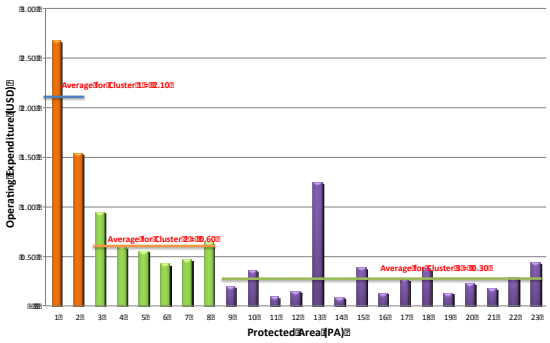

Fig. 3 Operational expenditure per ha.

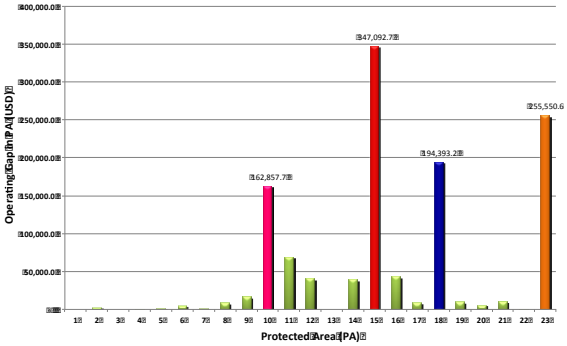

Fig. 4 Operational expenditure gap

Table 2 Resource gaps

Resources gap assessment	FTS (Number)	OpEx. (USD)
Existing resources (2009)	891.00	1,241,476
Estimated resources benchmark	1,339.55	2,462,881
Estimated resources gap	*448.55*	*1,221,405*

CONCLUSION

The resource gap analysis is reliant on data availability in setting indicators. The gap analysis is based on the *average* and the *highest* full time staff per 1,000 ha and operational expenditure per ha in year 2009. The *average* and the *highest* for both indicators vary from cluster to cluster according to the size of PAs. Logically, the bigger size of the PA presents bigger number of full time staff and a bigger operations budget. However, results of this study showed that the smaller PA size had the higher *average* of full time staff, and the higher *average* of operational expenditure. It is more than double expenditure compared with PAs which highest size.

Generally, PAs that had high resource gaps were from cluster 3 as this cluster had very wide gap between the *highest* and above *average*. For cluster 1 and cluster 2 each PA was not much different gap in terms of proportion.

The full time staff gap in this research did not taking into account the qualification of staff. Therefore, this study focuses on quantity only. To assess the effectiveness of PA management, staff quality should be considered as an important indicator and it should be considered for further research.

The protected area depending on the government budget was only able to support for staff salaries, uniforms, and medicine. This budget is neither adequate for effective management nor to improve facilities for resource mobilization. More than half of the total operational expenditure in 2009 received from external sources, if this study could assessed more information on budgets of conservation projects for PA management that supported and implemented by external partners, the figure of operation expenditure for 23 PAs would be increased.

In conclusion, to assess the resource gaps for effectiveness in PA management, gap of full time staff should examine both quantity and quality, including skills & professional requirements, and other criteria such as management plan, equipment, operation facilities etc. Without quality, motivation, and incentives, even if there are adequate staff, a successful or an effective PA management is not guaranteed. Although 1/3 of existing staff is required to fill the gap; or if existing staff can improve their capacity with well equippied facilities, there will be improvement in PAs management.

ACKNOWLEDGEMENTS

The author would like to thank the General Department of Administration for Nature Conservation and Protection, MoE for authorization to conduct this research, and thank the research team of the Department of International Conventions & Biodiversity for strong support in data collection. The author acknowledges all stakeholders including PAs' directors and rangers who were involved and provided information/data for this research. The author expresses her sincere thanks to Dr. Fermi Fransisco, Director of the Economy and Environmental Program for Southeast Asia (EEPSEA) for the financial support to conduct this research. Finally, the author would like to give sincere thanks to Prof. Dr. Machito MIHARA, Institute of Environmental Rehabilitation and Conservation, Tokyo University of Agriculture, for his support and professional guidance on this paper.

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Research article

Business Activities of "Transformed" Agricultural Cooperatives and their Role in Supporting Local Agriculture in Northern Vietnam

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Received 31 January 2015 Accepted 20 July 2015 (*Corresponding Author)

Abstract This study investigates the potential of "transformed" agricultural cooperatives in northern Vietnam to support local agriculture as the market-oriented economy develops. This case study approach examines four agricultural cooperatives introduced by the local government. This study finds that, first, cooperatives try to provide agricultural support to members, but the private sector mainly leads this business. Second, the range of agricultural cooperative business activities is expanding from production to livelihood support. Third, quite a few cooperatives provide marketing support and began to direct production instead of selling their members' products in order to secure the quantities required to fulfill their contracts. The results empirically indicate that cooperatives' business activities has limited impact on local agriculture or their members.

Keywords Vietnam, agricultural cooperatives, local agriculture, business activities

INTRODUCTION

The Vietnamese government began strengthening agricultural cooperatives' (created by small holders) ability to operate in the market economy. First formed under Vietnam's planned economy (similar to China's Model), the cooperatives have changed and lost their social role since the "Doi Moi" economic reformed. A Cooperative law in 1996 forced them to choose between transformation into a new type of cooperative serving their members according to International Co-operative Alliance (ICA) rules or dissolution. In twenty years after the enforcement, there have been currently two types of agricultural cooperatives. The first is the "transformed" cooperatives resulting from the 1996 law. The second is newly established cooperatives formed after 1996. Transformed cooperative are multi-purpose organizations organized around the community and based on regional relationships. Newly established cooperatives are organized based on members' products, such as flowers, fruits, vegetables, fish, livestock, and other single purposes.

Transformed cooperatives generally take over the organization, assets, activities, and businesses from old cooperatives, which existed as politically controlled organizations. Accordingly, transformed cooperatives are seen as nominal organizations, which business activities are diminishing. On the other hand, after the transition, and particularly because of the new cooperative law established in 2003, there is a clear lack of identity for such cooperatives. It is difficult to distinguish among limited companies, charity organizations, and cooperatives. Aside from acceptance as a registered legal entity as a cooperative member, cooperatives similar to a joint stock company are growing rapidly, especially in the South of Vietnam. Most cooperatives, in this case study, offer agricultural marketing output or business efficiency, and are newly established. These are economically effective compared to transformed cooperatives, though they have lost the cooperative's fundamental purpose.

Previous studies of agricultural cooperatives in Vietnam discussed changes in cooperative functions after the Doi Moi reforms (Nghiem, 2006; Miyazawa, 2005). Trends or changes in

activities at the provincial or national level were also studied (Wolz and Bao Duong, 2010; Trung, 2009). Some researchers investigated the role of cooperatives in agricultural distribution and marketing (Moustier et al., 2010; Takanashi and Sakazume, 2013) and compared Vietnamese agricultural cooperative characteristics with those in Japan (Dung, 2010). These studies concluded that most agricultural cooperatives worked mainly on irrigation management, assisted with starting difficult new businesses to address the shortage of capital, and human resources. Most transformed cooperatives had economically stagnated while new cooperatives achieved good economic performance. However, Miyazawa et al. (2005) argued that agricultural cooperatives maintained some security for their members by maintaining the traditional rural community and working as a mutual cooperative, even after Doi Moi, and emphasized the importance of "transformed" cooperatives.

Transformed cooperatives organized around rural communities have the potential to coordinate to counter the power of capital, support small holders' livelihoods, and the local subsistence agriculture that is the foundation of food security and an important part of the socio/economic/ecological landscape (FAO, 2013). Although previous studies mainly focus on efficiency in developing commercial agriculture or cooperatives' economic performance, few researches emphasize on how agricultural cooperatives support local agriculture through their business activities.

OBJECTIVE

The main objective of this research is to examine the potential for "transformed" agricultural cooperatives to support local agriculture and members as the market-oriented economy deepens.

METHODOLOGY

This study takes a case study approach to explore the trends in business activities of northern Vietnamese "transformed" agricultural cooperatives. In-depth interviews were undertaken with four agricultural cooperatives in Hanoi and Hai Duong provinces between November 2012 and January 2013 with the heads and management boards of each cooperative. They were asked about their business activities, how they started each business, and the businesses' management systems. The cooperatives were introduced to the researchers by the Department of Agriculture and Rural Development in Hanoi and Hai Duong provinces, in accordance with the study purpose. This paper is organized as follows. The next section provides general statistical data for current Vietnamese agricultural cooperatives, as background information. The subsequent section presents the main results and a discussion of the field research. The paper then concludes with findings and implications.

RESULTS AND DISCUSSION

Current Status of Agricultural Cooperatives in Vietnam

Cooperative sector and agricultural cooperatives: Table 1 summarizes the number of cooperatives and agricultural cooperatives in Vietnam by type and industry sector in primary production. Vietnam has 14,500 cooperatives, of which 44% are agricultural. The Red River Delta has a relatively high number of cooperatives, as 62.4% of all cooperatives are agricultural, and almost half are of the transformed type. A high number of cooperatives are located in the North part of Vietnam. However, the new type of cooperatives tends to be established in southern Vietnam. Previous studies show that the most popular activity or business for agricultural cooperatives is

irrigation, carried out by 73.4% of agricultural cooperatives (Table 2). This is because most transformed cooperatives maintain irrigation canals taken over from the old cooperatives and hold as a fixed asset. Technical extension comes and 42.0% of agricultural cooperatives providing these services is usually done through collaboration with the District Office of the Department of Agriculture. Providing electricity (38.5%) is the third highest activity. Marketing output considered as the most expected activity from an agricultural cooperative accounts for only 1.8%, so only a limited number of agricultural cooperatives engage in this business.

Table 1 Cooperatives in Vietnam (2008)

	Total	Transformed	Newly established	By Industrial sector (primary production)		
				Agriculture	Forestry	Fishery
Total	14,500	5,742	8,149	6374.0	59	200
Red River Delta	5,059	2,926	1,857	3155.0	9	26
North- East	2,628	385	2,214	354.0	17	57
North-West	604	123	402	190.0	3	11
North-Central	2,754	1,051	1,612	1462.0	11	18
Central coast	985	719	245	527.0	4	13
Central highland	490	87	380	136.0	9	3
North-east	834	306	505	109.0	3	13
Mekong Delta	1,146	145	934	439.0	3	59
Hanoi city	561	335	218	274.0		3
Ha Tay**	672	468	115	519.0	1	1
Hai Duong	701	183	475	318.0	3	5

** "To Hop Tac" (Farmer's Group) is a voluntary association of farmers without cooperate personality*
***Ha Tay province is absorbed by Hanoi city*
Source: Ministry of Planning and Investment (2009)

Table 2 Agricultural cooperatives' business activities by region (2005)

	Total	Irrigation	Marketing	Supplying electricity	Agricultural extension	Credit	Others
Total	8322	6106	153	3201	3492	770	4331
Red River Delta	3463	3047	15	1696	2019	100	2560
North- East	1010	627	58	348	307	67	324
North-West	305	180	4	20	97	9	117
North-Central	1591	1124	9	660	608	124	997
Central coast	707	636	11	418	263	327	191
Central highland	200	69	28	31	56	24	62
North-east	282	107	13	19	37	54	51
Mekong Delta	764	316	15	9	105	65	29
Ha Noi (2012)	958	-	-	-	-	-	-
Hai Duong (2011)	349	315	4	0	27	0	-

- : no data
Source: data by region: Nghiem (2006), Data for Hanoi: DARD Hanoi (2012), Data for Hai Duong: DRD, Hai Duong (2011).

Outline of sample cooperatives: The four sample cooperatives are of the transformed type, which each includes 2-4 communes; so there is a relatively large number of cooperatives (888 for *A*, 1,680 for *B*, 2,440 for *C*, and 1,457 for *D*). *A* and *D* cooperatives can secure some government land for housing and industrial use because these cooperatives are located close to the center of Hanoi or Hai Duong provinces. *A* cooperative lies along the dike of the Red River, an area that traditionally suffers from frequent floods. It is recognized as a disadvantaged production area. However, Hanoi city approves *A* cooperative as a safe vegetable production and marketing cooperative and the city has invested in irrigation. Consequently, safe vegetable production is rapidly growing, especially for leafy vegetables as this area has good access to the center of city. *B* cooperative is 18 km from the center of Hanoi and is strongly influenced by urbanization though it maintains the traditional production system dominated by rice. *C* cooperative is located between Hanoi and Hai Duong city. *D* cooperative is between Hai Duong and Hai Phong city. As many industrial zones have been constructed, there is an outflow of farm labor, and the number of part time workers has significantly been increased.

Previously, new members without cultivated land in a cooperative's jurisdiction could not join a transformed cooperative, and these cooperatives did not accept capital injection from members. *B* and *C* cooperatives revised their constitutions to solicit new members in 2008, and 38 and 43 new members were registered for *B* and *C*. The cooperatives pay dividends to these new members based only on their capital contribution invested in the cooperative's operations.

Additionally, business activities for daily support are growing, especially in the two cooperatives in Hanoi city. Agricultural cooperatives pick up garbage, supply household water, manage consumer markets in the commune, and subcontract construction. Table 4 shows that these activities provide a large percentage of total business profit.

Business Activities of Transformed Agricultural Cooperatives

Overall business direction: Table 3 shows the sample cooperatives' current business activities. Most are engaged in irrigation, technical extension, pest extermination, purchasing inputs, and distribution of electricity, which they continue from the old cooperatives. In terms of agricultural production, these cooperatives begin contracting agricultural work such as plowing by tractor, agricultural production, and marketing after the transition.

Table 3 Business activities of sample Cooperatives

	Agricultural production						Daily life support							
		Support for agricultural work												
	Irrigation	Extension	Plant protection	Pest Extermination	Plowing	Production*	Group purchase	Marketing	Electricity	Garbage pickup	Water	Management of market	ConStruc-tion
A	○	○				○	○	○	○	▲	○	○	
B	○	○	○		○	●	○		○	○			○
C	○	○	○	○	○		○						
D	○	○		○	○		(seed)						

Shaded activities are taken over from old cooperatives

**cooperatives' own farm. Cooperatives manage the farm as their business*

▲ *Until 2011 (from 2011, People's committee undertaking*）

● *From 2012, started on a trial basis*

Source: Field Research (2011-2012

Table 4 Annual profit and rate by business activity

	Total revenue	Profit	Rate by business activities								
			Irrigation	Plant protection	Veterinary	Production	Group purchase	ElecTricity	Garbage pickup	Marketing	Construction
	(mil. VND)		(%)								
A	NA	750	10.0	-	-	30.0	10.0	-	-	50.0	-
B	10,012	373.4	-	-	-	-	3.0	75.0	10.0	-	12.0
C	1,292	4.09	49.7	48.8	0.4	1.0	-	-	-	-	-
D	0	-0.1	-	-	-	-	-	-	-	-	-
Whole country	1,011	833									
Hanoi	950	70									
Hai Duong	491	11									

***including all cooperatives (not only agricultural cooperatives)*

*** - = no benefit, space=no data*

Source: Field research (2011-2012), MPI (2009), DARD Hanoi (2012), DRD Hai Duong (2011）

Support for Agricultural Production: Plowing

Of the cooperatives, three of them contract plowing by tractor. However, *B* and *C* cooperatives do not own a tractor, and so coordinate and mediate contracts between members and a contractor.

Contractors are usually a local group with members contributing capital that own a tractor. Each commune has several groups with contracting services that cooperatives coordinate, so all members have equal access to the service. Cooperatives determine contracting needs through board members or the heads of internal groups before plowing season, then negotiate prices with a contractor, allocate and request the work. Once complete, the cooperatives collect bills from each farmer and settle the payment. Contract fees are presented for consideration before a general meeting of cooperative representatives to ensure that the price is reasonable. *B* cooperative does not take commission for this work.

C and *D* cooperatives, which do not have enough contractors in their commune to provide plowing services to all households, make an effort to meet members' needs. For these cooperatives, members' demand for plowing service has increased with the development of contractors in neighboring communes. *C* cooperative has started its contract plowing service since it received government financial support in 2008 to purchase three tractors. Now, two board members are engaged in this business, and the cooperative has hired six operators. Accordingly, these groups can plow all agricultural lands in the commune.

D cooperative also lacks the contractors to meet members' demand and considers purchasing tractors. Though the cooperative cannot follow through the plan, it is unable to obtain a loan or government support. As a result, six board members, managers of the cooperative, executive members of the People's committee, and farmer's union together capitalized on this new business by purchasing three tractors, which are owned and managed by the cooperative. The six invested members can receive dividends when this business earns a profit.

Support for Agricultural Production: Marketing and Production

Among the four cooperatives, only *A* cooperative markets agricultural outputs. *A* and *B* have begun cooperative farm management and production on a trial basis.

Since Hanoi city was selected as a safe vegetable production area in 1999, *A* cooperative has arranged contracts with supermarkets and venders for school meals since 2003. It is to provide a

stable distribution outlet for members' products. It has become difficult to secure enough supply to meet the contract amounts in terms of quality and assortment because agricultural labor is declining as the number of farm households. *A* cooperative opens the cooperative's land by leasing land from members and hiring labor. Some of the cooperative's farms are used as experimental fields for new agricultural techniques.

B cooperative has started producing and marketing seed potato since 2012. The cooperative provides training and information for all members, and 14 interested members invest to hire labor and lease 3 ha of agricultural land to produce seed potato. All products from this field are sold to other cooperatives through *B* cooperative, which will consider investing in cold storage if more members participate in this business in the future.

CONCLUSION

Transformed agricultural cooperatives took over the business and activities from old cooperatives. The cooperatives have recently expanded their activities to include daily life support. Quite a few cooperatives market their agricultural outputs. Some of the cooperatives distribute agricultural products due to changes in the local agricultural production structure. Cooperatives have now become a business organization and a competitor to small households.

The consumer market is scattered, as the population has not yet concentrated in Vietnam's big cities. Additionally, agriculture in Vietnam is traditionally very small and multi-item production, so it is still not specialized and geographically concentrated. Under these conditions, it is difficult for cooperatives to organize marketing by taking advantage of scale, especially in urban neighborhoods. Marketing support through other means, as supporting farmer's markets, might be required in the future. Due to structural changes in the business sector and an outflow of labor, demand for agricultural production support is expanding. Most agricultural cooperatives act as intermediaries between contractors and members, though farmers' groups usually lead this business rather than the cooperative. However, contractors who can not provide services to meet members' demand for contract work have started to provide plowing services as their own business. This kind of effort will be important to maintain local agriculture.

There are three basic trends in cooperatives' business activities. First, the private sector mainly leads agricultural support. Second, business has expanded to include daily life support. Third, many have begun to own land; and because of coming from the same background, they have suffered from a serious capital shortage. All agricultural cooperatives have tried different means to earn active capital and profits. Under existing conditions, transformed cooperatives have prioritized keeping profits from business activities for the cooperative itself rather than for its members, so these business activities have limited impact on members or local agriculture.

There are several limitations to this study. The sample consists of cooperatives located in only two provinces, which are too small to draw conclusions about the entire cooperative movement in Vietnam. Future studies can explore some of the issues identified in this study by using a larger sample of "transformed" agricultural cooperatives.

ACKNOWLEDGEMENTS

This work is supported by the JSPS "Institutional Program for Young Researchers Overseas Visits."

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Research article

Floristic Inventory of the Proposed Site for Tarsier Tourism Center in Villa Aurora, Bilar, Bohol, Philippines

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Received 3 March 2015 Accepted 27 August 2015 (*Corresponding Author)

Abstract. The study assessed the present vegetation composition of the proposed site for the Tarsier Tourism Center (PTTC) at Villa Aurora, Bilar, Bohol and performed comparative analysis with the existing Tarsier Sanctuary (TS) at Canapnapan, Corella, Bohol. The bases for comparison were the computed importance values, species richness, species dominance, and percent distribution of plants according to self-defined DBH classes. Results showed that both sites had very high species richness and evenness values. Common overstorey and understorey plant species found in both areas were katagpo (*Psychotria sp.*), sagimsim (*Syzygium brevistylum* [C.B. Rob] Merr.) and bagauak (*Clerodendrum minahassae* Teijsm. & Binn.). Apart from sagimsim (*S. brevistylum* [C.B. Rob.] Merr.), selaginella (*Selaginella cuppresina* Lin.), and lunas (*Lunasia amara* Blanco) were also common in the ground vegetation of both areas. Percent distribution of trees according to self-defined DBH classes revealed that PTTC had 87.55% of the total recorded plants with DBH measurements of ≤10 cm. This was found lower by almost 10% from TS. Considerable percentages of trees were also shared in other DBH classes for PTTC. DBH class range of 10-20 cm had 6.88%, while 5.58% was computed for DBH class of >20 cm. Percent distribution of trees on these DBH ranges (especially on DBH class >20 cm) indicated the presence of medium and large trees. The largest DBH measured in PTTC was 70 cm, while in TS was only 22 cm. Based on the findings of the study, it has been concluded that the proposed 10 ha site in Villa Aurora, Bilar, is suited to be utilized as Tarsier Tourism Center. In case the proposed project is to be pursued, enclosure similar to what has been constructed in Canapnapan, Corella, Bohol, Philippines should also be established to prevent stray animals from predating the captive tarsiers.

Keywords floristic inventory, Philippine tarsier, Bohol

INTRODUCTION

The Philippine tarsier *(Carlitos syrichta* (L.) Shykelle) has attracted a lot of attention of scientists and collectors because of its interesting physical features and habit. It is often fancied as a crossbreed of a bat and a rat. The name "tarsier" is derived from the fact that the tarsal region is elongated, a trait of both tarsiers and gala goes (Embury, 1994 as cited by Villamor, 1995). Its size is not bigger than two fists held together. Undeniably, the Philippine tarsier, with three subspecies: *syrichta*, *fraterculus* and *carbonarius*, is one of the smallest among the different known species (Goodwin, 1991; Embury, 1994 as cited by Villamor, 1995; Neri-Arboleda, et al., 2002). This trait and its rarity status would be the reason why this creature is on the CITES endangered list. It was once then considered as "lower risk conservation dependent" based on the IUCN 2004, then became "data deficient" in 2006, and now under the "near-threatened" category since 2008.

The Philippine tarsier habitats are primarily located in secondary lowland rainforest of early- to mid-succession stage (Neri-Arboleda, et al., 2002; Reyes, 2006). In Bohol, it generally occurs in hilly areas with patches of second-growth forest (PAWB-DENR, 1992; Lagapa, 1993; Villamor, 1995; Reyes, 2006), bushes, bamboos, palms and some grasses (Karnain, et al., 1997 as cited by Reyes, 2006). The short trees, as well as bamboos, are good for the arboreal adaptation by the tarsiers. The dense nature of the undergrowth supports a wide variety of insects and small vertebrates which are vital to the survival of tarsiers. The close distance in between small diameter trees, on the other hand, appears to be a necessary condition which favors the locomotive behavior of tarsiers thus enabling them to have a firm grasp of the small trunks and branches making this type forest a favorable place to live (Villamor, 1995; Karnain, et al., 1997 as cited by Reyes, 2006). It is also found in abandoned clearings with signs of new growth of medium-high plants in lands of both low and medium elevations (Hoogstraal, 1947). These types of clearing were believed to be the tarsier's feeding sites (Rabor, 1977; Villamor, 1995) until they were disproved by Neri-Arbodela et al. (2002).

Habitat characterization of the Philippine tarsier has been conducted in Bohol by several local researchers and research institutions (Madulid [undated]; PAWB-DENR, 1992; Lagapa, 1993; Villamor, 1995; Neri-Arboleda, *et al.*, 2002; Reyes, 2000, 2006; and ERDS, 2009). Among the researchers, Neri-Arboleda, et al. (2002) and Reyes (2006) provided detailed discussions on several habitat classifications. Reyes (2006), in particular, described 11 variants of the tarsier's roosting territories based on species composition and thicket structure. He also correlated the presence of tarsiers and its scent-markings on abundance of small diameter plants in his study sites. The findings of the study of Reyes (2006), on this aspect, were used as the basis in evaluating the suitability of proposed Tarsier Tourism Area in Villa Aurora, Bilar, apart from the usual species richness and dominance assessment.

The study assessed the present vegetation composition of the proposed tarsier tourism site at Villa Aurora, Bilar, Bohol, Philippines and compared with the existing tarsier sanctuary at Canapnapan, Corella, Bohol, Philippines in terms of plant species composition.

METHODOLOGY

Study Site

The Proposed Tarsier Tourism Center (PTTC) is planned to be established at barangay Villa Aurora in the municipality of Bilar. The total area of the proposed tourism site is 10.194 ha (CENRO-Tagbilaran, 2013). It is located along the stretch of the prominent winding road of barangay Villa Aurora, a kilometer away from the famous Bilar-Loboc Man-made Mahogany Plantation. This will serve as an extension of the 6-ha Tarsier Tourism Area established at Upper Bonbon, Loboc, Bohol, Philippines.

The Tarsier Sanctuary and Conservation Site (TS), on the other hand, which is used for comparison is situated at barangay Canapnapan in the municipality of Corella, Bohol, Philippines. This 134-ha conservation site is managed by the Philippine Tarsier Foundation Incorporated (PTFI) and is open to public, since 1990s, for recreation and research.

Field Data Collection

Quadrat sampling was used in the collection of data. Twenty quadrats were established preferentially within the 10-hectare PTTC in Villa Aurora, Bilar. The 10 m x 10 m plots were laid selectively on thickets of small diameter trees and shrubs which could be identified as potential roosting sites of the Philippine tarsier. All plants with diameter at breast height (DBH) of $\geq$ 1 cm were recorded. Small nested subplot with a dimension of 1 m x 1 m was also established at the middle of each plot to facilitate the identification of the ground vegetation.

For comparative analysis, 10 plots and subplots were also established at TS in Canapnapan, Corella. The first five plots and subplots were laid in the PTFI tarsier enclosure where visitors are allowed to enter and see the captive tarsiers, and the remaining plots and subplots were laid outside the enclosure, about 30 m away from the PTFI building.

Data Analysis

Analysis of data was mainly concentrated on the determination of species abundance parameters such as density, frequency, and dominance values of each plant species. These parameters were used in the calculation of importance value (IV) of all encountered plants in the overstorey, understorey, and ground vegetation. IV is a measure of species abundance in an area. It is the summation of the relative values of density (number of species per unit area), frequency (number of occurrences of species relative to the number of plots established), and dominance (basal area of species relative to the total computed basal areas).

For the purpose of comparison of the two sites, species richness and dominance indices like diversity (Shannon-Wiener diversity index), evenness (Evenness index), and dominance (Simpson's index) were computed based on IV. The Shannon-Weiner diversity index assumes that individuals were randomly sampled from an indefinitely large population and also assumed that all species were represented in the sample. Evenness index, on the other hand, is the ratio of observed diversity to maximum diversity, while Simpson's index is the probability of any two individuals drawn at random from an infinitely large community belonging to same species.

Density of plants, in percent (%), on each pre-defined diameter class was also calculated to evaluate the suitability of the proposed site for tarsier conservation as the project proponents (wildlife permitees from Loboc) claimed its very purpose. This was based on the work of Reyes (2006) who tested the relationship of DBH to the number of tarsiers seen in the wild. DBH classes used in this study were: $\leq$10 cm; 10-20 cm; and >20 cm.

Formulas used in this study and presented below were adopted from Gruezo (1997), Fernando *et al*. (1998), Reyes (2000, 2006), and ERDS (2009).

For Tree and Shrub Layer:

Density = total number of individuals of a species/unit area
Relative Density = density of a species/total densities X 100
Dominance = basal area of a species/total area sampled
Relative Dominance = dominance of a species/total dominances X 100
Occurrence = number of times a species appeared/total number of established plots X 100
Frequency = number of occurrence of a species/total number of occurrences X 100
Relative Frequency = frequency of a species/total frequencies X 100
Importance Value = Relative Density + Relative Dominance + Relative Frequency

For the Understorey Plants and Grasses (weeds and broadleaves):

Species Dominance = Cumulative crown cover (%) of a species

For the Diversity and Evenness Indices:

Shannon Diversity (H') = $-\sum$ pi * (LNpi) where pi = species proportion

Evenness Index (E) = H'/ LN(s) where s = number of species

RESULTS AND DISCUSSION

Vegetation Composition

Overstorey and understorey plants: A total of 112 species of overstorey and understorey plants were identified in the PTTC at Villa Aurora, Bilar. These belonged to 82 genera under 44 families (Fig. 1). The recorded plant species and genera in PTTC were roughly twice than those in TS. Tables 1 and 2 show the summary lists of common overstorey and understorey plants in both areas. From the list in Table 1, the first three most common species were katagpo (*Psychotria sp.*), bayukbok (*Elaeocarpus macranthus* Merr.), and langin (*Micromelum caudatum* Merr.) based on the computed IV of 28.96, 10.94, and 10.62, respectively. The three most common species in Table 2, on the other hand, were alabihig (*Arthrophyllum diversifolium* Blume), tagoang uak (*Croton leiophyllus* Muell.-Arg.), and katagpo (*Psychotria sp.*) with IVs of 29.70, 19.91, and 19.77, respectively.

As shown in Tables 1 and 2, the species of plants which were found in both areas, apart from katagpo, were sagimsim (*Syzygium brevistylum* (C.B. Rob.) Merr.) and bagauak (*Clerodendrum minahassae* Teijsm. & Binn.).

There were also 52 species, 43 genera, and 35 families of ground vegetation in the PTTC. Same with the overstorey and understorey vegetation, its ground cover was more than twice species rich that the recorded ground vegetation in TS. Table 3 presents the summary list of common plants species identified on the ground based on the number of individuals. The most common species recorded with more than 30 individuals each, in decreasing order, were sagimsim (*S. brevistylum* [C. B. Rob.] Merr.), selaginella (*Selaginella cuppresina*), and lunas (*Lunasia amara* Blanco). These species were also listed common in TS, as shown in Table 4.

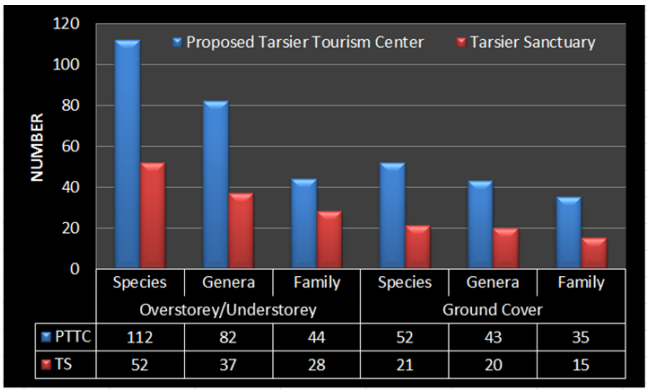

Fig. 1 Bar graph showing the taxonomic information of the Proposed Tarsier Tourism Center, Villa Aurora, Bilar and Tarsier Sanctuary, Canapnapan, Corella, Bohol, Philippines

Table 1 List of common overstorey and understorey plants arranged based on importance values (IV) in PTTC, Villa Aurora, Bilar, Bohol, Philippines

Common Name	Scientific Name	Family Name	IV
Katagpo	*Psychotria sp.*	Rubiaceae	28.96
Bayukbok	*Elaeocarpus macranthus* Merr.	Elaeocarpaceae	10.94
Langin	*Micromelum caudatum* Merr.	Rutaceae	10.62
Sagimsim	*Syzygium brevistylum* (C. B. Rob.) Merr.	Myrtaceae	9.89
Paginga	*Discocalyx cybianthoides* (A. DC.) Mez.	Myrsinaceae	7.80
Katong matsin	*Chisocheton pentandrus* (Blanco) Merr.	Meliaceae	7.18
Bagauak	*Clerodendrum minahassae* Teijsm. & Binn.	Lamiaceae	6.98
Batino	*Alstonia macrophylla* Wall. ex DC.	Apocynaceae	6.72
Malak-malak	*Palaquium philippense* (Perr.) C. B. Rob.	Sapotaceae	6.52
Big-leaf mahogany	*Swietenia macrophylla* King.	Meliaceae	6.44
Aniam-gubat	*Antidesma subolivaceum* Elm.	Euphorbiaceae	6.35
Malaikmo	*Celtis philippensis* Blanco	Ulmaceae	6.05
Talang gubat	*Diospyros copelandii* Merr.	Ebenaceae	5.79
Alahan	*Guioa koelreuteria* (Blanco) Merr.	Sapindaceae	5.74
Lunas	*Lunasia amara* Blanco	Rutaceae	5.62
Duguan	*Myristica philippensis* Lam.	Myristicaceae	5.51
Palosapis	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceae	5.23

Table 2 List of common overstorey and understorey plants arranged based on importance values (IV) in TS, Canapnapan, Corella, Bohol, Philippines

Common Name	Scientific Name	Family Name	IV
Alabihig	*Arthrophyllum diversifolium* Blume	Araliaceae	29.70
Tagoang uak	*Croton leiophyllus* Muell.-Arg.	Euphorbiaceae	19.91
Katagpo	*Psychotria sp.*	Rubiaceae	19.77
Sagimsim	*Syzygium brevistylum* (C. B. Rob) Merr.	Myrtaceae	19.50
Balinghasai	*Buchanania arborescens* Blume	Anacardiaceae	18.30
Bagauak	*Clerodendrum minahassae* Teijsm. & Binn.	Lamiaceae	14.04
Matang arau	*Melicope triphylla* (Lam.) Merr	Rutaceae	13.74
Takip asin	*Macaranga grandifolia* (Blanco) Merr.	Euphorbiaceae	10.08
Sudiang	*Ctenolophon philippinense* Hallier F.	Linaceae	8.19
	Mussaenda sp.	Rubiaceae	8.01
Niog-niogan	*Ficus pseudopalma* Blanco	Moraceae	7.93
Pandan gubat	*Freycinetia sp.*	Pandanaceae	7.83
Kubi	*Artocarpus nitida* Trec. subsp. *nitida*	Moraceae	6.77
Molave	*Vitex parviflora* Juss.	Lamiaceae	5.66
Tambo	*Thysonolaena latifolia* (Roxb. ex Hornem.) Honda	Poaceae	5.23
Ficus	*Ficus sp.*	Moraceae	5.14

Table 3 List of common plants species comprising the ground vegetation arranged based on the number of individuals in PTTC, Villa Aurora, Bilar, Bohol, Philippines

Common Name	Scientific Name	Family Name	Individuals
Sagimsim	*Syzygium brevistylum* (C. B. Rob.) Merr.	Myrtaceae	53
Selaginella	*Selaginella cuppresina*	Selaginellaceae	40
Lunas	*Lunasia amara* Blanco	Rutaceae	38
	Flacourtia sp.	Flacourtiaceae	27
Langin	*Micromelum caudatum* Merr.	Rutaceae	22
Tubli	*Derris sp.*	Fabaceae	20
Paginga	*Discocalyx cybianthoides* (A. DC.) Mez.	Myrsinaceae	17
Takipan	*Caryota rumphiana* Mart. var. *philippinensis* Becc	Arecaceae	11
White nato	*Pouteria macrantha* (Merr.) Baehni	Sapotaceae	11

Table 4 List of common plants species composing the ground vegetation arranged based on the number of individuals in TS, Canapnapan, Corella, Bohol, Philippines

Common Name	Scientific Name	Family Name	Individuals
Sagimsim	*Syzygium brevistylum* (C. B. Rob) Merr.	Myrtaceae	49
Selaginella	*Selaginella cuppresina*	Selaginellaceae	40
Langin	*Micromelum caudatum* Merr.	Rutaceae	27
Tagpo	*Ardisia squamulosa* Presl.	Myrsinaceae	15
Nino	*Morinda bracteata* Roxb.	Rubiaceae	10

Species Richness and Dominance

The results of species richness and dominance computations (Fig. 2) revealed that both sites were species rich given by Shannon-Weiner diversity index values of 4.26 for PTTC and 3.56 for TS. According to Fernando *et al*. (1998), diversity index values above 3.5 are considered very high. Values of the dominance indices such as evenness and Simpson's dominance index also supported this finding. Evenness values of almost 1.0 (0.9031 for PTTC and 0.9012 for TS) means that the observed (or computed) diversity value is almost equal to the expected maximum diversity value (Gruezo, 1997; Fernando et al., 1998; Reyes, 2000).

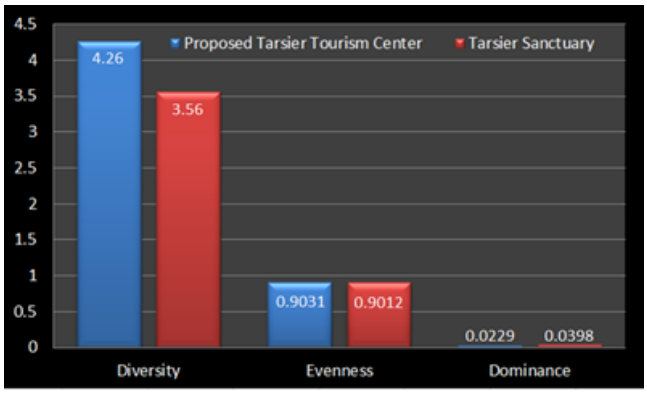

Fig. 2 Species richness and dominance index values for the Proposed Tarsier Tourism Center, Villa Aurora, Bilar and Tarsier Sanctuary, Canapnapan, Corella, Bohol, Philippines

Very high evenness index is always accompanied by very low dominance index. For both sites, Simpson's dominance index values were computed less than 0.04. This only means that there is only less than 4% chance that two individual plants to be selected in both sites would belong to the same species.

Reyes (2000) reported that the species diversity in the identified six roosting territories of the Philippine tarsier in barangay Cabacnitan, Bilar ranged from 2.01 (low) to 3.125 (high).

Self-defined DBH Classes

The computation on percent distribution of plants in three different self-defined DBH classes showed that PTTC had 87.55% of the total recorded plants with DBH measurements of ≤10 cm. This was found lower by almost 10% from TS. Considerable percentages of trees were also shared in other DBH classes for PTTC. DBH class ranged of 10-20 cm had 6.88%, while 5.58% was computed for DBH class of >20 cm. Percent distribution of trees on these DBH ranges (especially on DBH class >20 cm) indicated the presence of medium and large trees. The largest DBH measured in PTTC was 70 cm.

For TS, only less than 3% combined was computed for DBH classes of >10 cm. The largest DBH measured was 22 cm (Table 5).

Table 5 Percent distribution of plants in self-defined DBH classes

Study Site	DBH Class (cm)		
	≤10	10-20	>20
Proposed Tarsier Tourism Center	87.55	6.88	5.58
Tarsier Sanctuary and Conservation Site	97.13	2.01	0.86

CONCLUSION AND RECOMMENDATION

Based on the findings of the study, it is concluded that the proposed 10-ha site in Villa Aurora, Bilar, is suited to be utilized as Tarsier Tourism Center. Apart from the site's inherent diversity in plant species, the current vegetation composition and the presence of medium and large size trees in PTTC suggests its similarity to one of the variants described by Reyes (2006) as advance thickets of many small diameter trees, few medium- and large-sized trees and dense undergrowth. However, in case the proposed project will be pursued, enclosure similar with what has been constructed in Canapnapan, Corella should also be established to prevent stray cats and other animals from predating the captive tarsiers.

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Research article

Rapid Carbon Stock Appraisal (RACSA) Implementation in Wahig-Inabanga Watershed, Bohol, Philippines

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Received 3 March 2015 Accepted 27 August 2015 (*Corresponding Author)

Abstract. The study aimed at assessing the biomass and carbon stocks of all major land uses in Wahig-Inabanga Watershed, Bohol, Philippines and to estimate its total carbon budget. The "*A priori* stratification *cum* purposive sampling" was used. Field measurements were conducted following the destructive and non-destructive methods. The total C stored in the different land uses surveyed in the watershed was estimated at 3.89 Megatons, 83.23% of which was held in the cultivated perennial crops. Among the land uses assessed, it was only mangrove which had lower carbon density estimate relative to previously reported values indicating substantial degradation of mangroves vegetation over the years. The possibility of increasing its potential to store more carbon could only be improved if appropriate management and alternative livelihood interventions, coupled with conservation and protection measures are properly implemented.

Keywords RACSA, carbon stock, carbon budget, Wahig-Inabanga Watershed

INTRODUCTION

Carbon stock assessment is not new to science. Many researchers have attempted to document and quantify carbon stocks of almost every land use in the Philippines since the late 1990s, and even earlier in other countries. Lasco and Pulhin (2003) provided a list of several studies which have investigated the carbon stocks of forest ecosystems and other land cover types in the Philippines. Most of the carbon stock assessments were conducted in plantations where dynamics were only affected by the choice of species, management styles and decisions, silvicultural operations and environmental factors. Few have even designs species-plantation/stand-based allometric equations (Codilan et al., 2009). These were all triggered by the increasing importance of carbon stock assessment in policy and the possible consequences for economic incentives (C markets) (Hairiah et al., 2001 and Hairiah et al., 2011). In Bohol, carbon stock studies were implemented in a 2-hectare rubber plantation at Magsaysay, Talibon (Reyes et al. 2011) and oil palm plantations in Carmen, Sierra Bullones, and Pilar (Pulhin, personal communication).

The RACSA appraisal tool, which was used in this study, was designed to provide a basic level understanding of carbon appraisal and it introduced a scientifically sound methodological framework of accounting carbon sinks; while focusing on activities that could improve local livelihoods and alleviated rural poverty (Hairiah et al., 2011). Its application in the Wahig-Inabanga Watershed provided an idea of how much carbon was stored in the watershed and its potential in sequestering more carbon dioxide from the atmosphere.

This report focused only on the rapid carbon stock estimation of Wahig-Inabanga Watershed in Bohol, Philippines based on the current scenario. It assessed the biomass and carbon stocks of all major land uses in Wahig-Inabanga Watershed, Bohol, Philippines and determined the watershed's total carbon budget.

METHODOLOGY

Study Site

The study was conducted in Wahig-Inabanga Watershed, Bohol, Philippines. This watershed is the biggest in Bohol Province embracing a total land area more than 610 km^2 or over 15 % of the total land area of the Province. It is geographically located between 124º 3' 36" and 124º 23' 24" East longitude, and between 9º 43' 48" to 10º 4' 48" North latitude. It has two headwaters namely the Wahig and Pamacsalan Rivers and its outlet is geographically located at 10º 4'12" North latitude and 124º 4'12" East longitudes (Fig. 1). It traverses the municipalities of Garcia Hernandez, Jagna, Duero, Sierra Bullones, Pilar, Alicia, Carmen, Dagohoy, San Miguel, Sagbayan, Trinidad, Talibon, Jetafe, Buenavista, Danao, and Inabanga.

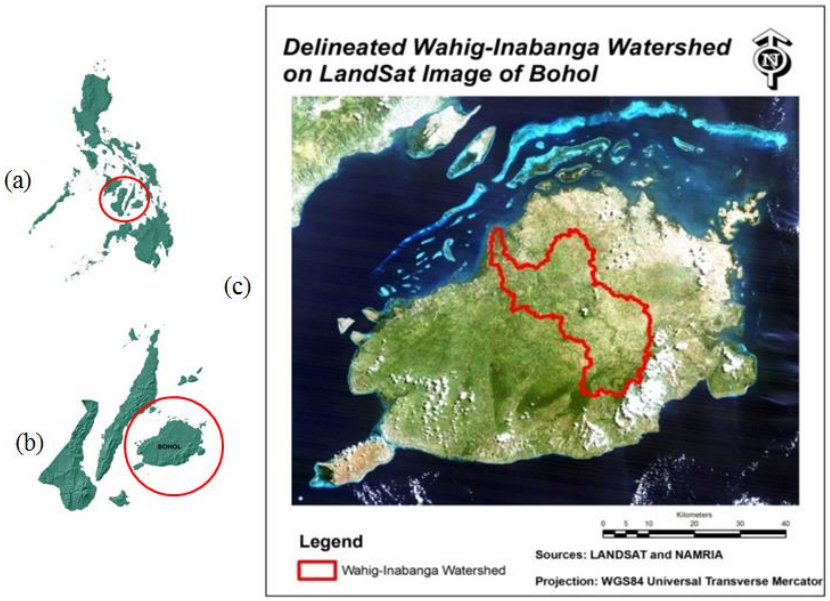

Figure 1 Location of the study area: (a) map of the Philippines showing the Central Visayas; (b) map of the Central Visayas showing Bohol; and (c) map of Bohol showing the Wahig-Inabanga Watershed

Site Selection and Sampling Procedure

The rapid carbon stock appraisal was carried out only in four identified municipalities of Wahig-Inabanga Watershed. Among the 16 municipalities within the watershed, Pilar, Sierra Bullones, Danao, and Inabanga were selected for this study. These are municipalities which cover large areas in the watershed. Selection criteria considered were the variability of land cover and land uses, elevation differences, and geological features which would represent the characteristics of the whole watershed.

The strategy used in this research was the "*Apriori* Stratification *cum* Purposive Sampling" (Hairiah et al., 2001) commonly known as preferential sampling patterned from the methodology suggested by Hairiah et al. (2011). This means that the sampling locations and plots are identified prior to successive field surveys. This approach was employed for the reason that it would be more expensive and very time consuming if one of the regular field survey methods, such as random sampling, systematic sampling, and stratified random sampling, is to be applied following a definite sampling intensity.

In this study, plots were laid in secondary forests; shrub/scrublands; cultivated perennial crops also referred in this paper as agroforestry areas; rice and cornfields; grasslands; mangroves; and existing tree plantations (i.e. *Swietenia*, *Gmelina*, *Tectona*, *Elaeis*, and *Acacia*s).

Sampling Layout and Plot Sizes

In this study, rectangular-shaped plots were chosen since these tended to include more of the within-plot heterogeneity, and thus, represented more heterogenic species than square or circular plots of the same area. Three different plots sizes were employed in the study based on Hairiah et al. (2001) and Hairiah et al. (2011). The 20m x 100m plot for trees with diameter at breast height (DBH) >30 cm and was used mainly in secondary forests, shrubs, and apitong (*Dipterocarpus grandiflorus*) natural stand. The 5m x 40m plot was established for trees in plantations, agroforestry farms (perennial crops), and mangrove sites. The same size of plot was also nested in the middle of the 20m x 100m plot to measure trees with DBH < 30 cm. On the other hand, plot with a dimension of 1m x 1m was employed to appraise undergrowths, agricultural crops (rice and corn), low stature weeds, and grasses.

Biomass Measurement of Aboveground Carbon Pools

Trees and other woody plants: Non-destructive measurement of trees, shrubs, and other woody plants as suggested by Hairiah et al. (2001) was adopted in this study. Diameter at breast height (DBH), merchantable height (MH), and total height (TH) were among the biometrics measured.
Understorey vegetation: Destructive or harvest method was used to determine the biomass of understorey vegetation. Total fresh samples were weighed and recorded, however only approximately 50-500 g of samples were collected for oven-drying. Oven-dried weight was again recorded in each sample after 3 days of drying.
Floor litter: Similar with the understorey vegetation, destructive or harvest method was also employed for floor litter. Total fresh samples were weighed and recorded, and only approximately 50-200g of samples were kept for subsequent oven-drying.
Cereals and weeds: The method applied to determine the biomass of the understorey vegetation was also used for land uses such as rice, corn, and grassland.

Estimation of Belowground Carbon Pool

Belowground biomass (root biomass): This is a fraction of aboveground biomass.An equation in Table 1 was used for this purpose.
Soil Stock Pool: Percent soil organic carbon and bulk density are important variables in the calculation of soil carbon. These values were derived from the ACIAR-BSWM project report (ACIAR, 2006) and results of BSWM soil chemical analysis on soils collected during the series of soil surveys done by the CSIRO-BSWM team.

Parameter values for percent soil organic carbon in each survey location were obtained using the Kriging interpolation function in ArcGIS. The values were derived employing the extract by sample function in the spatial analysis tool. On the other hand, bulk density values were directly taken from the BSWM soil survey report.

Data Analysis

Quantifying biomass and carbon stock: Allometric equations for trees and other plants suggested by Hairiah *et al*. (2011) for estimating above-ground and root biomass were used (Table 1).

Biomass and carbon content were calculated in kilograms and then finally converted in tons (=mega grams [Mg]) per hectare.

Table 1 Allometric equations used to compute for the above-ground (AGB) and below-ground biomass (BGB)

Plant Type / Species	Allometric Equation	Source
Tree/shrub	AGB= ρ* EXP(-1.499 + 2.148 LN(DBH) + 0.207 (LN[DBH])^2 - 0.0281*(LN[DBH])^3)	Chave *et al*., 2005
Mangrove		
Rhizophora	AGB = 0.2453 – 0.2165*(DBH) + 0.0658*(DBH^2) + 0.0270*(DBH^2*TH)	Codilan *et al*., 2009
Sonneratia	AGB = 0.2301 – 0.5382*(DBH) + 0.3370*(DBH^2) + 0.0474*(DBH^2*MH)	Codilan *et al*., 2009
Avicennia	AGB = 0.0198 – 0.0013*(DBH) + 0.0097*(DBH^2) + 0.0155*(DBH^2*MH)	Codilan *et al*., 2009
Banana	AGB = 0.030*(DBH$^{2.13}$)	Arifin, 2001; Noordwijk *et al*. 2002
Bamboo	AGB = 0.131*(BDC$^{2.28}$)	Priyadarsini, 2000
Oil palm	AGB = 0.0976 *(TH) + 0.0706	ICRAF, 2009
Palm	AGB = 4.5 + 7.7*(TH)	Frangi and Lugo, 1985
Nipa	AGB = 0.3999 + (7.907*TH)*0.2 Note: 0.2 added in the equation since nipa does not have aboveground stem	Modified from Teopolo *et al*., 2002
Coffee	AGB = 0.281 D $^{2.06}$	Arifin, 2001
Root Biomass	RB = EXP(-1.0587 + 0.8836*LN[AGB])	Cairns *et al*. (1997)

Note: AGB = estimated aboveground biomass (kg/tree); RB = estimated root biomass; DBH = diameter at breast height (cm); BDC = basal diameter of cluster (cm); TH = total height (m); ρ = wood specific gravity (Mg/m^3); EXP = exponent; LN = natural logarithm.

For this study, a conservative estimate of 45% tons of C per 100% tons of oven-dried biomass was adopted since the carbon content of biomass dry weight based on the studies conducted in and out of the country ranges from 40% to 55% (Lasco and Pulhin, 2000 as cited by Lasco *et al*., 2005).

Conversely, a simple formula on oven dried weight was used to compute for the biomass of understorey plants, weeds, rice, corn, and floor litter.

ODW = TFW- (TFW*(SFW-SODW))/SFW

Where ODW is total oven dry weight, TFW total fresh weight, SFW sample fresh weight and SODW sample oven dry weight

The carbon content of each pool was calculated by getting the 45% of the total biomass, except for soil carbon which was computed by obtaining the product of soil weight and % organic carbon. The total carbon was calculated as the summation of all carbon content in all pools.

RESULTS AND DISCUSSION

Biomass and Carbon Stock Assessment

Plantation: Among the major land uses considered in the study, plantation had the largest above- and belowground biomass which was estimated to be 630.64 tons ha^{-1} and 102.45 tons ha^{-1}, respectively. Its soil carbon was also computed at 3.64 tons ha^{-1}. Forty five percent of its combined biomass inclusive of soil carbon amounted to 333.53 tons of carbon per hectare (Table 2). Such quantity of carbon is almost 300 tons larger than the average of the total stored carbon in selected Philippine plantations amounting to only 55.6 tons ha^{-1} (Lasco and Pulhin, 2000 as cited by Lasco et al., 2005). Though the typical condition of most of the tree plantations in the watershed is not

ideal (crooked, and mostly thinner and shorter (stunted) relative to the trees age), their density (close spacing) has contributed much to their current biomass.

Conversely, Lasco and Pulhin (2003) reported that carbon stocks of plantations in Mt. Makiling ranged from 125.6 to 285.7 tons ha^{-1} and even way lower in other parts of the country. A separate study conducted earlier by Racelis (2000), however conformed with the result of this study and revealed that mahogany plantation in Mt. Makiling, due to its age, dense stocking and large girth, had a computed carbon stock of 542.05 tons ha^{-1}. These results also added that the dipterocarp stand in the same study area, sharing similar features, had even higher stored carbon of about 639.81 tons ha^{-1}.

Secondary forest including apitong stand: The second type of land use in Wahig-Inabanga watershed having considerable quantity of biomass and, thus, carbon was the secondary forest. Its above- and belowground biomass were 209.51 tons ha^{-1} and 38.13 tons ha^{-1}, respectively. Its soil carbon of 3.78 tons ha^{-1} was the largest among the computed soil carbon in all land uses. These gave a total carbon stock of 115.22 tons ha^{-1} (Table 2). The computed total stored carbon of secondary forest in Wahig-Inabanga watershed was comparable with that of the secondary forest in Kaliwa watershed. The latter, according to Lasco et al. (2005), has a total carbon stock of 121.21 tons ha^{-1}. Lasco and Pulhin (2009) stated an average of 111.10 tons ha^{-1} of stored carbon for several surveyed secondary forests in the country.

Agroforestry: Same with the first two land uses, agroforestry had an estimated total carbon stock of more than 100 tons ha^{-1}. Its estimated total stored carbon was 104.05 tons ha^{-1} (Table 2). This value is twice as high as the estimate presented by Lasco and Pulhin (2000) as cited by Lasco et al. (2005) disclosing an average of 50.3 tons ha^{-1} for agrorestry sites in the country. The bloated values in the present study were attributed to the dominance of coconuts and other tree crops in the surveyed areas. However, such amount of carbon is still below the carbon stocks of Taungya agroforestry and mixed multistorey systems in Bukidnon with 174 tons ha^{-1} and 162 tons ha^{-1}, respectively (Labata et al., 2012).

Shrub/brushland: The computed above- and belowground biomass per hectare in shrub/brushland amounting to 172.56 tons ha^{-1} and 32.77 tons ha^{-1}, and a soil carbon of 3.50 tons ha^{-1} provided an equivalent carbon stock of 95.90 tons ha^{-1} (Table 2). This value is comparatively higher than the estimates of Lasco and Pulhin (2000) as cited by Lasco *et al*. (2005), in several watersheds in the country which ranged from 29.0 tons ha^{-1} to 74.27 tons ha^{-1}. This could be due to the presence of few invasive timber species such as yemane (*Gmelina arborea*), mahogany (*Swietenia macrophylla*) and ipi-ipil (*Leucaena leucocephala*) which have been naturally dispersed from adjacent plantations and have grown with small-sized native shrubs and trees.

Mangrove: Among the major land uses, mangrove is generally noted as the most represented in terms of number of individuals. However, the density alone is not the only requisite for a particular land use to acquire high biomass. The foremost requirement is the availability of considerable number of huge diameter trees which, unfortunately, is not a good trait of the surveyed mangrove areas. Based on records, more than half of the measured plants (mostly young *Rhizophoras*) had diameters of less than 5 cm. For this reason, the computed biomass densities were only 87.98 tons ha^{-1} for aboveground and 17.72 tons ha^{-1} for belowground, with a corresponding carbon stock of not more than 50 tons ha^{-1} (Table 2). These values are over 3 times smaller than the country's average mangrove biomass and carbon stock of about 401.8 and 176.8 tons ha^{-1}, respectively (Lasco and Pulhin, 2000 as cited by Gevana et al. 2008). Gevana et al. (2008) reported that mangroves' biomass density may reach up to more than 500 tons ha^{-1} especially if it is dominated by large-sized *Rhizophoras*. One good example is the study of Fujimoto (2000) as cited by Gevana et al. (2008) in Matang, Malaysia which revealed that above-ground biomass alone was computed to reach 558 tons ha^{-1}. *Rhizophora*-dominated mangrove stands are noted to have large biomass and carbon density (Tanouchi et al., 2000 as cited by Gevana et al., 2008). The presence of their unique

physiognomic characteristics such as the presence of stilt roots, dense stem and branches, and relatively large canopy contributes much to the total biomass.

Grass: The result of the above-ground biomass density computation for the surveyed grasslands, together with its carbon stock, coincides with the estimates of Lasco and Pulhin (2000) as cited by Lasco et al. (2005). The carbon stock of 5.48 tons ha^{-1} is comparable with the country's average carbon stock for grasslands of about 5 tons ha^{-1} (Table 2).

Rice: Farms planted to rice are among the land uses with little amount of biomass and consequently carbon content. This is due to seasonal harvests leaving almost no traces of biomass especially after land preparation. The rice farms' computed above-ground biomass density and total carbon stock were 4.11 tons ha^{-1} and 5.3 tons ha^{-1}, respectively (Table 2). Same with grass, more than half of the total carbon stock for rice came from the soil carbon.

Corn: Among the land uses assessed in this study, it was corn which had the least estimated biomass and carbon stock. This was because of having only 3-4 individual plants which were harvested for biomass calculation in a standard one square-meter plot. In addition, regular care and maintenance like harrowing and weeding limit the growth of herbaceous weeds and grasses. For these reasons, the computed above-ground biomass was only 2.97 tons ha^{-1} and its carbon stock was 4.74 tons ha^{-1}. It is also noticeable that a big chunk, roughly 3.4 tons, of carbon per hectare was derived from soil carbon (Table 2).

Table 2 Computed above and belowground biomass and carbon in major land uses in Wahig-Inabanga Watershed, Bohol, Philippines

Land Use	AGB (ton ha^{-1})	BGB (ton ha^{-1})	Soil Carbon (ton ha^{-1})	Total Carbon (ton ha^{-1})
Plantation	630.64	102.45	3.64	333.53
Secondary Forest with Apitong Stand	209.51	38.13	3.78	115.22
Agroforestry	188.28	34.71	2.21	104.05
Shrub/Scrubland	172.56	32.77	3.50	95.90
Mangrove with Nipa	87.98	17.72	2.21	49.77
Grassland	4.52	-	0.96	5.48
Rice	4.11	-	3.45	5.30
Corn	2.97	-	3.40	4.74

Note: AGB = aboveground biomass; BGB = belowground biomass

Table 3 Carbon storage of different land uses in Wahig-Inabanga Watershed, Bohol, Philippines

Land Use	Area of Coverage (ha)	Carbon Stock (tons ha^{-1})	Total Carbon Stock (tons)
Secondary forest	1,247.75	113.29	141,357.60
Shrubland	5,910.05	92.12	544,443.81
Cultivated Perennials*	23,878.82		
a. Coconut/tree-based agroforestry farm	(90%)	104.05	2,236,132.10
b. Tree plantation	(10%)	333.53	796,430.28
Mangrove with nipa	537.63	49.78	26,763.22
Rice	14,146.65	5.30	74,977.25
Corn	9,401.21	4.74	44,561.74
Grassland	4,073.16	5.48	22,320.92
		Total	**3,886,976.90**

*Note: *"Cultivated perennials" is assumed composed of 90% coconut/tree-based agroforestry farms and 10% plantations.*

Total Carbon Budget

Table 3 provides a rough estimate of the carbon budget of the whole watershed. A total of 3,886,976.90 tons or 3.89 megatons of carbon was computed based on the land uses' areas of coverage and computed carbon stocks. The biggest share comes from cultivated perennial crops which had the largest area of coverage within the watershed and the highest estimated carbon stocks.

Shrub/brushland and secondary forest also had significant contributions on the watershed's carbon budget due to the substantial number of trees and shrubs which were appraised in these types of land use compared to those with extensive area of coverage however dominated by low stature annual plants.

CONCLUSION AND RECOMMENDATION

The Wahig-Inabanga watershed's estimated overall carbon stock of 3.89 megatons presents the finest contribution of the watershed to the global carbon budget. Around 83.38% of these are presented in cultivated perennial crops, while the rests are stored other land uses. The possibility of increasing its potential to store more carbon could only be harnessed if appropriate management interventions were implemented.

Open areas like grasslands, for instance, offer immense potential of sequestering carbon through tree planting and agroforestry. If in case tree planting and agroforestry, as immediate interventions, are inappropriate, natural or artificial regeneration may be the best alternative option.

Among the land uses assessed in the watershed, it was only mangrove which had lower carbon density estimate relative to previously reported values. This indicates substantial degradation of mangroves vegetation through time. For this type of land use, provision of alternative livelihood, protection and conservation, apart from reforestation activities are the best options to undertake. Any management intervention would only be wasted if alternative livelihood options are not available and conservation and protection measures are not properly enforced.

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Research article

Effect of Stake Storage Methods on Germination, Growth and Yield of Cassava (*Manihot esculenta* Crantz.)

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Abstract Quality of stakes is an important factor to determine the germination and plant population, as the tuber yield of cassava. Storage of cassava stakes before planting can affect the quality of the cutting. Therefore, the objective of this research was to investigate the effect of different storage stake methods on germination, growth, and yield of cassava. The field experiment arranged in randomized complete block design with 3 replications was conducted in Yasothorn soil series during April-October 2014 in Khon Kaen province, Thailand. The three stake storage methods comprised of storage under tree shade, under sunlight and store under sunlight with gunny sack coverage. Local cultivar of cassava was employed and stakes were stored for 45 days before planting. The results showed that moisture content of the stake, available part and germination percentage at 7 days after planting (DAP) of the stake stored under the sun with gunny sack coverage (69.08%, 73.93% and 85.71%, respectively) was significantly higher than that under shade (57.23% , 47.56% and 28.57%, respectively) and in sun (55.59%, 68.13% and 40.47%, respectively). However, germination at 14 DAP and survival rate at 30 DAP were not significantly different among storage methods but stakes covered with gunnysack tended to be higher than other methods. Stakes stored by covered with gunnysack gave the highest plant height at 14, 21, 28, 35, 42, 72, and 180 DAP. Moreover, there was no significant difference in leaf, shoot and total aboveground dry weight, tuber yield and starch contents that were found amongst the storage methods. The stakes stored under the sun and covered with gunnysack tended to give the highest values. This study shows the potential method for storing cassava stakes under field conditions before planting.

Keywords cutting storage method, germination, survival rate

INTRODUCTION

Cassava is usually planted by using vegetative part called stem cutting or stake. Normally, farmers use the cassava stems after harvest for the next growing season. These cassava stakes are kept in the field for a period of time before planting. Thus, exposure of the cutting to the sun can result in lost

viability within a short time due to dehydration. These poor stakes cause a poor establishment and finally a low yield. Andrade and Leihner (1980) reported that stake storage conditions were more critical than the duration of the storage. Sinthuprama and Tiraporn (1986) reported that stakes stored upright under shade for 45 days could obtain 80% survival rate but decreased faster when stems were stored in the sun and covered with leaves. However, Boonma et al. (2007) found that stake stored in the sun with the base earthen up resulted in greater stem moisture content and stem length than shade storage with no significant effect on germination and survival percentage. These contradicting opinions, therefore, needed to be proved by alternative method, which could be convenient for field practices by farmers.

OBJECTIVE

The objective of this study was to investigate the effect of different storage stake methods on germination, growth and yield of cassava.

METHODOLOGY

Experimental site and design: A field experiment was conducted at the Agronomy Field Crop Research Station, Faculty of Agriculture, Khon Kaen University, Thailand (latitude 16° 26´N and longitude 102° 48´E) during April-October 2014. The experiment was conducted in a loamy-sand soil (Yasothorn soil series) with pH 5.14, 0.48 % of organic matter, 28.60 mg/kg of available phosphorus, and 39.55 mg/kg of extractable potassium. The experiment was laid out in Randomized Complete Block Design with 3 replications. The treatments included stakes storage upright under 3 different conditions: under tree shade, in sun, and in sun with gunny sack coverage.

Materials and cultural practices: A local cultivar cassava named E-dam which was stored under different methods for 45 days was used in the study. The stakes of 20 cm in length were planted vertically with a 100 x 100 cm spacing in a 5 x 8 m plot. Plots were manually weeded 2 times at 1 and 2 months after planting. Chemical fertilizer grade 15-7-18 (N, P_2O_5, K_2O) at the rate of 312.5 kg/ha was applied 1 month after planting. Irrigation was applied during the period of 1-2 months after planting to ensure good establishment during April-May 2014 and the field was kept under rain for the rest of the growing period. The total amount of rainfall during the growing period was 946.7 mm and the mean values of daily maximum and minimum temperature were 33.5°C and 24.5°C, respectively.

Crop measurement: Before planting, 4 stakes were randomly selected to estimate moisture content by oven dried at 80°C to constant weight. The moisture content was calculated based on the stem fresh weight. Available portion in percentage and was measured by dividing the length of vital or usable parts with total stem length and multiplying it by 100. Germination at 7 and 14 days after planting (DAP) was counted and a survival rate at 30 DAP was also recorded. Plant height was continuously measured at 14, 21, 28, 35, 42, 72, and 180 DAP. Biomass measurement was done at 180 DAP by cutting the stem base of three plants at random per plot. Plants were separated into leaves, stems, and tubers and were oven dried at 80°C to constant weight. The fresh tuber root yield (t/ha) were calculated based on the harvested crops. The starch content in the tuber was determined by specific gravity method.

Statistical analysis: Analysis of Variance (ANOVA) for all data was done by using Statistix 10.0 software (Analytical Software, Tallahassee, Florida, USA.). The Least Significant Difference (LSD) was used to compare all mean values.

RESULTS AND DISCUSSION

Stake Characteristics and Germination

Storage of cassava stems under different conditions had a significant effect on stake moisture content and available plant part usable for planting. Cassava stems stored in the sun with gunny sack coverage had significantly higher stake moisture content (69.08%) and available plant part (73.93%) than other methods (Table 1). However, this study opposed with the report of Boonma et al. (2007) who had found that stakes stored in the sun with base earthen up had greater stem moisture content and stems length usable for planting than that in the shade. They indicated that photosynthesis of the newly sprouts is an important factor in maintaining the stems moisture content compared to the low light intensity perceived by the sprouts of stems stored under the shade. In this experiment, it was found that stems stored in the sun were burnt by sunlight which might result in lower stake moisture content. Stems stored in the sun with gunny sack coverage produced some bud sprouting but with pale and yellow color. Stakes stored under tree shade were destroyed by termite leading to the lowest available part (47.56%).

Table 1 Effect of stake storage methods on germination and survival percentage of cassava

Storage method	Stake moisture content (%)	Available part (%)	Germination (%) at 7DAP	Germination (%) at 14 DAP	Survival (%) at 30 DAP
Under tree shade	57.23b	47.56b	28.57b	88.64	83.33
In sun	55.59b	68.13a	40.47b	93.56	90.48
In sun with gunny sack coverage	69.08a	73.93a	85.71a	95.92	92.86
F-test	**	*	**	ns	ns
CV (%)	9.04	17.10	14.60	3.30	14.18

*Ns, *, **= not significant, significant different at p<0.05, 0.01, respectively. Means in the same column with different letters are significantly different at p<0.05 and 0.01 by LSD*
DAP= days after planting

At 7 DAP, cassava stems kept in the sun with gunny sack coverage germinated significantly faster (85.71%) than stems stored by other methods (28.57-40.47%) (Table 1). This might be contributed by the higher moisture content in the stakes which supported by the study of Leihner (1984) who found that stakes lost its viability when dehydration reduced moisture content less than 60%. The decrease in reserved carbohydrate of the cutting stem by respiration during the storage might also affect the germination rate of stakes (Leihner, 1984). However, no significant difference was found in germination at 14 DAP and survival percentage at 30 DAP among storage methods. But stakes stored in sun with gunny sack coverage tended to have the higher survival rate. Boonma et al. (2007) also found the same results when stems stored in the field and under tree shade. Even no significant difference in germination at 14 days after planting onward, the results from this study indicated that stem with high moisture content had vigorous germination. This would be important for growing cassava at the end of the rainy season, which soil moisture content was quickly loss. The faster germination of crop also indicated the higher leaf area coverage which could be possibly competing with weed.

Plant Height

Different storage methods significantly affected plant height at 14, 28, 35, and 42 DAP. Stakes stored in the sun with gunny sack coverage had significant higher plant height than other methods at 14, 28, 35, and 42 days after planting and tended to have higher plant height than other methods at 21, 72, and 180 days after planting (Table 2). This might be due to the ability of early

germination of seedlings grown from this method, which indicating the strong vigor of the stored materials.

Table 2 Effect of stake storage methods on height of cassava at 14-180 days after planting

Storage method	14 DAP	21 DAP	28 DAP	35DAP	42DAP	72DAP	180DAP
Under tree shade	12.15b	14.00	14.85b	20.67b	27.15b	77.49	238.78
In sun	13.31b	14.58	15.41b	22.79b	29.84ab	86.14	246.66
In sun with gunny sack coverage	15.96a	18.30	19.61a	27.31a	35.52a	86.91	250.78
F-test	**	ns	*	*	*	ns	ns
CV (%)	3.28	10.74	8.17	6.50	8.67	12.75	7.00

*Ns, *, **= not significant, significant different at p<0.05, 0.01, respectively. Means in the same column with different letters are significantly different at p<0.05 and 0.01 by LSD*
DAP= days after planting

Table 3 Effect of stake storage methods on cassava population, growth and yield at 180 days after planting

Storage method	Plant population/ha	Leaf dry weight (kg/ha)	Stem dry weight (kg/ha)	Aboveground dry weight (kg/ha)	Tuber dry weight (kg/ha)	Tuber fresh weight (t/ha)	Starch content (%)
Under tree shade	8333	1752.9	5558.1	7311.0	11556	32.6	20.90
In sun	9048	1776.1	5412.4	7188.5	10516	30.8	21.95
In sun with gunny sack coverage	9286	2549.1	7092.9	9642.0	12365	36.1	22.60
F-test	ns	ns	ns	ns	ns	ns	ns
CV (%)	14.18	18.15	12.58	12.92	15.84	13.31	7.56

Ns = not significant

Plant Population, Crop Biomass and Yield

Due to the higher survival percentage, population per ha of cassava grown from stems stored in sun with gunny sack coverage was higher than the other methods (Table 3). Different stem storage methods had no significant effect on crop biomass, root fresh yield, and starch content in the tuber (Table 3). However, due to the higher population, cassava planted from stems stored in sun with gunny sack coverage tended to have higher leaf, stem, aboveground, tuber dry weight per ha, and tuber fresh yield per ha than other methods. Storage methods did not have significant effect on root starch content. Boonma et al. (2007) also reported no significant difference between stakes stored in the field with the base earthen up and under tree shading in terms of fresh and dry root yield and root starch content. This study is consistent with the findings of Andrade and Leihner (1980) who indicated that final stand percentage or population of crops were not the factors responsible for yield variation of cassava if stem cuttings were kept under appropriate conditions.

CONCLUSION

Storage of cassava stake under field conditions before planting is critical for better germination and survival of the seedlings. The results show that stems stored in the sun with gunny sack coverage had the highest germination and survival percentage, which resulted in higher population and higher crop biomass and tuber yield per area. However, under the three studied storage conditions, other factors affecting shoot and root growth, rather than population, may determine cassava yield. Therefore, stakes can be stored by any of the three methods from this study.

However, in order to get the higher root yield and higher starch content, stem cutting stored in the field with gunny sack coverage should be recommended.

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Research article

Impacts of Atmospheric Temperature - Humidity Change on Yield Quality of Thai Soybean Cultivar

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Received 12 December 2014 Accepted 11 September 2015 (*Corresponding Author)

Abstract This study aimed to assess the impact of atmospheric temperature and humidity change on yield of Thai soybean, Chiang Mai 60 cultivar. The research experiment was conducted during July - October 2013 at Naresuan University Crops Field, Phitsanulok, Thailand. Soybean seed Chiang Mai 60 cultivars were planted in 16 open top chambers (OTCs) under 4 different temperature and humidity levels. The four simulated climate change situations in OTCs were, lower than ambient temperature, higher than ambient temperature, combined elevated temperature and high humidity and ambient temperature level, which all were controlled by an electrical system. Results indicated that yield loss by statistical significance occurred in all Low-level temperature treatment (25±2.9 ◦C), High-level temperature treatment (37±2.2◦C), and high Temperature-humidity (36±2.8◦C/ 81.7±2.2%), compared with ambient-level temperature treatment (31±1.7◦C). Exposure to simulated climate change situation in Low-level temperature treatment obviously reduced total pod/plant and total seed/plant by 40.8% and 48.5%, respectively. High-level temperature caused yield loss in total pods/plant and total seeds/plant by 35.6% and 39.5%, respectively. The combined effect of high temperature and humidity on soybean crop reduced total pods/plant and total seeds/plant about 36.4% and 47%, respectively. Finally, low temperature evidently increased in lipid content and all types of fatty acid in experiment, whereas the high temperature treatment could reduce the total mono-unsaturated fatty acids. It was concluded that temperature change situation at above and lower than ambient level in growing season could induce yield loss and some fatty acid in Thai soybean, Chiang Mai 60.

Keywords temperature change, Thai soybean, open top chamber, yield quality

INTRODUCTION

Climate change and variability can have significant impacted on phenology, physiological mechanisms, growth, nutritional value, genetics, and yield of crops (Bainy et al., 2008; Thanacharoenchanaphas and Rugchati, 2011). The "Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)" conclude that by 2081–2100, the globally averaged surface temperature will be in the range of 2.6-4.8 ◦C in comparison with 1986–2005 and, daily and seasonal high temperature extremes over most land areas will be more frequent in the future (IPCC, 2013). These changes and variability in climate may have significant impacts on yield of crops in various regions of the world (Smit and Yunlong, 1996; Kumagai and Sameshima, 2014).

Soybean is one of the important C3 plants that is sensitive to temperature change (Newman et al., 2011). On the basis of long-term field experiments (1987–2007) in northeastern China, Zheng et al. (2009) reported that soybean seed yield was increased by 6–10% per 1 ◦C rise in mean daily maximum temperature during seed filling. Thailand Department of Meteorology reported that the

annual mean temperature in Thailand rose by approximately one degree Celsius from 1981 to 2007. By 2050, the mean daily maximum temperature in Thailand will have been increased by 1.2 to 1.9 ˚C (Marks, 2011). Hence, current mean temperature during the soybean growing season in Thailand has been changed at meteorological observatories in the northern regions of Thailand. Based on these facts, we hypothesized that the increase/decrease in temperature and humidity during growing season have effects on soybean production. Our data clearly demonstrate the differences in soybean yield responses to the change of temperature – humidity.

OBJECTIVE

This study was set to investigate the differences in Thai soybean yield responses to the changes of temperature – humidity during growing season.

METHODOLOGY

Field Study and Experimental Design

The field study was carried out at Naresuan University in northern Thailand. The experiment was done at agricultural crops field in the university. It is located at coordinates 16 degrees and 44.003 minutes north of the equator, and 100 degrees and 11.810 minutes east of Prime Meridian. The total study area covered about 300 m^2.

Thai Soybean (*Glycine max* (L.) Merr.) Chiang Mai 60 cultivar was selected for the study; this cultivar was widely cultivated in northern Thailand. It was planted in growing season of Thailand during July 2013 to October 2013. Four replications of a Randomized Complete Block Design (RCBD) were used in four treatments with four different levels of air temperature and relative humidity. At the vegetative growth stage, the soybeans in all four treatments were exposed to temperature-humidity variability for 8 hr exposure (9.00 am – 5.00 pm) in open top chambers until harvest.

Temperature - Humidity Control

The square open top chamber was used throughout the study period. The chamber size was 1.5 m (width) x 3 m (length) x 2.5 m (height). It was constructed out of transparent plastic. There were four situations of air temperature-humidity change, at an ambient level (AT-treatment or control treatment), combination of low temperature and humidity at ambient level (LT-treatment), combination of high temperature and humidity at ambient level (HT-treatment), and combination of high temperature and high humidity (HHT-treatment). These were controlled by an electronic system. The high temperature and low temperature system was set up by green lighting and air conditioning exposure, whereas the elevated humidity treatments were set up by electronic water spray. Mean air temperature /humidity levels (± S.D) for 8 hr for each treatment were 25±2.9 ˚C / 62 ± 9.8 % in LT-treatment, 31±1.7 ˚C/ 63 ± 7.4 % in AT-treatment, 37 ± 2.2 ˚C/ 61 ± 5.7 % in HT-treatment, and 36±2.8 ˚C/81.7±2.2% in HHT-treatment, respectively.

Yield Quality Determination

Soybean seeds were harvested from the experimental field at maturing stage (95 days). Yield quality was analyzed by determination in yield quantity and nutrition value (lipid and fatty acid content). These samples were determined by number of pods/plant, number of seeds/plant and weight of 100 seeds. Lipid content and some important fatty acids were determined by gas

chromatography (GC) based on analysis of nutrition content by AOAC (1995) method to estimate grain quality.

Statistical Analysis

The experiment was designed as Randomized Complete Block Design (RCBD) with 4 replications. Data of yield and fatty acids content were statistically analyzed by the analysis of variance (ANOVA). Significant differences of parameters were reported at $p<0.05$ by DMRT.

RESULTS AND DISCUSSION

Yield Quantity

Seed yields were harvested at maturing stage. The yield component, including number of pods/plant, number of seeds/pod and weight of 100 seeds were determined to assess grain quantity. The results are shown in Fig. 1a - Fig.1b. The significant reductions were found in all 3 parameters of yield component. The significant reductions in number of pods/plant and number of seeds/plant appeared in LT treatment, HHT treatment, and HT treatment when compared to control treatment. Exposure to Low-level temperature treatment obviously reduced total pods/plant and total seeds/plant in comparison with control by 40.8% and 48.5%.

We also found that the cumulative effects of high-level temperature caused yield loss in total pods/plant and total seeds/plant by 35.6% and 39.5%, respectively. The combined effect of high temperature and humidity on soybean crop reduced total pods/plant and total seeds/plant by 36.4% and 47%, respectively. The results obviously showed that high level of temperature (plus ambient humidity) reduced the 100 seeds weight when compared to the others (Fig. 2). These results indicated that the higher temperature level and the lower temperature level (above ambient level) in growing season induced high suppression in yield Chiang Mai 60 cultivar soybean.

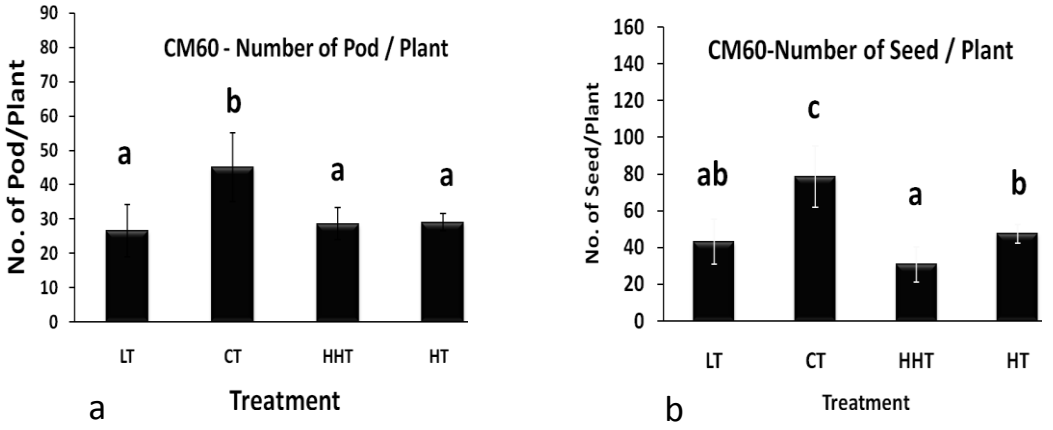

Fig. 1 (a) Effects of different air temperature – humidity levels on number of pod/plant of soybean, Chiang Mai 60 cultivar and (b) Effects of different air temperature –humidity levels on number of seed /plant of soybean, Chiang Mai 60 cultivar

Note: The different letters for each treatment indicate a significant difference at $\rho \leq 0.05$. Error bars above each histogram indicated standard deviations (S.D.) observed from samples of each treatment.

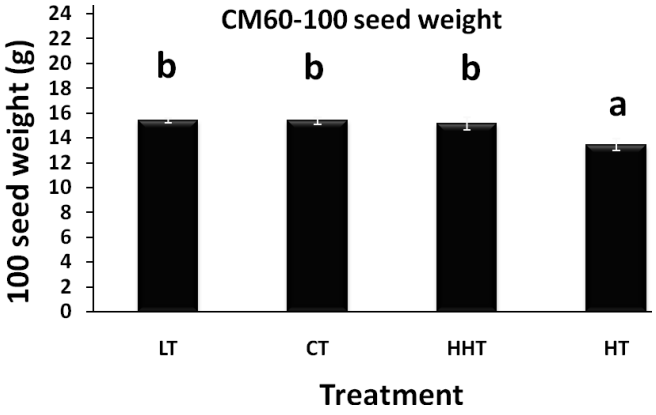

Fig. 2 Effects of different air temperature –humidity levels on 100 seed weight of soybean, Chiang Mai 60 cultivar

Note: The different letters for each treatment indicate a significant difference at $\rho \leq 0.05$. Error bars above each histogram indicated standard deviations (S.D.) observed from samples of each treatment.

Nutrition Value in Lipid and Fatty Acid Content

Exposure of soybeans to different air temperature-humidity levels was carried out in an open top chamber. In Table 1, we observed that the LT treatment (at lower temperature level than ambient level) induced high lipid content in the full maturing stage (R8). However, there were no significantly different results found in HT treatment (higher temperature level than ambient level). The significantly different results were also clearly shown in total saturated fatty acids (TSFA), total mono-unsaturated fatty acids (TMUFA), and total poly-unsaturated fatty acid (TPUFA). The results showed the most obvious effects of increasing air temperature (HT treatment) led to the reduction in fatty acid when compared with others. In contrast, the interested results showed that the low temperature treatment (LT treatment) in growing season (than ambient level) led to the significant increase in all 3 types of fatty acid (Table 1).

Table 1 Summary of the results of Lipid content, TSFA, TMUFA and TPUFA of soybean seed, Chiang Mai 60 cultivar grown under four temperature treatments (LT, CT, HHT and HT) in this study

Lipid and Fatty acid	4 treatments under different air temperature levels			
	LT	CT	HHT	HT
Lipid content (g)	21.5 ± 0.3 ^{b}	19.9 ± 0.4 ^{a}	19.8 ± 0.1 ^{a}	19.6 ±0 0.2 ^{a}
TSFA(mg/100g)	2815.7 ± 24.3 ^{c}	2547.6 ± 18.5 ^{a}	2592.8 ± 25.5 ^{ab}	2621.2 ± 34.2 ^{b}
TMUFA (mg/100g)	4680.7 ± 45.8 ^{c}	4498.1 ± 64.3 ^{b}	4753.7 ± 26.5 ^{c}	4414.8 ± 24.8 ^{a}
TPUFA (mg/100g)	11697.9± 67.6 ^{b}	11257.8 ± 61.3 ^{a}	11195.0 ± 78.4 ^{a}	11237.2 ± 87.9 ^{a}

Note: The different letters for each treatment indicate a significant difference at $\rho \leq 0.05$.

Many researches that have been investigated for decades showed similar results as this study. For example, Hatfield et al. (2011) predicted that a 0.8 ˚C temperature rise would cause a 2.4% decline in soybean yield in southern USA (current growing season temperature of 26.7˚C). Numerous studies have carried out to understand biochemical reaction taking place in plant's physiology under climate factors change, leading to the inhibition of photosynthesis and yield production. Its photosynthesis is very sensitive to ratio of CO_2 to O_2 in the atmosphere. Increasing in this ratio of CO_2 to O_2 leads to higher rates of photosynthesis (Newman et al., 2011). However,

the reaction of photosynthesis is disrupted at high temperatures and inhibit CO_2 fixation (Araus and Slafer, 2011). One of the most temperature-sensitive reactions of carbon assimilation is rubisco activase. Rubisco activase activity is exceptionally sensitive to thermal denaturation. Hence inhibition of the activase at high temperature prevents activation of rubisco in leaves suffering heat stress and leads to inhibition of CO_2 fixation (Crafts Brandner and Sulvucci, 2000; Salvucci et al., 2001). Heat stress is a serious threat to crop production worldwide. High leaf temperatures reduce plant growth and limit crop yields. Estimates range up to a 17% decrease in yield for each degree Celsius increasing in average growing season temperature (Lobell and Asner, 2003).

CONCLUSION

The results from the experiment showed that Thai soybeans, Chiang Mai 60 were grown under temperature-humidity change and revealed that exposure to high temperature, low temperature, and combination of high temperature-humidity during growing period led to the significant and obvious reduction in yield quantity. Even though low temperature evidently increased in lipid content and all type of fatty acid in experiment, the high temperature treatments could also reduce total mono-unsaturated fatty acids (TMUFA)**.**

ACKNOWLEDGEMENTS

The authors thank Naresuan University, Thailand for the funding. This work was also financially supported by Center for Agricultural Biotechnology, Faculty of Agriculture, Natural Resources and Environment, Naresuan University. We also thank to Office of Agricultural Research and Development, Phitsanulok for soybean seeds, Chiang Mai 60 cultivar.

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Research article

Periodic Fertilization Using Urea and Chicken Manure as Source of Natural Productivity in a Biofloc System during the Nursery of Pacific White Shrimp *Litopenaeus vannamei*

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Received 5 March 2015 Accepted 11 September 2015 (*Corresponding Author)

Abstract The effect of periodic fertilization on natural productivity, growth and survival during the nursery of *Litopenaeus vannamei* under a zero water exchange set up was investigated. Nursery culture was carried out for 15 days in 2 m^3 indoor concrete tanks with stocking density of one post larvae (PL)·$liter^{-1}$ using PL 16 shrimp. Urea and chicken manure were initially applied a week before stocking and added weekly to maintain green water condition. There was no significant difference in the phytoplankton densities and microbial flocs in the two treatments. The results demonstrated that the weekly periodic application of urea in a zero water exchange set up was not viable while fertilization using chicken manure improved feed conversion rate as well as shrimp survival and production.

Keywords fertilizer, natural productivity, specific growth rate, post larvae

INTRODUCTION

World aquaculture has dramatically grown in the last 50 years. From a production of less than a million tonnes in the early 1950s, production in 2006 had risen to 51.7 million tonnes excluding aquatic plants (FAO, 2008). In terms of value, shrimp was by far the largest commodity representing 17% of the total value of international-traded fishery products in 2006 (FAO, 2009). From 2000 to 2005, its global market had expanded from less than $1 billion to $5.8 billion (FAO, 2008). Since then the increase in shrimp production has been brought about by so many factors, as it is the intensification of culture systems. Advancements in aquaculture engineering and biotechnology amongst others have triggered the transformation from extensive to intensive culture of shrimps. Introduction of new aquaculture species in certain regions is another major factor. An example is the introduction of the Pacific white shrimp *Litopenaeus vannamei* to Asia. In 1996, *L. vannamei* was introduced on a commercial scale in mainland China and Taiwan and subsequently spreaded to the Philippines and other neighbouring countries (FAO, 2004).

However, the intensification of shrimp aquaculture is coupled with pollution, environmental degradation, and occurrence of diseases caused by heavy effluent discharge and pathogen contamination of water supply. Thus, reducing waste outputs of shrimp aquaculture operations is essential to ensure a long-term sustainability. According to McIntosh et al. (2001), this could be achieved by improving feed and water management, application of water treatment to wastewater and adoption of zero or minimal water exchange. The latter is the soundest possible option because it does not only control effluent discharge but also reduces introduction of water borne pathogens by increasing biosecurity of the cultured organism (Gomez-Jimenez, 2005). The bioflocs technology is an important discovery in the zero water exchange or closed system of shrimp farming. Bioflocs technology (BFT) is a system wherein heterotrophic bacteria, algae, and other microorganisms are grown in flocs controlled conditions within the culture period (Jorand et al., 1995; Avnimelech, 2009). The microbial biomass or bioflocs utilize dissolved and particulate nitrogenous compounds in the water coming from the waste of the cultured organism; the assimilation of these compounds is stimulated by addition of carbon sources to the system (Avnimelech, 1999). The presence of bioflocs does not only improve water quality but also serves as additional food for the cultured organism. The BFT represents a sustainable way of producing food by the production of new biomass grown on the nutrient waste and is used as an alternative food source (Crab et al., 2007). Studies on zero water exchange during the nursery culture of *L. vannamei* showed several benefits. Baloi et al. (2010) reported higher survival of *L. vannamei* post larvae cultured using reclaimed water from a super intensive zero-water exchange pond in tanks without water exchange for seven days. Widanarni et al. (2010) demonstrated that the optimum carbon-nitrogen ratio 2:1 using the biofloc technology in *L. vannamei* nursery production obtained the best shrimp growth, yield and feed efficiency.

Another strategy to improve sustainability while increasing shrimp production is to promote natural productivity in the culture system. Natural food production in an aquatic system is enhanced by fertilization. Inorganic and organic fertilizers supply nutrients needed to increase primary productivity that supports the maintenance of other communities occupying higher trophic levels. Stahl (1979) reported that natural food alone consisting primarily of a mixture of organic detritus and soil, produced growth rates in freshwater prawn *Macrobrachium rosenbergii* post larvae better than commercial production ponds. Anderson et al. (1987) demonstrated that 53–77% of the growth of juvenile *L. vannamei* raised in earthen ponds was due to the assimilation of in situ natural pond biota. Porchas-Cornejo et al. (2011) reported that promotion of natural feed had a positive effect on weight gain, survival and final biomass of *L. vannamei*. Martinez-Cordova et al. (1998) found out that the growth and biomass of *L. vannamei* were higher in fertilized ponds despite lower feeding rate. *L. vannamei* grown extensively (without supplemental feeding) in fertilized ponds resulted to moderate to high survival rates (Jaspe et al., 2010). However, research on the use of different fertilizers in a zero water exchange set up during the nursery of *L. vannamei* is limited.

OBJECTIVE

This study determined the effects of periodic fertilization on natural productivity, growth and survival in the nursery of *L. vannamei* under a zero water exchange set up. Specifically, the following indices were measured: water quality – dissolved oxygen, pH, salinity; natural productivity – phytoplankton and zooplankton count and microbial floc; growth – specific growth rate in terms of weight and length, feed consumption rate; yield or production – survival.

MATERIALS AND METHODS

Experimental design and set up: The experiment utilized a complete randomized design with two treatments: inorganic fertilizer (urea) and organic fertilizer (chicken manure). Rearing of *L.*

vanammei post larvae lasted for 15 days (from PL 16 to PL 30). It was conducted in the facilities of the Central Bangus Hatchery located in Pangangan Island, Calape, Bohol. The experiment used six (2 m^3) indoor concrete tanks assigned to the two treatments. The tanks were chlorinated and washed prior, which were provided with 7-10 cm mud substrate. Tea seed was added at 100 ppm to eradicate naturally occurring predators in the mud and lime was applied at 100 ppm subsequently. Chicken manure and urea were applied initially at 1250 kg·ha^{-1} and 100 kg·ha^{-1} a week before stocking and added weekly at a rate of 625 kg·ha^{-1} and 50 kg·ha^{-1}, respectively to maintain green water condition. Tanks were filled with seawater with a salinity range of 30-35 ppt. Pond green water was inoculated in the tanks to provide initial algal population. Each tank was equipped with aeration line to provide sufficient dissolved oxygen level.

Stocking and feeding: *L. vannamei* post larvae (PL 14) were purchased from a private hatchery (Dobe Export International). The shrimps were acclimatized in a ten-tonner rectangular tank with same salinity and temperature of the hatchery water and were fed to satiation twice a day. Stocking in the experimental tanks was done early morning on the third day after obtaining the fry at a rate of 1 individual·$liter^{-1}$. Initial weight and length of the shrimps were 17.85 mg and 1.49 cm. First feeding was done a day after stocking based on 2.5% body weight. Subsequent feeding was adjusted based on the actual body weight. Feeding ration was administered four times a day at 8 am, 10 am, 1 pm, and 4 pm.

Water quality and natural productivity monitoring: Phytoplankton and microbial-floc population in the rearing water were monitored weekly and physico-chemical parameters such as temperature, salinity, dissolved oxygen, and pH were checked daily. Temperature and dissolved oxygen was measured using portable DO meter, pH with portable pH meter, and salinity with a refractometer. Dominant phytoplankton, zooplanktons, and microbial flocs were counted weekly using a standard haemacytometer under a compound microscope.

Growth and survival monitoring: Weight of the shrimps was monitored weekly to assess growth and adjustment of the feed ration. The shrimps were harvested after 15 days and counted individually. One hundred (100) representative samples from each tank were weighed using 1.0 g precision electronic balance and length measured using Vernier caliper to the nearest 0.01 cm. To estimate the specific growth rate (SGR), food consumption rate (FCR), and survival rate (SR), the following formulas were used: SGR = [(ln final weight − ln initial weight) /days] ×100. Where: ln = natural logarithm of final and initial weight. FCR = weight of feeds consumed/weight gained and SR = (recovered stocks/total stocks) × 100.

Statistical analysis: To determine significant differences in the water quality parameters, microbial floc and phytoplankton counts, growth, survival, yield, and FCR between treatments, T-test for independent sample was used.

RESULTS AND DISCUSSION

Water Quality

Good water quality is essential in the success of shrimp nursery operation. Table 1 shows the minimum, maximum, and mean levels of these parameters all throughout the duration of the culture period. The mean daily values recorded during the experiment fall under the optimum range for culture of *L. vannamei*. Moreover, the results of all the water quality parameters showed no significant difference between the two treatments. The mean salinities of the two treatments were at 37.1 ppt and 36.7 ppt, respectively. Ponce-Palafox et al. (1997) found out that the optimum range for best survival and growth of *L. vannamei* was between 33-40 ppt. Dissolved oxygen is one of the most important water quality parameters, minimum DO standard for good growth of shrimps is at 3

ppm (Fast and Boyd, 1992). The mean dissolved oxygen concentrations of the two treatments were at 5.0 ppm and 5.1 ppm, respectively. The temperature readings were relatively stable throughout the culture period in all the experimental tanks, which fall under the optimum temperature for shrimps at 26°C to 33°C. Mean pH in the two treatments was at 7.6 and 7.5 with very minimal fluctuation until the end of the experiment. The recorded pH, fall under the optimum pH in aquaculture systems, at 7.5 to 8.5 values.

Table 1 Dissolve Oxygen, pH, temperature and salinity of water in Pacific white shrimp (*L. vannamei*) nursery culture with different fertilizers

Treatment/Parameters	Salinity (ppt)			Dissolved Oxygen			Temperature (^{o}C)			pH		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Inorganic Fertilizer (Urea)	33.7	40.0	37.1[a]	4.8	5.2	5.0[a]	26.7	29.0	27.6[a]	7.6	10.2	8.1[a]
Organic Fertilizer (Chicken Manure)	32.0	39.0	36.7[a]	4.5	5.7	5.1[a]	26.4	29.0	27.6[a]	7.5	10.2	7.6[a]

Means with different letters indicate significant differences between treatments (P<0.05).

Phytoplankton and Microbial Flocs

Phytoplankton play a significant role in stabilizing the whole pond ecosystem and in minimizing the fluctuations of water quality. A suitable phytoplankton population enriches the system with oxygen through photosynthesis during day light hours and lowers the levels of CO_2, NH_3, NO_2, and H_2S. During the first week of the experiment there was no significant difference in the phytoplankton densities between the two treatments (Table 2). Common phytoplankton observed were diatoms and *Chaetoceros* species. A day after the 3rd fertilization, the algae bloomed, manifested by dark green coloration of the water in the tanks applied with urea. Mean phytoplankton count in these tanks increased from 372,500 $\pm$ 2,500 cells·ml^{-1} to 513,333 $\pm$ 11,273 cells·ml^{-1} and was significantly higher compared to the tanks fertilized with chicken manure. Generally, the phytoplankton densities all throughout the experiment were relatively low compared to the healthy phytoplankton abundance reported by Cordova et al. (1998) in ponds applied with organic and inorganic fertilizer at 530,000-980,000 cells·m^{-1}. The denseness could be attributed to the use filtered seawater. Pond green water was only added in the tanks to provide initial algal population.

Phytoplankton aggregates with microorganisms in the aquaculture system to form microbial flocs. Bio-flocs or the microbial flocs are a mixture of microorganisms (bacteria, phytoplankton, and zooplankton), algae, and other particles (Jorand et al., 1995). Typical flocs are irregular by shape, have a broad distribution of particle sizes, which are fine, easily compressible, highly porous, and permeable to fluids (Lee Chen, 2004). Microbial floc or flocculated particles were observed to be increasing as shown in Table 2. The build-up rates of the floc on the 2nd week followed the standard community succession principle wherein from a clear water condition, algal bloom follows, and bacterial communities are established when the water turns to brown. Build up of flocculated particles in the two week time was relatively low.

The microbial flocs observed in the experiment were visibly large and distinct under the microscope. Optimum water quality conditions were important in maintaining healthy population of microbial flocs and these were met during the experiment. High dissolved oxygen in the system was not only essential for the shrimps but also for the metabolic activity of the cells and structure of the microbial flocs. A trend towards larger and more compact flocs at higher dissolved oxygen concentrations was noted by Wilen and Balmer (1999). Temperature was also important in microbial floc morphology. Krishna and Van Loosdrecht (1999) observed that higher temperatures (30-35°C) resulted in bulking of the sludge due to the excessive production of extracellular polysaccharide, thus intermediate water temperature of 20-25°C would be best to obtain stable

microbial flocs. Similarly, pH has an effect on microbial floc; according to Mikkelsen et al. (1996) changes in pH determine the stability of bio-flocs present in the system.

Table 2 Mean phytoplankton and microbial floc count in the water of Pacific white shrimp (*L.vannamei*) nursery culture with different fertilizers

Treatment	Phytoplanktons (cell density ml^{-1})		Microbial Flocs (cell density ml^{-1})	
	Initial	Day 7	Initial	Day 7
Inorganic Fertilizer (Urea)	372,500 ± 2,500 [a]	513,333± 11,273[a]	723 ± 13[a]	797± 17[a]
Organic Fertilizer (Chicken Manure)	365,833 ± 3,819 [a]	423,333 ± 3819 [b]	732 ± 38[a]	836± 15[a]

Means with different letters indicate significant differences between treatments (P<0.05).

Growth and Survival

A day after the 3rd fertilization, the algae bloomed in the tanks applied with urea which resulted to mass mortality of all stocks. However, the fatality could not be attributed to the increase in phytoplankton density because it was relatively lower compared to a healthy phytoplankton bloom (Cordova et al., 1998). Furthermore, dissolved oxygen remained at its optimum level and apparently was not the cause of mortality. One possible reasons of the fatality could be the increase of NH_3 in the system triggered by the addition of urea. In the experiment conducted by Das et al. (2005) application of organic and inorganic fertilizer increased inorganic nutrients including ammonia. Application of inorganic fertilizer gave peak values of nitrogen species such as ammonia, nitrite and nitrate earlier during first to second week. Although natural food production was enhanced by applying organic and inorganic fertilizers, the results showed that weekly application of urea at 50 $kg \cdot ha^{-1}$ significantly affected survival, causing mass mortality of stocks. On the other hand, survival of shrimps in tanks fertilized with chicken manure was 92.68%; with specific growth rate ($\% \cdot day^{-1}$) of 14.05 in terms of weight and 18.17 in terms of length and total yield of 128.37 $g \cdot m^{-1}$. Lara-Anguiano et al. (2013) found out that *L. vannamei* culture in tanks with zero water exchange using organic fertilizer (molasses) had higher survival and production rates and reduced ammonia concentrations toward the end of the experiment while the use of inorganic fertilizer caused increased nitrogen and phosphorus.

CONCLUSION

Periodic fertilization using chicken manure at a rate of 625 $kg \cdot ha^{-1}$ improved feed conversion rate as well as shrimp survival and production within this experiment. Moreover, the results indicate that weekly periodic application of urea at a rate of 50 $kg \cdot ha^{-1}$ without any water replacement in tanks during the nursery of *L. vannamei* is not viable.

RECOMMENDATIONS

Further studies should design experiments that include the measurement of other water quality parameters such as NH_3, nitrites, nitrates, total suspended solids, and microbial evaluation such as total plate count and *Vibrio* count. It is also very interesting to determine the density of the zooplankton in the water vis-à-vis the feeding incidence.

ACKNOWLEDGMENT

We would like to express our sincerest gratitude to Engr. Ramon Alegre of DOBE Export International for free *Vannamei* fingerlings; Mr. Dionisio Colantro for the use of facility of Central

Bangus Hatchery at Barangay Lawis, Pangangan Island, Calape; 4th year BS Fisheries students for the assistance of the experiment.

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Research article

Ecotoxicology of Copper on Freshwater Fish with Different Water Hardness on the Mekong River, Lao PDR

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Received 23 February 2015 Accepted 11 September 2015 (*Corresponding Author)

Abstract The aquatic resources of the Mekong River are important to support the livelihoods of a large percentage of 60 million or more people living in the Lower Mekong Basin. A study on the impact of heavy metals on tropical freshwater fish in the Mekong River is needed. Ecotoxicology of copper on freshwater fish was studied using field-collected water from two local sites along the Lower Mekong Basin in Lao PDR, which focused on two different water hardness. In this study, US EPA method was used for the acute toxicity test to larvae *Labeo rohita* with 7 different copper concentrations (0, 0.02, 0.09, 0.16, 0.23, 0.3, and 0.37 mg/L) in moderately hardness of water (108±0.00 mg/L as $CaCO_3$) and (0, 0.02, 0.03, 0.04, 0.05, 0.09, and 0.13 mg/L) in soft hardness of water (20±2.83 mg/L as $CaCO_3$). The mortalities of fish were observed at 24, 48, 72, and 96 hr. The results clearly showed that amount of mortalities were increased from low to high copper concentrations. The 96-hr LC_{50} values of copper on larvae *Labeo rohita* with moderately hardness and soft hardness of water were 0.106 and 0.038 mg/L, respectively.

Keywords acute toxicity, copper, *Labeo rohita*, the lower Mekong basin

INTRODUCTION

The Mekong River is the 12th longest river in the world in terms of volume of water. The river runs for approximately 4,350 km from China through five countries, namely Myanmar, Lao PDR, Thailand, Cambodia, and Viet Nam. The millions of people living in different parts of the Lower Mekong Basin rely on some extent on the water resources of the Mekong River Basin for food supply and sustainability of their livelihoods (MRC, 2010a), due to the fact that the resources have potential to contribute to economic development of the countries. If not properly planned, managed, and monitored, it could also exert tremendous pressure on the basin's ecological health, livelihoods, and water quality.

Copper in the aquatic environment is usually related to anthropogenic sources rather than natural sources (McNeely et al., 1979). Industrial sources of copper include mining, electroplating, petroleum refining, metal works, and foundries. Copper is a micronutrient for both plants and animals at low concentrations and is recognized as all plants and animals (Kapustka et al., 2004). Concentrations of copper have been reported from 0.03 to 0.23 µg/L in surface seawaters and from 0.20 to 30 µg/L in freshwater systems (Bowen, H.J.M. 1985). However, it may become toxic to some forms of aquatic life at elevated concentrations.

Water hardness is one of the water qualities, usually expressed as mg/L $CaCO_3$. It substantially affects metal toxicity but seemingly has little effect on the toxicity of organic chemicals (Sprague, 1985; Mayer, 1988; Inglis, 1972). The relation of water hardness to metal toxicity concerning the lethal tolerance of freshwater fish to copper, is mainly dependent to the hardness of the water; as the increasing hardness reduces the uptake rate of copper by gill tissue. One hypothesis suggested that calcium-magnesium hardness may act intrinsically upon cell-membrane permeability at the gills (Spear and Pierce, 1979). Therefore, the objective of this study was carried out on the tropical fish species Cyprinidae, *Labeo rohita* to evaluate acute toxicity of copper with different water hardness to contribute the ecotoxicology data for the management of aquatic environment towards environmental quality standard revision in Lao PDR.

METERIALS AND METHOD

Location and sampling: The study sites were conducted at two different locations along the Lower Mekong Basin in Lao PDR by focusing on different water hardness. The first study site was Vientiane, the capital city (Lao PDR), located at 17°58´1.18´´N/ 102°35´1.66´´E. The city is around 692,900 inhabitants with a density of 176 people per km^2 (ADB, 2000). Municipal sewage is normally discharged into That Luang wetland and is consequently discharged into the Mekong River downstream. The second study site was Pakxan district, located at 18°22´23.29´´N /103°39´43.85´´E. Sources of pollution of this district included domestic, industrial waste, agricultural runoff, and mining activities. The sites were chosen based on proximity and activities that potentially polluted the Mekong River.

Reagents: All laboratory glassware, polyethylene, and polypropylene were soaked in 10% HNO3 acid for at least 48 hr and rinsed with distilled water more than 3 times prior using. Deionized (DI) water from a Millipore Milli-QTM ultra-pure (<18.2 MΩ/cm) water system was used throughout the study. Water hardness was measured by EDTA titration method. A standard solution of copper 1000 mg/L (Spectrosol grade, Merk) was prepared and diluted 100 mg/L with DI water for acute toxicity test.

Test specimen: Tropical freshwater fish, juvenile Cyprinidae *Labeo rohita* used in this investigation were obtained from the hatchery maintained by Khon Kaen Department of Fisheries, Thailand. The test specimen was conducted at Ecotoxicology Laboratory in Khon Kaen University. Juvenile *Labeo rohita* were acclimated with tap water by a portable pump for a period of 48 hr at $25^0C \pm 1^0C$ and arewere more sensitive to toxicants than adults, appeared healthy, behaved normally, fed well, and had low mortality in cultures12a. Therefore, Juvenile *Labeo rohita* 1-14 day(s) of age were used for acute toxicity test. At the beginning of bioassay, 25ºC±1ºC at a temperature control room with 16-hr light, 8-hr darkness photoperiod. Moreover, copper concentrations for each test chambers were determined based on the Factorial experiment in Completely Randomized Design (CRD). One fish was randomly selected at a time from the aquaria to complete the experiment of 7 treatments and 4 replications of 20 fish at 200 mL of test solution volume.

Data analysis: The acute toxicity of copper was determined as the median lethal concentration (LC50) for 96 hr in each exposure time, with 95% confidence intervals. The analysis used the Probit Analysis function of SPSS Version 17, statistical software.

RESULTS AND DISCUSION

Percent mortality of larvae *Labeo rohita* was evaluated at soft hardness and moderately hardness of water (20±2.83 and 108±0.00 mg/L as $CaCO_3$). After being exposed in different periods of time, copper concentrations are resulted in highly significant difference ($P<0.01$), as presented in (Tables

1 and 2). The LC_{50} values of Copper to larvae *L. rohita* at 24, 48, 72 and 96-hr for 20±2.83 mg/L as $CaCO_3$ were 0.083 (0.069-0.106), 0.065 (0.06-0.071), 0.055 (0.045-0.069), and 0.038 (0.021-0.077) mg/L; and for 108±0.00 mg/L as $CaCO_3$ were 0.271, 0.157, 0.129, and 0.106 mg/L, respectively. The result of LC_{50} values with 95% confidence limits of copper are summarized in (Table 3) which clearly indicates that at 20±2.83 mg/L as $CaCO_3$ soft hardness of water was more toxic than 108±0.00 mg/L as $CaCO_3$ moderate hardness to larvae *L. rohita.*

Table 1 Percent mortality of larvae *Labeo rohita* at 20±2.83 mg/L as $CaCO_3$ soft hardness at exposure time with different copper concentrations

Exposure concentration, (mg/L Cu)	% mortality on exposure time			
	24hr	48hr	72hr	96hr
0	$0±0^{f}$	$0±0^{e}$	$4±3^{e}$	$10±4^{e}$
0.02	$1±3^{ef}$	$3±3^{e}$	$10±6^{e}$	$18±10^{de}$
0.03	$6±3^{df}$	$14±3^{d}$	$20±4^{d}$	$24±9^{d}$
0.04	$11±5^{cd}$	$21±3^{c}$	$24±3^{d}$	$29±5^{d}$
0.05	$14±8^{c}$	$25±4^{c}$	$39±6^{c}$	$54±10^{c}$
0.09	$46±3^{b}$	$69±5^{b}$	$75±9^{b}$	$80±9^{b}$
0.13	$86±5^{a}$	$91±3^{a}$	$98±3^{a}$	$100±0^{a}$
F-test	***	***	***	***
C.V. %	17.63	9.71	13.7	17.08

Note: Value are mean ± SD (n=4). Difference litters indicate a significant difference ($p<0.01$) by one-way ANOVA analysis with lsd comparison.

Table 2 Percent mortality of larvae *Labeo rohita* at 108±0.00 mg/L as $CaCO_3$ moderately hardness at exposure time with different copper concentrations

Exposure concentration, (mg/L Cu)	% mortality on exposure time			
	24hr	48hr	72hr	96hr
0	$3±3^{d}$	$4±5^{d}$	$6±6^{e}$	$9±9^{e}$
0.02	$4±8^{d}$	$10±11^{cd}$	$15±14^{de}$	$20±17^{de}$
0.09	$5±0^{d}$	$14±3^{c}$	$21±3^{cd}$	$30±0^{cd}$
0.16	$13±3^{d}$	$19±3^{c}$	$26±3^{c}$	$34±6^{c}$
0.23	$40±8^{c}$	$63±9^{b}$	$66±9^{b}$	$68±9^{b}$
0.3	$59±10^{b}$	$95±4^{a}$	$98±3^{a}$	$99±3^{a}$
0.37	$76±9^{a}$	$96±5^{a}$	$99±3^{a}$	$100±0^{a}$
F-test	***	***	***	***
C.V. %	24.38	14.4	14.72	16.11

Note: Value are mean ± SD (n=4). Difference litters indicate a significant difference ($p<0.01$) by one-way ANOVA analysis with lsd comparison

Acute toxicity of copper in soft water hardness with copper concentration 0.13 mg/L, the mortality at 96 hours of exposure was 100%. On the other hand, 100% mortality at 96 hours in moderately water hardness was observed at copper concentration 0.37 mg/L, due to the toxic effect of heavy metals on freshwater organisms related to hardness (Kim et al., 2001; Plye et al., 2002; Rathor and Khangarot, 2003; Markich et al., 2006)

Comparing the effect of copper at two different water hardness on larvae *L. rohita*, it was observed that copper at the soft water had high toxic to the fish with LC_{50} value of 0.038 (0.021-0.077) mg/L, whereas copper at the moderately hardness of water was less toxic with LC_{50} value of 0.106 mg/L. It could be seen that the tropical freshwater fish was potentially sensitive to toxic elements.

Fish can have a quick response to various copper concentrations in the form of increased surface movements were observed in the first few hours of the experiment, which normalized within 24hr of exposure, thereafter fish settled on the bottom of the chamber. The response of fish mortality with exposure time is shown in Fig. 1. In freshwater, as water hardness increased, heavy metal toxicity decreased due to competition between metal ions and calcium and magnesium ions for the uptake sites of organisms (Javid et al., 2007; Kim et al., 2001; Pyle et al., 2002; Ebrahimpour et al., 2010). According to Penttinen et al. (1998), the uptake of calcium and magnesium ions by the cell membrane caused it to stabilize, and this reduced its permeability to metal ions. Water hardness reduced metal toxicity by saturating gill surface binding sites with Ca^{2+} to the exclusion of metal cations (Pyle et al., 2002).

Table 3 Lethal concentration (LC50 to 95% confidence limits) of copper to larvae *Labeo rohita* at exposure time

	LC50 (Medium Lethal Concentration) mg/L 95% Confidence Limits for conc.			
	24hr	48hr	72hr	96hr
20±2.83 mg/L as $CaCO_3$ soft hardness	0.083 (0.069-0.106)	0.065 (0.06-0.071)	0.055 (0.045-0.069)	0.038 (0.021-0.077)
108±0.00 mg/L as $CaCO_3$ moderately hardness	0.271 -	0.157 -	0.129 -	0.106 -

Note: (-) =95% Confidence limit (lower-upper value exposure time.

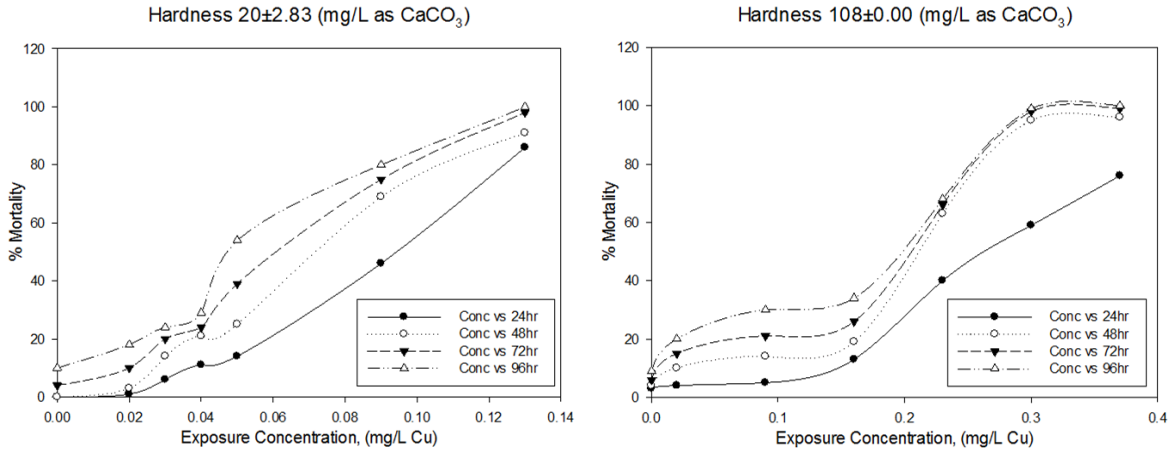

Fig. 1 Relation of percent mortality of larvae *Labeo rohita* to exposure copper concentrations with 2 different water hardness.

CONCLUSION

The toxicity of copper on larvae *Labeo rohita* under low water hardness was higher than in high water hardness. The results of this toxicity tests for copper contribute to ecotoxicology data to the management of aquatic environment towards environmental quality standard revision in Lao PDR.

ACKNOWLEDGEMENTS

This research project was funded by Integrated Water Resource Management Research and Development Center in northeast Thailand, Khon Kaen University; and the research collaboration project between Loyola University Chicago and Khon Kaen University supported by International Copper Association, Ltd. (ICA).

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Research article

Agricultural Extension and Advisory Services in Bosnia, Montenegro and Serbia: An Overview

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Abstract Agriculture is still important for socio-economic development in rural areas of Bosnia, Montenegro, and Serbia (BMS), especially in terms of employment and income generation. Good extension is recognized as a key to agricultural development. The paper aims to provide an overview on public agricultural extension and advisory services (AEAS) in BMS. It is based on an extended secondary data review and primary data collected by questionnaires with rural people, as well as semi-structured interviews and focus group discussions with agricultural advisors and extension specialists carried out in the years 2012-2013. Current agricultural extension structures has mainly been developed in the last two decades with international donors' help. Public extension structures exist besides other advisory services providers. Advisors use many groups and individual extension methods. Advisory services face many financial, management, and technical problems. Extension agents spend most of their working hours doing administrative tasks and lack systematic professional in-service training offers. Agriculture multifunctionality and the increasing rural economy diversification represent a real challenge for agricultural extension services. Public extension is largely focused on crop and animal production while rural development is only partially served. Rural advisory work is restricted to the activities of individual extension agents, as well as NGOs, donor projects, and private advisors. The involvement of other actors in rural extension work is crucial if the system is to meet rural people's needs. AEAS have been trying to address the emerging challenges through modernization of their extension approaches and communication media, as well as diversification and decentralization of their services. Nevertheless, there are still some weaknesses that should be overcome. Developing a pluralistic, participatory, decentralized, farmer-led, and market-driven advisory system is a milestone in the process of promoting rural innovation and diversification, and harmonization with the European Union's *acquis*.

Keywords agriculture, extension, advisory services, Bosnia, Montenegro, Serbia

INTRODUCTION

Despite the increasing diversification of the rural economy in the three countries of the Western Balkans (WB) - Bosnia, Montenegro, and Serbia (BMS) - agriculture still plays an important socio-economic role. The share of agriculture sector in gross domestic product amounts to 8.2% in Bosnia (EC, 2014a), 8.8% in Montenegro (EC, 2014b), and 11.4% in Serbia (EC, 2014c). The primary sector employs 18.9% of the total labor force in Bosnia (EC, 2014a), around 4.5% in Montenegro (EC, 2014b), and 21.3% in Serbia (EC, 2014c). Agricultural sectors in BMS are characterized by the prevalence of small family farms. Rural areas lag behind in terms of socio-economic development and still face many problems. The share of rural population is around 61% in Bosnia, 36% in Montenegro, and about 45% in Serbia (World Bank, 2014).

Easy and timely access to reliable and updated information is crucial for agricultural and rural development (ARD). Good extension is recognized as a key to agricultural development (USAID, 2012) and can contribute to improving the welfare of farmers and other people living in rural areas (International Initiative for Impact Evaluation, 2010). One can simply say that "*extension is getting knowledge to farmers so they will make a positive change*" (USAID, 2012). Advisory service is commonly used as an alternate term for extension services. Apart from their conventional function of providing knowledge and technology to improve agricultural productivity, agricultural advisory services are also expected to link farmers to markets, promote sustainable production techniques, etc. (Swanson, 2008; Swanson and Rajalahti, 2010). Agriculture multifunctionality and rural economy diversification are changing dramatically the classical crop production-centred mission of agricultural extension and advisory services (AEAS). They need to provide a wider range of services to a more diverse clientele to improve their capacity to access, adapt, and use knowledge, inputs and services (World Bank, 2008). For extension to be successful, it needs to include credible content, effective delivery, and be relevant to, and applicable by clients (USAID, 2012). In the WB, current agricultural extension structures have been developed mainly within the last two decades with the help of international donors. Public extension structures exist besides other providers such as NGOs and commercial extension agents (FAO, 2011).

The paper aims at providing an overview on public AEAS in Bosnia and Herzegovina (BiH), Montenegro, and Serbia with a particular focus on governance, financing, and extension approaches.

METHODOLOGY

The paper is based on an extended cross-checked secondary data review (*e.g.* FAO,USAID, European Commission (EC), Ministries of Agriculture in BMS, World Bank, etc.) and primary data collected by questionnaires with 108 rural households in BiH (winter 2012), 106 in Montenegro (autumn 2013), and 104 in Serbia (spring 2013). Questionnaires dealt, among others, with access of rural people to services provided by AEAS. A special attention was devoted to services regarding the off-farm sector and rural development. Moreover, semi-structured interviews and focus group discussions with agricultural advisors and extension specialists were carried out in the years 2012-2013. The prepared checklist for interviews dealt with many issues regarding AEAS in BMS such as (i) governance and organization structure; (ii) financing; (iii) human resources; (iv) role in building social capacity; (v) decentralization; (vi) gender; (vii) and advisory approaches, methods, and media. All secondary data were critically analyzed by key informants from the AEAS. Some recommendations were made to improve the AEAS performance in BMS.

RESULTS AND DISCUSSION

Agricultural Extension and Advisory Services in Bosnia and Herzegovina

AEAS, as known in practice world-wide,started to exist in *Bosnia* in 2002. They are organized on entity level: Agricultural Advisory Service of the Republic of Srpska (AAS-RS), cantonal agricultural extension services in the Federation of BiH (FBiH), and the Department of Extension Services in Brcko District. In May 2002, the Agricultural Extension Service of RS (AES-RS) was established within the Ministry of Agriculture, Forestry and Water Management of RS (MAFWR-RS). Two years later, the Government of RS established the Agency for Providing Services in Agriculture (APSA), as a separate organization with a wide range of activities including agricultural extension. In January 2013, APSA and the Agency for Animal Breeding and Selection were integrated in the AAS-RS, which was one of the five departments within the MAFWM-RS. The AAS-RS is headquartered in Banja Luka and there are seven regional offices *i.e.* Banja Luka, Gradiska, Prijedor, Doboj, Bijeljina, Sokolac, and Trebinje; where 36 advisors and 24 administrative staff (36.7% female) work for 221,000 rural households in the RS. The extension system includes 77 municipal based advisers - within the Department for Economic and Social Affairs - in most areas (MAFWM-RS, 2010). In the FBiH, the extension system was established at Canton level but the commitment of most Cantons was minimal and no central services were established to support the system. Field advisors were part of the municipal administration (FAO, 2011).

The AAS-RS is financed by the MAFWM-RS budget. All services provided by Bosnian public advisory systems are free; advisors' work is paid for with state, entity or municipality money (FAO, 2011). Besides public extension services, many institutions provide advisory services such as cooperatives, agricultural and veterinary institutes and stations, as well as private actors.

Advisors use many group extension and communication methods (*e.g.* lectures, seminars, demonstrations, field days, events, etc.) and individual methods (*e.g.* farm visits, contacts in extension offices, phone calls). The main media used are the internet, leaflets, posters, brochures, and mass media. Advisors provide services dealing mainly with agriculture production, processing and marketing (*i.e.* vegetables and fruit growing, animal husbandry, processing and quality of agro-food products, agro-economy). In the RS, out of the 36 extension agents, 33 are agriculture engineers that have general educational orientation while the number of specialists is modest. The fact that the majority of the field staff is agricultural experts, it induces a strong focus on production techniques and a relative preference given to large farms (FAO, 2011).

Advisory services face many finance, management, and technical support problems. According to the vice-minister in charge of AASRS (January 2015), the main problems faced by the public agricultural extension system are (Pasalic B., pers. commun.): different levels of extension service development between Bosnian entities, uncompleted/weak legislative (at the entity and state level), insufficient coordination between RS and FBiH extension services, low number of extension agents, limited funding, weak participation in international projects, undeveloped system of extension agents' training, low interest of farmers for training, and weak collaboration with the research institutions. According to FAO (2011), advisors spend most of their working hours doing administrative tasks related to incentive measures. Bosnian extension agents lack systematic offers of professional training as there is no systematically planned and performed in-service training program. However, there are donor projects that provide training on a broad range of agriculture and rural development issues.

Extension and Advisory Services in Serbia

In *Serbia*, agricultural extension service started its initial development during the 50's of the last century (Zivkovic et al., 2009). Nowadays, the network of professional extension services in Serbia is coordinated by the Institute for Application of Science in Agriculture (IASA), which is under the auspices of the Ministry of Science. About 251 field advisors and administration staff (40.3% female) are employed in 34 regional offices by the Serbian public extension. AEAS in Serbia is composed by public extension and private advisory services. Donor projects (*i.e.* World Bank project) provided extension agents with a sound base of technical (and partially methodological) knowledge and skills, before being left on their own (FAO, 2011).

Support for public services in agriculture (*e.g.*extension service, veterinary and phytosanitary services, etc.) is provided but the share of dedicated agricultural budgetary funds is small. Within the general services sector, the greatest proportion of funds is directed to extension services or to financing agricultural expert service (34-56 %) (Bogdanov and Bozić, 2010).

The majority of the field staff within the system is agricultural experts from the former system. In fact, the majority of advisors are age over 40 years. This strengthens two biases: the strong focus that is still directed towards production techniques and the relative preference given to large farms with respect to small and medium holdings (FAO, 2011). Serbian public agricultural extension is mainly addressed to commercial family farms and lesser attention is paid to small producers. Usually, small producers must go by themselves to ask for advice (Petrović et al., 2009). Approach to farm families is based mainly on individual contacts (sample farmer). Direct display methods include demonstration plots, field visits, field days and workshops. Extension workers also organise public lectures. Different media are used in information dissemination such as leaflets, brochures, Radio, TV and the internet.

The ISAA went a step ahead regarding provision of trainings to advisors in the few last years, as during the period 2010-2014 more than 40 practical training courses were organized for extension agents related to farm management, modern technologies in agricultural production, skill development, EU integration, and environment protection and sustainable development.

Public extension has an intensive cooperation with applied research institutions. Moreover, extension stations apply research by themselves. There is a regular cooperation with universities especially in Vojvodina autonomous province, where a university department developed and implements an extension monitoring system.

Extension agents provideinformation and advice on national subsidy programs. Nevertheless, according to FAO (2011), the Serbian public extension provides farmers and rural dwellers only partially with information and support on rural and agriculture tourism. However, Serbian extension services have recently started providing information on national and international rural development programs by the initiation of Rural Development Offices (RDOs). RDOs and individual municipal advisors provide also support for the initiation of associations.

Monitoring of advisory work is fairly advanced in Serbia, having a considerable database on advisors' activities, farmers' needs and the results of on-farm research. However, monitoring is more about examining the activities of advisors than documenting the impacts of advisory work. There are many best practices that can be shared with neighbouring countries (FAO, 2011). Nevertheless, Serbian extension services face many problems in dealing with producers, as well as finance and management problems, overload with non-extension activities, low number of extension agents, etc. (Petrović et al., 2009).

Extension Services in Montenegro

Montenegro has a relatively simple agricultural education, extension, research, and information system institutional set up. The main institution is the Biotechnical Institute that is the main partner

of the Ministry of Agriculture and Rural Development (MARD) (EC, 2011). The Biotechnical Institute is legally a part of the University of Montenegro and is financed from its budget, but the Livestock Selection Service (LSS) and Plant Production Extension Service (PPES) are financed by the MARD (EC, 2011; MARD, 2012).

LSS was initiated in 2000 and has performed four main groups of activities: animal breeding and herd improvement program, advisory services, realization of support measures to farmers, and carrying out AMIS program - Agrarian Market Information System (MARD, 2012; Markovic and Bovic, 2010). The first activity, animal breeding and herd improvement program, takes a major part of working time (Markovic and Bovic, 2010). PPES, established in 2003, aims at improving crops yield and products quality. It performs three main activities: advisory services, implementation of support measures, and carrying out of AMIS program (EC, 2011; MARD, 2012). At present it has 19 staff (academics or technicians) who work in seven regional centres (Bar, Bijelo Polje, Berane, Cetinje, Herceg Novi, Niksic, and Podgorica).

PPES uses different methods in everyday work. It gives expert advice and recommendations to farmers in the field, and organizes educative trainings, round tables, workshops, and seminars on different topics in plant production (MARD, 2012). It also provides general information on its website and publishes flyers and brochures (FAO, 2011). Radio and TV programs are also used to inform farmers. Up-to-date market information is provided to the national radio station to be broadcast in a weekly program (Stanisic Vukota-Director of PPES, pers. commun.).

Common challenges for both LSS and PPES is the implementation of indicators of performance and monitoring and the improvement of the extension staff's abilities and expertise through regular trainings (Markovic and Bovic, 2010). Moreover, the advisory services have sporadic cooperation with NGOs, private extension providers and farmers' associations but good cooperation with research centres, input suppliers, and processors (FAO, 2011).

There is in every Montenegrin municipality a kind of advisory service for agriculture which engages one or more employees (Stanisic V., pers. commun.). However, this service inherited from the previous system many burdens and its function is more focused on office work than to giving advices directly to farmers (Markovic and Bovic, 2010).

Montenegrin advisory services provide a limited support for the diversification of rural livelihoods and income generating activities. Moreover, they also support social capital building and strengthening activities. This is exemplified by the support for the initiation of processing and marketing associations (Stanisic V., pers. commun.).

Agricultural Extension and Advisory Services: User Needs and Challenges Ahead

According to the field survey, the need for agricultural advisory services is very high among the surveyed rural households in Bosnia (50.0%), Montenegro (60.4%), and Serbia (31.7%). Despite quite a high need, very few respondents (12.0%) in Bosnia use services provided by extension while in Montenegro (41.5%) and Serbia (37.5%); the share of households that in reality use services is higher. In all the three countries, needed help is mainly related to advices about market and its players, veterinarian service, cooperatives membership benefits, marketing, plant protection, fruit pruning, products' processing, legal-economic advices, animal husbandry, tillage operations, and manure use, etc. The majority of those who need help are agricultural households while mixed ones need less help and non-agricultural households do not need any help.

Public extension services in the WB in general and in BMS in particular are strongly focused on production techniques, while farm management, markets and marketing, regional rural development and the promotion of producer organizations are only partially served. Extension agents are only able to thinly cover the areas of farm economy and farm development planning. Rural development is not systematically supported by the public AEAS due to an overload of work, and to the general lack of knowledge (on projects and programs) and skills (on group facilitation and group management) (FAO, 2011). In fact, advice on rural development is generally restricted to

the activities of some motivated advisors in the public service, as well as to NGOs, private service providers, and donor projects dealing with rural development.

AEAS must be flexible, user-driven, and focused on local problems. Both public and private extension resources should be fully used; accountability to clients increased and more responsibilities transferred to the private sector. Linkages between AEAS and public stakeholders, as well as research and education institutions dealing with ARD should be strengthened. Agricultural education, training and research systems should be strengthened as well. It is essential that the research system engages universities, private sector research, and civil societies and stimulate the scaling-up of innovations (World Bank, 2008). Research needs to be more integrated into the agricultural sector transformation by moving from agricultural research and development to Agricultural Research for Development (AR4D). The agricultural education and training system needs to adapt and to meet the new dynamics of agricultural innovation. Education institutes have to offer more relevant subject matters for agricultural and rural innovation (Daane, 2010).

CONCLUSION

AEAS are back on the agenda and widely recognized as critical to rural development. Rural areas diversity in BMS, as well as the increasing diversification of the rural economy represents a challenge for agricultural advisory services. Advisors use many group and individual extension methods and media. Moreover, advisory services face many financial, management and technical problems. AEAS is largely focused on crop and animal production, while rural development is only partially served. In fact, public extension agents provide only partial information for rural development and rural livelihoods diversification.

Higher attention should be paid to supporting extension and advisory services in BMS to allow them to fully assume their role in the promotion of rural innovation, diversification, multi functionality and sustainability.It is necessary to develop a pluralistic, participatory, bottom-up, decentralized, farmer-led, and market-driven advisory system. The involvement of other actors in the rural extension work is crucial if the system is to keep up with rural people's expectations and to meet their needs. The programme for continuous training of field advisors should be strengthened and upgraded, especially in Bosnia and Montenegro.

The need for supporting agricultural advisory services is significant in BMS. It is truly essential in the time of institutional weakness of the sector that the technical and technological unpreparedness of farmers and rural people should meet complex requirements associated with the policy reform as it is needed to align the ARD policy and practice in BMS with the European *acquis*. Moreover, well-performing AEAS is a *conditio sine qua no* for achieving sustainable agricultural and rural development.

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Research article

Relation Between Rural Diversification and Governance: Some Insights from Bosnia, Montenegro and Serbia

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Abstract Rural areas in the Western Balkans are experiencing two profound changes *i.e.* increased diversification of the rural economy and new governance models and arrangements. The paper aims at providing some insights into linkages and interdependences between rural livelihoods, diversification, and rural governance in Bosnia, Montenegro, and Serbia (BMS). In particular three different conceptual frameworks were used to analyze governance-rural development, governance-rural livelihoods and governance-rural economy diversification linkages. Input data to substantiate the conceptual frameworks in the rural contexts of BMS were the results of surveys dealing with rural governance and rural livelihoods diversification performed in the period 2011-2013. There is a linkage between agricultural and rural development governance and coordination, and exploitation of the full potential for rural livelihoods and economies diversification. Governance is relevant for rural livelihood diversification and rural development both as process and structure. Governance - comprising institutions, policies, and processes - affects access to and use of livelihood assets with impacts on diversification. Diversification is also affected by a set of sectoral policies that go beyond agriculture. Government policies can act as a stimulus to the diversification of economic activities of rural households. Governance - as actors and institutions - also affects diversification. Governance arrangements determine the range of actors involved in policy design. Depending on actors involved and their interests the policy character and architecture are defined. Meanwhile, also diversification has impacts in terms of governance in rural areas. In fact, changes that happen in rural areas, thanks to diversification, influence also rural governance and policy. Many new rural actors are consulted about rural development which was not the case in the past. Diversification affects the typology of actors that are involved in policy design which has implications in terms of priority policy measures definition. These insights should be taken into consideration to redesign rural development policy.

Keywords rural areas, diversification, governance, Bosnia, Montenegro, Serbia

INTRODUCTION

Agriculture plays an important socio-economic role in the Western Balkan (WB) in general and Bosnia, Montenegro, and Serbia (BMS) in particular. The share of agriculture in GDP amounts to 7.4% in Bosnia (EC, 2013a), 9.5% in Montenegro (EC, 2013b), and 10.1% in Serbia (EC, 2013c). Agricultural sector employs 20.6% of the total labor force in Bosnia (ASBiH, 2012), 5.7% in Montenegro (EC, 2013b), and 21% in Serbia (EC, 2013c). Rural areas lag behind in terms of socio-economic development and still face many problems. The share of rural population is 61% in Bosnia (UNDP, 2013), 38% in Montenegro (Arcotrass et al., 2006), and 43% in Serbia (RDNS, 2010). Rural areas in BMS are experiencing two profound changes *i.e.* increased diversification of the rural economy and new rural governance models. Sustainable development of rural areas cannot be based only on agricultural development, rural economies should also be diversified by developing off-farm and non-farm income-generating activities.

Diversification means exploiting all the multifunctional functions of agriculture while introducing new off-farm and non-farm income-generating activities. Households' income can be increased by adopting many livelihoods strategies (Chambers and Conway, 1992). In terms of agriculture, the concept of diversification is often taken to mean a shift away from the production of surplus commodities to those which may be expanded – a focus on the diversification of output – with emphasis placed on diversification into other agricultural products. Alternatively, it is used to describe the strategy of utilizing excess capacity of farm production factors, involving the use of farm resources for non-agricultural activities – a focus on diversification of resources. A third sense of diversification – a focus on the location of the activity – is also considered (OECD, 2009).

Agricultural and rural development (ARD) processes in general and farm activity diversification initiatives in particular should be well governed in order to yield expected outcomes and impacts. Governance comprises mechanisms, institutions and processes of decisions making and implementation through which persons and groups articulate their interests, exercise their legal rights, meet their obligations, and mediate their differences (Cheema, 2005). Governance analysis focuses on the actors involved in decision-making and implementing the decisions made and the structures that have been set in place to arrive at and implement decisions (Sheng et al., 2007).

The paper aims at exploring relations and interdependences between rural livelihoods diversification and rural governance in BMS.

METHODOLOGY

The paper is based on an extended secondary data analysis and different surveys. Three different conceptual frameworks were used to analyze governance-rural development, governance-rural livelihoods and governance-rural economy diversification linkages. The conceptual framework developed by IFPRI highlights linkages between governance and rural development. It shows why governance decentralization and rural service delivery are so important for sustainable ARD (IFPRI, 2007; IFPRI, 2007b). The second conceptual framework of Shtaltovna (2007) focuses on relations between governance and diversification. It shows how and in which way governmental support should be targeted in order to contribute to rural development. In particular, it highlights how governance arrangements in local rural areas can influence the diversification of rural economy through their impact on household assets (Shtaltovna, 2007). The rural livelihood framework of the UK Department for International Development (DFID) was used for getting insights into linkages between governance and livelihood strategies. This conceptual framework shows how governance structures and processes influence livelihoods. The framework highlights as well how livelihood strategies – including diversification – are affected by a number of governance structures and processes (Satgé et al., 2002).

Input data to substantiate the conceptual frameworks were the results of surveys dealing with rural governance and rural livelihoods diversification. As for ARD governance, questionnaires were sent via email to 120 actors in Bosnia and Herzegovina (BiH) in winter 2011, to 50 in Montenegro in winter 2012, and to 120 in Serbia in summer 2013 (Berjan et al., 2014). Respondents included purposively selected representatives of public, civil society and international organizations. Concerning rural livelihood diversification, the field questionnaire surveys were carried out in winter 2012 with 104 randomly chosen households' heads in south-eastern Bosnia (Berjan et al., 2013), with 50 households in autumn 2013 in northern Montenegro and in spring 2013 with 99 households in south-western Serbia.

RESULTS AND DISCUSSION

Analyzing linkages between rural governance and rural livelihoods diversification is about studying policies that are put in place to foster diversification, as well as the stakes of the different involved rural actors and how they have evolved over time with the increasing pace and level of diversification. It goes without saying that there are differences among the three countries but there are also some commonalities. From this point of view, it is very interesting to take a stock of the experience of other countries, whose rural areas have been engaged in the process of diversification for many years, in order to get insights about what policies should be enacted, as well as what are the implications of rural economy diversification in terms of ARD policy. This is particularly the case of many OECD countries.

Creating an improved environment for farm activities, diversification requires the efforts of many actors. The roles of government actors are often critical for facilitating, catalyzing, and mediating initiatives taken by other private and civil society stakeholders (IFAD, 2010). Local governments as well as civil society and the private sector have an important role to play in the provision of infrastructure and public services in rural areas with a special emphasis placed on agricultural services governance (IFPRI, 2007b). The system of governance of rural development policies has witnessed the progressive coming into play of several levels (national, regional, intermediate and local); many more actors than before; and new instruments and approaches (Mantino et al., 2010).

Governance arrangements in rural areas can influence the diversification of rural economy through their impact on household assets. In fact, governance arrangements can influence effectiveness and efficiency of different activities that are performed by governmental institutions in rural areas. They affect governance as a process *i.e.* partnerships, networks and cooperation agreements. Governance arrangements also affect the *modus operandi*, visions and missions of local governance structures, *i.e.* institutions and organizations, that deal with RD in general and rural livelihood diversification in particular (cf. Shtaltovna, 2007).

Despite recurrent discourses about participation and bottom-up approaches in governance and policy arena, the spectrum of actors involved in the different stages of the policy cycle in the three countries remains limited. In particular, the involvement of the private sector and civil society organizations in rural policy design and formulation is generally still marginal. This is particularly true at central level (*i.e.* entity level in BiH) while the situation is much better at local level. However, since these countries are still largely centralized the funds at disposal of local councils and administrations are very low which limits their maneuvering space and the scope of their interventions.

Insufficient institutional capacities at the local level hinder economic diversification development and it is necessary to further strengthen local structures seen as key drivers for diversification of rural economy. In order to face this challenge, about a third of municipalities in Bosnia established funds for local economic development and support small and medium sized enterprises (SMEs) (FAO-ROECA, 2012).

Governance surveys results show that many actors have a stake in rural economy diversification. These stakeholders have various backgrounds but share a similar goal which is the socio-economic development of their territory. Each single actor contributes to new activity formation and support assets. In particular, stakeholders recognize the true value of assets, especially the human and social capital, as new possibilities for diversification of their local rural economies. It was also noticed that the emergence of new participatory governance structures and arrangements allow mobilization of local assets and resources as well as diversification of rural activities in the non-farm sector.

The larger share of the surveyed households believes that local and national governments (also entities' governments in the Bosnian case) should make more effort in helping them compared to what they have done until now. Disproportion in help demand and help delivery by local councils and state institutions in south-eastern Bosnia and western Serbia is huge and Bosnian and Serbian rural households feel that primary responsibility lies on local and state/entity level governments while it seems that the surveyed Montenegrin rural population is quite satisfied with local and state authorities' engagement in the development of rural areas.

Another key factor explaining why respondents in south-eastern Bosnia and western Serbia share opinion that authorities do not take adequate care about rural areas is also the lack of trust in them. The capacity of local NGOs, beside capacity of municipalities, is important to support economic diversification. Willingness of NGOs and local authorities to work together is also important. However, it seems that civil society organizations yet do not have enough developed capacities to cope with the situation in rural areas (FAO-ROECA, 2012). Effective local institutions that deliver goods and services must be in place in rural areas to sustain positive rural livelihood outcomes. These institutional structures condition livelihood outcomes through community capacity-building and institutional strengthening (Frankenberger, 2001).

Government intervention is among the main factors that influences the diversification of farm households into non-farm activities. If governments want to foster diversification, they need to make sure that policies are in place, whether sectoral or broad, and do not put unintended obstacles in the way of such diversification (OECD, 2009b). For rural policy to be more effective, small fragmented programs should be replaced by an integrated rural development policy, that rural farm and non-farm households can benefit from, which requires a strong horizontal coordination effort at all governance levels.

Rural development policies should stimulate development of diverse income-generating activities outside agriculture. Many of the elements of rural development policies, such as improvements in infrastructure and the provision of local services, are crucial for economic and social sustainability in rural areas (OECD, 2010). As highlighted by IFPRI (2007b), it is important to improve the ability of the rural population to demand services and hold service providers accountable. It is also crucial to increase the capacity and effectiveness of local service providers. This is also related to political decision-making processes with respect to the formulation of rural development strategies and agricultural policies.

The survey on rural household livelihoods diversification showed that adequate access of all rural people to services and structures (including infrastructure) necessary to engage in diversification endeavors was far from optimal. This is in part explained by the fact that the survey – especially in BiH and Montenegro – was performed in remote rural areas. However, the quality of rural services and the performance of structures in charge of service delivery was a problem in most of rural areas in the three countries.

A number of policy measures designed to encourage diversification, have been introduced in certain OECD countries. These include vocational training and business development schemes (OECD, 2010). Human capital strengthening and rural dwellers' capacity-building efforts must focus on service delivery as well as risk-management skills (Frankenberger, 2001).

Weak human capital is a problem in the three studied rural regions. What is alarming is that it seems that the situation is getting worse because of migration of most of well-educated young rural

people to cities or even abroad. This undermines one of the most important endogenous assets and resources of rural areas that can be exploited in the diversification journey. In fact, it is well-known that, in contrast with agricultural activities, non-farm activities require a range of new skills that most of rural people do not have. This highlights the importance of the role of extension and advisory services as well as of other institutions dealing with capacity building and human capital strengthening in rural areas. These actors should work together and coordinate their activities in order to address this challenge. Coordination with international development agencies dealing with business skills development is also crucial.

Different factors regarding livelihoods interrelate and affect each rural household quality of life. Governance structures and processes directly influence livelihoods. Human, physical, social, financial and natural capital in different combinations are affected by a number of governance structures and processes and how people use their capital in order to achieve desired livelihood outcomes through developing different livelihood strategies (Satgé et al., 2002) such as diversification (Goodrich, 2001).

Governance decentralization and rural service delivery are so important for sustainable ARD. Decentralized political system would better answer needs of local communities. Strengthening and improving service providers' capacities will directly affect the supply and quality of services (IFPRI, 2007). A vibrant service sector is both vital for a prosperous local economy and crucial for meeting the needs of the rural population (OECD, 2010b).

Some regulations governing tax, social security, land zoning, and labor markets may complicate diversification in countries where agriculture is not treated the same as other sectors. The impact of labor regulations and the social security and tax systems on diversification essentially depends on how agriculture is defined under national regulations/systems. When a narrower definition is applied, diversification activities increase the administrative requirements and complexity of the farm operation (OECD, 2009). In some countries access to other forms of support (*e.g.* income support), may be limited if farmers earn too much income from non-agricultural activities (OECD, 2010).

While there are references to diversification in national agricultural and rural legislation of the three countries - which is mainly the outcome of the process of alignment with the EU *acquis* in ARD - what is missing is a concrete long-term strategy to promote diversification on the ground as well as a favorable institutional and legal environment to foster diversification.

Harnessing farm diversification especially in the non-farm economic activities requires improving the environment, thus strengthening incentives and reducing risks for the actors involved. This involves improving rural infrastructure and services, as well as governance and the business climate to encourage private investment by providing business development and financial services suited to the small rural entrepreneurs' needs (IFAD, 2010).

CONCLUSION

Promoting rural development through farm activity diversification poses numerous policy and governance challenges because it requires coordination across sectors, across levels of government, and between public and private actors. There is a need of a paradigm shift in the approaches of the three countries to accommodate such important challenges. Farm activity diversification initiatives and processes should be well governed in order to yield expected impacts. Governance is relevant for the rural livelihood diversification and rural development for both process and structure.

Governance (cf. policies and processes) affects access to and use of capitals with impacts on diversification. The pace of diversification depends on whether regulations are favorable for diversification or not. Governance (cf. actors and institutions) affects diversification. Governance arrangements determine the range of actors that are involved in policy design. Depending on actors involved and their interests, the policy character and architecture are defined. For rural policy, to be

more effective, it is of paramount importance that all actors, including also the civil society and rural dwellers, are engaged in preparing a common approach to rural economy diversification.

Meanwhile, changes that happen in rural areas, thanks to diversification, influence also rural governance and policy. Many new rural actors are consulted about rural development, which is not the case in the past. In fact, diversification affects the typology of actors that are involved in policy design which has implications in terms of definition of priority policy measures. This change in rural actor landscape represents a dramatic change in the rural policy arena with respect to some decades ago when mainly agricultural actors are involved in rural policy formulation.

The insights provided by this paper should be integrated in rural policy in order to effectively unlock the growth potential of rural areas in Bosnia and Herzegovina, Montenegro and Serbia. That being said, the main weakness of this study is that, it is to a large extent of quantitative and empirical. Therefore, further quantitative studies are needed to better elucidate and understand relations and linkages between diversification and governance in rural areas in the three countries.

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Research article

Promoting Gummy Guyabano (*Anona muricata* Linn.) Candy

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Received 13 March 2015 Accepted 30 October 2015 (*Corresponding Author)

Abstract Guyabano fruit is from guyabano tree "*Anone muricate*", a small tree. With its native to Central America, the Caribbean, and South America, Guyabano can be found in Mexico, Colombia, Brazil, Peru, and Venezuela, and sub-Saharan African countries. The tree is adaptable to tropical climate and is currently cultivated for its fruits in most Southeast Asian countries such as Malaysia, Indonesia, and the Philippines. Guyabano tree is usually 5 to 7 meters tall, with characteristics of fruit bearing, broadleaf, flowering, and evergreen trees. Guyabano or soursop is known to fight cancer, diabetes mellitus, and other illnesses. It is nutritious, as it is high in carbohydrates, particularly significant amount of fructose, vitamin C, vitamin B1, and vitamin B2. With the mentioned benefits of Guyabano, the author is motivated to come up with a product that allows convenient consumption, availability, and attractiveness for all ages of consumers. In this study, the author ventured into producing a type of candy by using pulp of Guyabano fruit. The study sought to determine the candy's acceptability and promoted its utilization to rural community. The study also identified shelf life and marketability of the product. This study is an experimental research using four-point hedonic scale in rating its acceptability in overall preference, appearance, texture, scent, taste, and aftertaste. A total of 100 participants rated the product consisted of 65 students and people from rural communities and 35 faculty members. The result showed that both faculty and community members had the same descriptive rating, which presented five attributes: overall preference, appearance, texture, taste and aftertaste; however, they was a difference in their ratings for scent attribute; students rated only Like while the faculty members rated Like Very Much for this attribute. It was also found that the product was marketable and could last for a month. It can be concluded that Gummy Guyabano Candy is acceptable and can be prepared in the community because availability of ingredients, easy to follow procedures, and availability of tools and equipment.

Keywords Guyabano, candy, gummy, Hedonic Tasting, sensory attributes

INTRODUCTION

Guyabano fruit can be called in several names such as soursop, custard apple, graviola, and guyabano. Its scientific name is "*Annona muricata*." It is a green, pear-shaped fruit covered with soft spines. Matured guyabano or soursop fruit weighs about 2 to 5 kilograms. It is ovoid and can be up to 18 centimeters in lenght.With thin skin and soft edible whitish fleshy and fibrous pulp, Guyabano black seeds are inedible. It has a distinctive sweet-sour flavor that tastes like pineapple and strawberry with a tang of sour citrus taste.

Guyabano trees bear fruits in 3 - 5 years after planting. They flower most months of the year but the peak period is in May and June, and the fruits ripen in November and December.

It is one of the minor crops that is gaining popularity because of its economic uses and great demand in processing industry, especially in producing guyabano drinks. The crop is now gaining

its prospect in the world market, therefore, expansion and more production should be encouraged to meet its demand. (bpi.da).

Guyabano is widely known to possess medicinal properties like cancer fighting, diabetes mellitus herpes inhibiting, anti-depressive, anti-bacterial, effect against Staph aureus and Vibrio cholera (Tesio, 2013).

Guyabano is a nutritious fruit, rich in ascorbic acid, potash, phosphorous and calcium. The edible portion is 70% with food energy of 63 calories and sugar content ranges from 4 to 14%. It is high in carbohydrates, particularly fructose. The fruit also contains significant amounts of vitamin C, vitamin B1, and vitamin B2 (Barrette, 2013). Because of the health benefits, it has been on high demand from consumers. Restaurants and hotels sell them raw or as fresh ripe fruit as dessert or a snack item in a form of juice or shake. The green fruits are consumed as vegetable or used for meat sweetening. Its juice is used for flavoring ice cream, sherbet, canning and for preparation or refreshing drinks. It may also be processed into preserved food such as candy, jam, and jelly.

The researcher intends to introduce Guyabano to community in an easy and convenient way. The method also includes preserving the fruits in a form of candy that can be consumed anytime and anywhere, without a concern of fruiting season. preserve the fruit after its fruiting month by preparing it into a candy so that anybody can readily take healthy guyabano fruit comfortably anytime and anywhere.

Candy is a type of sweets or lollies, a confection that features sugar as a principal ingredient. Unlike sweet pastries served as a dessert course at the end of a meal, candies are normally eaten casually, often with fingers or as a snack between meals. Each culture has its own ideas of what constitutes candy rather than dessert. The same food may be considered a candy in one culture and a dessert in another.

Candy is also a source of empty calories, because it provides little or no nutritional value beyond food energy. At the start of the 20th century, when undernutrition was a serious problem, especially among poor and working-class people, and when nutrition science was a new field, the high calorie content was promoted as a virtue. Researchers suggested that candy, especially candy with milk and nuts, was a low-cost alternative to normal meals (Labau, 2012). This study seeks to produce a candy with nutritious Guyabano fruit, so that the finished product is nutritional.

In this study, gelatine is added to make the candy more gummy and more appetizing to the consumers at all ages. According to LaBau (2013), gummy candies are made with a base of gelatine and are often flavoured with fruit juices or extracts.Gelatine gives them a distinctive chewy texture that ranges from soft to very firm, depending on the amount of gelatine used.

Gelatine is a protein obtained by boiling skin, tendons, ligaments, and/or bones with water. It is usually obtained from cows or pigs. Gelatine is used as a thickener for puddings (such as Jell-O), candies, marshmallows, cakes, ice cream, and yogurts. In this study, gelatine is mixed with guyabano fruit pulp, so that the finished candy is more nutritious, and therefore can be used as alternative to normal meals (Cunningham, 2013).

OBJECTIVES

This study ventured to produce gummy candy from the pulp of Guyabano fruit. It sought to identify the ingredients, tools, and equipment to be used in producing the candy, as well as easy to follow procedures. Further, the study sought to determine its acceptability in terms of overall preference, appearance, texture, scent, taste, aftertaste, shelf life, and marketability. This study was conducted at the Food Technology Laboratory of Bohol Island State University of Academic Year 2013-2014.

METHODOLOGY

This is an experimental study where the products are subjected to sensory appraisal. According to Walker (2004), sensory appraisal is a scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of food and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing. The product of this study was subjected to sensory analysis. A total of 100 participants rated the product, 35 of them were teachers and instructors of Food Technology, Technology and Livelihood Education, which were considered as experts in the field; and 65 were students and people from rural community, acting as consumers of the product. After preparing, the finished candies were given to the two groups of participants to test the product. The two groups rated the product using four point hedonic scale sheet. A sensory score sheet of four point hedonic scale was utilized by the participants in rating the product under the following numerical and descriptions: 1-Dislike Very Much, 2- Dislike, 3- Like, and 4- Like Very Much. For purposes of analysis, the following ranges and descriptions were also used: 1.00-1.75, Dislike Very Much; 1.76- 2.51, Dislike; 2.52 – 3.27, Like; and 3.28 – 4.00, Like Very Much.

RESULTS AND DISCUSSION

Ingredients, Tools, and Equipment

Gummy Guyabano Candy was produced by mixing together 2 cups of blended Guyabano pulp, 1 cup of unflavored gelatine, 2 cups of centrifugal sugar, and 2 tablespoons of glucose.

The candy was prepared with the use of a blender, a mixing bowl, a measuring cup, a measuring spoon, a rubber scraper, a wooden ladle, a carajay pan, and a stove. It was prepared by washing the ripe Guyabano fruit, separating skins and seeds, and blending the fruit pulp. In a mixing bowl, fruit pulp, unflavored gelatine, and centrifugal sugar were mixed. The mixture was transferred to a carajay pan and was cooked under moderate heat. When caramelization was almost reached, glucose was then added until reaching the caramelization stage.

Table 1 manifests that the faculty group rated the product as Like Very Much in all sensory attributes with the average numerical rating of 3.52. Among the six sensory attributes, after taste attribute got the highest rating of 3.77, which was Like Very Much. It was followed by taste and overall attributes, the preference results showed a numerical rating of 3.57 and 3.54, respectively; which all were described as Like Very Much. Texture attribute was rated at 3.37. Although, it showed the lowest rating the descriptive rating was still in the Like Very Much range. The faculty group did not like the chewy characteristics of the product.

The students and rural community group gave the product an overall rating of 3.45 with a descriptive rating of Like Very Much. Taste attribute got the highest rating of 3.69. It could be noted that in this candy artificial flavoring was not added so the taste, which the respondents felt, was the natural taste of the fruit. It could be deduced that the respondents liked the sour taste of Guyabano as it was apparent in the finished product. Taste attribute was followed by aftertaste attribute, which had overall preference with numerical ratings of 3.66 and 3.55, respectively. Normally, characteristics of aftertaste attribute are quality, intensity, and duration. Quality describes the actual taste of the food, intensity conveys the magnitude of that taste, and duration describes how long the aftertaste of that food lasts. Foods that have lingering aftertastes typically have long sensation durations. In this study, the taste of the product lingered longer making respondents rate high in aftertaste attribute. The three sensory attributes, which were taste, aftertaste, and overall preference received a descriptive rating of Like Very Much. This result indicated that the product was really acceptable. On the other hand, scent attribute was rated at 3.17 described as Like. This showed that the respondents did not like the smell of the Guyabano which was very obvious in the product. Aside from the rating of 3.17 which was the lowest rating but still under the descriptive rating of like in the scent attribute, the participants commented that they did not like the smell of the finished candy. Usually good food and smell are inextricable bound to one another.

The product of the study although rated very high in taste, aftertaste, and overall preference and was rated low in scent. It was not implied that the finished product was not good but only the respondents did not like the natural smell of the Guyabano.

Talking about the appearance of the finished product, the respondents rated Like Very Much. The appearance of a food or beverage influences crave ability and acceptance, before the product touches the lips (Berry, 2013). This is because "we eat with our eyes before we ever smell or taste" (Shelke, 2010). Visual appeal is why chefs put so much time and effort into plate presentation. "Color and appearance serve to entice the consumer" (Brown, 2012). The product of the study was molded into heart and flower shapes in bite size with golden brown color, which the researcher believed that these factors influenced the rating of the respondents. They liked the size, the color, and the form of the product. It can be gleaned that product characteristics like color, size, and form could attract and of course effected the judgment of the respondents in rating product appearance. When the ratings of two groups were combined, the overall rating of Gummy Guyabano Candy was 3.49 or Like Very Much, despite the low rating of Like in the scent attribute given by the students and community group, which had no effect on the entire rating of the candy.

Table 1 Participants' rating of the product

Sensory attributes	Faculty		Community		Overall rating	
	Rating	Description	Rating	Description	Rating	Description
Overall Liking	3.54	Like Very Much	3.55	Like Very Much	3.55	Like Very Much
Appearance Liking	3.43	Like Very Much	3.38	Like Very Much	3.40	Like Very Much
Texture Liking	3.37	Like Very Much	3.30	Like Very Much	3.33	Like Very Much
Odour Liking	3.49	Like Very Much	3.17	Like	3.33	Like Very Much
Taste Liking	3.57	Like Very Much	3.69	Like Very Much	3.63	Like Very Much
Aftertaste Liking	3.77	Like Very Much	3.66	Like Very Much	3.72	Like Very Much
Overall Rating	3.53	Like Very Much	3.46	Like Very Much	3.49	Like Very Much

Shelf Life of the Product

In testing the product shelf life, the product had been placed in room temperature for two months and daily observations on the product were done and properly recorded. It was observed that the changes in the product took place on the thirtieth day where molds were founded. It could be declared that the product could be good for human consumption for a month. The occurrence of molds in the product indicated that it was no longer good to be eaten. According to Dr. Kung'u (2013), foods or feeds contaminated with mold are risky and should be avoided at all times, eating such foods could result food poisoning due to mycotoxin or bacterial contamination, or both.

Marketability

The product was potentially marketable because when it was displayed in an elementary school, all was consumed in three days for three consecutive weeks. It was sold at two pesos per piece, which was a bit expensive compared to other candies that were two pesos for selling three pieces or fifty centavos for each piece.

CONCLUSION

It can be concluded that Gummy Guyabano Candy can be produced by the rural community as a value added product of Guyabano fruit. It is easy to prepare since the ingredients are locally available in the locality; the tools and equipment are also simple which can be found in kitchen of ordinary households; the preparing procedures are easy to follow. It can be safely concluded that Gummy Guyabano Candy is generally acceptable.

RECOMMENDATION

It is recommended that the product be introduced to local community through the extension function of the university. Since the product contains gelatine, this is not good for vegetarians. There is an alternative chance of marketed gelatine for vegetarians called "agar agar", which is derived from a type of seaweed. Candy can be moulded into smaller size because bigger size can cause choking to smaller children who might wish to eat the candy.

ACKNOWLEDGMENT

This undertaken research comes into fruition with a kind assistance from Bohol Island State University administration, faculty members, and Food Technology students. In particular, the researcher is grateful to Dr. Elpidio T. Magante, CE, Ed.D., University President, for the permission and warm support in the conduct of the study. Acknowledgement is likewise given to the Campus Director Dr. Nelson M. Patena and Mrs. Anelsa B. Sumalinog for research assistance.

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Research article

Heavy Metal Contamination in Meat and Crustaceans Products from Thailand Local Markets

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Received 23 February 2015 Accepted 30 October 2015 (*Corresponding Author)

Abstract The aim of this study was to investigate heavy metal contaminations (cadmium, chromium, and lead) in meat and crustaceans products from three markets of Pathumthani province, Thailand. Heavy metals from beef, pork, chicken, scallop, and prawn were analyzed by using ICP-OES. The results showed that the heavy metal concentrations ranges found in meat and crustaceans' products were 0.002-0.032 mg/kg for cadmium, 0.003-0.040 mg/kg for chromium, and 0.006-0.200 mg/kg for lead. The levels of heavy metal contamination in all products are still below the food safety standard of Thailand. The maximum levels of metals in meat and crustaceans products were found as follows: lead > chromium > cadmium, in the three markets. The results of this study provide valuable information to livestock and aquaculture production for food-safety products, and for protection of human health.

Keywords heavy metals, meat and crustaceans products, local markets, food safety

INTRODUCTION

Human diet, meat, fish, and crustacean's products provide well-known proteins, minerals, vitamins, and trace element contents. Concerning about the effects of anthropogenic pollution, and heavy metal contamination, it is a serious threat because of the toxicity, bioaccumulation, and biomagnification in food chain (Eisler, 1998). Not only do heavy metals have important positive roles in human life, but also there are negative roles as well. Some of the heavy metals are considered essential, and these include iron, zinc, and copper, while some other metals such as mercury, cadmium, lead, and arsenic have toxic roles in biochemical reactions of our body (Divrikli

et al., 2006). Non-essential elements such as Pb, Cd, Cr, Ni considered as toxic and their presence in the body can cause profound biochemical and neurological changes in the body (Nielsen, 1982). All metals are toxic at certain levels of intake, however, in contrast to elements such as arsenic chromium, copper, selenium, and zinc that have useful biological functions, cadmium, lead, and mercury play no useful role and their intake should be limited to avoid organ damage (Parekhan et al., 2014; Kramer et al., 1983).

In recent years, there are several studies that focus on the contamination of heavy metals, pesticide, and other toxic in raw food and environment (Iwegbue et al., 2008; Khalafalla et al., 2011; Pakvilai et al., 2012; Hussain et al., 2012; Aitbek, 2013). Samples of beef, veal, pork, chicken, and horsemeat were analyzed for Ca, Cu, Fe, Mg, Mn, Ni, Zn, Cd, and Pb by Hecht and Kumpulainen (1995). Furthermore, Mn, Cu, Zn, Cd, Hg, and Pb concentrations were determined in liver, kidney, and muscle meat of ducks, geese, chicken, rabbits, and sheep slaughtered in northern of Poland (Falandysz, 1991). Under certain environmental conditions, heavy metals might accumulate up to toxic concentrations. Thus, heavy metals acquired through the food chain, as a result of pollution, are potential chemical hazards threatening consumers.

The aim of this study was to assess heavy metal contamination, including Cd, Cr and Pb concentrations, in meat and crustaceans products from local markets in Pathumthani province, Thailand. Moreover, the data were assessed by comparing with the food safety standard of Thailand.

OBJECTIVE

The purpose of this work was to investigate heavy metal contaminations in meat products which were purchased from three local markets in Pathumthani province, Thailand.

METHODOLOGY

Sample Collection

A total of 45 samples of meat and crustaceans products (beef, pork, chicken, scallop, and prawn) were collected randomly from local markets in Pathumthani province. At each location, meat samples were collected from three different local markets to provide replicate samples of each meat. According to their types, all collected samples were stored in clean polythene bags and brought to the laboratory for preparation and treatment. All samples were stored at -10^{o}C until analysis (Parekhan et al., 2014).

Sample Preparation

Before being analyzed, meat and crustaceans products samples were put outside to melt at a room's temperature. All samples were washed with distilled water to remove any contaminated particles. Then samples were chopped to small pieces using a ceramic knife, thoroughly mixed; weight 1-gram of meat was placed in a test tube for the analysis. The meat was later digested by 5 ml concentration nitric acid (69%) in a water bath at 80^{o}C for 15 minutes and cooled down to room temperature; the samples were dried in an oven at 135^{o}C and cooled down to room temperature. One milliliter of Hydrogen peroxide acid (30%) was added and then filtered the supernatant using No.1 and No.48 filter paper.

The complete volume of the final solution was 50 mL in volumetric flask, and the determination of heavy metal was conducted using an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) ULTIMA2, HORIBA scientific, FRANCE. The samples were analyzed in triplicated. A statistic using scientific program was used to calculate standard deviation and

meanvalues. Linear regression equations and regression coefficients (R^2) of standard are presented in Fig 1.

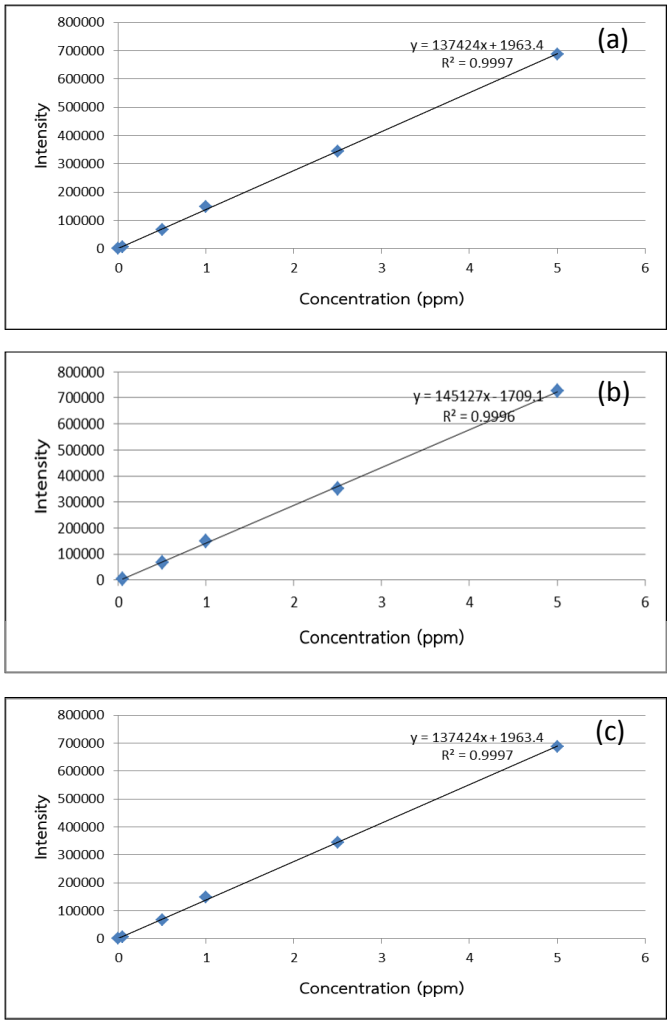

Fig. 1 Calibration curve for determination of (a) cadmium (b) chromium (c) Lead

RESULTS AND DISCUSSION

The result for determination of the heavy metal residues in wet weight are shown in Table 1. Meat and crustaceans products residue samples shown in Table 1 representing the heavy metals ranged from 33 to 100% of samples analysis while the samples were detected 100% of chromium and lead. Cadmium found 33 % in pork, 44 % in scallop and prawn, and 56% in beef, respectively.

Table 1 Positive percentage of heavy metal residues in meat product samples

Meat and crustaceans products	Cd	Cr	Pb
Beef (n=9)	56	100	100
Pork (n=9)	33	100	100
Chicken (n=9)	nd	100	100
Scallop (n=9)	44	100	100
Prawn (n=9)	44	100	100

The result of the study showed that 33-100% of Cd, Cr, and Pb concentrations were found in all meat products, Cd concentration was not found in chicken. Although, their concentrations are below the food safety standard of Thailand, heavy metals can be harmful due to their potential to accumulate in different parts of human body. Even in low concentrations, they can cause adverse health effects (Ikeda et al., 2000). Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage, and reproductive deficiencies (Commission of European Communities, 2001). Lead is known to induce reduced cognitive development and intellectual performance in children, and increased blood pressure and cardiovascular disease in adults (Commission of European Communities, 2001). Chromium is an essential element helping body to use sugar, proteins, and fat; at the same time it is carcinogenic for organisms, thus excessive amount of Cr may cause adverse health effects (Parekhan et al., 2014).

Table 2 Mean concentration and standard deviation of heavy metal in meat and crustaceans products samples (mg/kg)

Meat and crustaceans products	Cd	Cr	Pb
Beef (n=9)	0.024±0.018	0.020±0.010	0.040±0.049
Pork (n=9)	0.008±0.004	0.019±0.009	0.032±0.034
Chicken (n=9)	nd	0.015±0.008	0.032±0.018
Scallop (n=9)	0.004±0.003	0.018±0.007	0.167±0.096
Prawn (n=9)	0.009±0.006	0.029±0.014	0.100±0.091

In Table 2, the results are presented as mean concentrations of a triplicate analysis of the sample extracted. The Cd concentrations ranged from 0.004±0.003 to 0.024±0.018 mg/kg. Among the analysis of meat and crustacean product, the highest Cd level was found in beef sample at 0.024±0.018 mg/kg but not found in chicken. The Cd concentration followed the order: beef > prawn > pork > scallop. The study of Rahimi (2013) determined the Cd concentrations in goat, cow, sheep, and buffalo milks collected from different regions in Iran. The study reported the amount of 0.74 ng/mL. Another study of Pimonwan (2009) reported that the Cd concentration in seafood from Maung district, Rayong province ranged from 0.009 to 0.31 mg/kg. But in comparison of a maximum Cd content of 0.05-0.1 mg/kg of the European Union (2008), the Cd content of this study was exceeded the standard allowance. In general, Hech (1983) stated that Cd concentrations in meat increased with the age of animal and depended on the concentrations of Cd in the feed.

According to analyzed data presented in Table 2, the results ranged from 0.015±0.008 to 0.029±0.014 mg/kg of Cr concentration. Prawn was found the highest Cr level at 0.029±0.014 mg/kg, while the Cr concentrations of other products were prawn > beef > pork > scallop > chicken. The Cr values of the study were below those reported of Kwon and Lee (1999) at 0.18 to 0.25 µg/g of fish tissue in Masan Bay, Korea. Although, Cr^{3+} is an essential element that helps the body use sugar, proteins, and fat; at the same time Cr^{6+} is carcinogenic for organisms (Institute of Medicine, 2003).

Lead is a toxic element that has no biological role and cause carcinogenic effects in marine biota and humans. From the present study, Pb concentration had the highest concentration in the samples as compared to the other elements. The Pb concentration in meat and crustaceans products ranged from 0.032±0.018 to 0.167±0.096 mg/kg. Scallop was found to have the highest Pb value at 0.167±0.096 mg/kg. The concentrations of Pb for other products were scallop > prawn > beef > pork, and chicken. The Pb concentration in scallop (0.167±0.096 mg/kg) was similar to the study of Sankar et al. (2006), which reported that Pb value of *J. dussumerri* was at 0.13 mg/kg. In addition, the study of Sivaperumal et al. (2007) recorded 25% of Pb concentrations in finfish, shellfish, and other fishery products from the EU's Indian coast. However, the EU's acceptable limit for Pb

concentration is 0.5-1.0 µg/g. The Pb concentrations of this study were found to be lower than the acceptable limit suggested by the European Union (2008).

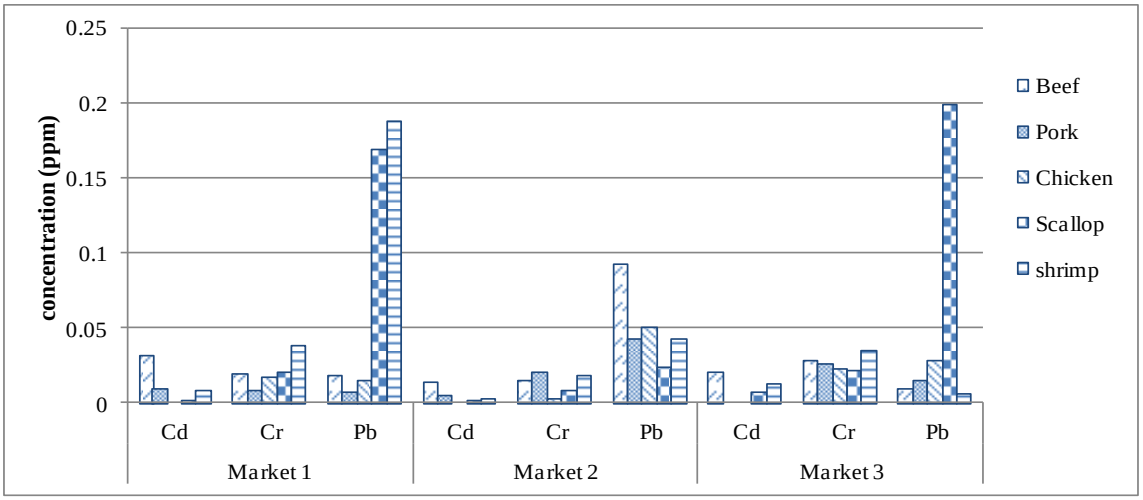

Fig. 2 Comparison of heavy metal residues in meat samples

Fig. 2 shows of the heavy metal comparison by type and market location. Lead presents a higher concentration than another compound in scallop of market 1 and 3, and prawn in market 1. Within prawn samples, it was found higher chromium in markets 1 and 3 than in market 2. Market 3 was found to have higher chromium than other markets except in prawn from market 1. From the study, the Pb levels of all samples were higher than other heavy metals trace. The result of this study indicated that the problem of Pb in food is more widespread.

CONCLUSION

The levels of heavy metal contaminations in meat and crustacean's products from Thailand local markets were determined and assessed by comparing contamination levels with permissible limits of the food safety standard of Thailand. However, all the heavy metal levels of this study were below the allowance of the food safety standard of Thailand. It is necessary to assess human exposure to these vital metals through food consumption, as human is one of the top most consumers in the ecosystem.

ACKNOWLEDGEMENTS

We are grateful to Miss Sureerat Phonmasri for her assistance in sample collection and work in laboratory for ICP-OES analysis Integrated Water Resource Management Research and Development Center in Northeast Thailand, Khon Kaen University, Thailand.

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Research article

Comparative Spatial Assessment of Regulating and Supporting Ecosystem Services in Nay Pyi Taw, Myanmar

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Received 13 December 2014 Accepted 31 October 2015 (*Corresponding Author)

Abstract Rapid urban development may induce deterioration in biodiversity and ecosystem services (BD/ESs) at the global scale. According to Millennium Ecosystem Assessment (MA) 2005, it is well known that biodiversity provides benefits in the form of ESs. In particular, four types of ESs (namely, provisioning, regulating, supporting, and cultural services) were defined in a previous study. Here, a case study was conducted in Nay Pyi Taw, Myanmar. First, the primary unit values of each ES were obtained based on a literature review. Second, by utilising a satellite image of Nay Pyi Taw from the Advanced Land Observing Satellite, land-use types were classified into five categories: forest areas, urban areas, agricultural land, water areas, and bare land. Then, the unit values of each ES were applied to develop seven types of ESs and habitat maps and a priority layer map was created using the Zonation software. The results revealed the spatial distribution of ESs and the priority areas for conservation. In future, this method can be used to consider a wider range of ESs.

Keywords ecosystem services, land-use, zonation, Myanmar, biodiversity

INTRODUCTION

Ecosystem services (ESs) are the benefits provided by ecosystems and can be classified into four types according to MA (2005): provisioning, regulating, supporting, and cultural services. ESs can help for not only the environment, but also human's livelihoods. During the last decades, ESs has been destroyed owing to development and increased economic and societal prosperity (MA, 2005). So the methods to identify priority areas for the provision of ESs need to be developed (Casalegno et al., 2014). Although scientific and political interest in ESs has increased, there are gaps in knowledge of the spatial distribution of ESs (Garcia-Nieto et al., 2013). In this context, spatial assessment of ESs provides some indication of the role of spatial flows in the delivery of ESs (Serna-Chavez et al., 2013). Although many studies have been conducted to assess ESs globally, few such studies have focused on Myanmar, where 68% of the population live in rural areas (World Bank, 2012). This rural population typically relies on ESs such as firewood, wood, food, etc. A new capital city, Nay Pyi Taw, was developed in Myanmar in 2006, with degradation of ESs occurring in the region during the course of the development. Accordingly, an understanding of the characteristics of ES provision is important for conservation in this region.

OBJECTIVE

The present study aims to understand the status of ES provision for different land use types in Nay Pyi Taw, Myanmar. To achieve this, spatial analysis of ESs was conducted for the region. In mapping ESs, land use/land cover classification was undertaken to help assess ES provision.

MATERIALS AND METHODS

Study Area

Myanmar, which was formerly known as Burma, is a country in Southeast Asia. Nay Pyi Taw (19°44′40.3"N, 96°07′46.1"E; city hall in Nay Pyi Taw) is a new capital city in Myanmar and was founded in 2006 in a previously undeveloped area. The city lies at elevations of 0-500m and has slope conditions of approximately 1-20° (FAO, Myanmar country profile). Its population is approximately 1,558,367 as of 2014 (Department of Population, 2014), and it covers a total area of 7,054.37 km^2.

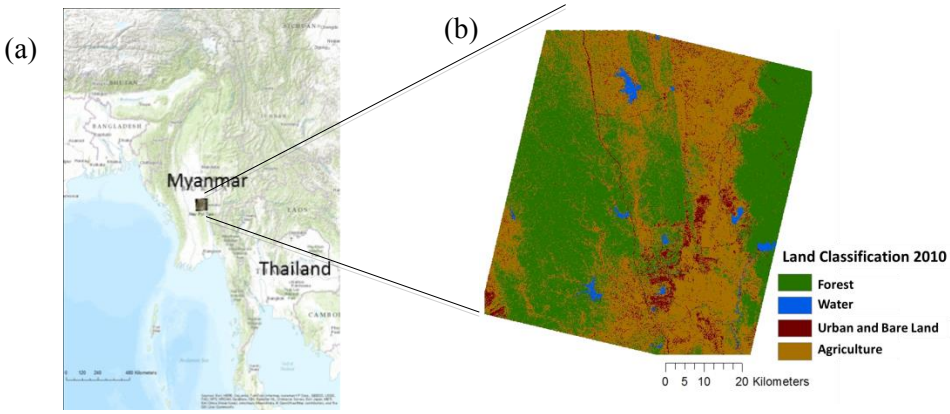

Fig. 1 (a) Location map of Myanmar and study area and (b) land use/land cover classification map produced by the authors of the present study
Source: satellite image by JAXA/Distribution RESTEC

Research Flow

In the present study, the Advanced Visible and Near Infrared Radiometer type 2 (ANVIR-2) of the Advanced Land Observation Satellite (ALOS, dated 20101110) was used to classify land use types in the ERDAS Imagine software version 2014 (Intergraph Corporation) and accuracy assessment was conducted. Second, primary unit data for several ESs were collected and then applied to the land classification maps using the ArcGIS10.1 software (ESRI). Third, seven ES maps were developed and a priority layer map was made using Zonation (Lehtomaki and Moilanen, 2013).

Land Use/Land Cover Classification of Satellite Image

Different land use types have different functions and capacities to provide ESs (Burkhard etal., 2012). Land use classification was conducted using satellite image and was classified into five land use types using the ERDAS IMAGINE: forest areas, agricultural land, urban areas, water bodies,

and bare land (Fig. 1 (b)). The land use classification was conducted using a supervised classification method, which is a type of land use classification that uses maximum likelihood criteria as parametric rules. The overall accuracy assessment of the land classification was approximately 91% by comparing with Google earth in ERDAS Imagine software and 2010 forest cover map of Myanmar (Forest Department, FRA 2010) in ArcGIS 10.1.

Literature Survey of Ecosystem Services Unit Value

The area-based primary unit values for each ES were obtained based on a literature survey (Table1). In particular, unit values regarding provisioning services, regulating services, supporting services, and habitat were collected. For provisioning services, the unit value of agricultural products (such as rice and pulses) was collected. For regulating services, CO_2 absorption, soil erosion control, and water infiltration were selected. For the soil erosion data, low values were considered favourable and high values were unfavourable; this is in stark contrast to the other ESs considered. Accordingly, the soil erosion data were inversed before being used for analysis. The unit of water infiltration was mm/h and the percentage of water infiltration by different land use types was calculated by using unit value of water infiltration. For supporting services, carbon stock, and gross primary production (GPP) were selected. According to Rui (2014), Green Distance Index (GDI) evaluates how much green area is concentrating in each cell for habitat distribution and the GDI is calculated from Green Index (GI) which extracts forests and water as green areas and assigns it as "255" and other land use as "0". Data describing the primary unit values of ESs in Myanmar were limited for this analysis. In the unit value of ESs in this study, the unit values of carbon stock and agricultural product (food production) were the data of Myanmar. The other unit values were for other Asian countries in which the forest types, the elevation, and the slope conditions were similar to Nay Pyi Taw Area and were used in this study.

Table1 Types of ESs and primary unit value of ESs in this study

Types of ecosystem services	Forests	Agricultural Area	Urban	Water	Bare Land	Source
Supporting Services:						
GPP (t/ha/yr)	30.7	12.093	0	0	0	Chen etal. (2013), Hirata et al. (2013)
Carbon stock (t/ha)	433.7	31.02	0	0	0	Oo (2009), Takeuchi (2012)
Regulating Services:						
CO2 absorption (t/ha/yr)	2.737	3.250	0	0	0	Chen et al. (2013)
Soil erosion factor (t/ha/yr)	0.038	3.9	31	0	94.5	Sidle et al. (2006)
Water infiltration (mm/h)	100	38.5	2	15	2	Chaplot et al. (2002)
Provisioning Services:						
Agriculture Products (t/ha)	-	5.38	-	-	-	FAO (2009)
Habitat (GDI)	-	-	-	-	-	Rui (2014)

Mapping using Arc GIS

Spatial analysis was conducted using ArcGIS to understand the spatial distribution of ES provision and its relationship to land-use type. To develop seven ES maps, the land-classified map and the unit values of ESs for each land use type were used. Before applying unit values for the land classification mapping, a grid with a mesh size of 1 km ×1 km was developed for the land classification map.

Determination of Priority Areas for Conservation

Zonation is an approach and software for spatial conservation prioritisation, and is used primarily for the efficient and effective allocation of conservation action. Spatial conservation prioritisation is also a form of conservation assessment (Knight et al., 2006) and incorporates decision support for conservation planning (Ferrier and Wintle, 2009). Zonation firstly sums the value of each ES layer and discards the least valuable cell one by one until all cells are removed. Zonation includes four types of cell removal rules, namely, core area zonation, additive benefit function (ABF), target-based planning, and generalised benefit function; moreover, many parameters are available for analysis (Moilanen et al., 2012). Of the available rules, the present study used ABF to account for the proportions of all map layers proportions in a given cell. ABF tends to produce a higher average proportion of feature distributions retained. To weight the ESs in this Zonation analysis, equal weights were selected for all ESs. Moreover, although the units of the ESs were different, the normalisation of data was conducted automatically by Zonation. By using ABF, the present study achieved the best performance on average for all features or ESs. The main result of this Zonation analysis was a priority ranking map for the entire landscape.

RESULTS AND DISCUSSION

In the present study, GIS-based spatial analysis was conducted for the assessment of ES provision for different land use types. Fig. 1 (b) shows that forest and agricultural land were the dominant land use types in the study area, whereas Fig.2 demonstrates the spatial distribution of ESs in the Nay Pyi Taw region.

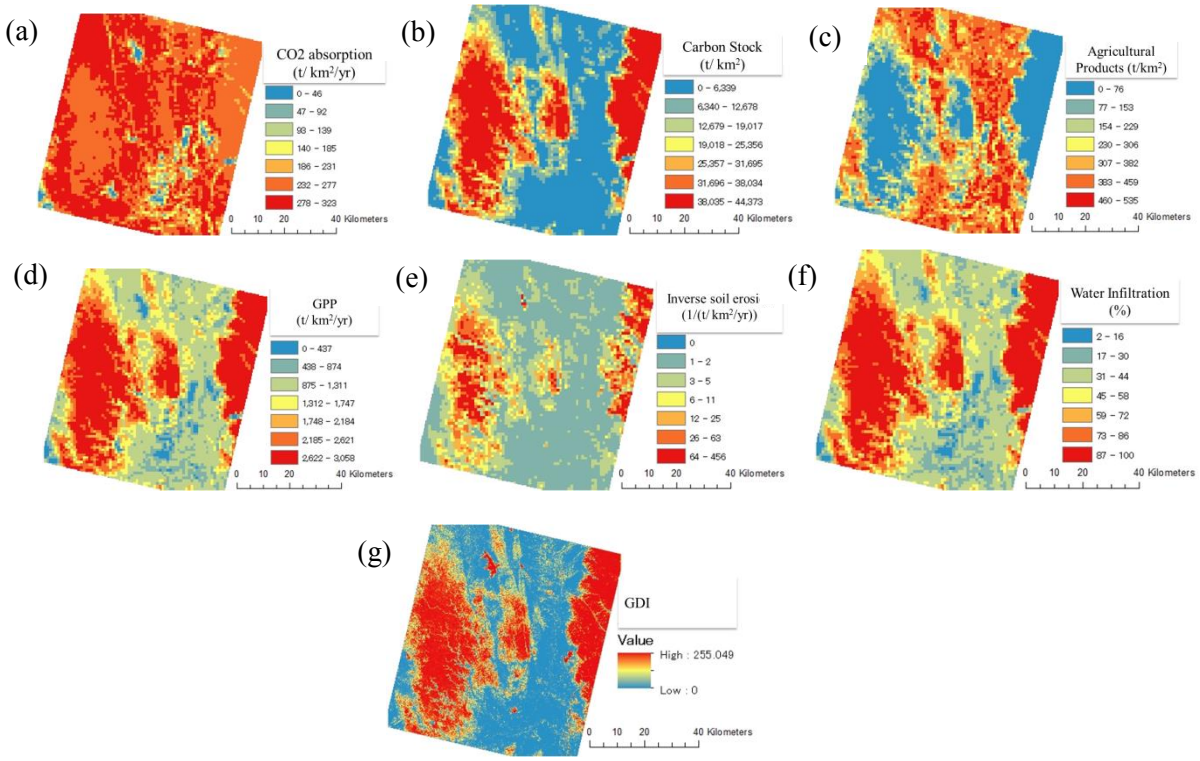

Fig. 2 Maps of seven ESs in Nay Pyi Taw, showing (a) CO_2 absorption, (b) carbon stock, (c) agricultural products, (d) GPP, (e) soil erosion control, (f) water infiltration and (g) habitat (GDI)

In Fig. 2, the red and blue colours indicate high and low values, for ES provision. Overall, relatively high provisions of ESs, except agricultural products and CO_2 absorption, were found in forest areas. Fig. 2 (a) and (c) illustrate the high provision of CO_2 absorption and agricultural products in agricultural areas. In particular, the map in Fig. 2 (a) indicates that agricultural land had a net uptake of atmospheric CO_2. Chen et al. (2013) noted that the carbon sink function of Asian cropland was likely related to cropland management practices and cropping systems that supplied adequate nutrients, abundant residues, and organic matter to the soil. This explains the high rates of CO_2 absorption for these agricultural areas. Fig. 2 (b, d, e, f, g) shows the ES provision of carbon stock, GPP, soil erosion control (inversed value), habitat, and water infiltration. In particular, Fig. 2 (g) shows that habitat is the greatest in the mesh dominated by forest and water areas. For habitat, GDI was calculated by extracting the forests and water areas as green area because those areas were good for habitat of the wildlife. In supporting and regulating services, all of ESs provision is high in the forest areas. So, the forests are the most important area to conserve to provide ESs and conservation activities of forests need to be promoted to be sustainable use of ESs.

The main output of the Zonation analysis was a priority rank layer map (Fig. 3 (a)). These results show the important areas in terms of ES provision, with the priority rank of the site illustrated by a colour scale. The most important and valuable areas in terms of the potential distribution of ESs and conservation of ESs are shown in Fig. 3 (a), and these data were derived from the Zonation analysis. In Fig. 3 (a), the dark red color represents the top priority areas for conservation and the violet color represents the lowest priority areas. In Fig. 3 (a), the top priority areas were mostly forested areas and the areas located close to forest areas had relatively high priority. It is well-known that forest ecosystems are the main providers of ESs. Therefore, it makes sense that forested areas were identified as the top priority areas for the conservation of ESs. In general, the lowest priority areas were urban developed areas and bare land. Priority maps were made to identify the most important areas for ES conservation; many of this land consisted of forested areas. Fig. 3 (b) and (c) illustrate another output of ZONATION analysis and Fig. 3 (b) shows the performance of each ESs during prioritization analysis; and Fig. 3 (c) shows the performance of minimum, maximum, and average distribution of all ESs. Fig. 3 (b) represents that according to the algorithm of prioritization analysis, the lowest valuable cells were firstly removed and the highest were removed lastly until no cell remains. The horizontal line of Fig. 3 (b) means the percentage of the removal of cells (landscape) and the vertical line means the remaining percentage of each ESs when cells are removed. In horizontal line, "1" means 100% of landscape which means "there is no removal of cells" and the dotted line represents the 20% remaining of landscape before all cells are removed. When the 20% of landscape were remaining, the proportion of agricultural product was nearly 10% and of soil erosion remained nearly 90%. Fig. 3 (b) and (c) are not the main results of the analysis and can not be used as effective results. The main result of this analysis is presented in Fig.3 (a) priority rank map.

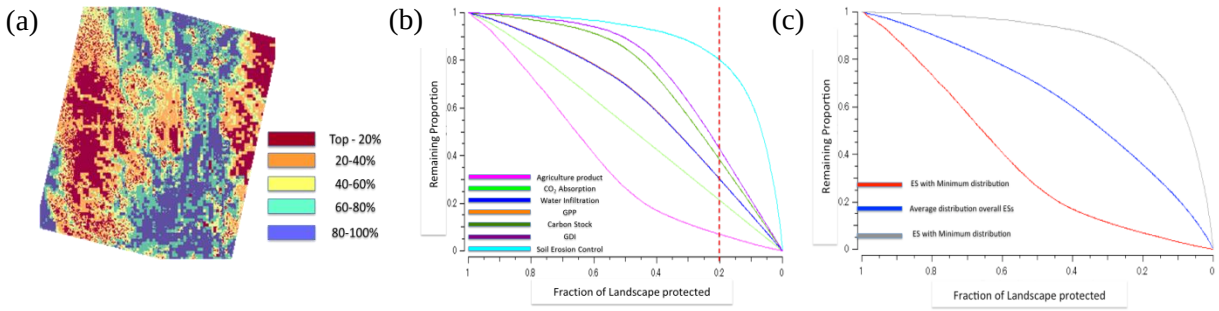

Fig. 3 Results of Zonation analysis showing (a) priority rank map and (b), (c) performance curves, the top 20% of priority areas remain at a level of 0.2 (vertical dashed line)

Finally, using the Zonation conservation planning tool, the priority areas for ES provision were determined. Based on the results of the present study, this method will be useful in determining the conservation areas required for ESs and in selecting habitat for multiple biodiversity conservation.

CONCLUSION

Land use change and urban development are likely to accelerate in the coming years. Therefore, the protection of BD/ESs will become increasingly necessary, particularly in urban areas. In the present study, according to the resulted land use map, the study area is covered primarily by forests and agricultural areas. Based on the results of mapping of ES unit values, forest and agricultural areas had the highest provisions of ESs. Furthermore, according to the Zonation results, the high priority areas should be conserved for the sustainable use of ESs in the future. And then, the priority maps should be useful for land use planning, policy development, and protected areas establishment in the Nay Pyi Taw region. Also, by using these results, we can remind not to extend the development activities in the priority areas of ESs provision.

ACKNOWLEDEGMENTS

This work was performed by using the fund from the EcoTopia Science Institute, Nagoya University.

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Research article

Comparison of Semi-Quantitative and Statistical Regression Models in Assessing Landslide Prone Areas in Wahig-Inabanga Watershed, Bohol, Philippines

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Received 3 March 2015 Accepted 10 November 2015 (*Corresponding Author)

Abstract The study attempted to compare and evaluate the two landslide hazard assessment models, semi-quantitative (index-based) and statistical regression (bivariate statistical analysis and logit regression) in predicting landslide prone areas in Wahig-Inabanga Watershed, Bohol, Philippines. This was performed by comparing the predictive power of each model based on the frequency distribution of past landslide events. Findings revealed that the combined bivariate statistical analysis and logit regression model outdone index-based method in predicting landslide occurrences. Results indicated high prediction accuracy on statistical model greater than the 75% threshold level set for evaluation on both pooled moderate to very high hazard zone and the combined high and very high hazard zone with accuracy values of about 83.82% and 76.72%, respectively. Conversely, the semi-quantitative model failed to meet the accuracy threshold. The study showed that statistical regression model, though relatively difficult to implement, can be a better substitute to the most commonly used semi-quantitative method as a decision-support tool for watershed management and land use planning in relation to landslide risk mitigation, reduction, adaptation, and management.

Keywords bivariate statistical analysis, landslide hazard, logit regression, semi-quantitative method

INTRODUCTION

Several computer-based tools are found useful in landslide prediction, hazard assessment, and mapping especially when these tools are made use in tandem with geographic information system (GIS). GIS serves as an indispensable tool for mapping areas prone to unpredictable hazard events, particularly landslides. One of the best advantages of using this technology is the possibility of improving hazard occurrence models by evaluating results and adjusting the input variables (Lanuza, 2008).

There are several methods used in landslide hazard assessment. Ayalew et al. (2005) and Reyes (2014) briefly discussed each method and grouped them into three major categories: semi-quantitative, quantitative, and hybrid. According to Ayalew et al. (2005) and also cited by Reyes (2014), some of the methods are simple, especially those which rely on subjective assessments. Others, however, depend on complex mathematical concepts and are difficult to understand. Some old approaches have long disappeared, others underwent a sort of refinement, and new methods are always coming. Many of the latest methods are not yet available in known commercial GIS packages either as built-in functions or additional modules. Data, then, are usually transformed to external software products for core analyses.

The semi-quantitative method is the collective process of index and overlay analysis, thus termed "index-based method". It is also called as expert-driven (Zhu and Huang, 2006) in which expert opinions make great difference and become the basis during assessing of the type and degree

of any natural hazard. In the Philippines, it is commonly used in provincial and municipal local government units for disaster risk reduction and management and even recommended by the Department of Environment and Natural Resources (DENR) to be a decision-support tool in forest management and conservation planning. A vulnerability assessment manual adopting this method has been prepared by the Ecosystems Research and Development Bureau (ERDB) and made available for public use since 2011.

On the other hand, the statistical regression model, uses logit regression to develop a functional relationship between a process and factors inherent in them. The applications of this model in the field of slope instability have evolved as an important tool, with specific reference to landslide hazard mapping. In landslide hazard mapping, an area is classified according to relative classes of instability on the basis of the degree of occurrence of landslide and mass movements (Jade and Sarkar, 1993).

In this study, both methods were applied for landslide hazard assessment in Wahig-Inabanga Watershed, Bohol, Philippines to determine which between the two models is more appropriate in predicting future landslide events based on the frequency distribution of past landslide occurrences.

METHODOLOGY

Landslide Hazard Mapping using Semi-quantitative (index-based) Method

The landslide hazard map prepared using the semi-quantitative method, particularly the index-based, was completed following the procedures suggested by the ERDB-DENR in its vulnerability manual published in 2011. It involved division of pre-defined landslide-related instability factors such as slope, soil type, rainfall, lithology, and land use into 5 classes using a set of criteria that influence vulnerability of the study area to landslide. These criteria were also used in assigning class ratings. The most influential class trait was given the highest rating of 1, while the least influential was rated 0.

This was followed by overlaying of instability factors based on desired factor weights. Weights used were 0.35 for slope, 0.20 for both rainfall and geology, 0.15 for land use, and 0.10 for soil type.

Landslide Hazard Mapping using Logit Regression (Combined Bivariate Statistical Analysis and Logit Regression) Model

The statistical regression model, same with the index-based method, also necessitated factor and class weighing. Bivariate statistical analysis was used to determine class weights, while logit regression allowed the computation of factor weights. However, the logit regression, unlike semi-quantitative method, required the utilization of landslide inventory or landslide occurrence map (van Westen, 1994 as cited by Wahono, 2010) to implement factor and class weighing. This means that factor and class weights are dependent on the landslide inventory and not on pre-defined vulnerability or susceptibility criteria. To do this, the landslide inventory map was overlaid with nine significant landslide-related instability parameters like elevation, slope, aspect, lithology, distance from fault line, distance from rivers, distance from roads, rainfall, and land use. Landslide pixels laid on each class of instability factors were computed as landslide frequencies. These frequencies served as class weights and were used as class numerical values in logit regression. Important outputs of logit regression in SPSS included regression coefficients of all parameter considered as factor weight and the model prediction probability.

Details on how these two maps were generated are discussed in the DENR Vulnerability Assessment Manual (ERDB, 2011) for the index-based method and the works of Reyes (2014),

Ayalew et al. (2005) and Ayalew and Yamagishi (2005) for the logit regression with bivariate statistical analysis referred in their reports as quantitative method.

Comparison of the Two Models

Model comparison was performed to determine which of the two approaches was more reliable in landslide hazard prediction. Comparison was based on the frequency distribution of past landslide events [=pixels] rested on the pooled upper moderate to very high hazard zones [$P(Y=1) \geq 0.5$ logit regression default cut-off value] and the combined zone rated as high and very highly [$P(Y=1) \geq 0.6$] prone to landslide occurrences using the 75% model prediction accuracy threshold. This was done by applying the overlay and extract by sample function in spatial analyst tool of ArcGIS.

RESULTS AND DISCUSSION

Landslide Hazard Assessment

Semi-quantitative method: Table 1 presents the summary results of landslide hazard assessment using the semi-quantitative method. Based on Table 1 and depicted in Fig. 1, the biggest part of the watershed, about 71.50% or 44,540 ha, was predicted moderately prone to landslides. Considerable areas had estimates of low (10,400 ha) and high (7,338) hazard ratings, while very small areas of the watershed were estimated very low (4 ha) and very high (13 ha). From these results, it appears that the semi-quantitative method overestimated the moderate landslide hazard zones and underestimated the very low and very high landslide hazard areas. As shown in Fig. 1, most of the relatively flat areas in the watershed fell within the moderate landslide hazard zone.

Table 1 Landslide hazard class ratings, area of coverage (ha) and percent distribution generated using semi-quantitative method

Class Range	Rating	Area (ha)	Percent (%)
< 0.2	Very low	4	0.01
0.2-0.4	Low	10,400	16.69
0.4-0.6	Moderate	44,540	71.50
0.6-0.8	High	7,338	11.78
> 0.8	Very high	13	0.02
Total		62,295	100

Table 2 Landslide hazard class ratings, area of coverage (ha) and percent distribution generated using statistical regression model

Class Range	Rating	Area (ha)	Percent (%)
< 0.2	Very low	38,180	61.29
0.2-0.4	Low	10,360	16.63
0.4-0.6	Moderate	6,692	10.74
0.6-0.8	High	4,101	6.58
> 0.8	Very high	2,962	4.75
Total		62,295	100

Statistical regression model: Table 2 shows the landslide hazard class ratings generated using the statistical regression model, and their corresponding area (ha) and percent distribution. Results indicate that more than 60% of the total area of the watershed (about 38,180 ha) was identified to

have very low probability of landslide occurrence. About 16.63% or 10,360 ha had low landslide hazard, while roughly 6,692 ha or 10.74% was estimated to fall under the moderate landslide class. Conversely, high and very high landslide ratings were predicted for areas mostly situated on the upper elevations of the watershed (Fig. 2) having 4,101 ha and 2,962 ha, respectively.

The results show a decreasing area distribution against the increasing vulnerability of the area to landslide.

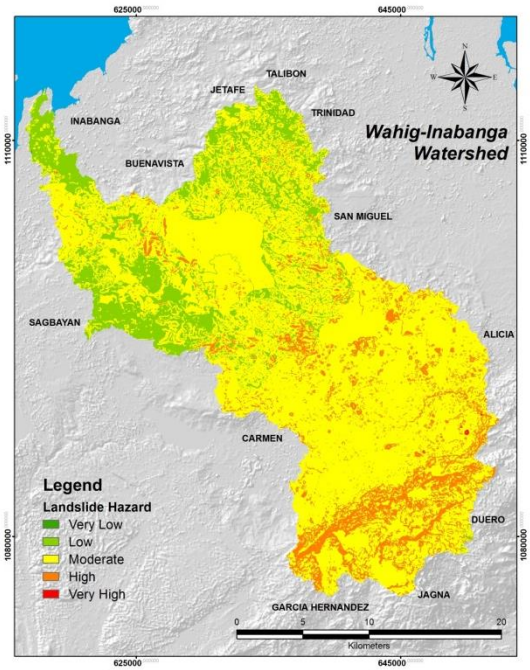

Fig. 1 Landslide hazard map generated using semi-quantitative method

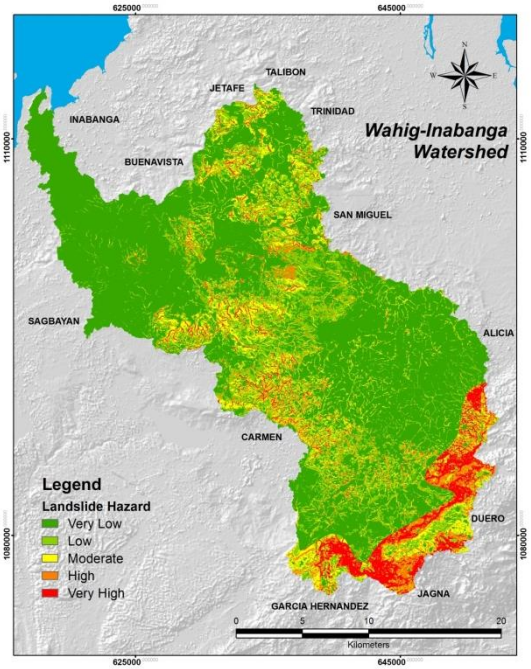

Fig. 2 Landslide hazard map generated using the statistical regression model

Table 3 Comparison of two models showing the frequency distribution of landslide pixels in different hazard classes

Hazard		Statistical regression		Semi-quantitative	
Class range	**Rating**	**Frequency**	**Percent**	**Frequency**	**Percent**
< 0.2	Very Low	83	4.39	0	0.00
0.2-0.4	Low	124	6.56	48	2.54
0.4-0.6	Moderate	232	12.27	1,005	53.15
0.6-0.8	High	364	19.25	772	40.82
> 0.8	Very High	1,088	57.54	66	3.49
Total		1,891	100	1,891	100

Method Comparison

Table 3 indicates the result of the landslide inventory layer and the landslide hazard maps overlay. It is noticeable that there was a direct agreement between the landslide frequency (= number of pixels lying on each hazard class) and the hazard zones for the statistical regression model, a characteristic of an ideal method (Fig. 3). The highest landslide frequency of 1,088 or 57.54% was

obtained from the very high landslide hazard zone. This was followed by high and moderate hazard zones with 364 (19.25%) and 232 (12.27%), respectively.

Conversely, the distribution of landslide pixels was variable among the hazard zones of semi-quantitative model, thus no relationship was observed. The result on Table 3 clearly shows that most of the landslide pixels were found on moderate (1,005 or 53.15%) and high (772 or 40.82%) landslide hazard zones, while only 66 pixels (3.49%) fell on very high hazard zone.

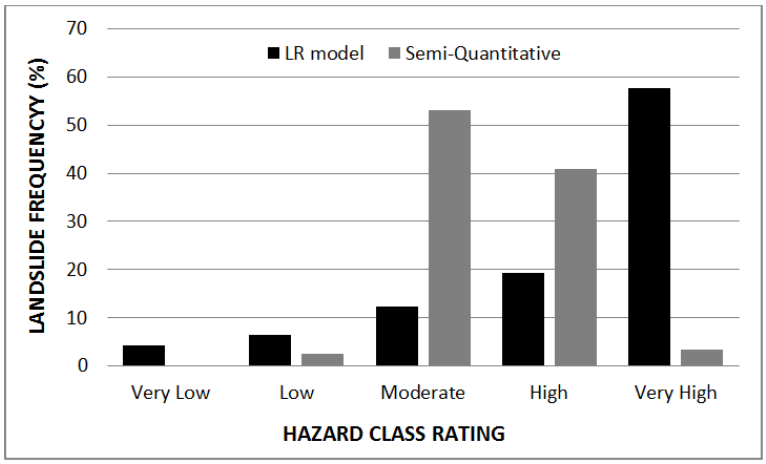

Fig. 3 Comparison of two models based on the percent distribution of landslide pixels in different hazard classes

A process of combined zonation (combining classes) was also used to clearly evaluate the predictive power of each model. The combined zone is referred to as unstable zone (=area) in the study of Dhakal *et al*. (2000) such as the pooled upper moderate to very high hazard, and the high and very high landslide hazard classes. Table 4 reveals the result of the model comparison based on the computed landslide frequency on these combined zones. Compared to the semi-quantitative method, statistical regression model, at par, had higher prediction accuracy values of 83.82% and 76.72% [both greater than the 75% threshold level] based on the frequency and percentage of landslide events that fall on moderate to very high [$P(Y=1) \geq 0.5$] and high and very high [$P(Y=1) \geq 0.6$] hazard zones, respectively.

Table 4 Comparison of two different models showing the frequency distribution of landslide pixels

Model	P(Y=1) ≥ 0.5*		P(Y=1) ≥ 0.6**	
	Frequency	Percentage	Frequency	Percentage
Semi-Quantitative	1,386	73.29	838	44.32
Statistical Regression	1,585	83.82	1,452	76.78

*Note: * = default logit regression cut-off value in SPSS; upper moderate to very high hazard zone*
*** = areas rated as high and very highly prone to landslide*

With lower computed prediction accuracy, the semi-quantitative method, unfortunately, failed to meet the threshold level set for acceptability which only means that this method is not suitable for landslide hazard assessment and mapping particularly in Wahig-Inabanga Watershed. The statistical regression model, then, becomes a better alternative method and substitute to semi-quantitative or index-based method.

CONCLUSION

Based on the findings of the study, it is concluded that the statistical regression method is a better option to use when assessing landslide hazards in Wahig-Inabanga Watershed, Bohol, Philippines. The advantage of applying a bivariate statistical analysis provided numerical values on instability factor classes which were used in determining factor weights through logit regression. The idea of factor weighing in logit regression is to find the best fitting function in defining the relationship between the presence or absence of landslides and a set of landslide-related instability parameters. The objectivity of logit regression method in determining the significance of instability parameters in landslide prediction is wanting in semi-quantitative or index-based method.

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Research article

Farm Machineries and Equipment Needs Assessment of the Corn Block Farming in Dagohoy, Bohol, Central Philippines: Basis for Financial and Support Services

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Received 28 February 2015 Accepted 30 November 2015 (*Corresponding Author)

Abstract To increase production, land productivity, and farming efficiency in the corn-producing municipality of Dagohoy, Bohol, Central Philippines, the Candelaria Multi-Purpose Cooperative of the locality in collaboration with the Department of Agrarian Reform have proposed corn block farming involving the Agrarian Reform Beneficiaries (ARB's) from two Agrarian Reform Communities (ARC's) in the municipality. Funding agency of the proposed project required the needed number and type of machinery and equipment for a productive and profitable corn block farming in Dagohoy, Bohol ARCs. Thus, an in depth assessment on the farm machineries and equipment needs of corn block farming in the area was done based on the characterization of its natural and physical resources, as well as the size of the potential area for corn block farming. A set of participatory rural appraisal techniques were adopted in the assessment process. After the thorough analysis of the data collected, corn block farming was found to be suitable in the proposed project site considering soil types, climatic condition, availability of water, infrastructures, and other required facilities. The project site had 724 potential hectares for corn production. However, full mechanization was not possible due to existing moderate slopes (8-18% slope) in some areas. Traditional farming methods at production stage could be integrated considering that some of the fields did not favor full mechanization and the farming methods could also provide employment for the displaced labor in some farm operations. Due to high investment requirement, pilot production among others could be started in a 30-40 hectare portion to be managed by the Candelaria Multi-Purpose Cooperative.

Keywords corn block farming, needs assessment, Agrarian Reform Communities (ARCs), common service facilities, corn machineries

INTRODUCTION

Agriculture provides food and livelihood to the people. This sector represents 1/5 of the total economy and generates 1/3 of the Philippines total employment (Philippine Climate Change Commission, 2010). This great contribution to the national economy communicates the government to provide the needs and addresses the identified gaps for continuous and more contributions. Because of the poverty incidence in Bohol, Philippines was significantly reduced in 2012 after achieving 100% rice self-sufficiency level including some other commodities, (PGBh ELA, 2011-2013). Thus, the provincial government is thrusting to increase the agricultural production for food security and further the reduction of poverty incidence in the island. The government is interested on mechanized farming for timely production and postharvest operations to increase yield with better quality products. Hence, to minimize production cost while maximizing efficiency of farm

machineries and equipment, block farming is introduced through the support of the Department of Agrarian Reform (DAR) Program. In Bohol, corn block farming is proposed by Candelaria Multi-purpose Cooperative (Candelaria MPC) in the municipality of Dagohoy to maximize the utilization of the 380 hectares out of its aggregate land area of 2,302 hectares, and to attain a timely production, however, financial assistance, associated farm machineries and technical support services are highly needed.

Based on the Sugarcane Industry Development Act of 2014 of the country, infrastructure, funding for farm mechanization and modernization, capability trainings, and other support services are provided for block farming. Musaba et al. (2014) also affirms that focusing access on better production inputs will improve farm efficiency. Moreover, Asadullah et al. (2005) states that household/farmers' education significantly reduces farm production inefficiencies, thereby, increasing productivity. Accordingly, providing the needed input supports associated with the adoption of block farming practice may ensure farm efficiency and productivity. To realize, and for the efficient implementation of the corn block farming project in Bohol, the Candelaria cooperative needs the information on the: number, kind/type, and specifications of the machineries and equipment which are to be used in this important block farming venture. This study was conducted with the support of DAR.

OBJECTIVES

This study was conducted to assess the farm machineries and equipment needs of Candelaria Multi-purpose Cooperative for corn block farming in a 380-hectare area in Dagohoy, Bohol, Philippines. The objectives were specifically aimed to characterize the natural and physical resources of the community for suitability to corn production; to determine the size of the potential area for corn block farming; to describe the corn production and postharvest practices of the farmers; and to identify the existing farm machineries and tools of the farmers and those needed in the operation of the corn block farming in the ARCs.

METHODOLOGY

Pre-assessment activities were done through a series of consultations with the Municipal Agrarian Reform Officer (MARO) and Chairman of the Cooperative, preparation, and revision of data collection materials, as well as the orientation of the Research Team on the mechanics of the study. The needs assessment used a set of tools from the participatory appraisal approach. The techniques and the data sources were triangulated. The employed techniques were the collection and analysis of secondary data from the DARPO, MARO, and the Cooperative; the semi-structured survey questionnaire-aided interview answered by the officials and members of the cooperative as well as barangay officials. In addition, a focus group discussion for a group interaction was conducted to obtain detailed information on particular issues, gaps and problems regarding their needs for farm machineries for their corn block farming enterprise, which was led by the cooperative. Descriptive and quantitative data analysis was adopted to obtain the needed information from the different tools used.

RESULTS AND DISCUSSION

Soil suitability of the area to corn block farming: The edaphic condition of the ARCs in Dagohoy is dominated by two soil types namely: Ubay clay and Ubay clay loam. Ubay clay covers 8,266 hectares (66.16% found in the central part of the municipality) and Ubay clay loam in the northern and eastern sides, with the remaining 4,229 hectares (33.84%) of the total land area, including the south-western border of the municipality. The 380 hectare-corn block farm of

Candelaria ARC is located at the central to the south-western border, (Figs. 1 and 2). These types of soil are suitable to all kinds of crops including corn (DARPO, 2003). The most desirable soil for corn production is deep, medium textured, well drained, and with high organic matter and water holding capacity. Soil types with these characteristics are loam, silt loam, and silty clay loam (PCARRD,1981). Hence, the soil conditions in the ARC are very suitable for corn production but thorough land preparation remains a requirement, which is the reason for the need of efficient farm implements and machineries.

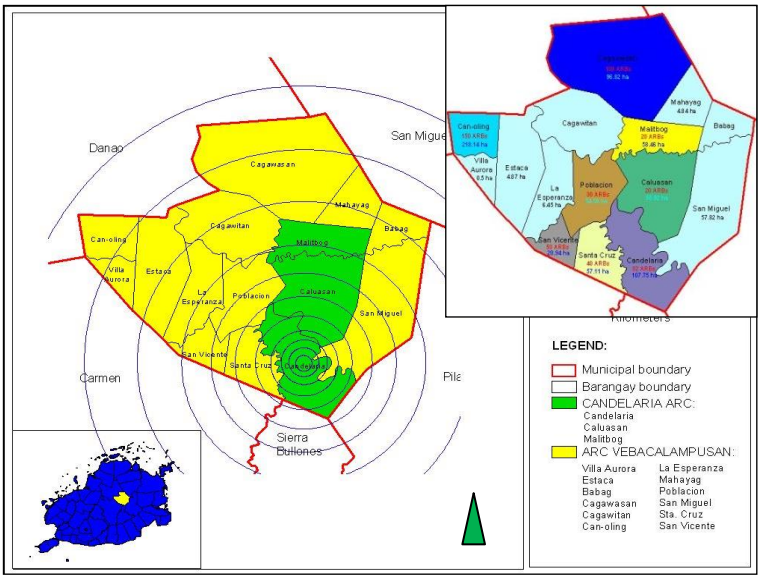

Fig. 1 Connectivity map showing the ARC's and ARB's corn areas by barangay

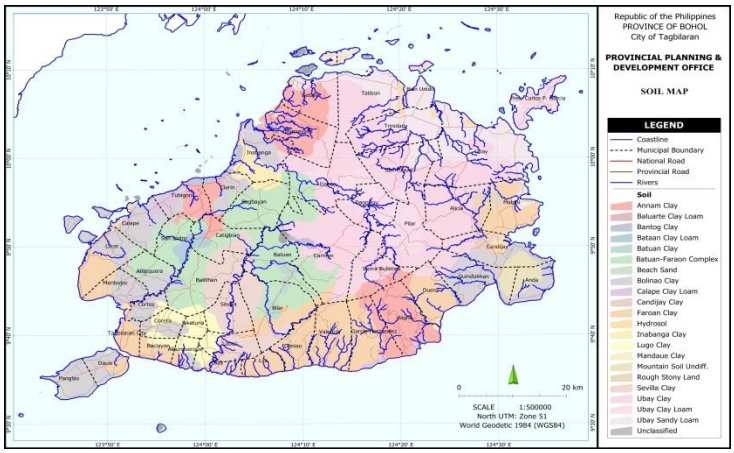

Fig. 2 Soil Map of Bohol showing the Ubay Clay and Ubay Clay Loam soil of the Municipality of Dagohoy, Bohol

Climatic suitability: Most of the country's corn-producing areas are rainfed. A good cropping of corn is highly dependent on sustained rainfall, especially during the critical stages of the crop development (Reyes et al., 2009). It also requires fair soil moisture and warm climate. The municipality of Dagohoy is classified as under Type IV climatic condition, characterized by more or less stable distribution of rainfall throughout the year with moderate rainy season (kidlat.pagasa.dost.gov.ph). The average temperature is 28.6^0C with the coldest months having average temperature of 24.4^0C from November to January. The relative humidity is more or less

uniformed throughout the year. The area is rarely hit by a typhoon and has high precipitation from July to November (DARPO, 2014). Hence, farmers commonly plant corn in May for the first cropping and the second cropping in September.

Water resources: Groundwater is the main source of potable water in the municipality. There are 3 water supplies: Level 1 comprising of 618 water wells; Level 2 including communal piped water system; and Level 3 serving for the water system reaching respective households. There are several springs and small creeks in Barangay Caluasan and Candelaria apart from the three rivers, namely Wahig-Pamacsalan River, Malitbog River, and Hamoog River, which are considered potential sources for irrigation water (DARPO, 2004). It is believed that these resources can already support corn crops as the plant requires 4 to 5 mm of water per day. During critical periods like silking and soft dough stages, the requirement could be as much as 6 to 8 mm/day. It is estimated that the most critical point falls around 55 days after planting (Lansigan, 2004). Literatures have stated that water should be available at 40 DAP during the start of flowering and reproductive stages (Reyes et al., 2009).

Slope: Most of the agricultural lands, 30-75% of the total land area, in the ARCs of Dagohoy are from flat to undulating 0-15% slope (DARPO-DARMO, 2013). The topography of ARC Candelaria ranges from level to rolling where 1,286 hectares have 0-3% or level to nearly level; 790 hectares have 3-8% or gently sloping to undulating; 226 hectares with 8-18% or moderately sloping to rolling. These ranges of slope are suitable for upland crops like corn (DARPO, 2004).

Potential production area: Barangay Candelaria, Caluasan, and Malitbog of Dagohoy have an aggregate area of 2,302 hectares of land in which 1,889 hectares (82%) is agricultural lands including 365 hectares for cornfields (DARPO, 2014). The 2013 survey found that all of the respondent-ARBs had a total land area of 107 hectares with 38 hectares planted with corn (Fig. 2). The respondents were only 10% of the total number of ARBs in the community. Correspondingly, the data imply that the current cornfield utilization is almost similar to the one in the year 2004 with a derived value of about 380 hectares. Thus, the expected total area covering the project is 380 hectares. Data from the MARO and CMPC show that Dagohoy has a total potential area of 724 hectares planted with corn by 34.25% (512hectares) of the ARBs. Some of the corn fields are owned by non-ARBs. There are also areas in the ARCs that have been previously planted with cassava potentially turning to corn fields.

Average yield: Survey results of DAPRO (2013) show that the average yield of the corn fields at the ARCs is 2.89 metric tons(Mt)/ha with an average production of 2.66 Mt per cropping costing an average of ₱5,000.00 per unit area. This production rate conforms with the average national production rate of 2.83 Mt/ha (DARPO, 2004). The production cost is observed to be ₱6,000/ha providing an average income to the farmer-respondents of ₱38,000 per hectare per cropping.

Market: Corn farming in the ARCs in Dagohoy can be classified as subsistence and market driven. Seventy percent of the respondents who own only 0.60-1.00 ha corn area is belong to the subsistence group, as their production is intended for food security of household. Being influenced by marketing campaigns and given supports, other corn growers evolve themselves by adopting high-yielding hybrid corn technology. The market of their hybrid corn products owns a feed mill and operates a commercial scale hog and poultry farms (DARPO, 2013). This market driven corn farming has assured an immediate market of its products.

Rural infrastructures: All barangays are accessible through the road networks constructed out of gravel and limestone with about 17.0 km stretch within the ARCs. Few areas are not passable during heavy rainy season due to sticky/muddy/slippery situations. The Pilar Irrigation System of the National Irrigation Administration is functional and serving 440 hectares of agricultural areas in the municipality. Gridlines for electrical source are also available to the majority of the areas. This facility is needed in any electrically-powered stationary corn processing machineries and equipment.

Means of communications are also available to facilitate delivery of information to any farmer-officials and members (DARPO, 2004 and DARPO, 2013).

Production and postharvest practices of the corn farmers: The subsistence corn farmers in the ARC employ farming methods for both production and post production operations in the same way as the market-driven producers. There are a number of processes during production operations. Farmers select seeds of their preferred varieties improved varieties; hybrid; do thorough land preparation with 2-3 plowings and furrowing using carabao-drawn plow; manually complete planting; either use commercial complete fertilizers or do not apply any kind of fertilizer; conduct off-baring and hilling-up at knee-high stage; perform weeding, which bolo and scythe are used in traditional hand weeding; and sometimes spray chemical pesticides for pest and disease management. Post-production activities include manual harvesting and dehusking; shelling used dull bolo or shredder; and using wooden-toothed sheller for seeds or using corn shellers. Sun drying in buri mats, tarpaulin, nets or drying pavement are very common but the cooperative has mechanical drying services. Farmers deliver small volume of corn grains in wooden sled or employ motorcycle-service to buyers in the local; but corn ears in bulk are picked-up by private feed mill operators.

Existing farm tools, equipment and machineries: The total farming households in the ARC own 621 draft animals and a total of 822 moldboard plow for land preparation (DARPO, 2004).

Table 1 The quantity, type of machineries, equipment, its specifications needed in the corn block farms in Dagohoy, Bohol with an area of 380 hectares based on the assumptions

Quantity	Image	Technical Specifications
5 units		Front Wheel Assist (FWA), Four-wheel tractor-diesel engine, Drawbar-96Hp (min), 172 Hp (min) PTO (includes with 6-60ϕ disk plow implement and an offset harrow)
5 units		Model 2BYF-3, Tractor-drawn, 3-row corn planter/seeder with fertilizer applicator CTN Size: 1700x1620x1100 mm
1 unit	No image	Self-propelled corn seeder/planter with fertilizer applicator, 3 ha field capacity daily
13 units		Self-propelled harvester, Model 4YW-2C, 20HP, with storage tank vol (1cu.m) CTN Size: 3200X1300x2800

The study found that the cooperative has a multipurpose drying pavement and a mechanical dryer (DA-distributed flatbed) with a shed commonly utilized in drying rice, and corn ears/grains during inclement weather; farmers have traditional farming tools and equipment such as moldboard plow, sharp/dull bolo, scythe (long), wooden sled, home-made shredder, home-made wooden-toothed sheller for corn grain production and buri mat. Tarpaulins were used by the majority of the farmers in corn production and post-production.

Machineries and equipment needs and assumptions: Corn production cycle analysis was used to determine the machinery and equipment needs of the farmers for corn block farming. The analysis considered the current production area of 380 hectares, existing production, and post-production practices of the corn farmers in Dagohoy, Bohol. Some assumptions were made as follows:corn production is fully-mechanized; land preparation will be done using 4-wheeled tractor travelling at

8 kph having 6-60 cm disk plow with offset, and effective width of 1.8-2.0 m.; land preparation will be done for 30 days which includes one plowing and two harrowing operations; post-production operations (harvesting to shelling) will be done for 15 days; tractors will be used for seeding/planting and fertilizer applications; self-propelled corn planter has fertilizer application function; and self-propelled corn harvester has a capacity of 1.0 ha a day.

CONCLUSION

Considering the overall requirements of corn crop, the agricultural uplands of the municipality of Dagohoy are very suitable for corn production in terms of soil types, availability of water source subsuming well-distributed rainfall during the year, and the weather condition which favors for its growth and development. In a view of the field conditions, due to existing moderate slopes (8-18%) in some areas of the Municipality of Dagohoy, Bohol, only partial mechanization is possible. Engaging into corn block farming, the Candilaria Multipurpose Cooperative needs a big investment based on the identified machineries, equipment, technical support services, and skilled manpower required for efficient and timely operation of the planned agri-enterprise.

ACKNOWLEDGEMENTS

Expression of deep and sincere gratitude is to the Department of Agrarian Reform-Provincial Office and the Municipal Agrarian Reform Office and the Candilaria Multipurpose Cooperative and the Dagohoy respondent-ARBs.

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Research article

Evidence-based Modeling of Landslide Hazard in Wahig-Inabanga Watershed, Bohol, Philippines using GIS and Statistical Models

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Received 3 March 2015 Accepted 30 November 2015 (*Corresponding Author)

Abstract. The study combined geographic information system (GIS) and statistical models in predicting landslide hazard in Wahig-Inabanga Watershed, Bohol, Philippines. The bivariate statistical analysis (BSA) and logit regression (LR) were employed for class and factor weighting, respectively, to determine landslide prone areas using eleven significant landslide-related instability factors such as elevation, slope, aspect, lithology, soil order, soil type, fault line proximity, river proximity, road proximity, rainfall, and land cover. The very satisfactory results of model evaluation warranted the application of the LR model in evidence-based landslide hazard assessment. Out of the eleven instability factors, only soil order and soil type were determined not significant. The first three most important instability factors based on the values of regression coefficients were elevation, slope, and lithology. Landslide hazard assessment revealed around 7,063 ha or 11.33% of the total area of the watershed had high to very high landslide hazard ratings. The study showed that GIS, in tandem with useful models, provided pertinent results which could be used as scientific basis for watershed management and land use planning in relation to landslide disaster risk reduction and management.

Keywords bivariate statistical analysis, GIS, landslide hazard, logit regression

INTRODUCTION

As a natural phenomenon, landslide usually occurs in high elevation, and sloping areas. Its severity is definitely influenced by the type of vegetation cover and the geomorphological structure of the soil. This geologic hazard is often triggered by excessive and continuous rainfall, and seismic events. One of the most unforgettable landslide events which struck the Philippines was that which happened in Guinsaugon, Leyte where in a matter of minutes, the homes and families in barangay of Guinsaugon were wiped out and buried under a mountain of soil and rock (Catane et al., 2006).

The province of Bohol, in particular, had experienced frequent landslides and massive erosion in the upland, and floods at lowland areas. Its susceptibility to landslides and floods had been recorded by the Mines and Geosciences Bureau (MGB) in 2007. There were more than 100 barangays identified prone to these hazards out of the 46 municipalities covered in the survey. Specifically for landslide events, 64 barangays within the Wahig-Inabanga watershed were rated with moderate to high vulnerability to landslides based on 13 out of 16 municipalities evaluated. The 52-hectare Mayana landslide which happened on July 13, 2005 was triggered by a surface-wave magnitude 4.9 earthquake with its epicenter recorded somewhere in Sierra Bullones on March 31, 2005. The landslide's average slope was only about 13%, described as elongated, oriented east-west and had a total length of 1.4 km (Catane et al., 2005).

Geospatial technology is increasingly being used in spatial decision support systems. This has been the trend since its functions and applications have been made known to the public, especially to experts, practitioners, and policy makers around the globe. In the Philippines, GIS, in tandem

with remote sensing and modeling technologies, are used in many applications since the 1990s from resource assessment, land use classification, and mapping to environmental hazards assessment and management.

In the Philippines, the utilization of logit regression model and GIS for landslide susceptibility mapping in the country was initially, and perhaps solely, conducted by Lee and Evangelista (2005) in Baguio City. The method which has been used in this present study was a modification from their work with the intention of increasing the predictive power of the LR model by initially applying the numerical values of landslide frequencies as class weights derived using bivariate statistical analysis (BSA) prior to the actual logit regression analysis.

This current study assessed the applicability of GIS and logit regression combined with BSA in determining landslide prone areas in Wahig-Inabanga Watershed, Bohol, Philippines.

METHODOLOGY

Study Site

The Wahig-Inabanga Watershed is the biggest watershed in the province of Bohol, Philippines (Fig. 1). From the northwest bay of Inabanga, the river dissects the central part of the island embracing a total land area of more than 610 km^2. According to Genson (2006) and Ludevese (2006), this watershed is more or less 15.20% of the total land area of the province.

It is geographically located between 124^{o}3’36” and 124^{o}23’24” East longitude, and between 9^{o}43’48” to 10^{o}4’48” North latitude. It has two headwaters namely the Wahig and Pamacsalan Rivers, and its outlet is geographically located at 10^{o}4’12” North latitude and 124^{o}4’12” East longitude.

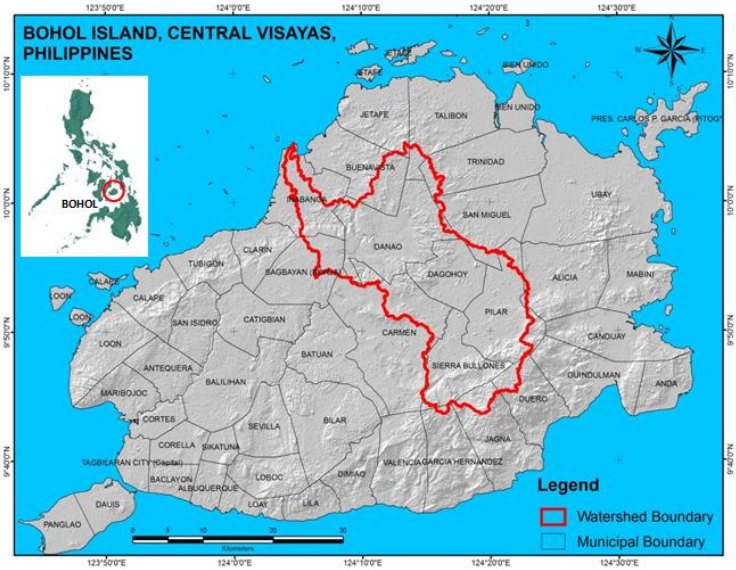

Fig. 1 Location map of Wahig-Inabanga Watershed, Bohol, Philippines

Acquisition of GIS Input Files

Thematic layers and other GIS input data which were used in this study were obtained from several Philippine government authorities and well-known sources. The digital elevation model which was used to derive elevation, slope, and aspect layers were downloaded from the ASTERGDEM

website. The SPOT5 image, river and stream network, land use and land cover, contour, and spot height layers were taken from the National Mapping and Resources Information Authority (NAMRIA). The soil order and lithology layers were obtained from the Mines and Geosciences Bureau (MGB) while the soil series and soil type layers were solicited from the Bureau of Soils and Water Management (BSWM). The political boundaries and road network layers were acquired from the Bohol Provincial Planning and Development Office (PPDO), and the updated ground rupture map was secured from the Philippine Volcanology and Seismology (PHIVOLCS).

Inventory of Landslide

The identification and mapping of existing landslides are prerequisite to perform statistical analysis on the relation between the distribution of landslides and influencing parameters (Saha et al., 2005). Any landslide susceptibility or hazard assessment must begin with the collection of information on where landslides are located. Collection of information is done in many forms. Most of the researchers utilize aerial photographs and satellite image interpretation to locate landslides. Others employ the same interpretation method in tandem with ground validation. In this study, both image interpretation and extensive field surveys were performed.

The ortho-rectified Spot 5 Image (scene: 313330) acquired from NAMRIA was used to delineate visible landslides. Ground validation was carried out during the field surveys. The complexity of image interpretation for a huge watershed like Wahig-Inabanga led the conduct of extensive field surveys. Field surveys were done mostly in, but not limited to, areas within the watershed. The buffer zone of 100 m along the watershed boundary was also considered. Major [= deep-seated] and minor [= shallow] landslides were identified and their GPS coordinates were taken either at the center or along the landslide boundaries. A total of 215 landsides were recorded throughout the study area.

GIS Processing

Mapping of landslides: The geographic coordinates taken in the field were retrieved from GPS receivers using Garmin BaseCamp software (version 4.2.1). Coordinates were identified as to those taken around the corners of huge and medium-sized landslides and those taken at the center of small landslides and classified as to size of the landslides.

To prepare the landslide inventory map, coordinates were all geo-processed in ArcMap. Polygon shapefiles were created for landslides with corner coordinates, while buffer function in ArcMap interface was used for landslides with coordinates taken at the center. These, including the digitized landslides from Spot 5 Image, were all clustered into one shapefile using merge function and then projected to WGS84_UTM_Zone_51N. To complete the landslide inventory map, the projected landslide polygons were combined with the Wahig-Inabanga Watershed mask and was finally converted to raster format with a pixel size of 10-m. The landslide pixels were given a value of 1 and non-landslide pixels as 0. There were a total of 1,891 landslide pixels and 6,749,911 non-landslide pixels.

Sample size computation and selection: The power calculator (http://calculator.stat.ucla.edu /powercalc, accessed on December 2013) was used in the computation of the sample size. Setting the confidence level at 95% and confidence interval of 3, sample sizes of 1,058 and 1,067 were calculated to represent all landslide and non-landslide pixels, respectively. The rasterized landslide inventory map facilitated the preparation of combined landslides and non-landslides vector grid map with an aid of Hawth's Analysis Tool, a freeware ArcGIS extension. Landslide and non-landslide sample selection was also performed from the vector grid map using the same tool. Two sets of samples were selected, one for model generation and another for accuracy evaluation.

Statistical analysis: The landslide hazard assessment using logit regression (LR) adopted in this study followed the method of Ayalew et al. (2005) and Ayalew and Yamagishi (2005) which required class and factor weighing.

Bivariate statistical analysis (BSA): BSA was applied to the first set of samples to determine class weights through the calculation of landslide frequencies on input parameter classes. Overlay analysis and extract by samples in ArcGIS were used in this respect and the output dbase file was imported in Microsoft Excel for landslide frequency computation.

Logit regression analysis: Logit regression was employed to define factor weights. The result of BSA in excel was imported in SPSS and the method of stepwise backward selection was used. The outputs of the regression analysis included the measures of model fit, model prediction probability, and regression coefficients. The regression coefficient of each factor [also known as predictor or parameter] served as the factor weight.

The model equation adopted in the study is shown below:

$$Y = b_o + b_1 (P_1) + b_2 (P_2) + b_3 (P_3) + \ldots + b_{11} (P_{11})$$

where:
Y = landslide occurrence (presence or absence)
b_o = constant value (Y intercept)
$b_1, b_2, b_3 \ldots b_{11}$ = regression coefficients
$P_1, P_2, P_3 \ldots P_{11}$ = input parameters or instability factors

Below was the equation used to compute for the probability of landslide event:

$$P = \Pr [Y=1] = 1/1+e^{(-X*B)}$$

where:
P = probability of landslide occurrence
= $\Pr [Y=1] = 0$ to 1
e = exponential function
X*B = Y value of the logit regression function

RESULTS AND DISCUSSION

Model Assessment

Out of 11 parameters, only soil order and soil type were found not significant and were eliminated in the final model. Model rerun identified elevation as the most significant parameter based on the value of regression coefficient [*B*=0.007162]. This was followed by slope and lithology (Table 1).

Table 1 Logit regression output for the regression coefficient estimation using the model of significant parameters

Predictor (Factor)	Regression Coefficient (*B*)	Std Error	P-Value
Elevation	0.007162	0.001	0.000
Slope	0.004933	0.001	0.000
Aspect	0.002949	0.001	0.000
Lithology	0.003533	0.000	0.000
Fault line proximity	0.000825	0.000	0.000
River proximity	-0.001247	0.000	0.000
Road proximity	-0.001002	0.000	0.000
Rainfall	0.000717	0.000	0.000
Land cover	0.001842	0.000	0.000
Constant	-6.069435	0.535	0.000

Model assessment in SPSS was very satisfactory. The model of goodness of fit was significant [*p*-value < 5%], model chi-square was not significant [*p*-value > 5%], and the pseudo R^2 was relatively high [pseudo R^2 = 0.607] (Table 2). The P-value of less than 5% for the goodness of fit test shows that the LR model fits with the selected data. This is supported by the model chi-square P-value of more than 5% which implies the model fit is good. In addition, the pseudo R^2 value 0.607 means that the 60.7% of the total variation in the data is explained by the model. According to Clark and Hosking (1986) as cited by Ayalew *et al*. (2005) and Ayalew and Yamagishi (2005), a pseudo R^2 greater than 0.2 indicates a relatively good fit.

Moreover, the prediction probability was determined very high [PredProb = 83.2%] (Table 3). This value denotes a very acceptable prediction accuracy of the LR model for both cases (presence [84%] and absence [82.4%] of landslides).

Table 2 Summary comparison of model fit statistics of the logit regression function

Statistics	Value
Goodness of Fit	
Omnibus Test Chi-square	1290.114
P-value	0.000
Model Chi-square	
Hosmer and Lemeshow Test	17.330
P-value	0.051
Pseudo R^2	
Nagelkerke R^2	0.607

Table 3 Classification table showing the results of the landslide model prediction probability

Model	Observed	Predicted		Percentage Correct
		Absence	Presence	
LR with significant factors only	Absence	879	188	82.4
	Presence	169	889	84.0
Overall Percentage				83.2

Landslide Hazard Assessment

Result of the landslide hazard assessment indicated that more than 60% of the total area of the watershed (about 38,180 ha) was identified to have very low probability of landslide occurrence. About 16.63% or 10,360 ha had low landslide hazard, while roughly 6,692 ha or 10.74% was estimated to fall under the moderate landslide class. Conversely, high and very high landslide ratings were predicted for areas mostly situated on the upper elevations of the watershed, as shown on Figure 2, having 4,101 ha and 2,962 ha, respectively. These amounted to a total of 7,063 ha or 11.33% of the total area of the watershed.

CONCLUSION

Logit regression, with bivariate statistical analysis, is best applied if landslide inventory is available. The landslide inventory aids in the quantitative assessment of landslide prediction probability and serves as a means of determining the accuracy of the model.

The application of bivariate statistical analysis in determining landslide frequencies and the utilization of these computed frequencies as quantitative substitutes to nominal variables of landslide predictors simplify the logit regression equation and the interpretation of its results.

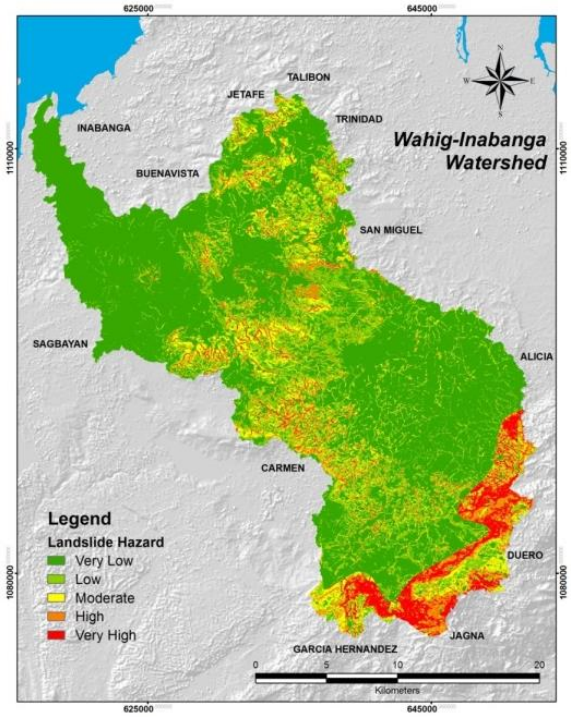

Fig. 2 Landslide hazard map generated from the LR model

Modeling landslide is very important to measure the relationship between each causative factor with every single landslide location. The relationship between landslide and its causative factors vary according to area, time, and climate. By modeling landslide, the inherent characteristics of landslide activities can be quantified. This is very important in order to identify which causative factor plays a major or a minor role. Such information can then help the authority to plan the activities and land utilization in areas prone to landslides.

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