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Infrastructural Systems:

Water Resource Development, Land Reclamation, Road Construction, etc.

Contents

Research article

Climate Change and Disaster Risk Reduction Management in Banacon Island, Philippines

JOSE T. TRAVERO*
Director, Regional Climate Change Center, Bohol Island State University, Philippines
Email: jose_travero@yahoo.com

MARINA A. LABONITE
Director, Research and Development Center, Bohol Island State University, Philippines

DIOSCORO A. AVERGONZADO
Campus Director, Bohol Island State University, Philippines

Received 29 October 2012 Accepted 30 January 2013 (*Corresponding author)

Abstract The research was conducted to determine the socio-economic and environmental condition of the island, to understand the problems and needs of the people of a climate change vulnerable island, to determine the level of awareness of villagers on climate change, find out the community initiatives on climate change adaptation and mitigation and find out if disaster risk reduction management is in place in the community. Banacon Island, the research site, has 318 households sporadically spread in a 15 hectare dry land of the village. It has a population of 1514 (2010 data), majority (93%) has a family income of less than P3,000 ($67) a month or less than P100 ($2.2) per day. The source of electric power is a portable electric generator which is enjoyed by only 8% of the households and the majority (92%) are still using kerosene lamp at night. There is no potable water in the island. Majority of the households (85%) has no toilet, 12% has their own and 3% of the households shared their toilet. The leading causes of infant mortality are diarrhea, malnutrition and pneumonia. Only 3% of the residents are well-off while majority (87%) are in the average level which is below the poverty line. A significant number (3%) lived in a miserable condition. Fishing is the main source of livelihood. Fifty percent (50%) of the residents are involved in seaweeds culture and business. Community problems are directly related to health, sanitation, livelihood, education, source of power for electricity, peace and order and problems with the children. Community members are aware of the changing pattern of climate with increased temperature, extensive rainfall and sea level rise as their indicators. Disaster risk reduction management mechanism is already in place in their locality through the village officials.

Keywords climate change, disaster risk reduction, mitigation, adaptation, empowerment

INTRODUCTION

The Intergovernmental Panel on Climate Change predicts that the pace of climate change is very likely to accelerate with continued greenhouse gases emission at or above current rates with globally averaged surface temperatures estimated to rise by 1.8 °C to 4.0 °C by the end of 21st century (Simpson, et al 2008). It is also projected that there will be an increase in globally averaged surface temperature of 1.4 °C to 5.8 °C over the period of 1990 to 2100 and global mean sea level is projected to rise by 0.09 to 0.88 meter between the years 1990 and 2100 (Amadore, 2005). This will translate to a sea level rise which is expected to threaten small islands in the Philippines and in Bohol in particular.

It is believed that if one key aspect such as the average global temperature is altered, other climate elements may likewise change (Amadore, 2005). Being an archipelago, the Philippines has one of the vast irregular coastlines in Asia. Recognizing the vulnerability of the Philippine and its small island communities, particularly the poor, women and children to potential dangerous

consequences of climate change (RA 9729), it is imperative for us to get the perception of the local communities with regards to climate change. Hence, there is a dire need for us to look into the community's perception on climate change and document their mitigation and adaptation measures.

On the other hand, it is stipulated in the Climate Change Law of the Philippines that disaster risk reduction shall be integrated into climate change programs and initiatives (RA 9729) as it is recognized that climate change and disaster risk reduction are closely interrelated and it is considered that effective disaster risk reduction will enhance climate change adaptive capacity of the community.

Assessing the impact and vulnerability to climate change and subsequently working out adaptive needs requires good information (UNFCC, 2007). The local knowledge and information that are gathered in this study shall be a good input in planning a climate change resilient community.

Project Location

The site of this project is in an island village of Banacon which is one of the 40 small islands within the 300 square kilometer Danajon Double Barrier Reef, the only barrier reef in the Philippines and one of only three in the Indo-Pacific Region. Banacon is in the coastal municipality of Getafe, north of Bohol. The island has a vast yet diverse and beautiful seascape sprawling along a double barrier reef which is known for its mangrove forest, the largest man-made mangrove forest in Asia. This mangrove has an approximate area of 425 hectares which acts as the breeding ground for fishes and other coral reef animals. It also protects the islands from the impacts of typhoons and storms.

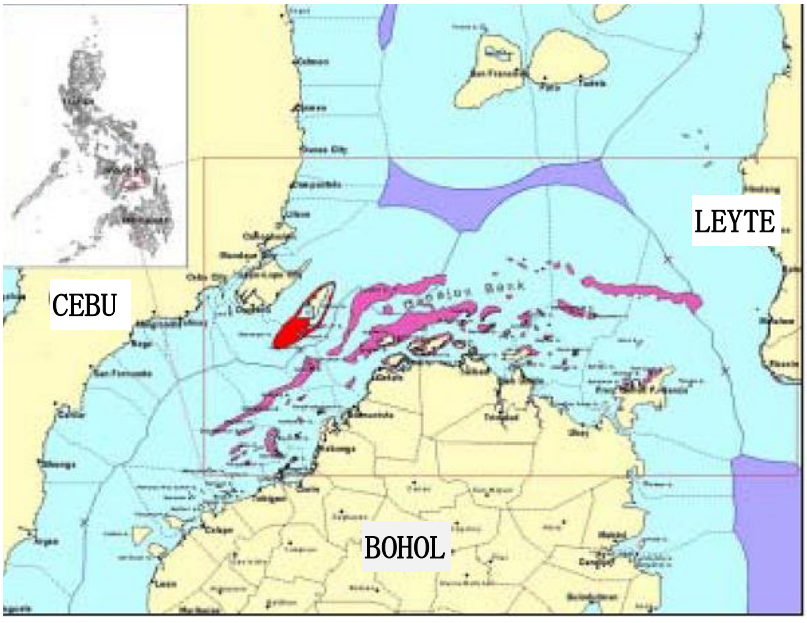

Fig. 1 Location map of the research site

OBJECTIVES

This research was conducted with the following objectives:

1. To determine the socio-economic and environmental condition of the island;
2. To understand the problems and needs of a climate change vulnerable village;
3. To determine the level of awareness about climate change and find out their indicators of climate change;
4. To find out the community initiatives on climate change mitigation and adaptation; and
5. To find out if Disaster Risk Reduction Management is in place in their community.

METHODOLOGY

This research was done through a participatory approach. This project is part of a long term program called Socio-economic and Environmental Education in the island of Banacon, Bohol, Philippines. This was done in 2011 to 2012. The tools used include the focus group discussion, ranking, mapping, diagramming, time lining, seasonal calendar and a questionnaire-aided interview. Preliminary visit was done to identify the key persons who can facilitate the conduct of the activity and to get the needed secondary data. The usual protocol with the village officials was done. There were 32 participants of the research process who were mostly women, health workers, fisher folks and basic education teachers. The focus group discussion was done at the barangay hall and at the elementary school building. The interview was done in a house-to-house visit. For result validation, the data gathered were presented back to the community particularly to the teachers of the Department of Education and the barangay officials.

RESULTS AND DISCUSSION

Current Socio-Economic Realities of Banacon

A participatory resource appraisal (PRA) was conducted in the island community of Banacon to validate the available secondary information about the village. This was done through a focus group discussion (FGD) using resource mapping, time lining, seasonal calendar, well-being ranking and diagramming to capture the vital information of the community. The PRA was done to assess the current problems and needs for possible interventions.

It was found out that Banacon Island has 318 households sporadically spread in a 15 hectare dry land of the village. It has a population of 1514 (2010 data), majority (93%) has a family income of less than P3,000 ($67) a month or less than P100 ($2.2) per day. The source of electric power is a portable electric generator which is used by only 8% of the households and the majority (92%) are still using kerosene lamp at night. The electric generator will operate only from 6:00 until 10:00 o'clock in the evening. There is no potable water in the island. There are seven (7) households who own a rainwater collector and there are four (4) public rainwater collectors installed in public buildings like the school and village hall. Majority of the households (85%) has no toilet, 12% has their own and 3% of the households shared their toilet. The leading causes of infant mortality are diarrhea, malnutrition and pneumonia. As far as the socioeconomic status of the community, it was revealed in the Focus Group Discussion that only 3% of the residents are well-off while majority (87%) are in the average level which is below the poverty line. A significant number (3%) living in a miserable condition.

Current State of Their Environment

The Coastal Conservation and Education Foundation reported that due to illegal fishing activities and coral extraction, among other harmful practices, the double reef where Banacon Island is located is now vastly degraded. On an ocular observation of the mangrove plantations, we noticed that there are portions of the mangroves that are illegally cut. In the FGD that we conducted, it was revealed by the community residents that they also have to address the issue of solid waste management.

Being an island village, fishing is the main source of livelihood. Fifty percent (50%) of the residents are involved in seaweeds culture and business. Very few are into buying and selling of seashells which are harvested by the villagers from the mangroves shorelines and shallow waters of the island.

Problems, Needs and Potential Interventions

During the FGD session, villagers identified their problems, needs and potential solutions based on

their perception. It came out that the problems that they identified are those that are directly related to their daily activities like health, sanitation, livelihood, education, source of power, peace and order and problems with the children. Issues like protecting the mangroves, protecting the marine resources; climate change adaptation and disaster management are not their immediate concern.

Table 1 List of community needs, problems and their suggested interventions

Needs	Problems	Potential Interventions
Sanitation	Toilet; Solid Waste management	Sanitation Education, Public Awareness on the Health impact of unsanitary environment
Health	No potable water; No Immediate access of medical assistance/services ; prevalence of malnutrition; absence of food supply like vegetables and root crops	Local Medical Service providers; Public Awareness on Preventive Measures on Climate Change Related health problems; Disaster Risk reduction and management of water-borne related diseases
Discipline	Juvenile delinquency problems	Values formation education among parents
Education	Many out-of-school youths	Alternative Learning System
Livelihood	No livelihood program	Livelihood trainings/courses
Light	No power	Install non-conventional source of power
Peace and order	Stealing in Seaweed farms	Strengthen local police

Seasonal Calendar of the Community

During the FGD, island residents have identified major activities which happened on a regular basis every year. These include social and economic activities which are of critical importance in their daily survival. The seasonal calendar also indicated the time of the year where their household income and expenses goes high or down. It also indicates the trend of disease occurrence especially among children.

Community Social Mobility

Islanders indicated during the FGD the mobility of the residents. The main reason of moving out from the island is economic in nature. Residents have to seek employment in the nearby urban community or outside the country like in Hongkong, Kuwait, Singapore and United States. Parents with economic capacity to send their children to college and high school will send their children to the city. Hence, young people also have to go out from the island for education purposes.

Climate Change Awareness

With a questionnaire-aided interview, island residents were asked about their knowledge on climate change. It was found out that all the respondents are already aware of the changing pattern of climate with the following as their perceived indicators: increased temperature, extensive rainfall and sea level rise. All respondents indicated that they observed an increase of sea level in their island where majority said that sea water has encroached their dryland area by almost ten (10) meters from the coastline. Some of them, however, said that the sea water reached up to five (5) meters beyond the coastline.

When asked if there was an initiative of the village on climate change awareness, thirty percent (30%) said that they learned about climate change issues in a village community meeting called by the local officials and ten percent (10%) said that they got the information from an Information, Education and Communication (IEC) materials. The rest of the islanders do not have access of any information about climate change and disaster risk management.

IMPORTANT ACTIVITES/ EVENTS	J	F	M	A	M	J	J	A	S	O	N	D
GUSO FARMING	harvesting								planting	planting	harvesting	harvesting
FISHING												
SOCIAL ACTIVITES		1			2	3	4		5	6	7	8
EXPENSE TREND	↑	↓	↑	↓	↑		↓	↓	↓	↓	↓	↑
INCOME TRENDS	↑ 9	↓	↓	↓	↓	↓	↓	↓	↑	↑	↑	↑
DISEASE OCCURRENSE	10		11	12								10

1=Fiesta SantoNino-Purok 5, Fiesta sa Lourdes-Kapilia Centro, Ist Comunion of Children
2=Fiesta Sta. Crruz-Tibook Banacon
3=Fiesta Mother of Perpetual Help-Centro and Purok 3
4=Visita sa Birhen
5=Fiesta Sta. Cruz-Purok 1 and 2
6=Fiesta Corazon de Jesus-Purok 6; Fiesta Berhin sa Berangay-Purok 3 and 5
7=Fiesta San Vicente Ferrer-Purok 7
8=Fiesta Sta. Teresita/Banacon Youth Day (Banacon Catholic Organization Youth Organization [BCYO])
9=High income attributed to "high catch-saeson"for fish, shellfish, crabs, s Shrimps
10=Ting-tipdas [sagolflu moragpamiangan ang lutahan]
11=Diarrhea
12=Mumps [2012]

Fig. 2 Seasonal calendar of the community

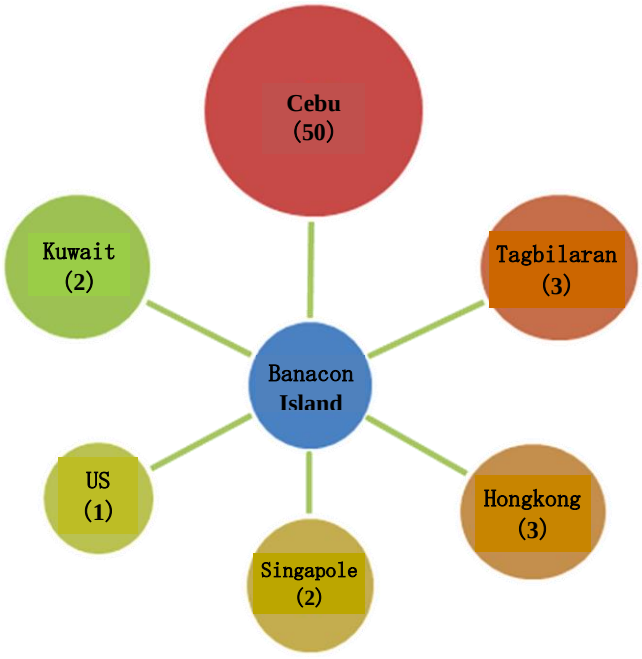

Fig. 3 Mobility map of the island residents

Climate Change Mitigation and Adaptation

The villagers knew (90%) that they will continue planting mangrove trees to mitigate climate change and the same number said that they will adapt the changing climate by doing alternative livelihood in the island especially non-fishing economic activities or livelihood skills like dressmaking for women and shellcraft, mechanic and computer skills for out-of-school youth.

Disaster Risk Reduction Management (DRRM)

Disaster risk reduction management is a mandate of the local government units as provided in the Philippine Disaster Risk Reduction Management (DRRM) Law. There is in every village a Local Disaster Risk Reduction Management Council with appropriate funds to support DRRM activities. The DRRM council of Banacon Island has already put in place the mechanism to respond all types of disaster in the island. Village officials who were given the DRRM tasks were given basic equipment like emergency lamps and even a mobile phone for them to quickly respond any form of disaster.

CONCLUSION

It is concluded that fishing is the main source of livelihood. Majority of the villagers has an income of less than P100 ($2.2) per day. Only 3% are considered well-off and the rest are living below the poverty line. There is an observed degradation of the reef as perceived by the residents and there are some issues on mangrove management. The community is also aware of the existing solid waste management problems in the village.

Villagers identified the following areas as their problems: sanitation, livelihood, source of power, peace and order and problems with children. Residents are aware of the changing pattern of climate with increased temperature, extensive rainfall and sea level rise as their indicators. Majority of the villagers does not have access on information about climate change. However, they knew that to mitigate climate change, they have to continue planting mangrove trees in the island. On the aspect of climate change adaptation, the community suggested to have alternative livelihood especially non-fishing activities.

It is recommended that the existing knowledge and preparedness of the villagers about climate change and disaster risk management shall be scaled-up through environmental and climate change education and by installing alternative non-fishing livelihood to augment their income. Having another source of income will lessen the social pressures that will affect adversely the surrounding coastal and marine resources of the island. It is also recommended that the potential interventions identified by the villagers shall be addressed by the concerned government agencies for community empowerment and prosperity.

ACKNOWLEDGEMENTS

We wish to acknowledge the active participation of the island villagers and the generous support of the teachers of Banacon Elementary School, headed by their principal Mr. Julius Quillopas, the Health Workers and the Barangay Officials of Banacon Island for their hospitality and moral support.

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Research article

New Records of Rotifer Fauna in the Upper Cambodian Mekong River Basin

SEANGHUN MEAS*
Centre for Biodiversity Conservation, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Phnom Penh, Cambodia
Email: meas_seanghun@yahoo.com

RATHA SOR
Centre for Biodiversity Conservation, Faculty of Science, Royal University of Phnom Penh, Phnom Penh, Cambodia

Received 18 December 2012 Accepted 30 January 2013 (*Corresponding author)

Abstract Rotifer samples were seasonally collected in 2010 from ponds, lakes, reservoirs and rivers in the upper part of the Cambodian Mekong River in Kratie, Stung Treng and Ratanakiri Provinces. A 30 µm mesh plankton net was used to collect samples. The water quality parameters: temperature, pH, electrical conductivity, turbidity and dissolved oxygen were also collected from each of the sampled sites. A total of 175 species of Monogononta Rotifers were found, 64 of which were new Cambodian species records. This investigation brings the total number of rotifers identified from Cambodia to 260 species. Of the 4 habitat types, ponds had the highest species richness, followed by lakes, reservoirs and rivers.

Keywords rotifers, species richness, Mekong River basin, Cambodia

INTRODUCTION

Rotifers are microscopic zooplanktons that are mostly found in freshwater, although they have also been recorded from saline waters and terrestrial environments, including moist tree bark. Rotifer are very important to aquatic food webs as they provide a food source for other aquatic animals, including larger zooplankton and fish larvae in both natural and human made habitats and improving the water quality by the consumption of algae (Beres et al., 2005; Tasevska et al., 2010).

Several studies of rotifers have been conducted in Cambodia and new species records continue to be found. Bēzins (1973) found several species, *Anchitestudinella mekongensis*, *Brachionus donneri*, *Filinia camasecla,* and *Lecane blachei* in the Mekong River near Phnom Penh City. A biomonitoring program along the Lower Mekong River Basin subsequently recorded at least 65 species in the Cambodian Mekong River basin (Davidson et al., 2006 & Vongsombath *et al*., 2009). The number of rotifer species was substantially increased by Meas & Sanoamuang (2008) who found 143 species, of which 102 species were new country records. Data have also been collected on seasonal changes of plankton and zoobenthos in Tonle Sap Great Lake but the identity of these species was not presented (Ohtaka et al., 2010). The first description of sessile rotifers was recently conducted and 23 species were found, all of them were new country records to (Segers et al., 2010). Furthermore, at least 79 species of rotifer were found in ponds from the north of Cambodian Mekong River basin, seventeen of them were new records in Cambodia (Min *et al.,* 2011), one of which *Lepadella punctata* is considered to be rare in Thailand (Chittapun et al., 2003). The most recent study found one hundred and seven species in lakes and reservoirs from the northern part of the Cambodian Mekong River basin, twenty-five of them were new country records (Sor et al., 2011).

According to rotifer distribution known to Southeast Asia (Segers, 2001, 2007), most of the species found in Cambodia are considered common or cosmopolitan species, except a few which were endemic to Southeast Asia. These endemic species include *Anchitestudinella mekongensis* Bērzinś, 1973, *Brachionus murphyi* Sudzuki, 1996, *Cephalodella songkhlaensis* Segers &

Pholpunthin, 1997, *Keratella edmonsoni* Ahlstrom, 1943, *Lecane blachei* Bērziņš, 1973, *L. superaculeata* Sanoamuang & Segers, 1997, and *L. thailandensis* Segers & Sanoamuang, 1994.

OBJECTIVE

This investigation aimed to explore the diversity of rotifers in the Upper of Cambodian Mekong River Basin from 4 different habitats within 2 different seasons in the year 2010.

METHODOLOGY

A total of 64 rotifer samples were seasonally collected from rivers, lakes, reservoirs, streams and ponds (Table 1) in three provinces in northeast Cambodia (Fig. 1), Forty samples were collected in the late dry season from 25th to 30th April 2010 from 4 habitat types, and twenty four samples were collected in the late rainy season from 7th to 12th November 2010 from only 3 habitat types (excluding river samples) using a 30 micrometer mesh plankton net (Table 1). A sample was obtained by dragging the net 15 times through open water in each habitat. All samples were preserved by adding a small volume of 4% formalin. Environmental parameters measured at each sampled locality included water temperature, pH, conductivity (pH/EC/TDS/Temperature, model HI 98129 • HI 98130, HANNA Instruments company), turbidity (ISO Portable Turbidity meter, model HI 98713, HANNA Instruments company), and dissolved oxygen (Dissolved Oxygen Meter, model HI 9146, HANNA Instruments company). The locations of the sampling sites were recorded using a Global Positioning System (GPS). The sampling sites are part of a detailed study to evaluate rotifer distribution and diversity in the upper part of the Cambodian Mekong River basin, which in turn may serve as a baseline study for assessing the change of water quality in this region.

Rotifers were identified of species level under a compound microscope using published keys (Segers, 1995; de Smet & Pourriot, 1997; Nogrady & Segers, 2002). Photographs of rotifers were taken using an Olympus BX51 attached to the microscope. Species nomenclature follows Segers (2007).

Correlation analysis was carried out to determine whether there was any linear relationship between species counts and the various environmental parameters measured.

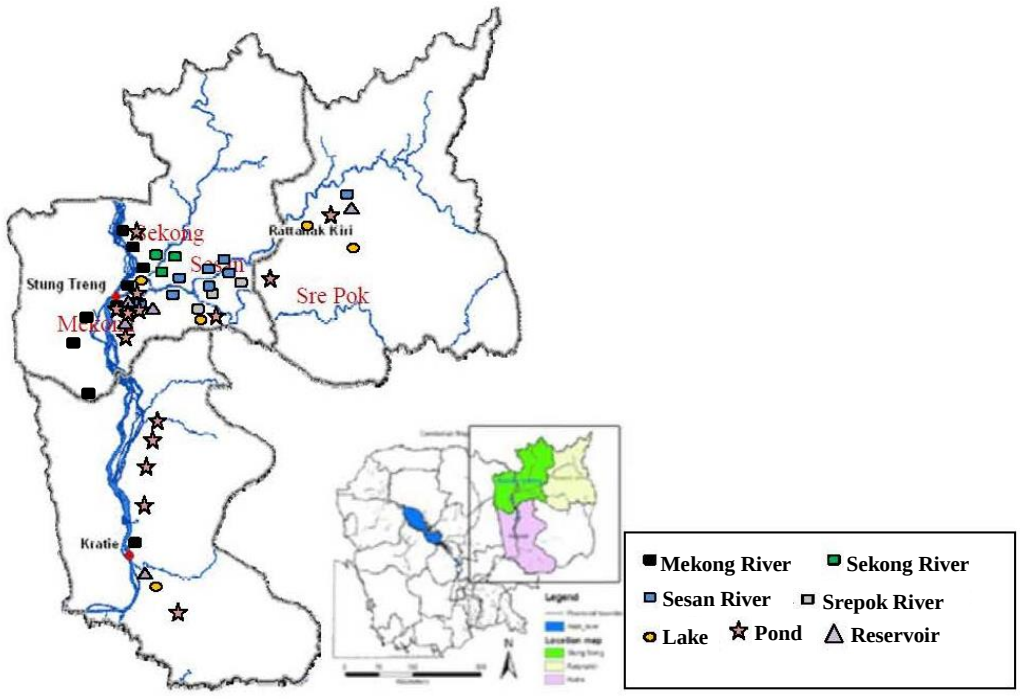

Fig. 1 Study area

Table 1 Number of samples in each habitat types

Habitat types	Number of Samples		Total Number of Samples	Total Number of Sampled Localities
	Late dry season	Late rainy season		
River	20	0	20	20
Pond	10	14	24	14
Reservoir	5	5	10	5
Lake	5	5	10	5
Total	40	24	64	44

RESULTS AND DISCUSSION

One hundred and seventy five species of rotifers were recorded from this study, 64 of which were new Cambodian species records (Table 2). The highest number of species found was in a pond in Stung Treng Province collected in April 2010 with 44 species (44 of 175 species= 25.14%), followed by a reservoir sampled in November 2010 (39/175 species= 22.28%) also in Stung Treng Province. The lowest number of species from a sample was collected from a pond in Ratanakiri Province with only 3 species (3/175 species= 1.71%). However a sample from the Mekong River in Kratie Province contained no rotifers.

Overall the highest number of species were found in ponds (e.g. a pond Stung Treng Province, 44 species), followed by lake and reservoir, with the river tending to support few species (0 species at a Mekong River site in Kratie Province).

Common species were *Keratella tropica* (found in 42 of 64 samples = 67.18%), followed by *Anuraeopsis fissa* (41/64 samples = 64.06%), *Lecane bulla* (38/64 samples = 59.37%), *A. coelata* (36/64 samples =56.25%), *Brachionus angularis* and *K. cochlearis* (34/64 samples = 53.12%). Fifty species were found in only one sample (1.56%).

Conductivity, turbidity, pH and temperature data obtained from ponds, lakes and reservoirs were seasonally compared to the number of rotifer species collected from each of the habitats. For conductivity, the number of species seems to be positively correlated in lakes and reservoirs while it tends to be negatively correlated in ponds (Fig. 2), that is the lower the conductivity, the lower the number of rotifer species expected. This finding is in agreement with the study of Jersabek (1995) that found the low numbers of rotifer species at sites with low conductivity. This is more likely to be true in this study because ponds have a higher conductivity and support more species than lakes and reservoirs which have a lower conductivity (Fig. 3).

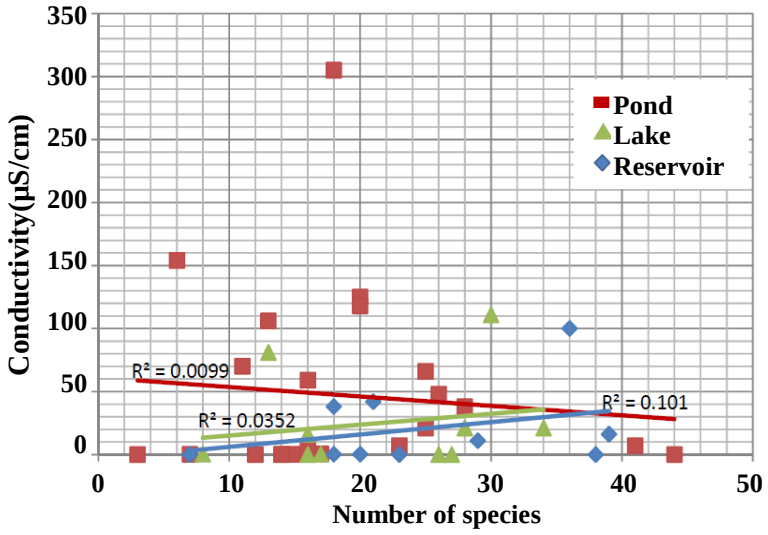

Fig. 2 Correlation between number of species and the level of conductivity in ponds, lakes and reservoirs

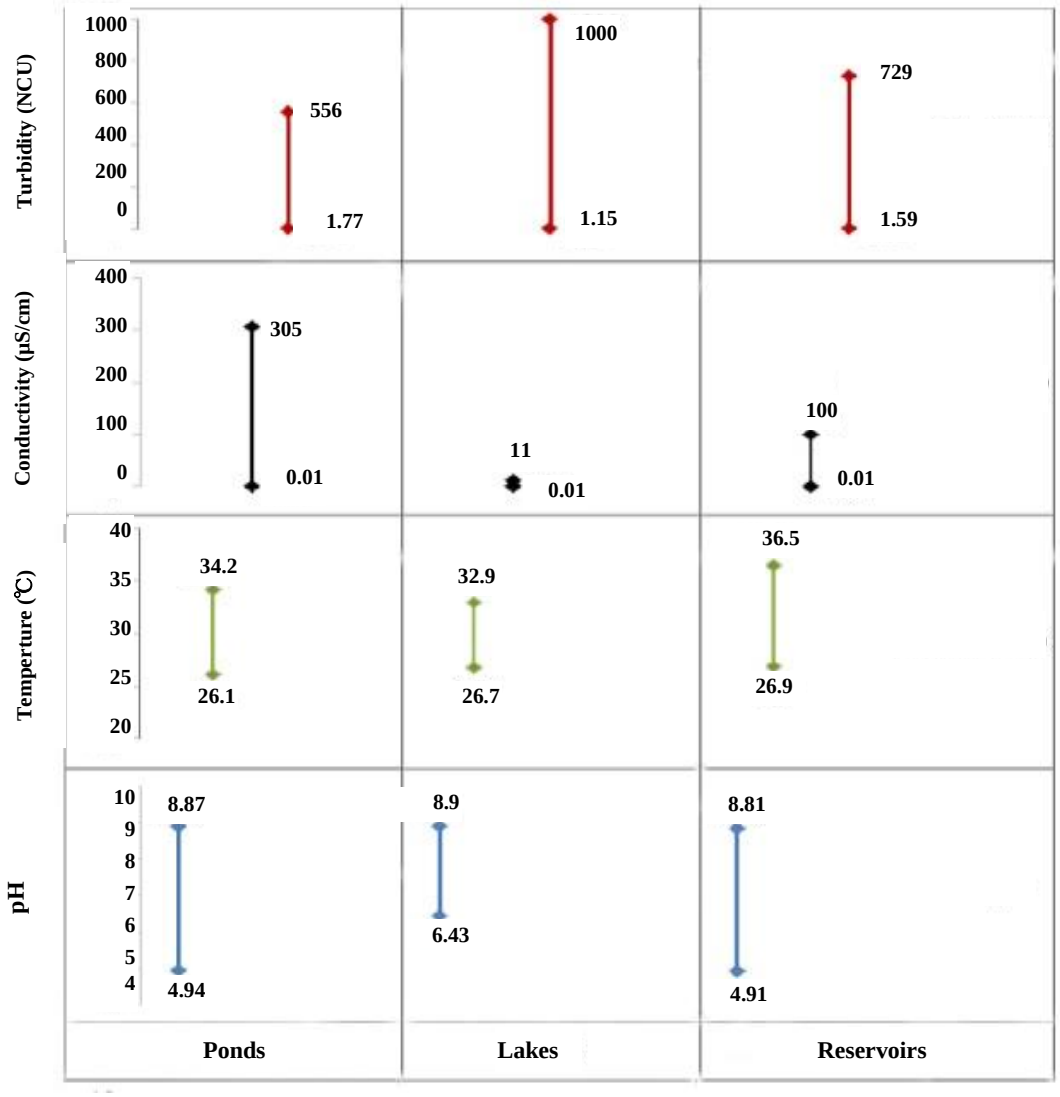

Fig. 3 Range of each water quality parameter in each habitat type

Water temperature is also considered to be one of the most important factors influencing the rotifer community. In this study, the numbers of rotifer species were not significantly correlated with water temperature. This could result from the life history and adaptation of each species to a particular temperature range; for example, *Synchaeta* sp. *Nothola squamula*, *Polyarthra dolichoptera*, *Brachionus angularis*, *Keratella quadrata* and *K. hiemalis* were found out to be negatively correlated with the water temperature (Devetter, 1998).

The other parameters were not found to be significantly different among the three habitat types. The range value of each parameter in each habitat type from site to site. Among the three habitat types, lakes showed a smallest (conductivity) and widest (turbidity) range values (Fig. 3).
Cosmopolitan: Found in at least five of the eight biogeographic regions of the world (Afrotropical, AFR; Antarctic, ANT; Australian, AUS; Nearctic, NEA; Neotropical, NEO; Oriental, ORI; Pacific, PAC; Palearctic, PAL) according to Segers (2007).

CONCLUSION

This study increased the number of new rotifer species records from Cambodia by 64. Ponds, lakes and reservoirs were found to contain a greater number of rotifer species than the river sites which tended to be low. This difference is most likely a result of the high flow in the river providing unsuitable habitat for these tiny organisms which may reduce both the number of species that can

survive in this habitat and their density. In addition to flow the conductivity of the water body appeared likely to be important in determining the number of rotifer species found in particular habitats.

Table 2 New records for Cambodia, their incidence in the present study and occurrence elsewhere

No	Species	Records elsewhere
1	*Anuraeopsis navicula*	AUS, NEA, NEO, ORI, PAL
2	*Asplanchna tropica*	AFR, ORI.
3	*Brachionus amazonicus*	NEO
4	*B. sessilis*	Cosmopolitan.
5	*Cephalodella forficula*	AUS, NEA, NEO, ORI, PAC, PAL
6	*C. hollowdayi*	NEO.
7	*C. intuta*	Cosmopolitan.
8	*C. mucronata*	AFR, AUS, NEA, NEO, ORI, PAL
9	*C. songkhlaensis*	ORI, Thailand.
10	*C. tenuior*	ANT, AUS, NEA, ORI, PAL
11	*C. ventripes*	Cosmopolitan; Thailand
12	*C. xenica*	NEA, PAL
13	*Colurella colurus*	-
14	*C. hindenburgi*	Cosmopolitan
15	*C. obtusa*	Cosmopolitan; Thailand
16	*C. sulcata*	Cosmopolitan, Thailand, Lao PDR.
17	*Conochilus coenobasis*	Cosmopolitan, Thailand, Lao PDR.
18	*Dicranophorus corystis*	NEA, PAL
19	*Encentrum felis*	AUS, NEA, NEO, PAL; Laos
20	*Gastropus hyptopus*	Cosmopolitan, Thailand.
21	*Itura aurita*	Cosmopolitan; Thailand
22	*Lapadella monodactyla*	-
23	*Lecane arcuata*	Cosmopolitan; Thailand
24	*L. aspasia*	NEA, NEO, ORI, PAL; Thailand
25	*L. batillifer*	AUS, ORI; Thailand
26	*L. braumi*	AFR, AUS, ORI, Thailand.
27	*L. calcaria*	NEA, ORI
28	*L. fl exilis*	Cosmopolitan; Thailand
29	*L. inermis*	Cosmopolitan, Thailand, Lao PDR.
30	*L. inopinata*	Cosmopolitan; Thailand
31	*L. nelson*	AFR, NEO, ORI, Thailand.
32	*L. nitida*	AFR, AUS, NEO, ORI, Thailand, Lao PDR.
33	*L. pumila*	AFR, AUS, ORI, PAL
34	*L. pyriformis*	Cosmopolitan, Thailand.
35	*L. schraederi*	ORI
36	*L. simonneae*	AFR, ORI
37	*L. tenuiseta*	Cosmopolitan; Thailand
38	*Lepadella ehrenbergi*	Cosmopolitan, Thailand.
39	*L. punctata*	ORI, PAL; Thailand
40	*L. triptera*	Cosmopolitan, Thailand.
41	*Macrochaetus longipes*	Cosmopolitan; Thailand
42	*Microcodon clavus*	AFR, ANT, AUS, NEA, NEO, ORI, PAL
43	*Monommata actices*	Cosmopolitan, Thailand.
44	*M. caudata*	NEA, PAL
45	*M. longiseta*	Cosmopolitan*, Thailand, Lao PDR.
46	*Notommata collaris*	Cosmopolitan*.

**Although considered cosmopolitan, this species was not listed in ORI by Segers (2007).*

Table 3 New records for Cambodia, their incidence in the present study and occurrence elsewhere (Cont.)

No	Species	Records elsewhere
47	*N. endoxa*	NEA
48	*N. tripus*	Cosmopolitan.
49	*Polyarthra dolichoptera*	AFR, AUS, NEA, ORI, PAC, PAL
50	*Resticula melandocus*	AFR, AUS, NEA, NEO, ORI, PAL
51	*Scaridium bostjani*	Cosmopolitan, Thailand, Lao PDR.
52	*Squatinella lamellaris*	Cosmopolitan, Thailand, Lao PDR.
53	*S. leydigi*	AUS, NEA, NEO, PAL.
54	*Synchaeta oblonga*	Cosmopolitan
55	*Taphrocampa selenura*	AFR, AUS, NEA, NEO, ORI, PAL
56	*Testudinella truncata*	AFR, NEA, PAL
57	*Trichocerca bidens*	Cosmopolitan, Thailand, Lao PDR.
58	*T. collaris*	AFR, AUS, NEA, NEO, ORI, PAL
59	*T. heterodactyly*	species inquirenda
60	*T. iernis*	Cosmopolitan; Laos
61	*T. macera*	AFR, AUS, NEA, PAL
62	*T. scipio*	Cosmopolitan; Laos
63	*T. tenuior*	Cosmopolitan, Thailand, Lao PDR.
64	*Trocosphaera aequatorialis*	AUS, NEA, NEO, ORI, PAL.

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Research article

The Analysis of Rattan Productions in Prek Thnot Community Protected Area, Kampot Province, Cambodia

SREYNEANG CHHEUN*
Royal University of Agriculture, Phnom Penh, Cambodia
Email: chheunsreyneang@yahoo.com

MONIN VORN
Dean of Faclity of Forestry, Royal University of Agriculture, Phnom Penh, Cambodia

OU RATANAK
Rattan Project Manager, WWF-Cambodia, Phnom Penh, Cambodia

Received 16 December 2012 Accepted 30 January 2013 (*Corresponding author)

Abstract This study generally aims to illustrate, promote and increase the awareness of the dwellers in the study area regarding the beneficial aspects of rattan. Particularly, it aims to identify the ways that the committee can use to sustain their rattan production and to determine the advantages (or beneficial effects) of rattan production to committee members' livelihood. To achieve these objectives, stratified random sampling was performed. Out of 82 respondents, 65 were collectors 13 were processors and 2 were middlemen, all living in three villages namely, Prek Thnot, Prek Kreng, and Chang Huon and 2 retailer reside in Kampot city. The study illustrated that rattan committee sustain rattan resource in their community by providing harvesting guidelines and initiating additional jobs from the production chain managing the amount of rattan resource to be used annually and replanting them, and applying harvesting technique from WWF. Rattan production with its beneficial effects is extremely important for all households in the production chain. It is not only used for food or handicraft but also a source of income for all actors along the chain.

Keywords rattan, management, rattan benefit, Prek Thnot Community Protected Area

INTRODUCTION

Majority of Cambodian population are farmers living in rural areas and depend on agricultural activities (Ros et al., 2011). The level of productivity of agriculture in Cambodia is low in comparison with neighboring countries in Asia (FAO, 2013). Since the lead source of income of farmers is low, additional income from other agricultural activities is significant. Mountainous people harvest forest products such as bamboo, resin, honey, and rattan which we know as Non-Timer Forest Product (NTFPs) after farming activity. A working paper of CDRI published in 2006 shows that average income from NTFPs is 280 USD per year for poor people in Cambodia. Moreover, NTFPs is used as a source of food, medicine, construction materials, shelter, and income for rural poor throughout the world (Warner et al., 2007; Khou, 2010). They are scarce resource and important to people who rely on harvest with sustainability. The people living near forest must be allowed to benefit from NTFPs in line with the development and sustainable resource management, which will encourage them to protect the forest for future generations (Tuan, 2007). Meanwhile Prek Thnot Community Protected Area had founded a rattan committee in order to manage rattan resource for the benefit of the community members and to ensure the stability of its usage. On the other hand, the information regarding rattan harvest, rattan production chain, and income from rattan production were still limited. In order to overcome these limitations, information about harvest, production chain, and economic condition of rattan were acquired during the study. This paper will identify the ways that the community can use to sustain rattan

production which serve as an important resource for Cambodians for food, furniture's, shelter, and extra income besides being one of their agricultural activities over centuries (WWF, 2010). Also, it will determine the profitability of rattan production to the Prek Thnot Community Protect Area members who are living and using rattan resources in Bokor mountain forest wherein they will be also encouraged to protect the forest and forest products. The awareness of profitability of rattan production in the study area is really significant. It is useful not only for protecting rattan resources but also many other important forest products in the study area.

OBJECTIVE

The analysis of rattan production in Prek Thnot Community Protected Area aims to identify the ways that the committee can use to sustain their rattan production and to determine the profitability of rattan production.

METHODOLOGY

This research was conducted in Prek Thnot commune, Teuk Chhou district, Kampot province Cambodia. Stratified random sampling was used to determine the representative household out of 118 rattan committee members in the three villages. The samples were composed of collectors, processor and middleman in three villages: Prek Thnot, Prek Kreng and Chang Huon. The sample size was 82 households in which 65 households were collectors, 13 were processors 2 middlemen and 2 retailers from Kampot City. Two types of data were collected for analysis; primary data which was generated from Rural Rapid Appraisal, e.g. key information deep interview, group discussion, semi-structured interviews using questionnaires, while secondary data was taken from rattan project publications, community records, committee records, the books, reports, and journals. All the data were stored and analyzed using the program SPSS version 16 determining useful tools such as frequency mean, compare mean analysis. Cost and Benefit and Margin method was applied to generate cost and return to all actors along the production chain. The history of community, timeline activities, and management strategies were described.

RESULTS AND DISCUSSION

History of rattan committee: There are three different divisions namely rattan group, medicine group and ecotourism group in the Prek Thnot Community Protected Areas. In 2007, Prek Thnot Community Protected Area founded rattan committee under support from rattan project of WWF-Cambodia, Forestry Administration and the Ministry of Environment which aims to manage rattan resource with sustainable manner and to provide job opportunity to community members throughout rattan collecting and rattan processing. Moreover, rattan project initiated a training course on how to produce several kinds of rattan furniture such as chair, bookshelf, and table as well as providing support material for furniture production to those interested. In 2012, there are 1,841 people who benefited indirectly from Prek Thnot Community Protected Area. Therefore, there are 118 people who got the profit from the rattan committee and they are potential in using the rattan resource for commercial purpose. Nevertheless, they are actively involved in rattan committee for setting up and practicing the regulation.

Rattan resource management: The structure of the committee is divided into three division namely marketing, financial management and natural resource management divisions. The division of marketing was created to enable market information for processors and collectors. Division of natural resource management is very important to manage resources in the forest when destroyed by fire or deforestation as well as planning rattan resource for annually usage and managing rattan nursery for replanting or sell out for cash income. Division of financial management is responsible for managing money usage. The income comes from selling rattan cane, contribution free of 1,000 R from members per harvesting, and per selling rattan furniture, and funding from other sources such as WWF and MAFF, FA. The main harvesting zone of rattan committee is around 78.30

hectares located in three villages namely Chang Huon (11.37 hectares), Prek Thnot (40.56 hectares) and Prek Kreng (26.39 hectares) village. Harvesting is being done by cycle in each zone depending on the time, number, and amount of actual plan of rattan committee. Moreover, around 30,000 rattan plants, from the nursery station of the community, were planted in the Prek Thnot Community Protected Area zone every year. However, the average rattan harvest of the community is around 27,000 canes (5 m per cane) per year or more which depending on the ability of committee members (collectors) and market force. The rattan committee helps on management of rattan resource and also contributes in sharing the profits and solving some problems of the collectors. Furthermore, the profit will be shared to committee members in case of cash need, hiring someone to manage the nursery, training, replanting, and helping the members in emergency cases like accidents in harvesting rattan.

Rattan collection technique of committee members: There are 21 species of rattan in Cambodia. Their harvest season varies according to species of each rattan. There are only five commercial species namely *Calamus rudentom, C. viminalis, C. palustrist, Korthalsia,* and *Som.* Collectors harvest rattan fallow the traditional and specified committee technique. Traditional technique used by the dwellers long time ago is unsustainable though because they harvest the rattan by digging its roots, destroying the young rattan. The committee technique, on the other hand, was taught and supported by WWF. These included three main activities. First, collectors identify the age and length of rattan. Second, only 60% of the rattan in clumps is being harvested while the 40% is left to support and provide nutrition to young rattan. Last, rattan cane should be cut 20-70 cm above the roots because the rattan trunks provide nutrition for young rattan. Only around 80% of the respondents are following the rule of committee harvesting. This technique for harvesting is very significant but it still needs to be improved and should be taught to all committee members. This harvest technique helps to enhance the sustainable resources in the protected area. According to the WWF (2011), the sustainable harvesting of rattan must consider the rattan age, seasonal harvesting, materials consumption and harvesting technique. The rattan recognized to be suitable for harvesting must have the fallowing characteristics; (a) mature in age; (b) height is over five meters; (c) rattan cane is dark green with black thorn; (d) leaves are dried and falling out; and (c) bearing flower and fruit. The best season for harvesting is during the dry season wherein the tree is protected from moles and insects infestation that could affect rattan growth. In addition, the proper harvesting tools should be utilized such as bush-whacker, special scissors, crampon and jungle-knife. These tools are very important. Crampon is being used for isolating cane from other trees growing with rattan. Bush-whacker is being used to cut and clean leaves from rattan cane which is easier than knife. Special scissors cuts rattan twigs looped to other tree. These tools avoid destruction of other plants significant for a sustainable rattan resource. The recommended four main steps for harvesting rattan are (a) collectors identify the right species; (b) cutting, rattan ten centimetres above the root; (c) removal of branches or twig meshed with other cane or tree before pulling: (d) pilling up of waste to the bush for fertilizer and to avoid fire. These steps are important harvesting technique for sustainable rattan production.

Importance of Rattan Production

Cost and return of collectors: Rattan is a potential resource for collectors because they do not invest capital but they can get profits from it. Time of collection of rattan depends on market demand and households' consumption. The collectors harvest the rattan around 22 days per person person. For every harvesting time, men can collect around 47 canes while women can carry 35 canes from the forest. The average capital cost is 61,600 R per household such as jungle-knife, thick clothes, gloves and so on. Average annual income of collectors is around 474,000 R per household.

Cost and return of processors: According to the study, 70% of processors produce rattan furniture only after farming or fishing and 30% of processors produce rattan furniture around 7 months and a half in average per year. There are three main types of rattan furniture that processors produce such as bookshelves (3 shelves with width=0.4 m and height=1.5 m), chairs (width=0.4 m, Height=1 m), and table set (4 chairs and a table with height=0.4 m and width=0.5 m). In average

processors can earn around 3,872,200 R per year and spend around 466,400 R in average for capital or expenses. Processors use 100% of family labour.

Detail Cost of Producing Certain Furniture

There are two options for calculating the total cost of processing rattan. First option is that the total cost includes the cost of hiring labour and cost of buying raw rattan while second option is the use of 100% of family labour of the processors in processing and harvesting rattan from the forest.

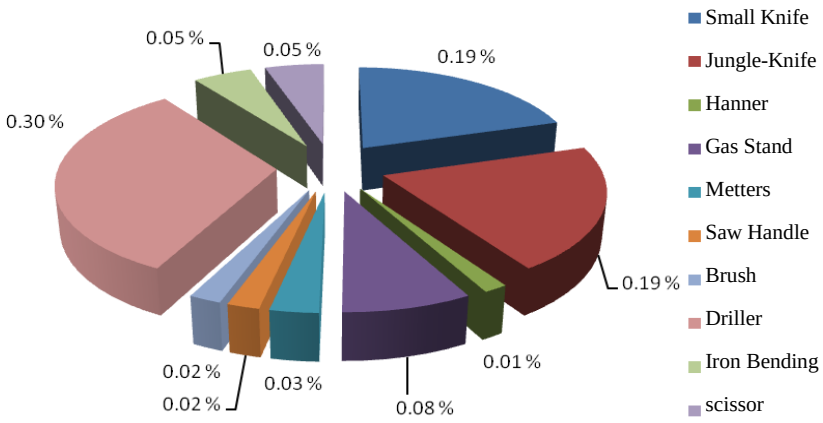


Fig. 1 Fixed cost of rattan processing

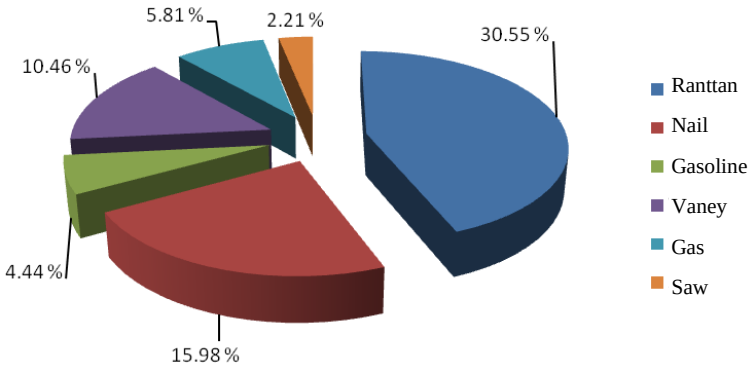


Fig. 2 Percentage of variable cost

Table 1 Processor's margin

Main Type of Furniture	Total Cost		FG Price	Margin	
	Option1	Option 2		Option 1	Option 2
Chair	19,700 R	4,900 R	20,000 R	300	15,100
Table Set	139,900 R	23,300 R	150,000 R	10,100	126,700
Bookshelf	26,800 R	4200 R	20,000 R	-6,800	15,800

Note: FG: farm gate

Profit of middleman and retailer: Middlemen are also community members who act as agents to collect rattan for traders in Phnom Penh City. In average, they earn 200 R commission per cane of rattan and around 426,600 R per season. Retailers are residents of Kampot market in the Kampot city; they can earn around 20,000 R profit from selling rattan furniture per month.

Timeline activities of rattan production: Timeline of activities contributed for evaluating and assessing the time spent by the actors in rattan production versus the benefits that they get. Table 2 show that after their main activities or in between of their activities farming or fishing activities,

rattan committee members can have more additional income from rattan production aside from farming and fishing. Based on the table, committee members don't harvest rattan the whole year but only during dry season and a little during rainy season.

Table 2 Timeline activities of committee members

Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rattan Harvest												
Processing												
Collecting												
Selling Furniture												
Farming Activities												
Fishing Activities												
Hiring labour												

Furthermore, there are some rattan collectors that go to the forest during rainy season. From October until mid-May, collectors can harvest rattan because they are free from their farming or fishing activities. They can also harvest during mid-May until the end of September but they harvest during the day when they finished from their farming or fishing activities. With regards to the collectors, they mostly process furniture almost every day except from mid-May until mid-July because during that time they are busy with their farming activities. Retailers sell out their product every day because their main job is to sell rattan furniture and other furniture in Kampot Province.

Rattan Production Chain

The production flow shows how rattan resource is used in the community. According to the study, rattan production is mainly being sold out fresh, about 69% of all rattan from the forest, while only 30% is being processed as furniture and 1% is used as houses building materials

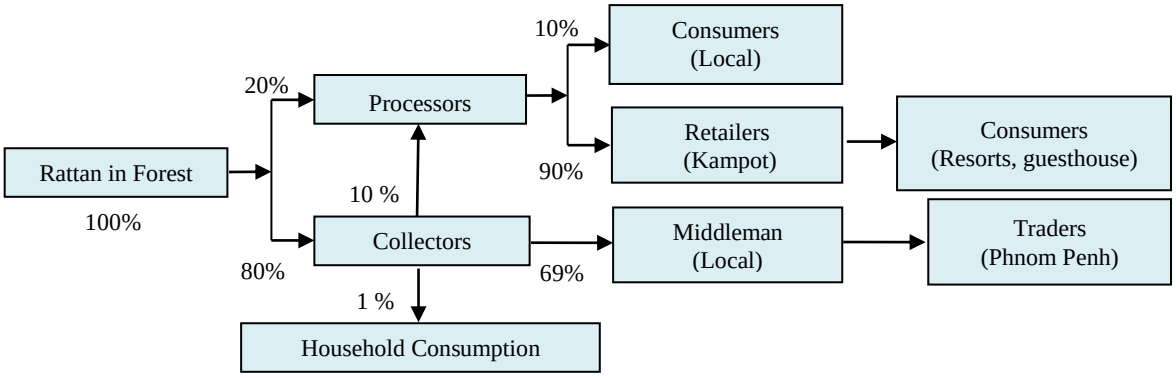
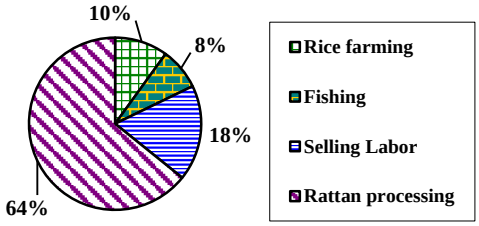


Fig. 3 Rattan production flow

Contribution Income to Committee Members

Rattan is very important for people along the production chain. People use rattan for food, and not only to make handicraft for household usage but also contributes to household gross income. The benefits of rattan production are extremely important for all households in the study area. They use the income to support child education, household repairs, food, and other expenditures for daily living. Furthermore, rattan production offers employment to all members of the family. It reduces migrant labor and members of household can earn more profit from collecting rattan and selling furniture's. According to Fig. 4 and Fig. 5, rattan processing had shared about 65% to processors annual income while collection had shared about 9% of collectors' annual income.



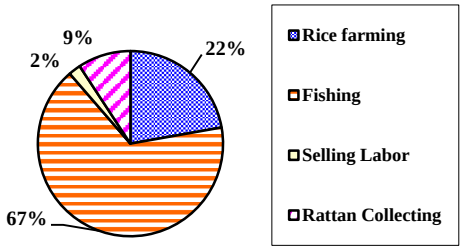


Fig. 4 Income source of rattan processors **Fig. 5 Income source of rattan collectors**

CONCLUSION

The rattan committee sustain rattan resource in their community by providing harvesting guidelines and initiating additional jobs from the production chain managing, the amount of rattan resource to be used annually and replanting them, and applying harvesting technique from WWF. Rattan resource in the study area share benefits to all actors along the production chain and it plays an important role in the income source of committee members after agricultural activities and fishing. Annually, collectors can earn 474,000 R which shared 9% of annual income and processor can earn 3,872,200 R which shared 64% of annual income. Middlemen earn 200 R commission per selling of cane of rattan, while retailers earn 20,000 R per month on selling rattan furniture. Nevertheless, the rattan resource is limited and need long time to grow for harvesting again plus it requires management.

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Research article

Effect of Agricultural Land Reform Development Project on Rural Livelihood: Experience from Thailand

NIRAMON KAEWKALLAYA
ALRO, Ministry of Agriculture and Cooperatives, Thailand

RAJENDRA P. SHRESTHA
School of Environment Resources and Development, Asian Institute of Technology, Pathumthani, Thailand

ANISARA PENSUK TIBKAEW*
Faculty of Technology and Community Development, Thaksin University, Thailand
Email: anisara.pensuk@gmail.com

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Abstract Thailand has faced from long time the problem of land tenure, and agriculture land reform program has been implemented in Thailand for about three decades particularly in the areas identified as the encroached national reservation forest. Todate more than 5.12 million ha of land have been allocated to the farmers in 69 provinces of the country for settlement and agricultural purposes. The collaborative project between JICA and ALRO called D/S North project has been implemented during 2004-2007 aiming to improve the living standard of farmers through promoting the practices of sustainable agriculture and integrating the proper natural resource management and environmental conservation measures into their living activities. This study, therefore, examines the achievement of the integration of the natural resources conservation measures to farmers' livelihood under the D/S North Project in the representative site, namely BorLek Long sub-district, Phrae Province. The Sustainable Livelihood Framework, developed by DFID was used to investigate the livelihood situation of the people who implemented the project. The study shows that the people have better living condition with better natural, financial, and social capital as a result of project implementation.

Keywords Agricultural Land Reform Office, agricultural land reform, rural livelihood, sustainable livelihood framework

INTRODUCTION

Like other developing countries, Thailand also had adopted the liberal market-oriented policies to develop the country (Isarangkun and Pootrakool, 2005). The developmental strategy was implemented in Thailand aiming to improve the quality of life of its people by expanding the basic infrastructure throughout the country such as roads, electricity and irrigation projects. Consequently, the expanding of the basic infrastructure can bring in the foreign and local investments were encouraged to increase agricultural commodities in order to support country's economic. Focusing on economic growth gave a great pressure especially on forest areas, which were rapidly destroyed and encroached for agricultural expansion (Department of Environmental Quality Promotion, n.d.). Furthermore, the need for land areas was high to meet the demand of increasing population and the high competition on land for residential, industrial, and agricultural purposes has also led to the land tenure insecurity for farmers. Accordingly, in response to those problems and the land protection for agriculture, the Agricultural Land Reform Office (ALRO) was established under the Ministry of Agriculture and Cooperatives in 1975 to take responsibility concerning the access of the poor people to land through implementation of land reform. ALRO's mission was in line with the King's wish to have agricultural land protection in order to have the

most efficiency farming (Agricultural Land Reform Office, 2009). ALRO is not only responsible for distributing land to poor farmers for agriculture and resident purpose, developing infrastructure and occupation but also promoting the effective natural resources of rehabilitation and utilization.

One of many rural livelihood improvement projects initiated by ALRO, The Development Study on Planning and Capacity Building for Natural Resources Management and Sustainable Rural and Agricultural Development in the North Thailand Project or "D/S North Project" had been implemented in cooperation with the Japan International Cooperation Agency (JICA) during 2004-2007 (Satutum, 2009) aiming in improving the living standard of farmers in the project areas through the practice of sustainable agriculture, integrated to proper natural resources management and environmental conservation of the protected areas, including local capacity building. Varieties of activities and provision of required basic infrastructure were carried out within the project, including forest plantation, making firebreak line, forest boundary marking, small-scale check dams construction, nursery of local plants, head water source protection, herbal harvesting and utilization, producing bio-gas using pig manure, organizing saving group and membership, swine meat processing, practicing kitchen garden, low chemical inputs farming, soil surface protection farming, soil improvement by bio-fertilizer/compost, livestock raising extension, plant material processing, water melon cultivation extension and Wood vinegar production.

This study examined the achievement of the integration of the natural resources conservation measures to farmers livelihood under the D/S North Project in the representative site, namely BorLek Long sub-district, Phrae Province. The Sustainable Livelihood Framework (SLF), developed by DFID. According to DFID, SLF assumes that livelihood resources comprised of five different capitals or assets, namely human, natural, financial, social and physical asset and each asset can be represented by number of factors affecting livelihoods. Different researchers used different indicators for assessing the livelihood asset, such as skill, literacy, knowledge, ability to labor and health of household members as human asset (Ahmed and Chowdhury 2006; Cramb et al. 2004; de Sherbinin et al. 2008; DFID 1999; Kristjanson et al. 2005; Scoones 1998; Westley and Mikhaev 2002) and also family structure, education, occupation, link to outside the farm sources of income (Soini 2005). Natural assets are the natural stocks and environmental services (de Sherbinin et al. 2008; Scoones 1998). Land holding size is one of the most commonly used natural asset indicator by several researchers, e.g. Ahmed and Chowdhury (2006); Cramb et al. (2004); Westley and Mikhaev (2002). Some other natural asset indicators in use are rainfall, wildlife density, and likelihood of having tick diseases (Kristjanson et al. 2005). Financial asset can be represented by cash, savings and credit (DFID 1999). In other cases, livestock possession (Kristjanson et al. 2005; Ahmed and Chowdhury 2006; Cramb et al. 2004; Westley and Mikhaev 2002; Soini 2005) and remittances (de Sherbinin et al. 2008; Westley and Mikhaev 2002) are also used as financial asset. Social asset are found to be represented by networks and connections, memberships of formalized groups and the relationship of trust (de Sherbinin et al. 2008), density of active community and benefit from kinship (Kristjanson et al. 2005; Westley and Mikhaev 2002; Ahmed and Chowdhury 2006) and collective action and accessibility to knowledge (Soini 2005). Physical asset comprises of basic infrastructure and producer goods (DFID 1999), houses and occupational equipments (Ahmed and Chowdhury 2006; Cramb et al. 2004; de Sherbinin et al. 2008), transportation network (Kristjanson et al. 2005), vehicles, machinery, shops and other agricultural implements (Westley and Mikhaev 2002) and even land under possession (de Sherbinin et al. 2008). Besides assessing livelihood using five assets, the SLA has also been used in studying the coping strategies and adaptation to change of rural livelihoods (Salisbury and Schmink 2007; Soini 2005). SLA as a wider view-based approach for addressing poverty and environment than conventional income-based approach, which recognizes the importance of the ability to access to resources, however the completeness of the assessment depends on the availability of data (Cramb et al. 2004). The indicators selected to be used in this study was appropriately designed as good representative of each asset in order to give the best responses of the villagers' livelihood.

Study Area

The project has been implemented in Phrae province, North region in Thailand (Fig. 1) where is the most significant area of the country for management and conservation of natural resources because of its extensive forest cover with unique biodiversity. The area is surrounded on all sides by mountains with level plains in the middle. The main occupation of the people is agriculture, particularly rice cultivation, cash crops and orchards. It was found that villagers have unbalanced income and high expenditure problem. Their main income source was from agriculture, livestock raising and fishery, etc.

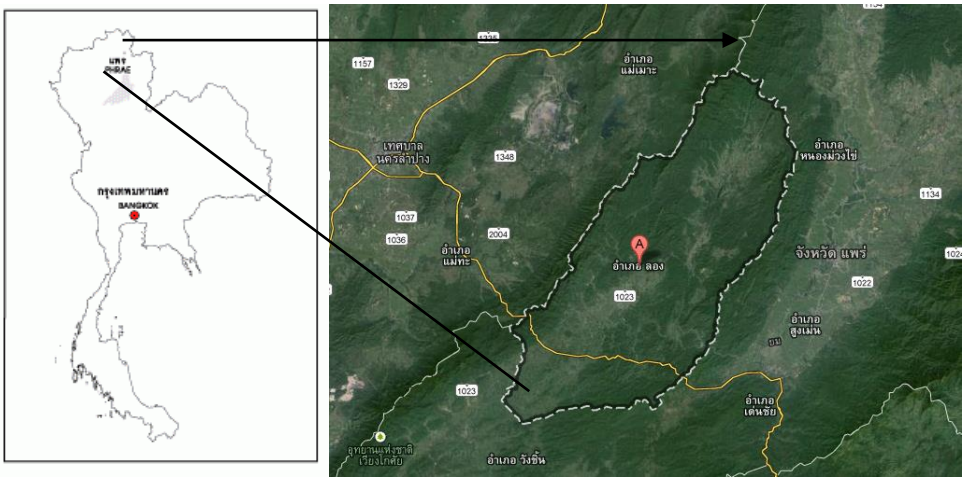

Fig. 1 The location and the aerial photo of the study area

METHODOLOGY

The D/S North Project activities were implemented during 2004-2007. The project had adopted the method of participatory approach by which villagers were encouraged to conduct all process of the project by themselves. The outcome of the project was evaluated 3 years after project has been terminated in order to investigate the changes of villagers' livelihood as policies, institutions and processes can have a great influence on access to assets (DFID, 1999). The study made use of the sustainable livelihood framework (SLF) developed by DFID (Department for International Development).The primary data was collected through household survey. A total of 75 households, who participated in the project from the beginning until the project termination, were interviewed using semi-structured questionnaire to determine significant change by asking specific questions relating to before and after implementation of the project. The indicators representing those five livelihood assets were assessed in order to investigate by comparing the changes of their livelihood after project has been implemented. Thirteen indicators were used to represent four livelihood assets. The physical asset comprised of the necessary infrastructures especially for agricultural activities was constructed with the supports of the D/S North Project, therefore this asset was considered significantly improved. The human asset indicators were derived from two indicators, namely experience/knowledge from training and gaining indigenous. The natural asset was derived from four indicators, namely forest condition, forest product dependence, quality of water resource and soil condition. The financial asset was assessed based on household income, expenditure, saving and debt. The social asset was derived from network building, cooperation among group, cooperation between local organizations, networking between neighboring communities, the relying on external services. The collected household information was described and analyzed using the Statistical Package for the Social Sciences (SPSS) software.

RESULTS AND DISCUSSION

Natural Asset

The natural asset of the villagers under the D/S North Project was assessed through four important indicators included forest condition, forest production dependence, quality of water resource and soil condition. Nearly 89% of the respondent perceived that their natural asset became better after the project has been implemented, whereas only 1% claimed that their livelihood was getting worse and 10% perceived that their livelihood remained unchanged (Fig. 2). Forest, water and soil condition were investigated as the indicators of natural asset. Nearly 95% of the villagers perceived that the condition of the forest was increase while only 5% of the respondent perceived no change in condition of the forest but none of the respondent detected the decreasing of the forest. However, the forest condition is better but the villagers whose livelihood rely on the forest was decreasing as only about 4% of the respondent still live by using the forest product whereas 86% perceived that they stopped relying on the forest product. The better forest condition consequence the better water quality and soil condition as 80% and 92% of the respondent perceived the better water and soil condition, respectively.

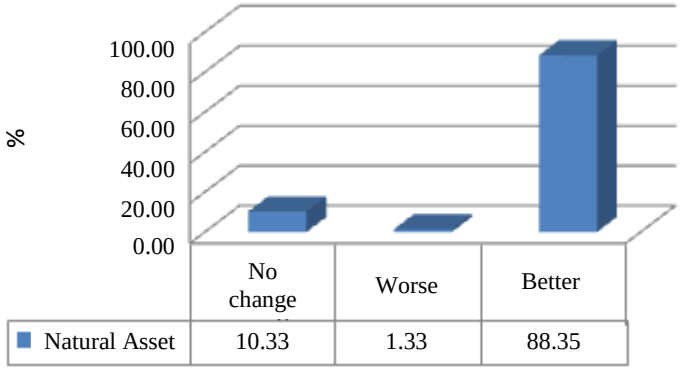

Fig. 2 Perceived natural asset due to the D/S North Project

Table 1 Perception of respondents on natural asset indicators

Perception on	%		
	No change	Decrease	Increase
Forest condition	5.3	0.0	94.7
Forest products dependence	9.3	86.7	4.0
Quantity of water resource	20.0	0.0	80.0
Soil condition	6.7	1.3	92.0

Source: Household survey

Financial Asset

The financial asset was assessed mainly through income and expenditure of the respondent. Overall financial asset of the villagers under the D/S North Project became better as about 86% of the respondents perceived that their income and saving has been increasing (Fig. 3) whereas the expenditure has become smaller after the project has been implemented. However, 1.68% respondents perceived that their financial situation got worse due to their higher expenditure and debt whereas 12% of the total respondents mentioned their financial situation remained almost the same (Table 2). In detail, the financial indicators showed positive results which help improving their livelihood. The respondents responded that they have higher income (according to 86.7% respondents) with higher saving (89.3% respondents) and reduction of expenditure (89.3% respondents) and debt (80% respondents).

Table 2 Perception of respondents on financial asset indicators

Perception on	%		
	No change	Decrease	Increase
Household income	13.3	0.0	86.7
Household expenditure	8.0	89.3	2.7
Household saving	10.7	0.0	89.3
Household debt	16.0	80.0	4.0

Source: Household survey

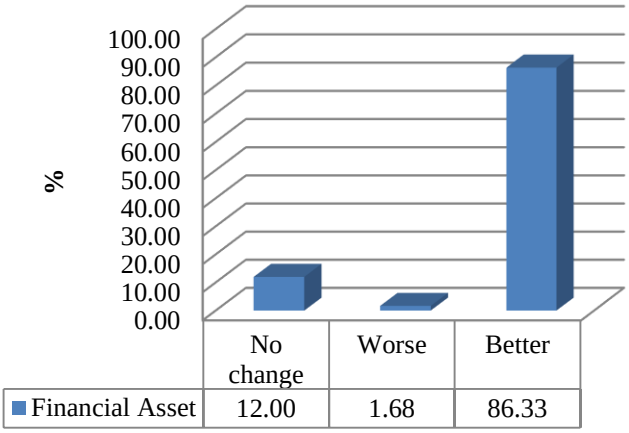

Fig. 3 Perceived financial asset due to the D/S North Project

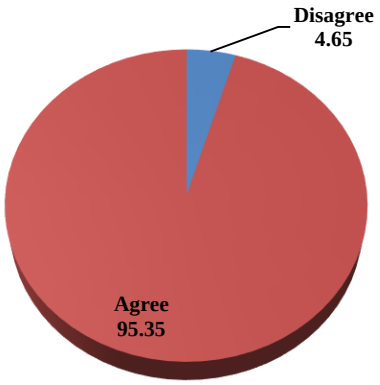

Fig. 4 Perception of the respondent on benefit of community networking and farmers group on overall social asset

Social Asset

The social asset of the respondent was assessed through various indicators which related mostly to farmers group and the networking. The questionnaire was designed to investigate the benefit of the network and the farmer group on their livelihood. The positive results were found from the household survey as more than 95% of the respondents have agreed that having network and farmer group can support their livelihood (Fig. 4). Especially networking and farmer group can help reducing their dependency on external services (Table 3), as they can produce and use the production within group member. All respondents have agreed that the D/S North Project was capable to improve their livelihood through social asset as they can reduce their dependency on external service by being self-reliance. About 98% of the respondents had agreed of making network and established the farmer group can improve their livelihood by having better cooperation from local organizations and neighboring communities (Table 3).

Table 3 The percentage of perception of the respondent on benefit of community networking and farmers group on the social asset indicators

Benefits from network and farmers group	Disagree	Agree
Benefit on gaining a better cooperation with local organization	1.3	98.7
Benefit on creating a better networking with neighboring communities	1.3	98.7
Benefit on gaining less dependency on the external services and being self-reliance	0.0	100.0

Source: Household survey

Human Asset

All respondents (100%) had agreed that their human asset was perceived significantly improved through various types of training organized by the D/S North Project. They perceived that they

gained more experience and knowledge from training and meeting. On the other hand, the indigenous knowledge can be transferred among the group members.

CONCLUSION

As in other places of Thailand, agriculture has remained the major source of income to support people's livelihood in the BorLek Long land reform project (the D/S North Project) area. The investigation showed that the farm households are better off with regard to every livelihood asset after the project has been implemented. The physical asset was improved through various basic infrastructure obtained from the project. The villagers perceived that their natural asset was better as the conservation measurement were integrated into the project. Similarly, the financial asset was improved as they can reduce their expenditure by living on their own farm production, for example, the kitchen garden, low chemical input farming, organic fertilizer, etc. Their social asset and human asset were also improved through various types of training and they can make connection through trainings and forming farmers group.

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Research article

Factors Influencing Equity in Farmer-managed Irrigation Distribution in Sindh, Pakistan

JUNAID ALAM MEMON*
Pakistan Institute of Development Economics, Islamabad, Pakistan
Email: memon@gmx.us

FATEH MUHAMMAD MARI
Sindh Water Sector Improvement Project, Karachi, Pakistan

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Abstract Equitable distribution of irrigation has been one of the most compelling justification for irrigation management reforms in many countries. Policy response to such need in Pakistan had been the introduction of farmer-management of tertiary level irrigation affairs. This study presents an empirical analysis of the effect of reforms on equitable irrigation distribution in Farmer Organizations (FO) of three Area Water Boards (AWBs) in Sindh, Pakistan. Cross-sectional quantitative information obtained from secondary sources included the official datasets on irrigation discharge measurements, FO maturity indexes and FO profiles prepared by Sindh Irrigation and Drainage Authority (SIDA) and Water Sector Improvement Project (WSIP-I). A multinomial logistic regression model, having Equity between Head and Tail watercourses as the regressand and Institutional maturity index, Culturable command area, and Membership size of FO as the regressors were used to model the determinants of Equity in Farmer-managed Irrigation Distribution. The study identified institutional maturity as one of the influential factors explaining variation in the irrigation delivery performance of FOs. With some caveats, findings have useful policy implications for the success of irrigation reforms for sustainable agriculture in Sindh Province of Pakistan.

Keywords farmer-managed irrigation, irrigation equity, delivery performance ratio, Pakistan

INTRODUCTION

Irrigation is the lifeline for millions of poor who eke out their livelihood from agricultural activities carried out in the developing regions of the world. As a key component of the green revolution package, developing countries have invested heavily in building irrigation infrastructure like dams, diversion structures and irrigation networks. The benefits of such investments can be observed from the fact that the total area under irrigation has more than doubled during 1961-2003 (Gleick et al., 2011). Probably it would not be exaggerating to say that human civilization avoided the Malthusian pessimism of food shortages and hunger (Malthus, 1806) partly because of the advances in irrigation engineering and technology. Today, agriculture consumes 60 percent of freshwater withdrawal worldwide, 69 percent in Africa and 75 percent in Asia, whereas in some countries, this figure could be as high as 99 percent (Gleick et al., 2011). Since 1950s, the irrigation policies in various developing countries had largely been an artifact of international donors (Suhardiman and Mollinga, 2012).The importance of irrigation development on donor agenda can be understood from the fact that irrigation could secure more than seven percent of the total lending by the World Bank since 1950s (Plusquellec, 1999 cited in Bassi and Kumar, 2011). The extent to which the donor intervention in irrigation issues and policies in developing countries is qualified is something external to the scope of this paper. However, it worth reading the illuminating article by Suhardiman and Mollinga (2012) nicely describing the way in which the international donors authored, suggested and pushed national irrigation policies in developing countries in general and Indonesia in particular.

Over the years, the donor prescription of irrigation policy for developing countries has largely shifted from the infrastructure expansion to institutional development. The new narrative described the hydraulic bureaucracy as incapable of making full cost recovery of irrigation service, adequate operation and management of infrastructure and equitable irrigation distribution; while assuming that if organized, farmers could efficiently manage the irrigation affairs (Bandaragoda, 2006; Memon, 2012; Mustafa, 2002; Suhardiman and Mollinga, 2012). The donors may have some empirical or systematic understanding of the inefficiency of hydraulic bureaucracy irrigation affairs, but it is highly tempting (see for example Suhardiman and Mollinga, 2012) to relate this shift to the ascendancy of participatory approaches promoted by Ostrom (1990), Chambers (1983, 1989, 1997) during the same period. Regardless of the label, the underline theme of reforms in most of the countries was full or partial involvement of farmers in different aspect of irrigation management (Bassi and Kumar, 2011; Poddar et al., 2011; Samad, 2002). Garces-Restrepo et al., (2007 cited in Bassi and Kumar, 2011) reported that 60 countries covering about 80 percent of the irrigated area worldwide have already implemented some form of institutional reforms in irrigation management. South Asian countries such as India (Arun et al., 2012; Poddar et al., 2011), Pakistan (Memon, 2012; Memon, 2006) and Sri-Lanka (Bandaragoda, 2006) were also not an exception of the donor driven reforms. All of these countries have initiated some form of Participatory Irrigation and Management (PIM) on secondary and tertiary level channels.

Institutional reforms in Pakistan are particularly important since the country features the Indus River, which houses a gigantic irrigation system unparalleled in the world. The system developed through substantial assistance of international donors. Consistent with donor narrative elsewhere in the world (see for example, Bandaragoda, 2006; Suhardiman and Mollinga, 2012), the external push for reforms triggered the policy shift for PIM, assuming that it will facilitate full cost recovery, adequate operation and management and equitable irrigation distribution (Memon, 2006). Memon (2012) reported that despite more than 15 years of implementation, the reforms were still in their infancy. Advocates often report Sindh province for its relatively better performance in the implementing the reforms, but actual implementation could hardly be seen beyond the canal command areas of three Area Water Boards (AWBs) against the targeted 14 canals (Memon, 2012). Call for speedy implementation of reforms in the remaining canal commands in Sindh Province might be reasonable, but there are virtually no empirical evidences suggesting the policymakers about the efficacy of the farmer-managed irrigation system in terms of full cost recovery, adequate operation and management of infrastructure and equitable irrigation distribution.

OBJECTIVE

Thus, the objective of this study was to carry out an empirical analysis of the extent to which the institutional reforms in the irrigation sector of Sindh Province in Pakistan could achieve its equitable irrigation distribution objectives hoping that findings will guide appropriate policymaking. In order to achieve this objective, the next section describes the materials and methods followed by a section on results and discussion. The final section concludes the study and draws policy implication besides highlighting the areas for future research.

METHODOLOGY

Selection of Study Area and Sample FOs

The study covered all three canal commands of Area Water Boards (AWBs) namely, Nara Canal AWB (NCAWB), Ghotki Feeder Canal AWB (GFCAWB) and Left Bank Canal AWB (LBCAWB) where the institutional reforms were implemented (Fig. 1). Farmer Organization (FO) served as the main unit of analysis. Selection of FOs was arbitrary based on the availability of required information across all data sources explained in the Table 1. This means that any FO, for which the required information was available, qualified the selection process. This process provided 34 FO (27 from NCAWB, four from GFCAWB and three from LBCAWB).

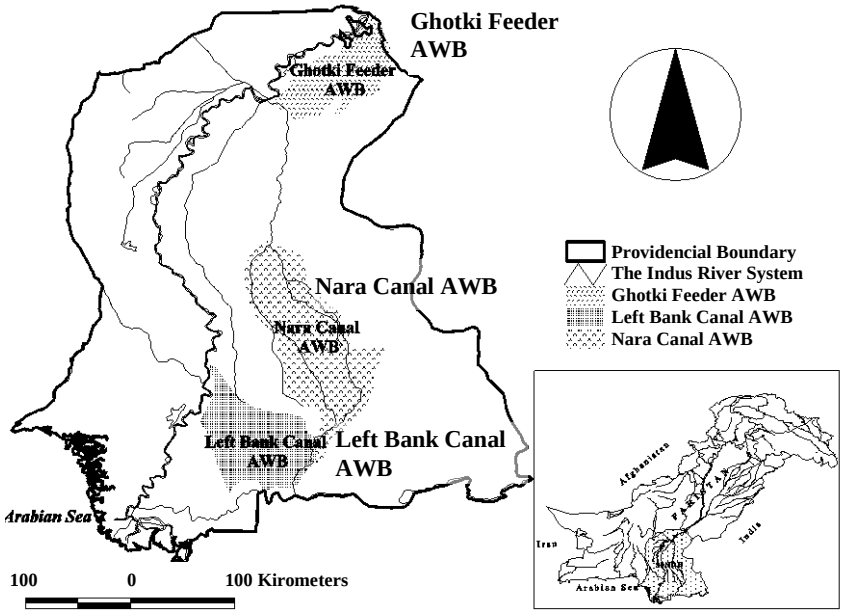

Fig. 1 Location of study area, main canals and three AWBs

Table 1 Description of data and indicators

Data set/Source	Description
1. Delivery Performance Ratio (DPR) (WSIP-I, 2012a)[1]	– DPR[3] calculated separately for any watercourse (WC): $DPR = ActualDischarge/MeasuredDischarge$ (1=getting designed share; <1= getting less than design share; and >1 getting more than the designed share) – Head to Tail equity[4] at the tertiary level channel was determined by: $HTEquity = (DPRHeadWC)/(DPRTailWC)$ (1= Equity between Head and Tail WCs of a FO; <1= Head WCs getting less than Tail WCs; and >1= Head getting more than Tail)
2. Institutional Maturity Index (2 Datasets) (SIDA,2012)[2] (WSIP-I, 2011)	– The institutional maturity index was the sum of four constituting indexes: 1. Organizational management 2. Financial Management 3. Conflict Resolution 4. O&M and Irrigation Service Delivery (Since both of the sources were different in terms of weights assigned to each of the above parameters, standardization was obtained by converting the original scores into percentages)
3. Profile Indicators (SIDA,2009) (WSIP-I, 2012b)	– CCA is Culturable Command Area in hectares irrigated on a tertiary channel – Size of FO (Membership)

Notes: 1. *Water Sector Improvement Project* 2. *Sindh Irrigation & Drainage Authority*
3. *DPR calculated at Water Course level* 4. *HT Equity calculated at FO level*

Materials and Methods

The study utilized secondary information obtained from two government agencies, namely: Sindh Water Sector Improvement Project (WSIP-I) and Sindh Irrigation and Drainage Authority (SIDA) (Table 1). Since the information was the part of official reports and publically inaccessible, the authors wrote emails and visited the concerned offices to get access. Some of the selected FO was present in both SIDA (2012) and WSIP-I (2011) maturity index datasets. In those cases, the information was extracted from the dataset provided by SIDA (2012) due to the consideration that it required no processing which could somehow affect the overall quality of the information.

Model Specification

Institutional reforms in the irrigation sector came out of a belief that organized and capable famers could take over the management responsibility of tertiary level irrigation affairs. This encouraged the policymakers to implant FOs and invest in building their institutional capacity until they become mature enough to assume the complete responsibility of tertiary level irrigation affairs. If such an assumption was reasonable, any increase in the maturity level of a FO could result in more equitable irrigation distribution. However, some other factors such as the membership size of FO and the agricultural area it served could also affect the equitable distribution of irrigation. With this premise, equity between head and tail watercourses (*HT Equity*) as dependent variable was regressed with three independent variables namely, the institutional maturity index of FO (*IMI*), the membership size of FO (*Mem*) and the culturable command area of FO (*CCA*). The dependent variable was re-coded into three categories (values < 0.90 = 1, head WCs drawing less water than tail WCs (*HDL*); values between 0.90 - 1.10 = 2, head and tail WCs drawing equal water (*HTDE*) by allowing ± 0.10 margin to 1:00 to account for technical and flow change reasons; and, >1.10 =3, head WCs drawing more water than tail WCs (*HDM*)). Thus, the dependent variable was categorical while all of the independent variables were continuous. Since *'HT Equity'* as a dependent variable had three categories, Multinomial Logistic Regression was an appropriate modelling choice. The model specifications were:

$$\log\frac{Pr(Y = HDL)}{Pr(Y = HTDE)} = \alpha + \beta_1 IMI + \beta_2 Mem + \beta_3 CCA$$

$$\log\frac{Pr(Y = HDM)}{Pr(Y = HTDE)} = \alpha + \beta_1 IMI + \beta_2 Mem + \beta_3 CCA \quad (1)$$

Where:

- *Y* was dependent variable: *HT Equity* having three categories (*HDL*, *HTDE*, &*HDM*)
- *HTDE* was the reference category
- *IMI*, *Mem* and *CCA* were independent variables
- α was a constant (the state of *HT Equity* without any effect of independent variables)
- β_1, β_2 *and,* $\beta_3$were coefficient of independent variables

RESULTS AND DISCUSSIONS

An average FO in Sindh Province could be a sufficiently large entity all in terms of its social, geographic and operational attributes (Table 2). Serving thousands of hectares within the range of various kilometers and satisfying hundreds of farmers must be a complex task if purely seen from a micro lens of collective action problems. These complexities could multiply if one takes in to account the power structure in the agrarian society where landholding size symbolizes social status, power and prestige. The difference in land holdings of the largest and smallest farmer and in FOs indicates that not all of the members were equally advantageous in the local power structure (Table 2). Within this context of the complexities, shall one expect that a FO could achieve its objective of equitable irrigation distribution?

Based on the analysis of a small sample of arbitrarily selected FOs, the answer to the above question appears to be a cautious 'yes' (Table 3). Taking equity between head and tail watercourses as a base category of the dependent variable, the results of multinomial logistic regression revealed that with one percent increase in institutional maturity index score, while keeping all other independent variable constant, there is relative risk that the inequity will decrease for about 10 percent (Table 3). This seems to be valid in both cases of inequality, i.e. if head was drawing less irrigation than tail or head was drawing more irrigation than tail (Table 3). Relative risk that inequity of irrigation will decrease essentially implies that equity will increase. None of the other independent variable had any significant impact on equity except that membership size had significant impact on equity in the case of head watercourses drawing more irrigation than tail watercourses. With an increase of 10 members, a FO would probably move five percent towards equity (Table 3). If one looks at the effect of membership size with a "small is beautiful" lens, the

contribution of membership size towards equitable irrigation distribution seems a paradox. This is because the complexities of irrigation management will perhaps increase with larger groups. Nevertheless, a valid explanation may come from the "mass effect" suggesting that increase in shareholders, will reduce the space for individual to demand more irrigation than their due share and thus compel FO management to ensure equitable irrigation distribution.

Table 2 Management context of an average FO in Sindh Province (N=354 FOs)

Salient Features (Unit)	NCAWB		GFCAWB		LBCAWB		Other AWB	
	x̄	SD	x̄	SD	x̄	SD	x̄	SD
CCA (Ha)	3280	3057	2659	2682	3457	2645	2414	2012
Design Discharge (Cusec)	35	32	59	57	112	102	68	91
Length of Channel (km)	10	13	12	11	11	6	9	3
Membership (Person)	280	231	347	401	348	383	280	138
Largest Landholder (Ha)	98	85	84	106	176	230	197	172
Smallest landholder (Ha)	3	2	2	3	5	22	2	2

Source: Prepared based on SIDA (2009)

Table 3 Results of multinomial logistic regression (irrigation equity as dependent variable)

Equity	RRR	Std. err	z	P> | z |	[95% confidence Interval]	
Head drawing less than tail						
– Institutional Maturity	.91991	.01055	–1.94	0.053*	.845374	1.001016
– Membership size	.98486	.01303	–1.15	0.249	.959645	1.010748
– CCA	1.00125	.00894	0.14	0.889	.983883	1.018921
Head drawing more than tail						
– Institutional Maturity	.89550	.01097	–2.45	0.014**	.819720	.978289
– Membership size	.95216	.02717	–1.72	0.086*	.900374	1.006927
– CCA	1.00987	.01113	0.89	0.373	.988291	1.031931

Notes:

1. *'Head and Tail are drawing equal' is the base outcome*
2. ** & ** denotes significance at 90 & 95 percent, respectively.*
3. *Supplementary statistics*

Number of observations	=	*34*
LR χ^2	=	*14.91*
Prob. > χ^2	=	*0.0210*
Pseudo R^2	=	*0.2154*
Log likelihood	=	*–27.15064*

CONCLUSION

Donors-pushed and demand-driven reforms in the irrigation sector posit various questions on the efficacy of FOs in achieving the intended objectives of PIM. One of the key questions raised in this study asked whether the implanted FOs could ensure equitable irrigation distribution. Drawing on the case of institutional reforms in Sindh Province of Pakistan, this paper concludes that it is plausible to expect that upon maturity FOs would deliver equitable irrigation distribution. Nevertheless, there are various caveats in accepting this conclusion. Surprisingly, when regressed individually none of the constituting indexes of IMI (Table 1) showed any significant impact on equity between head and tail watercourses. The impact came out only with the summation of the constituting indexes as IMI (Table 1). One may conclude that farmer organizations need an overall capacity building support in order to achieve its intended objectives. Nevertheless, given that the study was data constrained and carried out with a very small sample of arbitrarily selected FOs, this would be an imprudent jump into the conclusion. In order to serve as a real policy input, the study needs extension over adequate and representative sample of FOs. Such study should also include all constituting indexes as separate variables. This will not only confirm the tentative conclusions emerged out of this study but will inform policymakers about the specific areas of intervention for the success of institutional reforms in irrigation sector of Sindh Province.

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Research article

Beef Market Chain and Opportunities for Farmers in Kampong Cham Province, Cambodia

MIRANDA PEN*
University of New England, Armidale, Australia
Email: mpen@myune.edu.au

DARRYL B. SAVAGE
University of New England, Armidale, Australia

SOPHAL LORN
Department of Agriculture, Kampong Cham, Cambodia

WERNER STÜR
Farm and Agricultural Advisory Services, Queensland, Australia

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Abstract Most cattle raising in Cambodia is undertaken by smallholder farmers, based on a system of low nutritional input (crop residues) and high labour input. Options for increasing efficiency and introducing a market-oriented beef production system are considered a priority. This paper reports the outcomes of a cattle market chain study conducted in Kampong Cham province. Three districts were selected: Prey Chhor (paddy area), Tbong Khmum (highland area) and Kang Meas (Mekong area). A rapid market appraisal was conducted by following the market chain from producers to traders. Farmer groups, cattle brokers and small, medium and large traders were informally interviewed. Farmers in Prey Chhor frequently bought and sold draft cattle as a seasonal cycle for rice cropping. Farmers along Mekong area practiced a form of market-orientated production, buying thin cattle from other districts to fatten and sell. At all points of the market chain, interviewees reported that kilogram of meat was the basis of price. Interestingly, sale of raw meat at market (retail) is the only stage of the market chain at which weighing of meat takes place. At all other stages of the market chain, assessment of weight is undertaken by visual assessment and is therefore only an estimate. For breeding animals, their physical appearance rather than production-based measurements is the basis of price. Importantly, meat eating quality was not identified an issue of importance by farmers or cattle traders.

Keywords draft cattle, market chain, cattle production system, smallholder farmers

INTRODUCTION

Demand of meat is the primary driver for a livestock revolution, and in developing countries, poor people are consuming more animal products due to their increased income and urbanization (Dalgado, 2003). With projected population of 0.7 billion in 2005 and 0.9 billion in 2050 in Southeast Asia (SA) (Haub and Kaneda, 2012), annual growth of meat consumption during 1997–2020 is expected to be 3.4% per year in SA and 3.1% per year in China (Dalgado, 2003), where meats are exported to.

As one of the ASEAN (Association of South-East Asian Nations) countries, Cambodia will enter into one economic zone so called ASEAN Economic Community (AEC) by 2015 (ASEAN, 2012). This will promote more opportunities for Cambodia to increase its participation in export markets. However, there are challenges for the Cambodian producers to compete with other countries related to product quality and supply issue.

Cattle population in Cambodia was 3.4 million in 2011, down from 3.6 million in 2009 (MAFF, 2012). Cambodia has had relatively high growth rates of meat production (7.7%) and

consumption (8.6%) since the 1980s (Ahuja, 2012). However, cattle production of the Cambodian farmers is still small in number and is based on low nutritional input and high labor demand (Pen et al. 2009; 2010). Problems resulting from parasites and diseases are still severe for the Cambodian cattle herd (Copeman and Copland, 2008, Nampanya et al., 2011). Interventions to develop livestock sector in this country are very crucial to respond to the market opportunities.

Current cattle markets for the Cambodian livestock are mainly in local markets and in Vietnam, China and Thailand (Sieng et al. 2012). The cattle trading within the country is still modest and is laid in an extensive and traditional system. The understanding of cattle market chain among the farmers and traders will have an implication for cattle development in the country for income generation of smallholders and national economy. There have been studies to understand the livestock movement and disease spreading in Cambodia (Sieng et al. 2012; Kerr et al. 2012; Hawkins et al. 2012), that influenced the focus of the study reported in this paper.

OBJECTIVE

This study aims to analyze factors involving in beef market chain in Kampong Cham province of Cambodia and to discuss the opportunities for them to gain more participation in cattle markets.

METHODOLOGY

A rapid market appraisal (RMA) was used to collect data for this study. Informal interviews and meetings with farmers, brokers and traders were undertaken in Kampong Cham Province, Cambodia. This study were prepared by previous project funded by the Australian Center for International Agricultural Research (ACIAR), namely ACIAR project AH/2003/008 'Improved feeding systems for more efficient beef cattle production in Cambodia'. The project had defined three main sites for testing the adoption of forage planting and developing cattle fattening system. With the assistance of local extension workers for agriculture and head of districts, Prey Chhor (paddy area), Tbong Khmum (highland area) and Kang Meas (Mekong area), were selected based on its topography and agricultural activities. In each of the sites, there were 15 smallholder forage adopted farmers (referring to those who have less than 10 heads of cattle) to join and a series of questions focusing on cattle production purpose, breed selection, buying and selling activities, were asked. Farmers were allowed to discuss and to share their responses while all information were recorded and analyzed by the interview team. Breed type were discussed in the interview process, however, due to inconsistency of definition of breed-type, this data was discarded in the result section.

Five cattle brokers from each site were informally interviewed individually on cattle market network, cattle price and trading margin. With the help of the brokers, three levels of traders were identified: small, medium and large traders based on numbers of cattle traded. Ten smalls traders at commune level (buy and sell cattle; 15 cattle/month), 8 medium traders at district level (up to 60 cattle/month), 6 large traders at provincial level (300 cattle/month) were contacted and interviewed separately. They were invited to the Department of Agriculture in Kampong Cham Province to provide information related to cattle price and trading margin, trade flow and their perspectives on cattle market chain. The data are presented in form of flow chart and tables.

RESULTS AND DISCUSSIONS

Cattle Market Chain of Smallholder Farmers: An Example in Prey Chhor District

Prey Chhor District is a paddy area in the province. The cattle purchasing (Fig. 1) in this area mainly related to cropping activities (rice growing) because farmers purchased draft animal based on cropping cycle. They also purchased breeding cows from within district (for native cows) or from Kang Meas (for crossbred cows). Brokers and small traders involved more or less in cattle

purchasing in the district depending on their contacts with farmers.

Farmers in Prey Chhor sell claves, old cattle and draft cattle to the market (Fig. 1). Calves were mainly purchased by farmers within village or from nearby village. Small and medium traders played a strong role in purchasing old and draft cattle and in selling to local slaughterhouses or large traders. Large traders sold their stock to local slaughterhouses, or Phnom Penh or to Ho Chi Minh City in Vietnam.

The trade was done on unscheduled timeline with farmers, which means that it could occur anytime farmers wanted to sell their stock. Sieng et al. (2012) reported that to find stock for purchasing, traders contacted producers directly by traveling to their known sources or through phone contacts or family networks. It was clear that farmers did not produce cattle based on planned production. This becomes an issue for traders to optimize their activities on a basis of regular and steady production cycle. Hence, cattle market chain at the district level was generated in a traditional way and farmers' awareness of market information was limited.

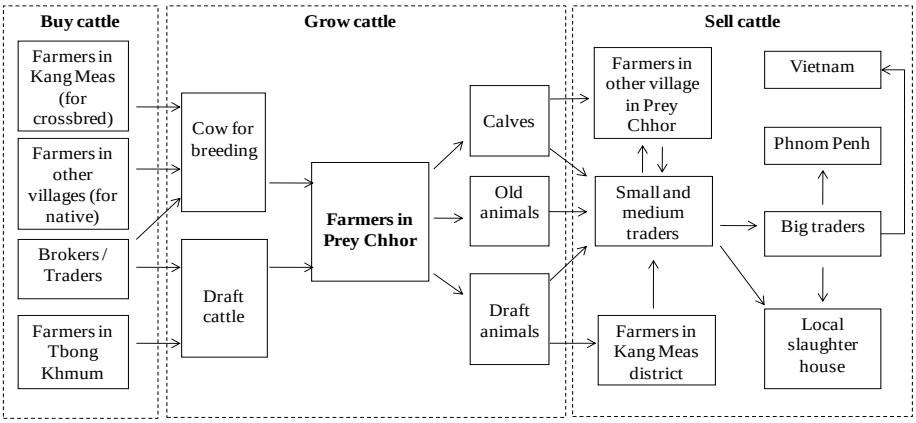

Fig. 1 An example of cattle market chain of farmers in Prey Chhor Distrcit, which is linked with other districts within the province and to market

***Broken box indicates cattle trading activities of farmers in Prey Chhor District. Arrows indicate movement of cattle within the chain.*

Table 1 Purpose of cattle production in the three project sites in Kampong Cham, Cambodia

Purpose of cattle production	Prey Chhor	Tbong Khmum	Kang Meas
Priority 1 – 2 – 3*			
Cow-calf	2	1	1
Drought	1	2	3
Fattening	-	-	2

**Information from farmer group interviews*

Purpose of Cattle Production

The purpose of cattle produced by farmers in the three project sites were different (Table 1). In Prey Chhor District (paddy area), draft power was the first main purpose, followed by cow-calf production. The later was more prior purposes in Tbong Khmum District (highland area). None of farmers fattened cattle for selling in these two districts. In Kang Meas District (Mekong area), cow-calf purpose was the first priority. Farmers also fattened cattle in this area where feed availability is abundant. As fattening cattle was one of the project objective to increase smallholder cattle herd and individual cattle price, more fattening activities was expected to achieve in others two project sites. This development towards more oriented-market supply will be achievable in case that nutrition of cattle is improved in terms of quantity and quality.

Cattle Purchasing and Selling Activities of Farmers

Farmers in Prey Chhor (paddy area) purchased draft cattle, mainly directly from farmers along the

river, as a cycle for cropping activity. When they finished the activity, they sold their old stock to farmers in Kang Meas for fattening. The calves were also being sold directly to other farmers or small traders. In Tbong Khmum (upland area), farmers purchased cross-bred cows, mainly through brokers, in order to increase the crossbred type proportion of their herd. They produced calves and steers for breeding or draft purpose to other farmers and old animals to traders. In Kang Meas (Mekong River area), farmers bought thin cattle from Prey Chhor for fattening sale. They might buy through brokers or directly from farmers. They also produced calves for selling and young cattle for breeding or draught. Their fatten cattle were sold to small traders for slaughter.

There was a relationship between how farmers selected the breed of their stock and the purpose of production. In paddy areas such as in Prey Chhor District, where draft power for rice cropping are crucial, farmers preferred to keep the local breed of cattle due to their less feed consumption and more suitable for draft power. In Tbong Khmum and Kang Meas Districts where cow-calf and fattening were the main purpose of keeping livestock, more crossbred cattle, which are larger than the local cattle, were observed. This means that smallholder farmers in these areas have been selecting better and more productive breeds of cattle for their stocks in order to get more benefit from their production.

Cattle Price and Trading Margin

To buy cattle for slaughter, traders estimated the amount of meat on animal and paid for kilogram (kg) of meat on the animal. Interviewees reported that when purchasing breeding cattle, the appearance of body (eg. head, skin, legs), body condition score and health condition were more important. Higher prices were offered to fatter cattle. While animal were not weighed during the purchasing, price were based on an estimation of meat yield per animal. Then traders calculated the value of individual cattle by multiplying its expected meat yield (kg) with a price per kg that they intended to pay. The prices of meat were 11,000-13,000 Riel/kg (~2.75-3.25 USD/kg) for farmers. Big traders in Kampong Cham paid 17,000 Riel/kg (~4.25 USD/kg). Brokers received a commission of ~4 USD per animal sold from both buyer and seller (2 USD from each). Medium and large traders tended to have a profit margin of $20-25 per animal traded.

Sieng et al. (2012) reported that the demand of red meat within Cambodia is important, but internationally, only the price of meat in the Vietnamese market determined the price of meat in Cambodia. Time of the year is also important determinant of price based on the seasonal supply which is high during festive seasons, for example during Khmer New Year (in April).

Trade Flow

Most often, the large traders purchased cattle through brokers and small or medium traders and paid the original price of cattle plus a marginal price (marginal prices were not disclosed). The large traders interviewed in Kampong Cham estimated that they sold 60% of their cattle to the Vietnamese traders, 30% in Phnom Penh (for slaughters) and 10% to the local slaughters. These traders reported that the market requires that cattle sold to Vietnam and Phnom Penh must have at least 50-70 kg meat/animal. Larger animals with more meat were preferred. The Vietnamese traders paid ~17,000 Riel (4.25 USD) for thin cattle and ~20,000 Riel (5 USD) for fat cattle per kilogram of meat. Interestingly, sale of raw meat at market (retail) is the only stage of the market chain at which weighing of meat takes place. At all the other stages of the market chain, assessment of weight is undertaken by visual assessment and is therefore only an estimate.

The trade of live animals is unreliable to predict because the formal trade is still small and informal trade of live animals across the region is significant (Ahuja, 2012). Livestock trade (moving in and out) in Cambodia was unrecorded (Hing et al. 2007). Thailand is a big producer and exporter of large animals in the region. Cambodia (and Laos) is considered as a transit country for live animal movement from Thailand to high-value markets in Vietnam and China (Kerr et al. 2012). Competition of Thai cattle going to Phnom Penh and Vietnam became a threat to the Cambodian farmers.

Farmer's Perceptions on Cattle Market

Farmers were thinking of how to make more profit from their small number of cattle. They understood that good health condition and fat cattle were easier to sell than thin cattle but they were not aware on how the prices were given by buyers/traders. They chose to keep their cattle longer rather than selling when the prices were low, thus they were not aware of extra input cost of labor and feeds during the delayed period. They tried to avoid trading costs made by brokers or small traders because they preferred to sell/buy directly to/from others farmers.

Trader's Perspectives on Cattle Trading

Traders did not think that supply/demand of cattle market would be a big issue for them to trade. Hence, the expansion of business was their main focus, but lack of capital limit their business. Besides these internal factors, they also mentioned some external factors that would be the issues for their trading. For example, there has been an increase of competition of cattle coming from Thailand to Phnom Penh and Vietnam. They recognized that Thai cattle were hard to compete with using local cattle that were produced by smallholder farmers. They explained that Vietnam market for cattle was a driver for cattle price in Cambodia that is in consistency with Sieng et al. (2012).

Opportunities for Smallholder Farmers

Vietnam and China will become key importing nations to meet their growing demand for foods although their productions are increasing each year (Ahuja, 2012). The ruminant meat, which come from mixed crop-animal system, will play the most important role for meat consumption in those countries (Devendra, 2002) beside pork and poultry meats which have the main source of animal protein.

Due to small demand of meat in the country (Kerr et al. 2012), Cambodia is also exporting cattle to Ho Chi Minh City. The demand of red meat in Cambodia is also increasing, hence strong supply of in-country consumption and exportation must be secured. At the same time, the safety must be considered, because trans-boundary diseases, such as foot-and-mouth disease (FMD), has been a major issue for cattle trading (Sieng et al. 2012).

Cattle nutrition in the developing countries depends on roughage and straws from crops that normally are sufficient in nutrients only for maintenance, but not for production, so supplementation of energy, protein and minerals are required (Leng, 1990). As supplementing concentrated feed and/or urea to low-quality diet was not cost-effective for farmers, leguminous forage may be an ideal solution for smallholder farmers (Pen et al. 2012).

The expected future growth of smallholder livestock will have potential impact on the livelihood of rural poor, hence on poverty reduction. However, the market participation of smallholder farmers must be secured. The main constraint in linking smallholders to markets was not only the production-level, but also the challenge of making efficient transactions between smallholder producers and the downstream players in the value chains (Ahuja, 2012). As it can be seen the cattle market chain in this study, many stakeholders involved in the transaction and trading margin was still high. Improving producer knowledge about market opportunities and the production techniques to produce acceptable products for market is the key for the success of smallholder cattle business.

CONCLUSION

There is a move towards raising more crossbred cattle, which are larger than local cattle and bring a higher price. The price of cattle was related to the estimated amount of meat on the animal, so larger and fatter animals demanded a higher price. Neither farmers nor traders mentioned meat quality as a key factor in the business. There is big opportunity for farmers in Cambodia to produce fat, crossbred cattle for city markets. This needs better feeding and management practices.

Increasing market participation of smallholder farmers is also important in Cambodia. This needs some interventions such as rural infrastructure, appropriate technology transfer and a better delivery system of live cattle aiming to support the small-scale producers.

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Research article

Assessment on Local Awareness of Organic Farming Practices in Kampong Cham of Cambodia

LALITA SIRIWATTANANON*
Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, Pathum Thani, Thailand
Email: L_siriwattananon@hotmail.com

KUMIKO KAWABE
Graduate School of Agriculture, Tokyo University of Agriculture, Tokyo,Japan
Japan Research Center, Institute of Environment Rehabilitation and Conservation, Tokyo, Japan

MACHITO MIHARA
Faculty of Regional Environment Science, Tokyo University of Agriculture, Tokyo, Japan

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Abstract In rural areas of Cambodia, more than 70% of the total population is in the agricultural and related sectors, which are the important sectors of the Cambodian national economy. Rapid development of agricultural technologies depending on agricultural chemicals such as synthetic fertilizers, herbicide or pesticide has significantly increased agricultural production since 1990 (MAFF, 2009). However, overuse of agricultural chemicals is damaging the long-term soil fertility and productivity of farmlands. Also, agricultural chemicals released from farmlands to downstream cause the degradation of water environment. So, attention has been paid to promote sustainable agriculture through organic farming practices. Taking into account the conventional farming practices of rice and vegetable cultivations that have been done by local farmers, various workshops and trainings were conducted to promote organic farming practices. This paper dealt with the discussion on sustainability of organic farming practices introduced on the basis of local awareness. In addition, various workshops and trainings on organic farming practices were assessed in this study.

Keywords organic farming practices, crop production, local awareness, Kampong Cham

INTRODUCTION

In developing countries like Asia, agriculture plays an important role for economic growth as well as poverty reduction in rural areas. Rapid development of agricultural technologies has significantly increased agricultural production in Asia. Cambodia's economy is also based on agriculture. More than 70% of the total population of 13.8 million is in agriculture and related sub-sectors such as livestock raising, fisheries, aquaculture for their livelihoods. Although Cambodian farmers produce wide variety of crops, the major crop is paddy rice. However, agricultural sector remains unpredictable because it depends largely on natural topography and weather conditions. Currently in Cambodia, farming system tends to change to mono-cropping system with increasing cash crop demands, and the majority of farmers in Cambodia apply agricultural chemicals, such as chemical fertilizer, herbicide or pesticide to maintain high levels of crop yields.

Agricultural chemicals being released from farmlands cause not only polluting water environment but also worsening human health. The application of herbicides or pesticides without understanding of the safe usage results severe problems as the contamination of toxics in agricultural products that would induce human diseases. Also, the environmental integrity becomes necessary for human prosperity and sustainable development because of rapid and prevalent

environmental degradation, as agricultural practices by human beings are directly connected to the long-term environmental and sustainable development.

Recently, organic farming practices are promoted to local farmers in Kampong Cham province of Cambodia, as it contributes to increase organic and nutrient contents with improving soil physical and chemical properties, and to reduce the expenditure of agricultural chemicals for local farmers. In addition, organic farming practices may harmonize more with natural environment compared to conventional one depending on agricultural chemicals (Pinamonti, 1998, Brown et al., 2004 and ERECON, 2009). So, attention has been paid to suitable strategy to promote sustainable agriculture through organic farming practices. In this study, various workshops and trainings were conducted to promote local perception on organic farming practices, such as composting, making and applying bio-pesticide or liquid fertilizer. Based on various extension activities, this paper dealt with the assessment on local awareness of organic farming practices through the observation on the changes in farming practices.

METHODOLOGY

The target area of Roung Kor Village, Baray Commune in Prey Chhor District, Kampong Cham Province was selected for the case study to conduct the assessment on local awareness of organic farming practices, such as composting, making and applying bio-pesticide or liquid fertilizer. In the initial stage of this study, a baseline survey using a questionnaire sheet was conducted in August 2010 to get the basic information of local living as well as conventional farming practices in the village.

Then, various kinds of workshops and trainings were conducted to promote local awareness of organic farming practices as shown in Table 1. In the target area of Roung Kor Village, Baray Commune in Prey Chhor District, Kampong Cham Province, the core target farmers at 43 were selected in the study. And then, the local awareness and the changes in farming practices were evaluated.

Table 1 Important contents done for raising local awareness on organic farming practices

Month and year	Important contents	Number of participants
April 2010	Starting project	43
|	Conducting a baseline survey	43
	Holding workshop on composting	41
March 2011	Holding training on composting	43
April 2011	Holding workshop on compost application	41
	Holding training on compost application	43
|	Holding workshop on making and applying bio-pesticide and liquid fertilizer	42
	Holding training on making and applying bio-pesticide and liquid fertilizer	43
March 2012	Holding workshop on applying net for protecting insects	43
April 2012	Cultivating vegetables with organic farming practices	43
|	Cultivating rice with organic farming practices	41
	Selling safe agricultural products	43
March 2013	Assessing local awareness of organic farming practices	43

RESULTS AND DISCUSSION

Conventional Farming Practices

Local living: According to the results of baseline surveys, Roung Kor village has 756 inhabitants (196 households). There are 104 ha of paddy fields and 6 ha of orchards/upland fields. Around 20% of paddy fields are irrigated and others are depending on rainfalls. One household of farmer holds farmland at around 0.5 ha averagely. Around 66% of all households earn for their living exclusively from agriculture and all households cultivate rice and vegetables. The average rice yield varies from 1.5 t/ha to 3.0 t/ha. Rice is planted mainly for self-consumption but remains were

sold to middle man. Additionally, vegetable are cultivated in a small scale farms around resident. As a unit price of vegetables is high, many households generate cash income from vegetable cultivation.

Rice cultivation: Various species of rice have been cultivated by local farmers, such as IR66, Chul Sar, Sen Pidou, Riang Chey, Phnom Run, Car 6, Car 9, Ksay sticky rice, Somaly, Neang Nok, Kong or variety 59. Due to the lack of water for irrigation, farmers are conducting rice cultivation only once per year depending on rainfalls. To increase the rice productivity, chemical fertilizer is commonly applied for rice cultivation, especially 'Urea' (N:P:K 46-0-0) or 'Di-Ammonium Phosphate' (18-46-0).

Vegetable cultivation: In the target area, farmers are cultivating vegetables based on the market demands, especially various types of cabbage such as Chinese cabbage (*Brassica rapa L. subsp. ekinensis*), Green kuang futsol (*Brassica chinensis juslenius*) and Swatow mustard (*Brassica juncea* var. *rugosa*). Every two days, middle man comes to village for buying all vegetables then brings them to the market or restaurants. In the village, local farmers continue growing vegetable all round year, approximately harvesting 4 times per year. Some vegetables take only 30 days but some take longer more than 45 days. In dry season, some farmers cannot grow vegetables for a few months because of too many insects as well as lack of water. Additionally, farmers are afraid of applying multi-cropping or crop rotation; because they worry that enough income would not be achieved from selling various types but could get from small amounts of each vegetable. As same as rice cultivation, farmers are applying a lot of chemical fertilizers and pesticides for vegetable cultivation. Some farmers are applying more than 800 kg/ha of chemical fertilizer for cultivating vegetables. The most popular formula of chemical fertilizer applied in vegetable farms are granular form at N:P:K 46-0-0, 18-46-0 or 15-15-15, in addition to liquid form of 16-16-8 or powder form of 30-5-5, etc. Actually, farmers not well known about the benefit or effect of each fertilizer on vegetable growth, but they apply according to what they have been told by the sellers or other farmers.

Fig. 1 Crop cultivations and agricultural chemical application in Roung Kor village

Chemical pesticide or fungicide application: Based on the advertisements by the pesticide company or seller, a few types of chemical pesticide or fungicide such as Visor, Reagant 1.8 EC/Vitaco, Carbendazim and Abamectin, etc. are widely applied especially for vegetable cultivation by farmers. Farmers are expected it can help to decrease or stop insect or disease problems. Normally, the effectiveness of pesticide works well at the first time, and then it decreases because insect or disease improves their immunity. So, it is better to change a type of pesticide. However, they just try to apply same pesticide with increasing the amount applied, as farmers do not understand well. Most of pesticides or fungicides are imported from Thailand or Vietnam through both regular and irregular ways. However, farmers have a less understanding about the effect of those chemical on health or environment, even some sellers or farmers had been told or joined the safety use training coordinated by the governments or NGOs before start selling or using this kind of products. However, the safety use instruction is still not commonly understood by farmers.

Organic Farming Practices Promoted

Promoting organic farming practices: For decreasing the expenses of buying chemical fertilizer and the effects on natural resource and human health, sustainable farming practice through composting and liquid bio-fertilizer/pesticide making were proposed to farmers as alternative farming practices. According to the previous surveys and requests from farmers in Roung Kor village, 43 compost boxes (2 m x 4 m x 1 m) were constructed for composting as same as plastic container were distributed for making bio-fertilizer and bio-pesticide. Then, the workshop on "how to make compost" was conducted for giving knowledge and training to farmers at Roung Kor village. In addition to bio-fertilizer and bio-pesticide were introduced and trained to farmers by using available materials in/around the village.

Fig. 2 Workshops on making compost, liquid bio-fertilizer and liquid bio-pesticide

For 2 years, organic fertilizer application through composting and liquid bio-fertilizer/ pesticide making had been promoted to farmers in Roung Kor village for supporting to increase the productivity and decrease effects to health and environment. Totally 43 compost boxes had been provided to 43 farmers, and all 43 farmers learned how to make compost and application methods in farmlands.

During the 2nd year, farmers had produced compost averagely 4,363 kg per compost box. Since then a few times composting had been done and applied to farmlands especially for rice and vegetable cultivation. Averagely, 150 kg of compost had been applied for 100 m^2 of rice cultivation and 119 kg for 100 m^2 of vegetable cultivation. Additionally with the application of compost, farmers can decrease the amount of chemical fertilizer about 20-100 percent as shown in Table 2. Through farmers' observation, all of 43 farmers were satisfied with the effectiveness of compost (Table 3) and willing to continue composting. Also, farmers understanding on making bio-fertilizer and bio-pesticide and safety use of chemical pesticide. The results were summarized in Tables 4 and 5.

Table 2 Decrease in chemical fertilizer through compost application

Decrease in chemical fertilizer	Percentage of farmers (%)
0-20%	-
20-40%	10
40-60%	56
60-80%	32
80-100%	2

Source: Results from the questionnaire survey (ERECON, 2011)

Table 3 Changes in crop growing after applying compost

	Crop yield (%)	Crop quality (%)	Soil quality (%)
Increase	98	93	100
Same	2	7	-
Decrease	-	-	-

Source: Results from the questionnaire survey (ERECON, 2011)

Table 4 Percentage of amount of chemical fertilizer or pesticide to be decreased

Content	Decreasing percentage up to				
	0-20%	20-40%	40-60%	60-80%	80-100%
Decreasing chemical fertilizer with applying bio-fertilizer	2%	2%	21%	51%	24%
Decreasing chemical pesticide with applying bio-pesticide	0%	0%	35%	53%	12%

Source: Results from the questionnaire survey (ERECON, 2011)

Table 5 Summary of questionnaire results of workshop on bio-fertilizer, bio-pesticide and safety use of chemical pesticide

Content	Percentage of farmers		
	Yes	No	Not sure
Understand how to make bio-fertilizer	86%	14%	-
Interested in making bio-fertilizer	100%	0%	-
Bio-fertilizer is benefit to farmland	95%	5%	-
Want to continue making bio-fertilizer	100%	0%	-
Understand how to make bio-pesticide	91%	9%	-
Interested in making bio- pesticide	98%	2%	-
Bio-pesticide is benefit to farmland	86%	2%	12%
Want to continue making bio- pesticide	98%	2%	-
Knowing the safety use of pesticide before attend this workshop	60%	40%	-
Doing the safety use of pesticide before attend this workshop	65%	35%	-
Understanding the safety use of pesticide through this workshop	98%	2%	-
Willing to adapt the safety use of pesticide	98%	2%	-

Source: Results from the questionnaire survey (ERECON, 2011)

Evaluating participatory level: Additionally, the results of questionnaire survey conducted after the 1st workshop showed that 93% of farmers were applying chemical fertilizer and only 7% were applying cow manure instead of chemical fertilizer. However, after 2 years with 4 times of workshops and training, farmers' adaptability for organic fertilizer increased. The level of participation was evaluated according to the answers in questionnaire survey and attitudes of farmers in workshops. There are various levels or degrees of farmers' participation as shown in Table 6. The evaluation of level or degree of farmers' participation is important for increasing farmers' adaptability for organic fertilizer application.

At the 1st workshop, although many farmers attended, it was evaluated as low participation at Level 2 or 3, because most of them participated only for responding to the requests for attending. However, farmers became active after understanding the benefits of composting and bio-fertilizer /pesticide making at the 3rd workshops. At the 4th workshop, Roung Kor safety agriculture group was established and farmers' participation was very high and they were willing to adapt organic fertilizer to their farmlands. So the level or degree of farmers' participation was evaluated as interactive participation at Level 6.

The awareness of disadvantages to human and environment of agricultural chemicals pushed farmers to find natural materials for making compost, liquid bio-fertilizer and liquid bio-pesticide in order to increasing the nutrients to crop and control pest or plant diseases in farmland. Recently, farmers pay attention to produce and develop liquid bio-fertilizer or liquid bio-pesticide using some kinds of trees, herbs or spices which are available to that area. As these liquid bio-fertilizer and liquid bio-pesticide are new knowledge for farmers in Roung Kor village. However, various workshops and trainings could lead them to see and accumulate experiences of those practices. As more than 98% of farmers were willing to continue making bio-fertilizer and bio- pesticide as well

as to adapt the safety use of pesticide**,** so establishing the farmers' group had advantage to make continue and enhance of organic farming practices.

Table 6 Level of participation

Level	Type	Characteristics of each type
1	Passive participation	People participate by being told what is going to happen or has already happened. It is a unilateral announcement by an administration or project management without any listening to people's responses. The information being shared belongs only to external professionals.
2	Participation in information giving	People participate by answering questions posed by extractive researches using questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings, as the findings of the research are neither shared nor checked for accuracy.
3	Participation by consultation	People participate by being consulted, and external agents listen to views. These external agents define both problems and solutions and may modify these in the light of people's responses. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people's views.
4	Participation for material incentives	People participate by providing resources, for example labour, in return for food, cash, or other material incentives. Much on-farm research falls in this category, as faermers provide the fields but are not involved in the experimentation or the process of learning. It is very common to see this called participation, yet people have no stake in prolonging activities when the incentives end.
5	Functional participation	People participate by forming groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally initiated social organization. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These instructions tend to be dependent on external initiators and facilitators, but may become self-dependent.
6	Interactive participation	People participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systemic and structured learning processes. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
7	Self-mobilization	People participate by taking initiative independent of external institution to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Such self-initiated mobilization and collective action may or may not challenge existing inequitable distribution of wealth and power.

Source: Pretty (1994), adapted from Adnan et al. (1992)

CONCLUSION

According to the results through the observation and questionnaire surveys, many of farmers wanted to reduce chemicals application and the expenses for agricultural chemicals, if there were other things being available to replace. In order to improve the farming systems and economical conditions, it is important to provide the appropriate knowledge and to improve the technologies of farming practices for farmers. It is no doubt that this project has been contributed well for improving the farming systems and economical conditions at Roung Kor village. Sustainable agriculture enhances the quality of life for farmers and society, and in the long term enhances environmental quality and natural resources which agriculture depends. The capacity building of farmers and their institutions is essential for achieving a balance among economic, social and environmental development goals. Farmer-centered development and farmers' awareness was created to facilitate farmers to develop by them. The participation of farmers means that farmers assume a major role in decision-making and managing their own affairs. Efforts should be made to build confidence in farmers so that they make decisions on how to solve the facing problems. Other players such as governments and NGOs have a supportive role, providing some guidance, advices, comments, and trainings for building farmers' confidence. Grouping of farmers is a way for facilitating among farmers through exchanging knowledge and experiences related to agricultural

practices in sustainable way.

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Research article

Drought Impact on Rice Production and Farmers' Adaptation Strategies in Northeast Thailand

ANAN POLTHANEE*
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
E-mail: panan@kku.ac.th

ARUNEE PROMKHUMBUT
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

JIRAPORN BAMRUNGRAI
Department of Plant Science and Agricultural Resources, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

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Abstract Drought is an important constraint to rice production in Thailand especially the northeastern part, as a result of the erratic distribution of rainfall. The objectives of this research were to study rainfall characteristics in northeast Thailand, assess the impact of drought on rice production in 2012 and assess adaptation to strategies of farmers relative to drought. Rainfall data over the 10 year period (2001-2011) and the drought year (2012) of northeast Thailand, as well as selected site study in Nakhonratsima and Kalasin provinces were also investigated. Mean annual rainfall recorded in 2012 was only 966 mm in Nakhonratsima which declined by 239 mm, compared to the mean annual rainfall 1204 mm in the time period during 2001-2011. Similarly, mean annual rainfall recorded in 2012 was 1133 mm in Kalasin which declined 375 mm, compared to mean annual rainfall 1508 mm in the time period between 2001-2011. The crop cutting study were done in the farmer's fields to obtain rice yield and the yield components found that the actual yield loss due to drought was 59-68% in Nakhonratsima and 55-65% in Kalasin, respectively compared with the attainable yield. Farmer's coping adaptation strategies included crop diversification (short-term adaptation options), change of land use pattern (long-term adaptation options) and built on farm pond in the paddy fields.

Keywords drought, rainfall, rice, cassava, adaptation

INTRODUCTION

Drought is the most complex of all natural hazards, and more people are affected by it then any other hazard (Hagman, 1984). Many definitions of drought exist in the literature; however, the concept of water deficit is quite a common factor among all definitions. It is defined based on the precipitation deficit that results in water shortage (Wilhite and Glantz, 1985). Drought impacts are usually first apparent in agriculture through decrease in soil moisture and high evapotranspiration. It's severity mainly depends on the level of moisture deficiency and the duration to a lesser extent. In Asia drought has affected agriculture so adversely in different parts of the continent, production of rice, maize and wheat has declined in many parts of Asia due to increasing water stress (Bates et al., 2008). Drought has a significant effect on the livelihood of rainfed lowland rice farmers (Pandey et al., 2005). However, farmers employ various coping strategies of farming households against drought, including use of irrigation, early maturity and drought resistant crop varieties, soil and water conservation practices, adjustment in agricultural input and crop diversification (Bradshaw et al., 2004; Charles and Rashid, 2007; Ashraf and Roatray, 2013).

Drought is an important constraint to agricultural production in Thailand, especially the northeastern part which has been frequently subjected to drought as a result of the erratic distribution of rainfall dry spells in the rainy season and low water holding capacity of soils. Thirteen years out of thirty four years during the period 1970-2004, namely 1972, 1973, 1974, 1977, 1979, 1981, 1982, 1987, 1993, 1996, 1997, 1998 and 2004 were drought years of northeastern, Thailand (Prapertchop et al., 2007).

OBJECTIVES

The objectives of this research were to study rainfall data in the northeastern part of Thailand and assess the impact of drought on rice yield in the drought year (2012) at selected study areas. In addition, farmer's coping with adaptation strategies in sustaining their livelihood against drought in northeastern region are also assessed.

METHODOLOGY

Selection of the Study Area

Northeastern Thailand is located between 14 º to 18 ºN latitude and 100 º to 106 ºE longitude. The average elevation is between 200-230 meters above mean sea level. Initially based on newspaper reports, several provinces have been declared drought disaster in northeast Thailand, Thairath, 2/11/2012. According to Mongkolsawat et al. (2001) classified drought in northeastern into three zones, namely low risk area, medium risk zone area and high risk area. Nakhonratsima and Kalasin provinces are situated in high risk area and low risk area respectively were a site selected as the study areas where is located in the south-west and the central of the northeastern (Fig. 1). Again, newspaper reports have advised that drought severely hit several districts of Nakhonratsima and Kalasin provinces (Thairath, 8,9/11/55). Then, the authors visited a few places of districts within the two provinces and consulted with the District Agricultural Extension Officer, and deciding to select Pratai and Muang districts located in Nakhonratsima and Kalasin, respectively, as the study areas. An extensive field visit was made to observe the extent and magnitude of drought. Afterwards, four villages were primarily selected in Pratai and Muang districts for the crop cutting study.

Crop Cutting Study

Four farmers who had the paddy fields located in the village were randomly selected for crop cutting study to obtained actual rice yield (sampled areas 3x2 meter) and yield components. In general, rice mostly subjected to drought at the panicle development growth stage. The attainable rice yield was estimated by employing yield components data (Yoshida, 1997) base on the assumption that drought did not occurred after the panicle development growth stage as calculated in Eq. (1) to compared with actual yield.

$$\text{Yield (tons/ha)} = \text{Spikelet number/m}^2 \times \text{grain weight} \times \text{filled grain} \times 10^{-5} \quad \ldots\ldots\ldots (1)$$

Farmer's Adaptation Strategy Study

Field visit were done for direct observing the farmer's adaptation strategies hit by drought in such villages. Farming practices coping strategies against drought by the farmers were recorded. Rice production areas hit by drought which replaced by other crops were noticed. The crop cuttings studied were sampled to determine growth and yield, as well as economic return.

Rainfall

Data of rainfall for the time period from 2001 to 2011 of overall northeastern (27 meteorological stations) and 2012 rainfall data available from meteorological stations where located near the selected study area in Nakhonratsima and Kalasin provinces were utilized for the study. The rainfall data was analyzed to understand rainfall variability.

RESULTS

Observed Rainfall Change

In northeastern Thailand, mean annual rainfall intensity in 2012 was recorded 1,272 mm which is lower by 325 mm than for the time period 2001-2011 which showed 1596 mm (data not shown). In Nakhonratsima and Kalasin provinces a site selected in northeast showed a decreasing mean rainfall intensity in 2012 that recorded 239 mm and 375 mm respectively, in comparison with the time period 2001-2011. Among six months in the rainy season, the maximum decreased of mean annual rainfall intensity (98 mm) was observed in September of Nakhonratsima province. The maximum decrease of mean rainfall intensity (142 mm) was observed in July of Kalasin province (data not shown).

Drought Impact on Rice Production

Table 1 Yield components of rice at different villages, Pratai district, Nakhonratsima province

Village	Panicle*	Filled grain **	Unfilled grain		1000 grains
	(no./m^2)	(no./panicle)	(no./panicle)	(%)	weight (g)
Donkhang	114.6	29.4	53.8	64.7	22.3
Tungsawang	98.6	38.4	55.1	58.9	24.1
Nongwaeng	101.4	21.3	38.9	64.6	21.6
Nongwaengmai	122.6	27.2	57.8	68.1	22.2
Mean	109.3	29.1	51.4	64.1	22.6

**Average from four farmers sampled, **average from 40 panicles (10 panicles/1 farmer sampled)*

Table 2 Actual yield and attainable yield of rice at different villages, Pratai district, Nakhonratsima province

Village	Actual yield* (kg/ha)	Attainable yield** (kg/ha)	Difference (kg/ha)	Reduction (%)
Donkhang	740.6	2,097.5	1,356.9	64.7
Tungsawang	908.8	2,212.5	1,303.7	58.9
Nongwaeng	453.8	1,281.9	828.1	64.6
Nongwaengmai	733.8	2,292.5	1,558.7	67.9
Mean	709.3	1,971.1	1,261.7	64.0

**Average from four farmers sampled, ** estimation base on yield components*

Crop cutting was sampled in the farmer's fields at crop maturity growth stage. For four villages with selected site in Nakhonratsima province, the mean panicle number per square meter, filled grain number per panicle and unfilled grain number per panicle were obtained 109, 29 and 51, respectively. The mean 1,000 grains weight was received 23 g (Table 1). The unfilled grain percentage ranged from 59% to 68%, depending on locations (Table 1).

In case of grain yield, mean actual yield was obtained 709 kg/ha, while the mean attainable yield estimated about 1,971 kg/ha (Table 2). The yield different between actual yield and attainable yield showed 1,262 kg/ha with 64% reduction (Table 2). Yield reduction ranged from 59% to 68%, depending on locations (Table 2).

For the four village selected sites in Kalasin province, mean panicle number per square meter,

filled grain number per panicle and unfilled grain number per panicle were obtained 112, 37 and 55, respectively. While, mean 1,000 grain weight was received 21 gm (Table 3). The unfilled grain percentage ranged from 48% to 69%, depending on locations (Table 3).

In case of grain yield, mean actual yield was obtained 848 kg/ha, while mean attainable yield estimated about 1,947 kg/ha (Table 4). The yield gab between actual yield and attainable yield showed 1,098 kg/ha with 59% reduction (Table 4). Yield reduction ranged from 55% to 65%, depending on locations (Table 4).

Table 3 Yield components of rice at different villages, Muang district, Kalasin province

Village	Panicle* (no./m^2)	Filled grain ** (no./panicle)	Unfilled grain (no.panicle)	(%)	1000 grains weight (g)
Khumex	107.4	27.3	48.1	56.9	21.2
Nongkung	112.6	36.2	78.3	68.5	18.7
Joth	118.4	42.1	39.4	48.4	21.1
Najan	108.3	43.3	55.7	56.3	21.3
Mean	111.7	37.2	55.4	57.5	20.6

**Average from four farmers sampled, **average from 40 panicles (10 panicles/1 farmers sampled)*

Table 4 Actual yield and attainable yield of rice at different villages, Muang district, Kalasin province

Village	Actual yield* (kg/ha)	Attainable yield** (kg/ha)	Difference (kg/ha)	Reduction (%)
Khumex	613.8	1,488.1	874.3	58.7
Nongkung	753.8	2,155.0	1,401.2	65.1
Joth	1,040.6	1,891.9	851.3	55.0
Najan	985.0	2,251.3	1,266.3	56.2
Mean	848.3	1,946.6	1,261.7	58.8

**Average from four farmers' sampled, ** estimation base on yield components*

Farmers' Coping Adaptive Strategies towards Drought

Regarding to field visit in the areas where rice severely hit by drought in a villages selected site. Some farmers decided to plough the paddy fields in October and planted cassava replacing rice before harvest, while some farmers planted cassava after rice harvest in Kalasin province. On the other hand, some farmers decided to grow mungbean in the paddy fields after rice harvest in Nakhonratsima province. The crop cutting study was sampled for cassava in Khummex village selected site which occupied by lowland rice fields within a toposequence landform. Because of large variation in water availability among the upper toposequence position, middle position and lower position, the rainfed lowland rice can be separated into three paddy fields types, namely upper paddy, medium paddy and lower paddy. In the present study, farmers grew cassava in upper paddy and medium paddy. The author observed that farmer does not cultivated cassava in lower paddy. They mentioned that if cassava is grown in the lower paddy they may experience waterlogging early in pre-rainy season, due to lower paddy located at the bottom toposequence position. Crop cutting study was done for two farmers sampled (farmer A and B) who grew cassava in upper paddy and medium paddy in Khummex village. In the recent study, soil in cassava sampled plots are sandy in texture with low total N, available P, exchangeable K and organic matter both in upper paddy and medium paddy (Table 5). However, overall views of soil in medium paddy fields are more fertile than upper paddy (Table 5). Farmer A planted cassava in November after rice harvest while farmer B planted cassava in October before rice harvest. Cassava was harvested in June before normal rice planting. Cassava was grown in post-rainy season. Therefore, cassava must start their growth on residual soil moisture remaining in the soil and supplement with rainfall in summer season and pre-rainy season. The soil moisture contents were measured at 0-15, 15-30, 30-45 and 45-60 cm soil depth entire the growing season (Figure 1, 2 and 3). The results showed that soil moisture content (SMC) at 0-15, 15-30 cm soil depth close to the permanent wilting point (PWP) value during November to February. However, the SMC at 30-45 and 45-60 cm soil depth

were mostly higher than PWP during the growing season, except their close to PWP in March and April. In general, SMC in Farmer B's sampled plots was observed to be higher than Farmer A's sampled plots. This was due to Farmer A's sampled plots being situated at higher toposequence positions than Farmer B's sampled plots, even though their classifications were the same as medium paddy type.

Table 5 Soil physical and chemical properties at 1 month after planting cassava in paddy fields, Khummex village, Muang district, Kalasin province

Farmer/Paddy field type	Total N[1] (%)	Avail.P[2] (ppm)	Exch.K[3] (ppm)	OM.[4] (%)	Field capacity[5] (%)	Permanent[6] wilting point (%)
Farmer A						
Upper paddy	0.004	2.80	28.98	0.258	5.67	1.24
Medium paddy	0.006	3.97	33.73	0.354	6.25	1.26
Farmer B						
Medium paddy	0.007	7.66	99.27	0.284	6.67	1.27

[1]Kjeldahl method; [2] BrayII and molybdenum blue method; [3]1N NH_4OAC pH7; [4]Walkey and Black method; [5,6]Pressure plate and pressure membrane apparatus

Table 6 Growth, yield and starch content of cassava at harvest, and net income of cassava grown in the paddy field at Khummex village, Muang district, Kalasin province

Farmer/Paddy field type	Plant height (cm)	Total biomass (g/plant)	Root number (no./plant)	Root yield* (kg/ha)	Starch (%)	Net income** (USD.)
Farmer A						
Upper paddy	75.9	417.5	5.5	10.9	21.8	89 (0.16 ha)
Medium paddy	91.8	583.9	6.8	18.4	20.3	530 (0.48 ha)
Farmer B						
Medium paddy	120.2	775.7	8.9	23.8	23.9	720 (0.48 ha)
Mean	95.9	592.4	7.1	17.7	22.0	

**Average from four plots randomly selected area, **net income over fertilizer cost*

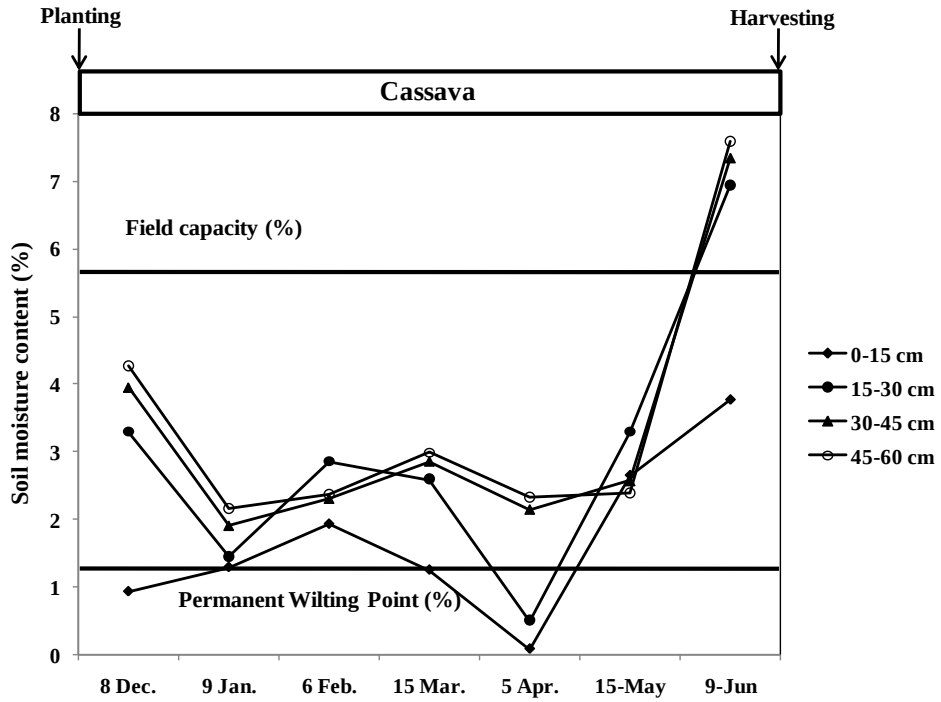

Fig. 1 Soil moisture content at 0-15, 15-30, 30-45 and 45-60 cm soil depth in upper paddy fields toposequence position (Farmer A)

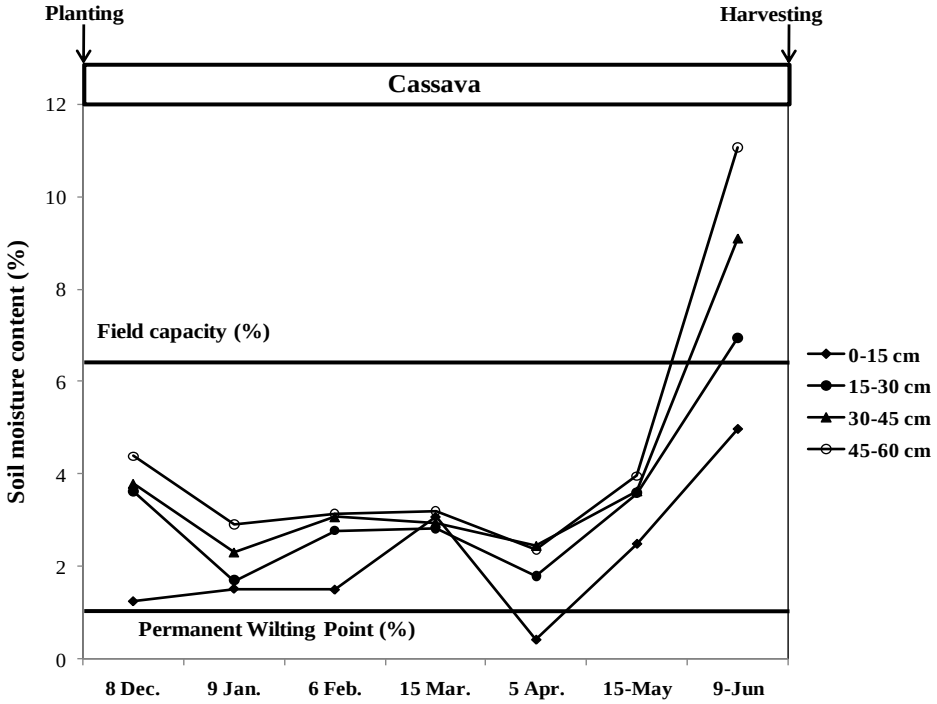

Fig. 2 Soil moisture content at 0-15, 15-30, 30-45 and 45-60 cm soil depth in medium paddy fields toposequence position (Famer A)

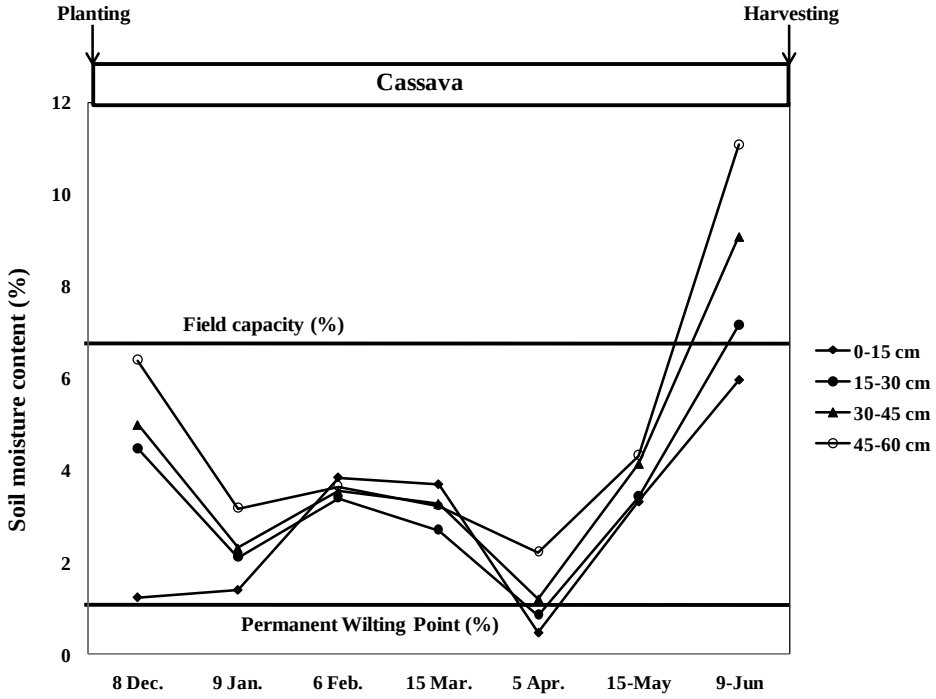

Fig. 3 Soil moisture content (%) at 0-15, 15-30, 30-45 and 45-60 cm soil depth in medium paddy fields toposequence position (Farmer B)

For cassava growth and yield, generally, the plant height, total biomass, root number and root yield obtained were higher in medium paddy than that of upper paddy (Table 6). This way is due to higher SMC in medium paddy. Mean root yield and starch content were 18 kg/ha and 22%, respectively. Farmer A received net income (gross income over fertilizer cost) 619 USD, while Farmer A earned net income 720 USD (Table 6).

Another coping adaptation strategy in Khummex village, is that farmers change land allocation by shifting rice to sugarcane especially in upper paddy fields. Some farmers built on farm pond in the upper paddy to collect water during rainy season.

In case of mungbean, the crop cutting study was done of one farmer sampled in the Naklang village selected site. The mungbean grain yield obtained was 159 kg/(0.48 ha) and provided a net income about 106 USD.

DISCUSSION

The majority of rainfed lowland areas are found in the northeast (4.8 million ha) and north (1.4 million ha) of Thailand. In the northeast, seasonal rainfall is bimodal, usually beginning in May and ending around mid October, but is highly variable. Drought may develop at anytime during the growing season. According to Gypmantasiri et al. (2003), 19% of northeast Thai farmers experienced drought while growing rice at planting stage, and 40% of them at tillering rice stage, although other 23% reported drought could affect rice growth at any growing stage.

In recent study, most rice planted areas beginning experienced to drought at panicle development stage and subsequently until harvesting, especially in the upper paddy (top position of the toposequence). Yield loss due to drought at selected site study ranged 55-68%, depending on locations. The rice yield component mainly affected by drought is the number of unfilled grains per panicle. Jongdee (2003) reported that yield loss due to drought as high as 45% in the upper paddy fields. Prapertchob et al. (2005) stated that overall loss in rice production during drought years is 56% in northeast Thailand.

In case of farmer's coping adaptation strategies, some farmers decided to grow cassava replacing rice before maturity when they observed that rice will produced low yield. However, some farmers waited until rice reach to maturity growth stage. Then, cassava will be planted soon after rice harvest in post-rainy season. Cassava started their growth using residual soil moisture remaining in the soil and with supplement summer rainfall and pre-rainy of consequence year during the growing season. In a recent study, cassava experienced to drought during the third week of March to the third week of May. Since the cassava crop receive rainfall once the last week of January (16 mm) and the first week of March (27 mm), and prolong drought until the third week of May. Then, cassava crop received accumulate rainfall about 80 mm until harvest. Cassava is regarded as a relatively drought resistant crop (Cock, 1985). During drought, it reduces water use by following an avoidance strategy of stomatal closure (Ike, 1982) and leaf area reduction (Connor and Cock, 1981).

Regarding to mungbean, the farmers planted immediately after rice harvest. Crops growth uses residual soil moisture remaining in the soil until maturity. There is no rainfall during the growing season. Mungbean is a short growth duration crop and harvested for 65 days.

The farmers practiced growing cassava and mungbean in the paddy fields indicating that they show a large emphasis on short-term adaptation options (autonomous adaptation) against drought. Farmer A and B who grow cassava earn net income about 619 and 720 USD, respectively. While the farmers who grown mungbean received net income about 106 USD, the farm incomes received by the farmers, although, seem relatively low. But, it's so important for livelihood of the smallholder farmers in drought year. Some farmers changes in land allocation (long-term adaptation or planned adaptation) by replacing of rice with sugarcane, especially in upper paddy fields. This means substitution of crop with high inter-annual yield variability by crop with more stable yields. Other current adaptation, some farmers devoted upper paddy fields to build on farm pond for collecting water during the rainy season.

CONCLUSION

Drought is an important constraint to crop production in northeast Thailand. In the drought year 2012, mean annual rainfall declined 239 mm and 375 mm in comparison with mean annual rainfall between the time periods 2001-2011 in selected site study of Nakhonratsima and Kalasin provinces,

respectively. Rice is the main crop affected by drought. The yield lose due to drought was about 59-68% and 55-65% in Nakhonratsima and Kalasin provinces, respectively. Farmers coping adaptation strategies include both short-term and long-term adaptation options against drought.

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Research article

Comparison of Inoculated Eri Cocoon and Eco-block for Pollutant Removal

CARLOS ONAN MENDOZA TOVAR
Graduate School of Agriculture, Tokyo University of Agriculture, Tokyo, Japan
Email: onan14@yahoo.com

KUMIKO KAWABE
Graduate School of Agriculture, Tokyo University of Agriculture, Tokyo, Japan

HIROMU OKAZAWA
Faculty of Regional Environment Science, Tokyo University of Agriculture, Tokyo, Japan

MACHITO MIHARA*
Faculty of Regional Environment Science, Tokyo University of Agriculture, Tokyo, Japan
Email: m-mihara@nodai.ac.jp

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Abstract The most popular medium for microorganism immobilization is eco-block. The easiest microorganism to obtain in Japan is *Bacillus natto* and used for producing food for human consumption. While, eri Cocoon has proven to be an efficient immobilization medium for bacteria. *Lactobacillus spp.* is a beneficial bacteria easily obtained in every country in the world. The main objective was to compare the performance of inoculated eri cocoon and inoculated eco-block for glucose and NO_3-N consumption. As a secondary objective we compared, through the inoculation rates, the capacity of eri cocoon and eco-block to allocate *Lactobacillus* and *Bacillus natto* separately. The methodology of this study was divided into two stages. First, a comparison of eco-block and eri cocoon's ability to allocate microorganisms within its structures; and second, the comparison of consumption between inoculated eri cocoon and inoculated eco-block. The comparison of the amount of *Lactobacillus* and *Bacillus natto* to be allocated by the eco-block and the eri cocoon, we found that there are no significant differences between the amounts of both *Lactobacillus* and *Bacillus natto*which can allocate, however, a higher inoculation rate was found in eri cocoon medium. Addition to the consumption of glucose for both microorganisms showed a significant difference between *Lactobacillus* and *Bacillus natto*.*Lactobacillus*had a higher consumption rate. When comparing within both different bacteria, the result foundthat the eri cocoon performed better against eco-block. In comparison the use of inoculated eri cocoon showed better results in both consumption of glucose and NO_3-N of both *Bacillus natto* and *Lactobacillus*. However, when comparing *Bacillus natto* and *Lactobacillus*, the last one showed better consumptions when combined with eri cocoon and *Bacillus natto* showing better results when combined with eco-block. In conclusion, pending an economical study, eri cocoon inoculated with *Lactobacillus spp.* presents the best option as a water pollutant removal tool.

Keywords eco-block, eri cocoon, *Lactobacillus spp*, *Bacillus natto*, water pollutant removal, NO_3-N consumption.

INTRODUCTION

The necessity for an effective and economic water pollutant removal tool, recently, has become an interest in the developing world. Previous studies has given information about the use of effective microorganisms for this effect (Ongley, 2000; de Vries et. al., 2008; Pebbles, 2003). These

effective microorganisms require an immobilization medium to make them easier to handle and apply.

A known microorganism immobilization medium for water filtering is the eco-block. The eco-block is any inert material where effective microorganisms can be immobilized and used for water quality improvement. Park and Tia (2004), conducted an experiment where porous concrete and industrial by-products was used for water purification. Although it was not inoculated the experimenter calculated the amount of organisms attached to the block by the consumption of dissolved oxygen. Matsunaga et.al. (2006), presented data where concrete eco-block inoculated with *Bacillus natto* performed better than regular block for water quality improvement. The use of immobilized microorganisms in blocks is usually for bio-filtration systems (Cohen, 2001).

Although, most of the substrates used to immobilize effective microorganisms are non-biological porous materials. The eri cocoon has the structures to immobilize *Lactobacillus spp.* within its fibers (Mendoza Tovar et. al., 2013); it was also determined the best treatment for the eri cocoon to be used. A study with *Lactobacillus acidophilus* has proven capable of removing up to 60% of Arsenic (III) from water solution within 3 hours (Singh & Sarma, 2010). In another experiment, *Lactobacillus spp.* isolated from shrimp farm water samples were capable of simultaneous removal of pathogenic bacteria and nitrogen (Ma, et.al., 2009)

OBJECTIVE

The main objective of this study was to compare the performance of eri cocoon and eco-block as porous mediums in glucose and NO_3-N consumptions.

As a secondary objective, was to compare eri cocoon and eco-block based on the amount of bacteria that can be allocated through the inoculation rates from both *Lactobacillus* and *Bacillus natto*.

METHODOLOGY

The methodology of this study was divided into two stages; the first was the comparison between two mediums, eri cocoon and eco-block, to allocate microorganism, and second was the comparison of consumption of glucose and NO_3-N between inoculated eri cocoonand eco-block (Fig. 1).

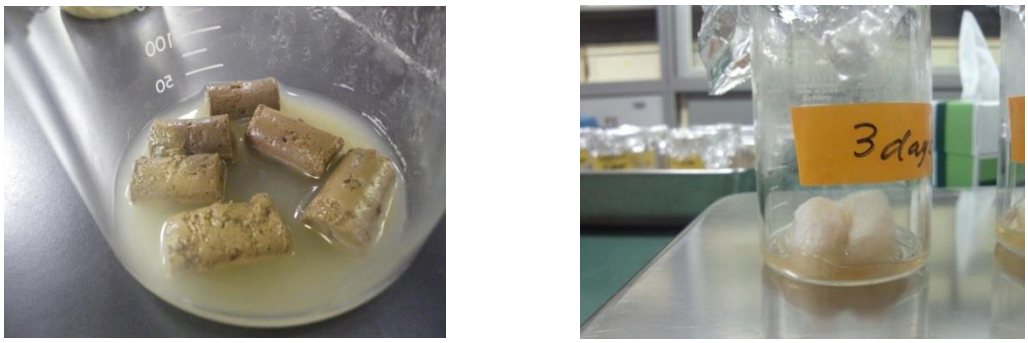
eri cocoon **eco-block**

Fig. 1 Immobilization mediums

Both eco-block and eri cocoon were inoculated with *Lactobacillus spp.* and *Bacillus natto* and cultivated for 3 days before making a dilution method to count the colony forming units of each one. Both microorganisms had the same management for both immobilization mediums.

The inoculation solution was added directly in order to cover half of the sample and allowing the other half to absorb by capillarity. The inoculated samples were incubated for 72 hours at 37 ^{o}C

(Fig. 2). Five count repetitions were made to get an average colony forming units (cfu) per milligram of both mediums in order to observe the difference.

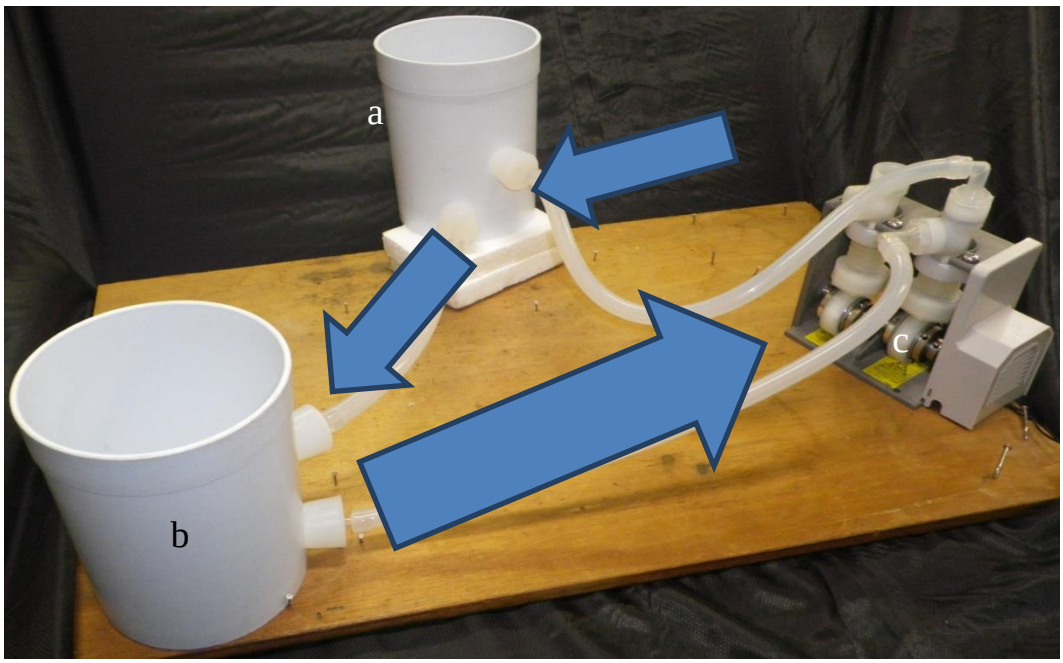


Inoculation of eco-block **Inoculation of eri cocoon**

Fig. 2 Inoculation method

Simultaneous consumption experiments for both inoculated immobilization mediums by *Lactobacillus* and *Bacillus natto* were carried out in a water recirculation system to simulate water movement in a reservoir (Fig. 3). Glucose at two level of concentration; low concentration was of 5% glucose solution and high concentration of 15% glucose solution. NO_3-N was determined at 10 mg/lat 0 hours before data collection. The data was collected at 3, 12, 24 and 48 hours and analyzed within 24 hours of the sample taking.

TheSPSS Statistics Version 19 was used to analyze the significant differences and comparisons among different microorganism, mediums, and consumptions.



a. *Medium application reservoir* ***b.*** *Solution application reservoir* ***c.*** *Water pump* ⇒ *Water flow*

Fig. 3 Experiment water recirculation system

RESULTS AND DISCUSSION

Within the inoculation rates (cfu/g), there was a significant difference between the eri cocoon and eco-block (Fig. 4) placing the eri cocoon as the best immobilization medium between them. Nevertheless, the low mass of ericocoon is an advantage over the eco-block when comparing them

by the same unit of mass of inoculated medium. It is also suspected that the clay material of which the eco-block consists may have had an effect on the immobilization ability or inoculation rate.

Even though there was no significant difference between bacteria allocation within each medium, *Bacillus natto* presents a higher rate in both mediums, hinting that *Bacillus natto* may be more effective in the immobilization process.The document by Matsunaga et.al. (2006) presented no inoculation rate of *Bacillus natto* in the concrete block used in his experiment; however, observing the dissolved oxygen in the document, it can be inferred that during the experiment they multiply after application.

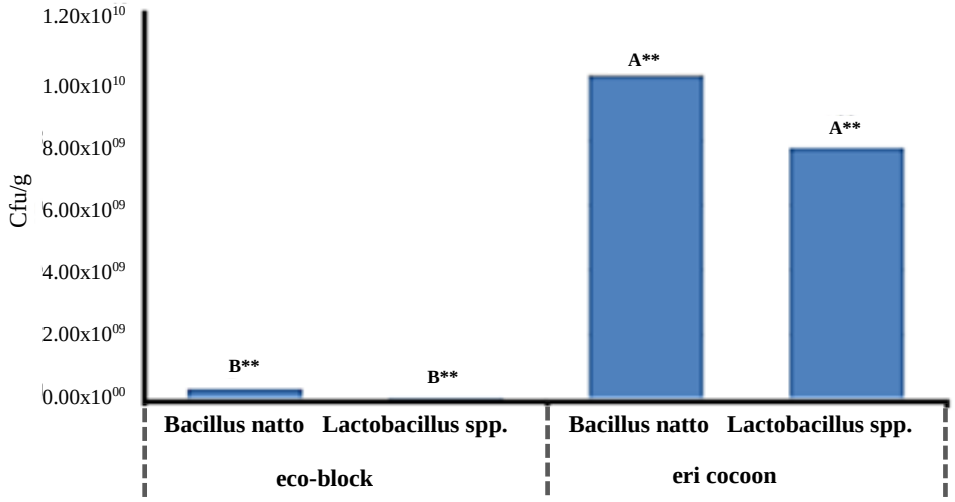


Fig. 4 Comparison of eri cocoon and eco-block by inoculation rate

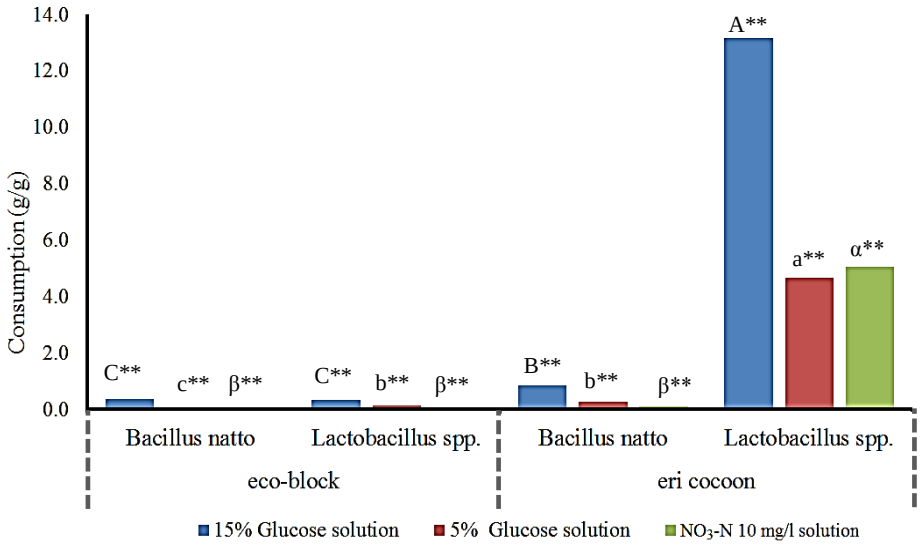


Fig. 5 Consumption comparison of inoculated eri cocoon and eco-Block

Fig. 5 shows the consumptions of both glucose and NO_3-N by both inoculated mediums. It is observed that the consumption of eri cocoon inoculated with *Lactobacillus* has a significant difference when compared with the other combinations. The differences in consumptions can be assigned to the *Lacto bacillus* consumption due to the lack of significant difference between inoculation rates within both mediums

The consumption of NO_3-N of eco-block in this experiment is better than the results by Matsunaga et.al. (2006) where after 24 hours of application there was an increase of NO_3-N.

During our experiments the consumption was observed to stabilize after 24 hours in the case of eco-block with both *Bacillus natto* and *Lactobacillus spp.* but there was no release of NO_3-N observed.

Overall in the consumptions ericocoon behaves better than eco-block having higher consumptions even if, when inoculated with *Bacillus natto,* does not present statistical difference. It is also observed that the consumption of glucose at low concentration presented a significantdifference between *Lactobacillus* and *Bacillus natto* inoculated in eco-block placing *Lactobacillus* in a higher consumption.

CONCLUSIONS AND RECOMMENDATIONS

As there was no significant difference between both microorganisms within the immobilization mediums while, a significant difference between mediums was found, the best immobilization medium by inoculation rate is eri cocoon. Due to the fact that it can allocate statistically the same amount of microorganisms in a smaller mass and volume than the eco-block. This sturdiness and lightness of the eri cocoon as an immobilization medium would make it easier to manage and to transport for any field application.

The eri cocoon inoculated with *Lactobacillus spp.* has the highest consumptions of all of the solutions. This infers that the best option to remove pollutant or create an economic pollutant removal tool is the eri cocoon inoculated with *Lactobacillus spp.Lactobacillus spp.* proved that is more effective at consuming nutrients from a water flow than *Bacillus natto*, nevertheless *Bacillus natto* may have with a different immobilization medium such as concrete have a better consumption results.

It is recommended that the tool may be utilized as a bio-string contactor with inoculated eri silk yarn; the combination of untreated eri cocoon and eri silk twisted yarn may give a better result when used together in water flow. The application could be by a spillway that ensures the contact of the bio-string contactor and the water for enough time for it to consume the pollutants in the water.

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Research article

Biochar Amendment to Different Paddy Soils on CH_4 Production, Labile Organic Carbon, pH and Electrical Conductivity Dynamics: Incubation Experiment

CHHIN PHY
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

KETSUDA DEJBHIMON
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

DAUNGSAMON TULAPHITAK
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

PHRUEKSA LAWONGSA
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

MATSA KEOPHILA
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

NIPA THAMMASOM
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

PATCHAREE SAENJAN*
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
Email: patsae1@kku.ac.th

Received 12 October 2013 Accepted 1 March 2014 (*Corresponding author)

Abstract Today biochar research in agriculture is worldwide interested to mitigate greenhouse gas emission. Application of biochar in anoxic condition to different textured paddy soils was proposed to study. We gave hypothesis that biochar rates in paddy soils will correlate to the changing of CH_4 production, soil labile organic carbon (LOC), pH and electrical conductivity (EC), and their interactions. Biochar amendment rates, 6.25, 12.50, 18.75 and 25 t ha^{-1} were anaerobically incubated in loamy, clayey and loamy sand soils for 28 days. At the end of incubation, biochar amended loamy soils gave the highest cumulative CH_4 production followed by clayey and loamy sand soils. CH_4 production was enhanced by biochar amendment in loamy and clayey, but suppressed in loamy sand. The highest cumulative CH_4, 47.03 mg CH_4-C kg^{-1}, was produced from loamy soil with 12.50 t ha^{-1} of biochar. The highest LOC was in clayey soil followed by loam and loamy sand in all rates of biochar amendment. Biochar had tendency to enhance soil pH in loam, but not in clay and loamy sand. In addition, highest EC was in clay, especially with 25 t ha^{-1} of biochar amendment, followed by loam and loamy sand. Through the whole of incubation, biocahar amendment rates significantly negative correlated to CH_4 production rates in all soil textures. The positive correlations between LOC and biochar rates were found in clayey and loamy sand soils, while the former was highly significant. However, fluctuated correlations were manifested in loamy soil. Furthermore, in loamy sand, the stronger correlation between biochar rates, and both pH and EC, compared to loamy and clayey soils. Biochar amendments suppressed CH_4 production in loamy sand, but enhanced in loamy and clayey soil under anaerobic incubation. Further studies on biochar feasibility should be trialed in paddy-field condition.

Keywords organic material, soil organic carbon, greenhouse gas

INTRODUCTION

Rice paddy is an important distribution channel of anthropogenic greenhouse gas (GHG) emission, which impacts to global warming or climate change aspects. CH_4 production and emission from soil is derived from C mineralization, and widely documented with relation to the effect of soil temperature, moisture, pH, Eh and plant cultivars (Zheng et al., 2007). In addition, soil labile organic matter fractions are very important in vulnerable to transform and play crucial roles for C and nutrient cycling, and perform a major role for source and sink of GHG change such as CO_2 and CH_4 (Tian et al., 2013).

Biochar is a carbon rich by-product derived from thermal decomposition of organic matter under pyrolysis system with low oxygen concentration promoted the potential for improving soil properties (Denyes et al., 2012). Today biochar research in agriculture is worldwide interested to mitigate GHG emission such as CH_4, or CO_2 to environment. Therefore, this incubation experiment is established in a laboratory in order to identify the effectiveness of biochar amendment rates on soil parameters and their interaction in different soil textures.

OBJECTIVE

To investigate CH_4 formation, labile organic carbon (LOC), pH and EC dynamic characteristics from application of different rates of biochar and their interactions in anoxic condition within loamy, clayey and loamy sand paddy soils**.**

METHODOLOGY

Treatments, soils and incubation: The experiment was laid out in completely randomized design (CRD) in triplicate, incorporated with 0, 6.25, 12.50, 18.75 and 25 t ha^{-1} of biochar with 7.98 and 0.94 dS m^{-1} of pH and EC respectively. Biochar derived from a 5 years old eucalyptus wood, combusted at conventional kiln by 350 ^oC. The loamy, clayey and loamy sand soils were sampled from 0-15 cm depth in a paddy field in northeast of Thailand. More details of chemical and physical properties of soils and biochar were shown in Table1. The soil was air dried, grinded and passed through a 2 mm. sieve. Enough amount of soil sample was pre-submerged in deionized water for one week. Prior to the soil incubation, moisture content of the muddy soil was determined.

A weight of muddy soil used in this incubation trial was equivalent to 5 g of dried soil, was placed in a 60 ml serum bottle. The soil-biochar mixture with 15 ml of deionized water was shaken by using vortex shaker in order to expel any gas bubbles in soil slurry, and flushed the head space in the bottles by ejecting N_2 (99.99%) gas with 1 bar pressure for 1 minute, the bottle was closed immediately with butyl rubber stopper and aluminum crimp top seal. They were wrapped up with aluminum foil for protecting the light radiation.

Table 1 Basic chemical and physical properties of soils and biochar

Soils/biochar	Sand (%)	Silt (%)	Clay (%)	BD (g cm^{-3})	SOC (%)	LOC (g-C kg^{-1})	TN (%)	C:N ratio
Clay	2.53	17.31	80.26	1.44	1.75	1.70	0.16	10.94
Loam	50.00	36.70	13.30	1.45	0.79	0.50	0.07	11.29
Loamy sand	84.14	11.95	3.91	1.80	0.12	0.10	0.02	6.00
Biochar	-	-	-	-	38.60	13.30	0.50	77.20

Gas samplings and soils analyses: Gas samplings were performed every week for 4 weeks. Before the actual gas samplings, the incubated samples were flushed with N_2 (99.99%) for 1 minute, sealed tight as mentioned previously and incubated again for 24 hours. One ml gas sample was taken from the head space of incubation bottle using an air-tight syringe. The concentration of CH_4 in the gas samples was analyzed with gas chromatograph (GC), Shimadzu GC2014, detector temperature 200 ^oC (FID), injection port 150 ^oC, oven 180 ^{o} C, stainless steel column 2 m length

packed with unibead C. Carrier gas is He and retention time is 2.25 minutes. To calculate the CH_4 production was mentioned by Ro et al., (2011). Labile organic carbon (LOC) was analyzed by permanganate-oxidation method (Moody and Cong, 2008). The actual soil pH and EC were measured by pH and EC meters, respectively.

Statistical Analysis: The data collected was analyzed statistically using Analysis of Variance (ANOVA) technique and treatment means were compared by using Duncan's Multiple Range Test (DMRT) with SAS statistical program.

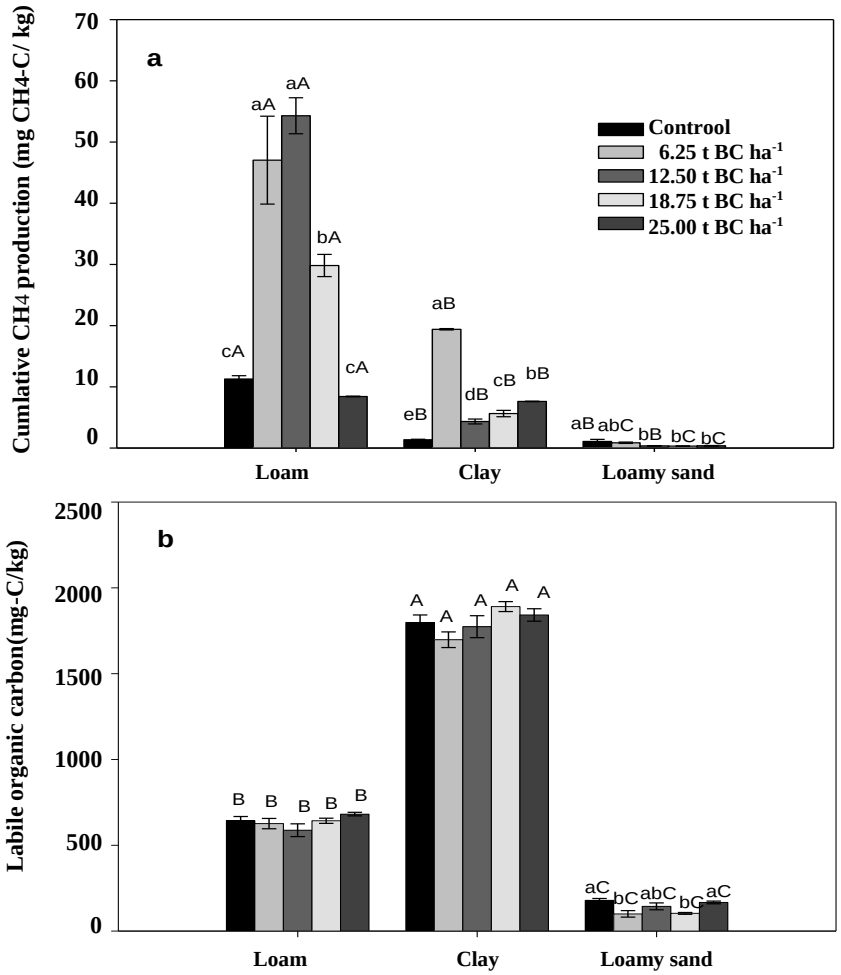
RESULTS AND DISCUSSION

Cumulative CH_4 production: Biochar amendment significantly enhanced cumulative CH_4 production accompanied with a large range (8.42 to 54.03 mg CH_4-C kg^{-1}) in loamy soil, and a moderate range (5.63 to 19.40 mg CH_4-C kg^{-1}) in clayey soil, when compared to its control without biochar Aemicalon, but it decreased CH_4 production with a very low range (0.31 to 0.86 mg CH_4-C kg^{-1}) in amended loamy sand soil (Fig. 1, a). Biochar amendment rates significantly negative correlated to CH_4 production rates in all soil textures (Table 2). A quadratic regression determination had identified that cumulative CH_4 production was influenced by LOC in loam, but not found in clay and loamy sand. While pH had impacts on cumulative CH_4 production in clayey and loamy sand, and EC had determined cumulative CH_4 production in all types of soil (data not shown). Zhang et al. (2012) had given a report that methane emission over the whole rice growing season was significantly increased by the rate of biochar amendment. Yu et al. (2012) also confirmed that under the high soil moisture, 85 and 100% water filled pore space, biochar enhanced methane emission. In contrast, Feng et al. (2012) indicated that biochar amendment in paddy soil decreased CH_4 emission as well as Liu et al. (2011) had proved that application of biochar reduced methane emissions from the paddy soil. These findings agreed to our results which CH_4 productions were enhanced in loamy and clayey soils, but decreased in loamy sand soil amended with biochar. Zhang et al. (2010) had emphasized that the degree of methane emission vary depending upon the type of soils, biochar application rates, soil moisture conditions, the fertilization, and water management regimes.

Labile organic carbon (LOC): The highest LOC was found in amended clayey soil, 1697.45 to 1890.71 mg-C kg^{-1}, followed by loamy soil, 587.46 to 681.20 mg-C kg^{-1}, and loamy sand, 99.93 to 178.99 mg-C kg^{-1}, respectively. The results found that biochar had no influence on LOC in loamy and clayey soils, but fluctuated among biochar rates in loamy sand (Fig. 1, b). The dynamic changes of LOC in loamy soil with 6.25, 12.50 and 18.75 t ha^{-1} of biochar were gradually increased from 0 to 21 DOI, but tended to go down at 28 DOI, contradictory to the LOC change in clayey soil, which was still keep increasing over the whole incubation. In addition, LOC changes in loamy sand soil were very low but fluctuated (data not shown). The positive correlations between LOC and biochar rates were found in clayey and loamy sand soils, while the former was highly significant (Table 2**)**. However, fluctuated correlations were manifested in loamy soil. Zhang et al. (2012) found that biochar amendment did not change LOC over the rice growing season.

Potential of hydrogen (pH): The dynamic changes of pH in different soil textures showed the same patterns, which increased from the initials to the fluctuated peaks at 7, 14 and 21 DOI and thereafter had tendency to go down at the end of experiment. The highest initial pH indicated in loamy soil followed by clayey and loamy sand, but at the end of incubation we did not find any significant differences among those soil amendments. The pH values were range from 5.87 to 6.93, 5.77 to 6.45 and 5.26 to 5.76 for loamy, clayey and loamy sand respectively. Furthermore, we did not see the effects of biochar on soil pH in clayey and loamy sand soils, except for amended loamy soil which bichar had influenced to enhance soil pH (Fig. 2, a). Furthermore, in loamy sand, the stronger correlation between biochar rates and pH, compared to loamy and clayey soils (Table 2). Farrel et al. (2013) had proved that pH change in biochar amended soils were higher than control soil over the duration of incubation experiment because biochar was highly alkalinity. Lai et al. (2013) also claimed that the application of biochar increased the soil pH due to their alkalinity. Nigussie et al. (2012) also supported the findings above, i. l. biochar stimulated soil pH, and the

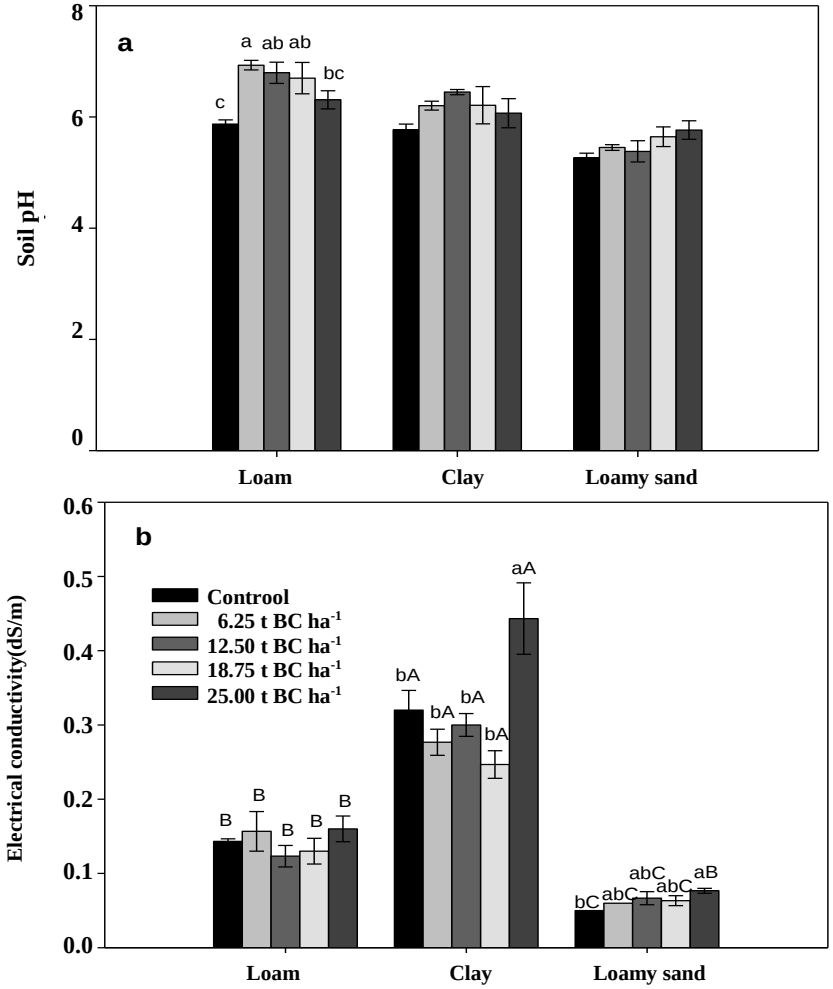
result gave another reason that the high surface area and porous nature of biochar and the factor increases cation exchange capacity (CEC) of the soil and significantly positive correlate with pH. Ventura et al. (2012) reported that biochar amended soil 30 and 60 t ha^{-1} had no effect on soil pH from upland field experiment.



Different letters showed significantly different at p<0.01, vertical bars represent SE-mean. The lowercase used to compare between the treatments within each soil type and the uppercase used to compare the same treatments among the three soil types

Fig. 1 Cumulative CH_4 production (a) and LOC at 28 DOI (b) from anoxic incubated soils an affected by different rates of biochar application.

Electrical conductivity (EC): The highest initial EC was in loamy soil (0.34 to 0.40 dS m^{-1}) followed by clay (0.20 to 0.32 dS m^{-1}) and loamy sand (0.02 to 0.08 dS m^{-1}), respectively, but at the end of experiment we found that the highest EC was in clayey soil (0.25 to 0.44 dS m^{-1}) followed by loamy (0.12 to 0.16 dS m^{-1}) and loamy sand (0.05 to 0.08 dS m^{-1}) soils, respectively. Fig. 2, b showed that biochar amendments had no potentials on soil EC in loamy soil, except for 25 t ha^{-1} of biochar amendment in clayey and loamy sand respectively, which promoted soil EC, compared to the control. In addition, in loamy sand, the stronger correlation between biochar rates and EC was evident, compared to loamy and clayey soils (Table 2).



Different letters showed significantly different at p<0.01, vertical bars represent SE-mean. The lowercase used to compare between the treatments within each soil type and the uppercase used to compare the same treatments among the three soil types

Fig. 2 Soil pH (a) and EC (b) at 28 DOI from anoxic incubated soils an affected by different rates of biochar application

Table 2 Pearson correlation coefficients (r) relating biochar rates to CH_4 production rate, LOC, pH and EC

Soil parameter	DOI	Loamy soil	Clayey soil	Loamy sand soil
CH_4 (mg CH_4-C $kg^{-1}d^{-1}$)	7	-0.80**	0.80**	-0.51
	14	-0.82**	-0.82**	-0.52
	21	-0.86**	-0.81**	-0.60*
	28	-0.85**	-0.88**	-0.69*
LOC (mg kg^{-1})	7	0.75**	0.73**	0.51
	14	-0.66*	0.69*	0.41
	21	-0.29	0.57	0.68*
	28	0.50	0.63*	0.51
pH	7	0.39	0.77**	0.85**
	14	0.19	0.58*	0.96***
	21	-0.32	0.15	0.16
	28	-0.61*	-0.22	0.50
EC (dS m^{-1})	7	-0.04	0.54	0.91***
	14	0.17	-0.22	0.86**
	21	-0.56	0.19	0.79**
	28	-0.05	0.58*	0.51

Ventura et al. (2012) indicated that biochar application significantly increases soil EC and it was a direct relationship between biochar rate and EC. The higher rate of biochar application results in higher EC. Nigussie et al. (2012) had emphasized that biochar amended soils enhanced EC in chromium polluted soil because biochar attributed to ash accretions as ash residue which was dominated by carbonates of alkali and alkaline earth metals, variable amounts of silica, heavy metals, sesquioxides, phosphates and small amounts of organic and inorganic N. In addition, Farrel et al. (2013) proved that biochar had highly EC, which tend to promote soil EC.

CONCLUSION

Biochar amendment had varied effect on CH_4 production in different soil textures under anaerobic incubation. Biochar enhanced CH_4 production in loam and clay, but decreased in loamy sand. Simultaneously, biochar amendment had no potential to change LOC in every soil. While, biochar had influenced to stimulate soil pH in loam, but not found any effectiveness in other two soils. In addition, EC changes were tending to increase by biochar in clay and loamy sand. The correlation was found between biochar rates and soil parameters in each soil texture and interaction between LOC, pH, EC, and CH_4 production. In order to minimize biochar production from tree feedstock, the future research should generate biochar from crop residues (rice straw, rice hull, grass etc.), or agricultural industrial wastes.

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Research article

Evaluation of Oxbow Lakes and Circulating Irrigation in the Ishikari River Basin, Japan

DAISUKE KUSA*
Tone River Basin Research and Management Office, Kanto Regional Agricultural Administration Bureau, Ministry of Agriculture, Forestry and Fisheries, Chiba, Japan
Email: kusadai@frontier.hokudai.ac.jp

TADAO YAMAMOTO
Hokkaido University, Hokkaido, Japan

TAKASHI INOUE
Hokkaido University, Hokkaido, Japan

TETUAKI NAGASAWA
Emeritus Professor, Hokkaido University, Hokkaido, Japan

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Abstract The study attempts to clarify the functions of oxbow lakes in rural irrigation systems. The status of oxbow lakes was briefly investigated through interviews with town officials and land improvement agencies. It is clear that even though canals have been constructed in the area, oxbow lakes in the Ishikari River basin are utilized as primary and auxiliary irrigation resources and as reservoirs for circulating irrigation systems. In the Urausu region, 14% of the irrigation water resource comes from oxbow lakes. The percentage of drainage into the oxbow lakes is 72.0% during the puddling period and 64.6% during the normal period. The percentage of water recycled through the oxbow lakes is 76.3% during the puddling period and 66.4% during the normal period. Furthermore, all water used in circulating irrigation is obtained from the oxbow lake in the region around Karisatonuma. This reduces the amount of water taken from the river. This suggests that rural resources, such as oxbow lakes, can continue to be used as a component of regional irrigation systems. This information may be beneficial as a reference for cost-effective development of rural irrigation systems in developing countries.

Keywords Oxbow Lake, regional resource, circulating irrigation, Ishikari River, conservation of water environment

INTRODUCTION

As global water demand increases, the development of irrigation systems, especially in developing countries, becomes increasingly important. This is also important for reducing poverty. Although international support is evident in many developing countries, in some cases, this support is insufficient to develop adequate irrigation infrastructure. Therefore, it may be beneficial to involve regional resources to facilitate the development of irrigation systems in areas of poverty.

To date, several studies have examined regional water usage. Yenigun et al. (2010) have studied and evaluated Turkey's irrigation systems, and Liyantono et al. (2012) studied the operational status of conjunctive water use in Indonesia. However, local resources, such as oxbow lakes, are not commonly incorporated in localized irrigation and drainage systems. Similar to lakes or ponds, which are typical water resources in mountainous areas, oxbow lakes are typical water resources in a river basin. Oxbow lakes are remnants of meandering flood plain rivers that have been cut off and physically isolated from their respective main river channels (Cullum et al., 2006). In Kenya, small-scale irrigation farming is being undertaken around a considerable number of oxbow lakes previously surrounded by seasonal wetlands (Mutero, 2002). In addition, oxbow lakes

are used for small-scale aquaculture in Bangladesh (Thapa, 2004). Therefore, oxbow lakes can be a useful water resource for primary industries in developing countries. McQueen et al. (1982) and the United States Department of Agriculture (1999) studied the relationship between water quality of oxbow lakes and agriculture in the Mississippi river basin. Yamamoto et al. (2004) conducted a similar study of the Ishikari River basin. However, studies of oxbow lakes as sources of water for irrigation have not been conducted. Studying effective use of rural water resources is important for the future development of a particular region and can also be used as a reference for other developing areas.

In this study, we target the Ishikari River basin in Hokkaido, Japan. This agricultural region has many oxbow lakes which function as rural water resources. By studying this region, we can obtain a complete view of oxbow lakes as localized rural sources of water. Furthermore, we aim to demonstrate the usefulness of utilizing existing rural water resources in irrigation development.

Overview of Oxbow Lakes in Ishikari River Basin

According to a study of oxbow lakes in the Ishikari River basin (Kusa et al. 2001), oxbow lakes have many features. Around the Ishikari River, there are many oxbow lakes that have been formed naturally **(**Fig. 1**)** and artificially.

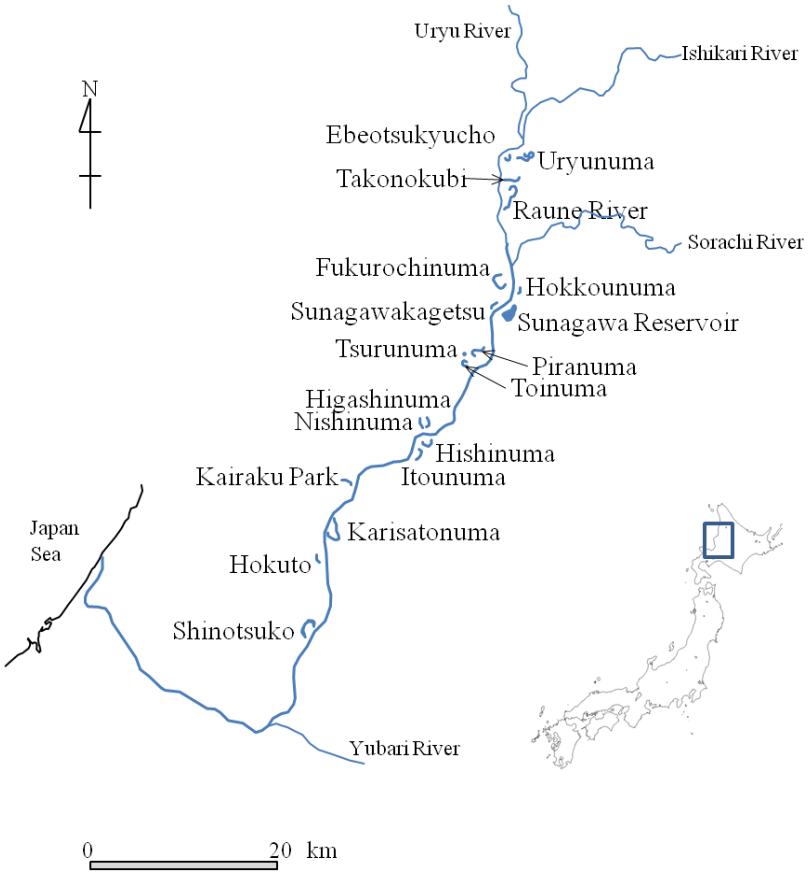

Fig. 1 Natural Oxbow Lakes in the Ishikari River basin

A common feature of oxbow lakes is that they have both sluice gates and agricultural drainage inflow from the surrounding areas. Generally, oxbow lakes are used for agriculture, parks, and flood control. From an agricultural perspective, oxbow lakes have sufficient water volume for irrigation because they originate close to large river systems. The land around oxbow lakes is often used for farming because the soil is well drained. Lands around oxbow lakes are also frequently used as parklands because of their unique biotope functions. In addition, oxbow lakes are also used

as temporary reservoirs during flooding to reduce pump overload. In the Ishikari River basin, oxbow lakes are primarily used for agricultural purposes (Table 1).

Table 1 Oxbow Lakes in the Ishikari River basin

No.	Name	Area (km^2)	Using situation				Sluice Gate
			Agriculture	Park	Flood Control	Others	
1	Tsuikari	-	○	-	-	A part of river	-
2	Old Ishikari River	0.359	○	-	○	-	○
3	Shimotappu	0.027	○	-	-	-	○
4	Kitsunemori	0.047	○	○	-	-	○
5	Karisatonuma	0.476	○	○	-	-	○
6	Kairaku Park	0.087	-	○	○	A part of river	○
7	Sunagawa Reservoir	0.773	-	○	○	-	○
8	Raune River	0.365	○	○	○	-	○
9	Takonokubi	-	○	-	-	A part of river	○
10	Shinotsuko	0.329	○	○	-	-	-
11	Itounuma	0.133	○	○	-	-	○
12	Hishinuma	0.100	○	-	-	-	○
13	Nishinuma	0.114	○	-	-	-	○
14	Higashinuma	0.112	○	-	-	-	○
15	Tsukinuma	0.018	○	-	-	-	-
16	Utsuginuma	0.013	○	-	-	-	-
17	Shin-numa	0.199	○	-	-	-	○
18	Urausunuma	0.075	-	-	-	-	○
19	Mikazukinuma	0.050	○	-	-	A part of river	○
20	Toinuma	0.145	○	-	○	-	○
21	Piranuma	0.105	○	-	-	-	○
22	Hokkounuma	0.065	-	○	-	-	-
23	Fukurochinuma	0.389	○	-	○	-	○
24	Uryunuma	0.044	○	-	-	-	○
25	Tambanonuma	0.014	○	○	-	-	○
26	Tsurutanonuma	0.077	-	○	-	-	-
27	Tsurunuma	0.008	-	○	-	-	-
28	Sunagawakagetsu	0.053	-	-	○	-	○
29	Ebeotsukyucho	0.077	○	-	-	-	○
Total			21	11	7		

Source: Kusa et al. 2001

Based on this, we focus on the actual various agricultural uses of oxbow lakes using concrete examples, such as a primary water resource, an auxiliary resource, and an intermediate reservoir for irrigation from the main canal.

METHODOLOGY

In this study, we focus on several oxbow lakes in the Ishikari River basin, Nishinuma and Higashinuma, which are used for irrigation in and around the town of Urausu. We also focus on Karisatonuma, which is used for irrigation between the town of Tsukigata and Iwamizawa city. To understand the movement of irrigation waters in these areas, we investigated ownership documents and interviewed representatives from local governments and land improvement agencies. We examined areas around oxbow lakes to assess beneficiary areas, the volume of irrigation water during normal and puddling periods, and drainage destinations. Based on this, it is possible to determine the irrigation water flow from the oxbow lakes and the drainage water flow into the oxbow lakes. By comparing these flows with the entire flow of water use in the region, we estimated the function of oxbow lakes in the regional circulating irrigation.

RESULTS AND DISCUSSION

Function of An Oxbow Lake as Auxiliary Water Resource for Circulating Irrigation

To facilitate our investigation of an oxbow lake as an auxiliary water source for irrigation, we examined the Urausu region. The town of Urausu is located on the Ishikari River in a region where many oxbow lakes have been formed by flooding. In this area, irrigation water is taken from the Ishikari River through main canals that were constructed in 1966. Before the construction of the canals, recycled drainage water by the oxbow lakes was used to supply irrigation water. After construction of the canals, circulating irrigation from the oxbow lakes has also been used.

Water use rights, specific to the use of irrigation water from oxbow lakes, were in place from the 1940s to the 1960s. The rights were extinguished after construction of the main canal in 1966. However, the demand for auxiliary water increased, and consequently, the rights were re-established in the 1983 and remain in effect. Since the re-establishment of the water rights, water from oxbow lakes has been used to satisfy various needs. Today, 14% of the irrigation water resource in the Urausu region comes from oxbow lakes and 24% comes from tributaries. This indicates that small rivers, as well as oxbow lakes, were recognized as local resources when the main canal system was constructed (Table 2).

Table 2 Irrigation water resources in the Urausu region

Water resource	Flow (m^3/s)	Percent (%)
Oxbow Lake	0.59	14
River	1.00	24
Irrigation Canal	2.59	62
Total	4.18	100

In addition to use as a source of irrigation water, oxbow lakes are used for other purposes.The pattern of total water usage in the Urausu region is shown in Fig. 2, which indicates extensive water circulation.

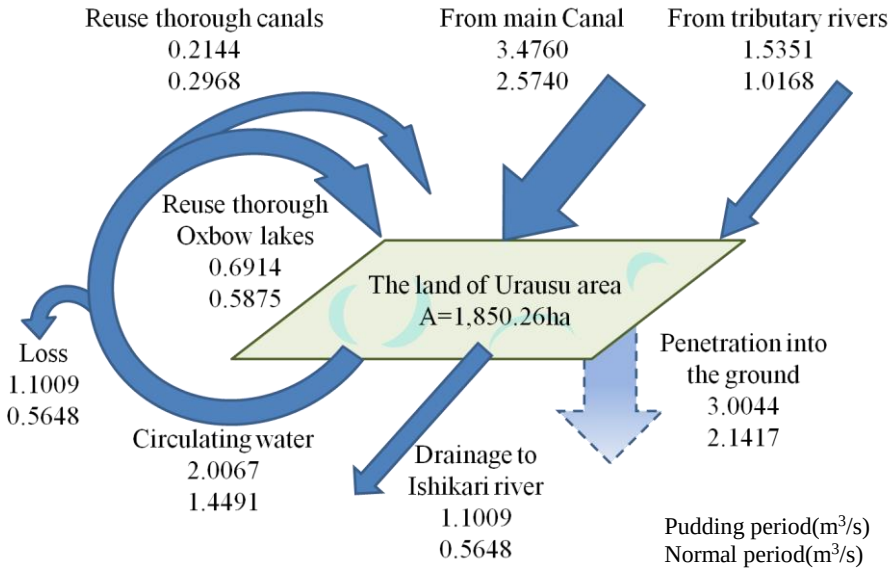

Fig. 2 Total water usage in the Urausu region

The circulation and use of agricultural water is a significant feature of the Urausu region. In the region, more water drains into the oxbow lakes than into to the Ishikari River. Drainage (X) can be expressed as in Eq. (1)

$$X(\%) = \frac{\text{Circulation water } (m^3/\text{s})}{\text{Circulation water } (m^3/\text{s}) + \text{Drainage Ishikari river } (m^3/\text{s})} \times 100 \quad (1)$$

In this calculation, X is 64.6% in the puddling period and 72.0% in the normal period. Some water is lost in the reuse process; however, the water that is recycled (Y) through the oxbow lakes can be expressed as in Eq. (2)

$$Y(\%) = \frac{\text{Reuse through oxblow lakes } (m^3/\text{s})}{\text{Reuse through oxblow lakes } (m^3/\text{s}) + \text{Reuse through canals } (m^3/\text{s})} \times 100 \quad (2)$$

Y is 76.3% in the puddling period and 66.4% in the normal period. A comparison with the actual flow rate is shown in Fig. 2. During the puddling period, water reuse from oxbow lakes increases to 0.6914 m^3/s from 0.5875 m^3/s in the normal period. Water reuse from canals decreases from 0.2968 m^3/s during the puddling period to 0.2144 m^3/s during the normal period. This indicates that an oxbow lake is more important during the puddling period because the storage function of an oxbow lake is more beneficial when water reuse increases. Therefore, it is reasonable to conclude that oxbow lakes have been used as a base for agricultural water circulation for this reason. On the other hand, canals do not contribute to water reuse significantly. Oxbow lakes in the Urausu region can collect waste water easily because they are located downstream from branches of the Ishikari River. Moreover, as oxbow lakes function as temporary storage repositories, it seems to be more practical to pump water from oxbow lakes than from canals.

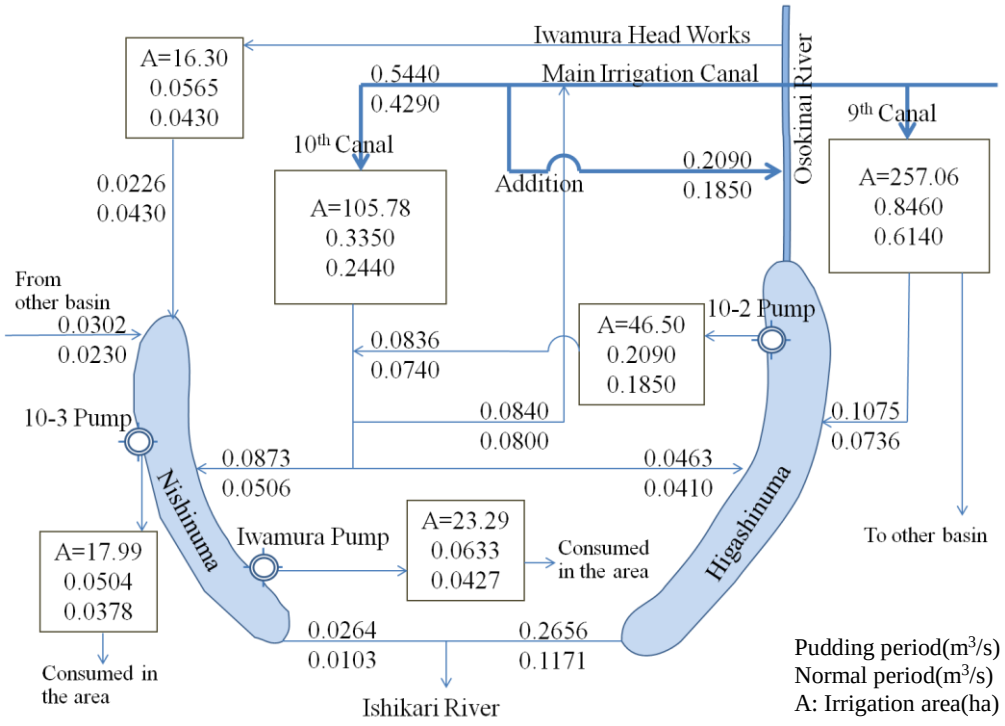

Fig. 3 Pattern diagram of water movement in Sangen-ya

In particular, in Sangen-ya, which is enclosed by oxbow lakes, irrigation water supply is more dependent on oxbow lakes than other areas. Fig. 3 shows a pattern diagram of water movement in Sangen-ya, which illustrates the complexity of water movement. Moreover, water flow into Nishinuma has been restricted such that it only receives agricultural drainage. Nishinuma also supplies irrigation water to land around the lake. Therefore, it is reasonable to conclude that only drainage water is used in the Nishinuma circulating irrigation system. Because Nishinuma is located at the end of the Urausu canal irrigation system, sometimes, for example during droughts,

water from the canal system does not reach the lake. When such conditions occur, farmers use water from Nishinuma. Therefore, it is evident that oxbow lakes water resources are important to stabilize farm management.

The plan associated with the water rights for Higashinuma stipulated that irrigation water should be taken from the main canal rather than from the lake. However, there are restrictions on the land enclosed by Higashinuma, and canals connecting the lake to farmland could not be built. In actual practice, irrigation water goes into Higashinuma and farmers pump water from the oxbow lake. As a result, we can say that, in this situation, the oxbow lake functions as a reservoir in the irrigation system.

Function of An Oxbow Lake as Main Water Resource for Circulating Irrigation

In this section, we describe a case in which an oxbow lake is used as the main resource for circulating irrigation. Karisatonuma is an oxbow lake that is located between the town of Tsukigata and Iwamizawa city. The land enclosed by the oxbow lake and the Ishikari River belongs to Tsukigata, even though the town is situated primarily on the west side of the river. Tsukigata's current location is the result of work conducted in 1940, which changed the course of the river. A land improvement project was carried out in 1981 and 1982. The pumps that are used currently were installed at that time. Moreover, even before the land improvement project, water from the oxbow lake was used for circulating irrigation. Fig. 4 shows the location of Karisatonuma. The most significant difference between this region and the Urausu region is that all irrigation water is taken from Karisatonuma.

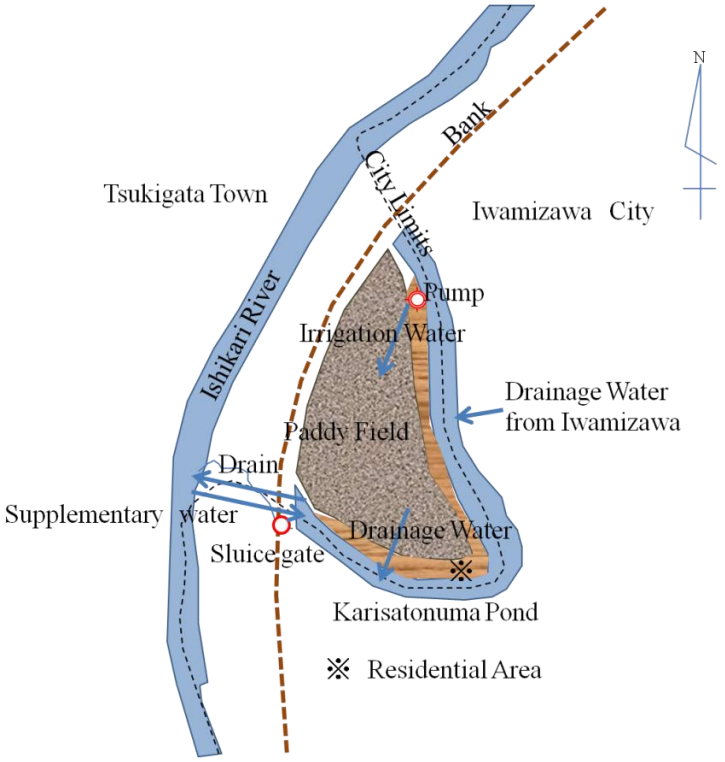

Fig. 4 Karisatonuma

There is no official plan to supply irrigation water to the oxbow lake from the river. However, when water levels are exceptionally low, water is resupplied through the sluice gate. Under such circumstances, Karisatonuma water is only supplied by drainage from each side of the oxbow lake. Incidentally, the water rights allow water to be pumped directly from Karisatonuma, as a part of the Ishikari River because the oxbow lake had been really part of the river until 1940. As indicated by

the above, water from the oxbow lake is used as circulating irrigation for the land around Karisatonuma, which reduces the amount of water taken from the river.

According to the local government, this water system functions satisfactorily and allows farmers access to water for various uses, such as deep ponding irrigation to protect crops from damage during cool summer weather.

CONCLUSION

In this study, from actual use of examples and data, it is evident that oxbow lakes in the Ishikari River basin have many functions. In particular, we can conclude the following:

1. Oxbow lakes function as primary and auxiliary resources for rural irrigation, and as a reservoir for circulating irrigation. In addition, each of the functions is dependent on geography, the existing irrigation systems, or other circumstances specific to each particular oxbow lake.
2. As the storage function of an oxbow lake is very useful when water reuse increases, the function of an oxbow lake changes relative to changes in the water balance in the area.

Although beyond the scope of this study, in 1956, a large land improvement project financed by the World Bank was undertaken in a different section of the Ishikari River basin. Major canals were constructed at that time. However, many oxbow lakes, which were used as irrigation resources before the land improvement project, still remain. Furthermore, in the Urausu region, a new dam was constructed in 2010. Consequently, irrigation in this region will stabilize and become less dependent on oxbow lakes. However, the change in water use will result in a change of the role of oxbow lakes and may affect the biotope and other environmental elements. Therefore, attention should be paid to the possibility that these changes may affect the ecosystem or the water quality.

An understanding of how oxbow lakes function may be a useful reference for rural development, especially at a community level in developing countries. Oxbow lakes have characteristics that can be leveraged to reduce both infrastructure costs and water use. Although economic conditions and infrastructure development differs among countries, many developing countries do not have sufficient financial resources to commit to effective but expensive infrastructure projects. Moreover, there are insufficient water supplies in some regions. In these cases, using rural resources like oxbow lakes seems more reasonable and promising than undertaking expensive infrastructure projects.

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Research article

Diversity and Community Composition of Ants in the Mixed Deciduous Forest, the Pine Forest and the Para Rubber Plantation at Chulaborn Dam, Chaiyaphum Province, the Northeastern Thailand

DUANGRAT THONGPHAK*
Entomology Section, Department of Plant Science and Agriculture Resources, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
E-mail: duathg@kku.ac.th

CHITIMA KULSA
Entomology Section, Department of Plant Science and Agriculture Resources, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

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Abstract The species diversity of ants in three different land use types: a mixed deciduous forest, pine forest and Para rubber plantation, were studied to determine and compare the ant species diversity in these areas. Four sampling methods: handling capture over constant time, honey bait trap, leaf litter sifting and soil sifting, were conducted from September 2011 to September 2012, inclusive. The species richness of ants in the area was 40 identified species, belonging to 23 genera in five subfamilies. The Shannon-Wiener's species diversity index indicated that the diversity was the highest in the mixed deciduous forest (2.65), followed by the pine forest (2.19) and lastly the Para rubber plantation (1.48). The β-diversity, using Sorensen's similarity coefficient to determine the similarity in community composition, was highest between the mixed deciduous forest and the Pine Forest at 71%, and then between the mixed deciduous forest and Para rubber plantation at 61%, and between the pine forest and the Para rubber plantation at 53%, indicating that both ant species diversity and community composition were varied in these three sites which may relate to their different land use types. Therefore, the information from this study suggests that ant species diversity may be used to assist the conservation and management planning of agro-forestry ecosystems.

Keywords ant, community composition, species diversity, land use type

INTRODUCTION

Ants play diverse and important ecological roles. They have functions in an ecosystem as herbivores, predators, prey, detritivores, mutualists and Alonso (2000) stated that their functions are usually related to the species and genera they belong to. Mayati (1996) reported that they improved soil, assisted in the decomposition process, create mycorrhizal reservoirs, effect nutrient immobilization, water movement, nutrient cycling, soil movement and physical and chemical changes to the soil profile. Because of their ecological significance in forest ecosystems, ants are considered suitable bioindicator species for biodiversity studies (Alonso, 2000). Moreover, ants have been used as biological agents of insect pests in agriculture in many countries such as Malaysia (Khoo and Chung, 1989) and Thailand (Kritsaneeapiboon and Saiboon, 2000). Although ants have relatively low species diversity, they are the single most important arthropod group by their dominance in animal biomass (Alonso and Agosti, 2000). Environmental changes have an impact on macro-arthropod abundance (Pearson and Derr, 1986; Adis and Latif, 1996). Many ant species are highly sensitive to the micro climate fluctuations and to habitat structure, and thus respond strongly to environmental change (Anderson, 1990; Alonso, 2000). Overall, common species, most habitats are likely to have specialized species, which occur in sufficient species diversity and

abundance as to be able to serve as suitable terrestrial indicator species of habitat quality and changes. Thus, the objective of this study was to comparison between the diversity of ants at the reserve forest area of Chulaborn dam and rubber plantation.

METHODOLOGY

The study sites were located within the Chulaborn dam, Chaiyaphum province in northeast Thailand. Three areas were selected based on differences in land use types: (i) a natural habitat represented by a mixed deciduous forest and a pine forest (ii) a monoculture based Para rubber plantation. The ants were sampled two seasons which of wet season and dry season during September 2011 to September 2012. The 100 m long line transects were established at each study site. Collecting ant specimens were performed by four sampling methods; hand collecting (HC), leaf litter sampling (LL), honey bait (HB), and soil sampling (SS). Ant specimens were identified to family, genus and species using the identification guides of Bolton (1994), Hölldobler and Wilson (1990), and Wiwatwitthaya and Jaitrong (2001). The specimens were also compared with the reference collections at the Ant Museum, Faculty of Forestry, Kasetsart University. The Shannon-Wiener's diversity index (Krebs, 1999), was used to calculate the diversity of ants collected. The formula of the Shannon-Wiener's diversity index used is presented as follows:

$$H' = \sum_{i=1}^{s} (pi)(\ln pi) \quad (1)$$

Where, *H*' = Species diversity index
s = Number of species
p_i = Proportion of the total sample belonging to i_{th} species

The Sorensen's similarity coefficient (Krebs, 1999) was used to measure the beta diversity or the similarity between two study sites as follows:

$$S = \frac{2a}{2a + b + c} \quad (2)$$

Where, *S* = Sorensen's similarity coefficient
a = Number of species in site A and site B
b = Number of species in site B but not in site A
c = Number of species in site A but not in site B

The evenness index (Krebs, 1999) was calculated to determine the equal abundance of ants in each study site as follows:

$$\text{Evenness} = \frac{H'}{H'_{MAX}} \quad (3)$$

Where, *H*' = Observed index of species diversity
H'_{MAX} = Maximum possible index of diversity

RESULT AND DISCUSSION

A total of 40 ants species in 23 genera distributed among the five subfamilies were identified from three difference land use types using four sampling methods (Table 1). With the comparative ant communities between the three sites, the highest number of species was recorded in the mixed deciduous forest followed by the pine forest and the lowest in the Para rubber plantation. Twenty eight species of ants in 21 genera and five subfamilies were found in the mixed deciduous forest follow by 25 species in 20 general and five subfamilies from pine forest. The lastly, there are only 13 species in 13 genera and four subfamily from rubber plantation. Four species of ants such as *Pachycondyla luteipes*, *Pheidologeton affinis* and *Odontoponera denticulata*, were found in all

three land use types, whilst other species, such as *Philidris* sp.1, *Camponoptus singualaris Oecophylla smaragdina, Polyrhachis furcata, Aphaenogaster* sp.1, *Hypoponera* sp.1, and *Pachycondyla higrite* were found only in the mixed deciduous forest. Whereas, some species, such as *Polyrhachis cyaniventris Polyrhachis fruhstorferi*, *Polyrhachis* sp.12, *Aphaenogaster* feae, *Pheidole* sp.2, were found only in the pine forest and one species of *Aphaenogaster* sp.2 was found only in the Para rubber plantation. At the genus level of all sites, *Polyrhachis* had the highest number of 8 species.

There was a difference in the number of ants species between wet and dry seasons, where in the dry season ant species numbers were high in pine forest and in Para rubber plantation whereas slightly lower in the dry season in the mixed deciduous forest.

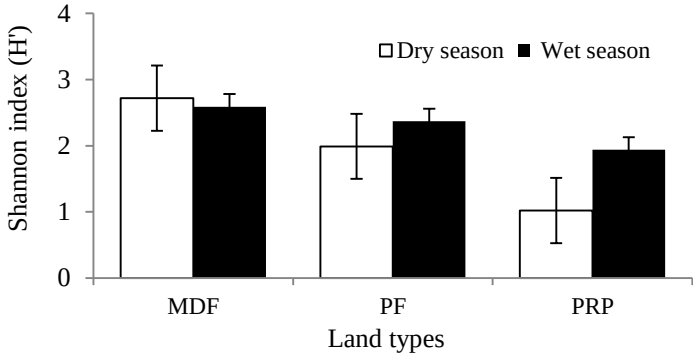
Table 1 Number of species, genera and family of ants in all sites at Chulabhorn Dam

	Number		
Subfamily	Genus	Species	Total(%)
Dolichoderinae	3	3	7.5
Formicinae	4	14	35.0
Myrmicinae	9	15	37.5
Ponerinae	6	6	15.0
Pseudomyrmercinae	1	2	5.0
Total	23	40	100

Table 2 Number of Subfamily, genera and species of ants in difference land use types at Chulaborn dam

Subfamily	Number					
	Genus			Species		
	MDF	PF	PRP	MDF	PF	PRP
Dolichoderinae	3	2	2	3	2	2
Formicinae	4	3	3	9	7	3
Myrmicinae	8	9	5	10	10	5
Ponerinae	5	4	3	5	4	3
Pseudomyrmercinae	1	2	-	1	2	-
Total	21	20	13	28	25	13

Note: MDF=Mixed deciduous forest, PF =Pine forest and PRP= Para rubber plantation

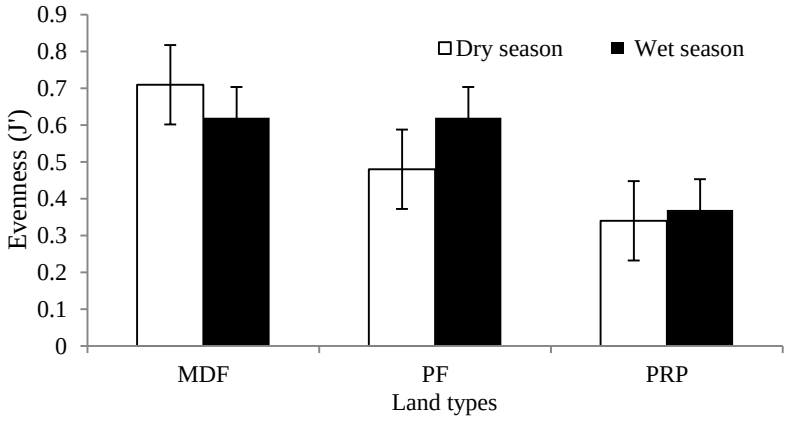


MDF=Mixed deciduous forest, PF =Pine forest and PRP= Para rubber plantation

Fig. 1 Comparison between Shannon index (H') of ant species in each land type at Chulaborn dam

The Shannon-Wiener's species diversity index (Fig. 1) indicated that the year round, diversity was the highest in the mixed deciduous forest, followed by the pine forest and lastly the rubber plantation. Moreover, the highest value of the evenness index of ants was in the mixed deciduous forest, followed closely by the pine forest, whereas that for the Para rubber plantation was markedly lower (Fig. 2). This indicates that a relatively equal abundance of each ant species

was present in the mixed deciduous forest and the pine forest whereas the Para plantation had an unequal abundance of some ant species.



MDF=Mixed deciduous forest, PF =Pine forest and PRP= Para rubber plantation

Fig. 2 Comparison between Evenness (J') of ant species in each land type at Chulaborn dam

Table 3 The Sorensen's similarity coefficient ants from the three sites

Types of land	Sorensen's similarity (%)		
	MDF	PF	PRP
MDF	1	-	-
PF	0.71	1	-
PRP	0.61	0.53	1

Note: MDF=Mixed deciduous forest, PF =Pine forest and PRP= Para rubber plantation

The species similarity between the mixed deciduous forest and the pine forest, as evaluated by Sorensen's similarity coefficient, was the highest whilst that between the mixed deciduous forest and the Para rubber plantation and between the pine forest and the Para rubber plantation were intermediate and the lowest, respectively (Table 3). The relatively high ant species diversity in the mixed deciduous forest may be caused by the correspondingly high diversity in the plant community and as such would potentially reflect the differences in the canopy cover and leaf shedding. Hasin (2008) reported that the leaf litter, soil moisture content, and leaf litter biomass in each study site would likely be affected by differences in each plant community. The leaf litter provides both food and nest sites to many ant species, so it might be expected that an addition of both resources will produce a stronger response from litter-nesting ants (Armbrecht et al., 2006). The higher species richness of ants in the natural forest than in the Para rubber plantation was similar to the reported trend for ant diversity at Sabah, Malaysia, which was higher in the primary and secondary forests than in the oil palm plantation (Yahya, 2000). Similarly with our report that the highest ant species richness was in the mixed deciduous forest followed by the pine forest and the Para rubber plantation, respectively, supporting that the forest is a more suitable habitat than the Para rubber plantation, all year round.

In the dry season, there were lower soil and litter moisture contents and a high temperature, conditions which are unsuitable for ants and their prey leading to a lower ant biodiversity and population levels and so a lower species number being recorded except in this study the mixed deciduous forest was slightly higher in dry season. In the wet season, there is more soil and litter moisture contents which are hence more suitable for many soil faunas that serve as ant prey. Thus, with an increase in the population size and potential biodiversity, a higher of predatory ants were found in this period. The similarity indices indicated that the species composition of ants between the natural forest and the pine forest was higher than that between the pine forest and Para rubber plantation. Compared with the primary land use as a natural forest, this result suggests that these a modified land usages reduce the ant diversity, meanwhile the Para rubber plantation can support a lower ant biodiversity than the forests. This may be due to the fact that the tree canopy of the Para

rubber was treated all year round by some chemicals such as the herbicide that can also affect some arthropods and other food sources.

CONCLUSION

In conclusion, the difference in land use types, which may reflect the different land usages of these sites but that awaits more detailed studies to confirm, potentially influenced the ant community species diversity and composition, as somewhat intuitively expected but not to date ascertained for these habitats. Some species were found in all three land use types, whilst other species were more specialized being found only in specific microhabitats in the forest. If an understanding of microhabitats used by specific ant species can be developed, along with the key trophic interactions, then the potential of using ants as terrestrial indicator species for detecting environmental changes can potentially be reliably and easily (low cost and time) performed compared to some other indicator species.

ACKNOWLEDGEMENTS

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Research article

Effects of Coastal Road Spacing on Deposition of Tsunami-Borne Sand

YOUKI MAEDA
Aoi Engineering Inc., Aichi, Japan

HIROMU OKAZAWA*
Faculty of Regional Environmental Science, Tokyo University of Agriculture, Tokyo, Japan
Email: h1okazaw@nodai.ac.jp

YASUSHI TAKEUCHI
Faculty of Regional Environmental Science, Tokyo University of Agriculture, Tokyo, Japan

TOMONORI FUJIKAWA
Faculty of Regional Environmental Science, Tokyo University of Agriculture, Tokyo, Japan

SHIGEYUKI MIYABAYASHI
Faculty of Regional Environmental Science, Tokyo University of Agriculture, Tokyo, Japan

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Abstract Large-scale infrastructure for tsunami damage mitigation includes tidewater control forests and tide embankments. It is said that installing a tidewater control forest of 200 m in width along the coast is effective in mitigating tsunami damage. Since the East Japan Great Earthquake, tide embankments of about 7 m high have been under construction on coasts of tsunami-hit areas. Restoration and installation of tidewater control forests require many years, and the construction of large-scale tide embankments requires enormous cost. This study focuses on existing roads in the coastal areas. We investigated the effects of road, depending on their conditions of spacing, on tsunami sand deposition. A 0.3 m-wide, 12 m-long open channel was used for tsunami experiments. To simulate a tsunami, a removable barrier was set near the upstream end of the channel to retain water. The barrier was lifted suddenly to generate a bore. The scale of the model was 1/100. A certain amount of sand and models of a tidewater control forest, a tide embankment and roads made of acrylic were placed at the longitudinal midpoint of the channel. The movement of sand carried by the reproduced tsunami was observed. Several combinations of the tidewater control forest, tide embankment and three roads were used in the tsunami reproduction experiment, with the spacing changed for each experiment. As the result of experiments, it was clarified that when the spaces between the roads were wide, the amount of deposited sand was controlled better. It was also clarified that the amount of sand deposition at the time of a tsunami in a coastal area was able to be controlled effectively by combining roads with wide spacing between them with a tidewater control forest or a tide embankment.

Keywords tsunami, tidewater control forests, tide embankments, road, sand

INTRODUCTION

Tsunamis generated by the Sumatra-Andaman Earthquake of 2004 (Mw 9.1) and the East Japan Great Earthquake of 2011 (Mw 9.0) caused catastrophic damage in coastal areas (i.e. Kandasamy et al., 2005). In the East Japan Great Earthquake in particular, large amounts of sand were carried by tsunami waves from the sea bottom to coastal areas. The sand deposition was up to 30 cm thick, and the deposition was widespread. Because of the extreme amount and wide area of sand deposition, removal work has not progressed yet at 2013.

Large-scale infrastructure for tsunami damage mitigation includes tidewater control forests and tide embankments. It is said that installing a tidewater control forest of 200 m in width along the coast is effective in mitigating tsunami damage (Maeda, 2013). Since the East Japan Great Earthquake, tide embankments of about 7 m high have been under construction on coasts of tsunami-hit areas. Restoration and installation of tidewater control forests require many years, and the construction of large-scale tide embankments requires enormous cost.

OBJECTIVE

This study focuses on existing roads in the coastal areas. Roads take less time and money to construct than tide embankments and tidewater control forests take. We investigated the effects of road, depending of their conditions of installation, on tsunami sand deposition.

METHODOLOGY

A 0.3 m-wide, 12m-long open channel was used for tsunami experiments. To simulate a tsunami, a removable barrier was set near the upstream end of the channel to retain water. The barrier was lifted suddenly to generate a bore. The scale of the model was 1/100. A certain amount of sand and models of a tidewater control forest, a tide embankment and roads made of acrylic were placed at the longitudinal midpoint of the channel. The movement of sand carried by the reproduced tsunami was observed. Several combinations of tidewater control forest, tide embankment and three roads were used in the tsunami reproduction experiment, with the spacing changed for each experiment.

The dimensions and alignment of the model trees in the tidewater control forest were determined based on the study by Shuto et al. (1985). Acrylic sticks of 2 mm in diameter and 10.5 cm in length were arranged in a staggered pattern. The width of the tidewater control forest was set as 200 cm (200 m in field scale), which was determined based on the Disaster Prevention Plan of Minami Soma City, Fukushima Prefecture. The dimensions of the trapezoidal cross-section of the tide embankment were determined, based on the same plan, as 5 cm wide at the top, 13 cm wide at the bottom and 7.5 cm high. The road model, simulating an agricultural road, was created as a rectangle of 4.0 cm in width and 0.5 cm in height. The road models were placed immediately downstream of the tidewater control forest model or the tide embankment model in three patterns of 15 cm, 20 cm or 25 cm intervals in each experiment. To evaluate the degree of sand control of the road, the tide embankment and the tidewater control forest at the time of tsunami, Toyoura silica sand, which was chosen to reproduce the sea bottom sand at the site, was laid in the channel bottom upstream of the tide embankment and tidewater control forest. 4.0 kg of sand was laid at 30 cm in width, 80 cm in length and 0.9 cm in thickness. The sand left in the assumed tsunami control zone, consisting of the tide embankment, the tidewater control forest and roads, after the tsunami simulation was measured for dry weight. Five experimental channel conditions were used: (1) no control structures (no models), (2) only the road models, (3) the roads and tide embankment, (4) the roads and the tidewater control forest, and (5) the roads, the tide embankment and the tidewater control forest. The interval of road was set as 15 cm, 20 cm or 25 cm in each experiment that used the road models. To reproduce tsunamis in the experiment flume, a law of similitude was used. Froude's law of similitude is generally used for studies involving open flume experiments; however, it was impossible to apply the Froude's law of similitude, because there were locations where water level differences were rapidly created by the presence of the tidewater control forest and the embankment models. In this experiment, use of a law of similitude, in which the water density and gravitational acceleration are the same for the original site as for the model, was determined based on the conditions described in the Port and Airport Research Institute Report (Kimura et al., 1968). The geometric similarity in this experiment was set as 1/100, and the height of tsunami that reached the coastal areas was assumed as 12 m, based on the Port and Airport Research Institute Report (Takahashi et al. 2011). The tsunami velocity measured in the experiment using the models was 1/10 that observed in the disaster area, which is the same as the result obtained using Froude's law of similitude (Maeda et al. 2013).

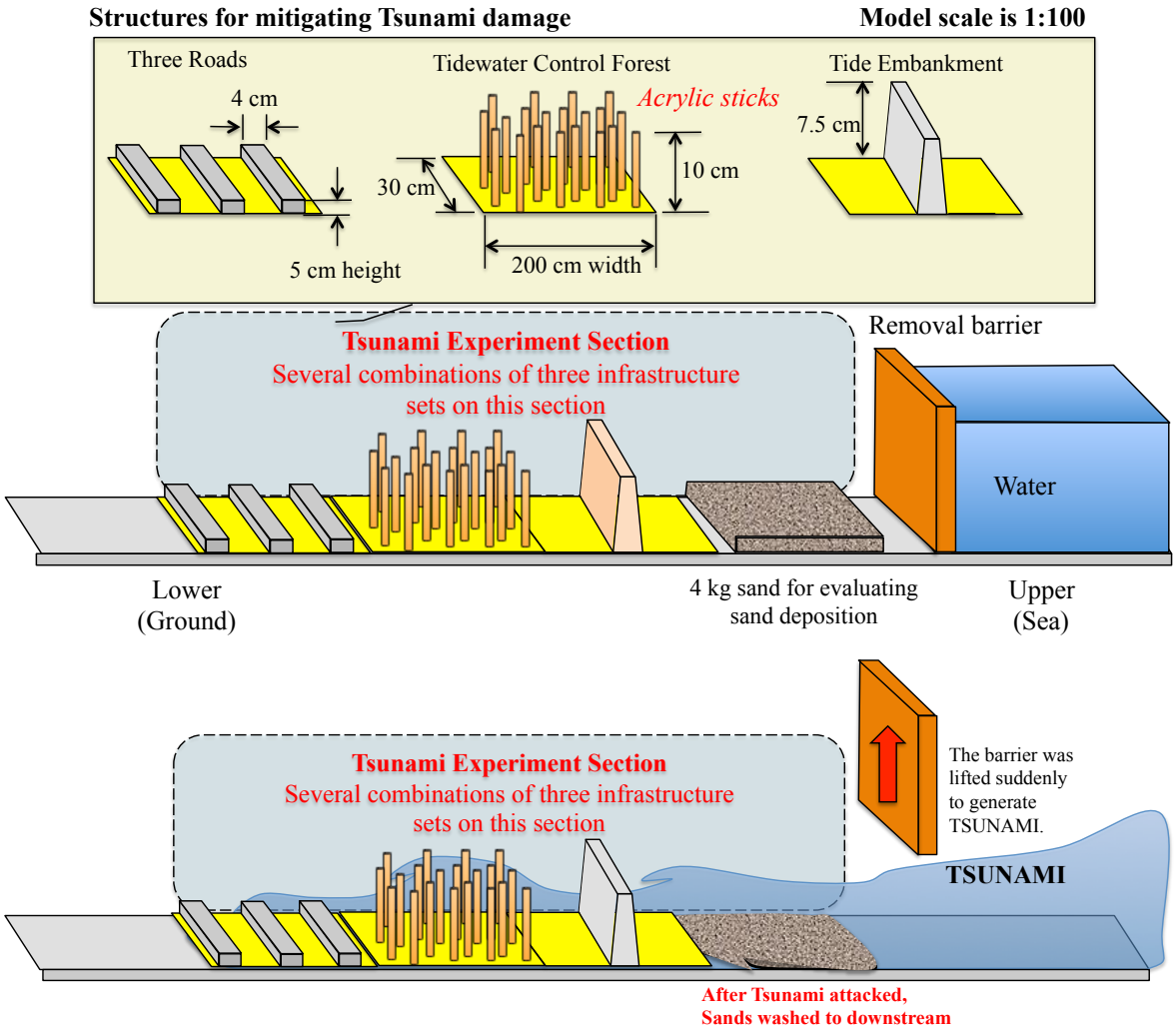


Fig. 1 Outline of Tsunami experiment

RESULTS AND DISCUSSION

Fig. 2 shows the relationship between the road interval and the amount of sand deposited by the water flow in the experiment. The values are the average and the standard deviation of three experimental flows. When road models were not installed, the sand deposition was 3.3 kg out of the 4 kg of sand in the flow. When the road models were installed perpendicular to the flow at intervals of 15 cm, 20 cm and 25 cm, the respective sand depositions were 3.1 kg (78%), 2.7 kg (68%) and 2.5 kg (63%) and it's standard deviation were 0.36, 0.16 and 0.11. It was clarified that the amount of sand deposited by the tsunami waves decreases with increases in the interval of roads. It was demonstrated that the tsunami drag force decreased when roads were installed.

Fig. 3 shows the result of experiments with four different conditions. (1) Without any structures, 3.2 kg of sand was deposited by tsunami waves. It was clarified that the amount of sand deposited by the tsunami waves decreased in stages by combining the roads with a tide embankment and a tidewater control forest, in the following order of least to most increase: (3) with roads and a tide embankment, (4) with roads and a tidewater control forest, and (5) with roads, a tide embankment and a tidewater control forest. It was clarified that combining the roads with a tidewater control forest was effective in mitigating sand deposition caused by tsunami, because the amount of sand controlled by the tidewater control forest was particularly large.

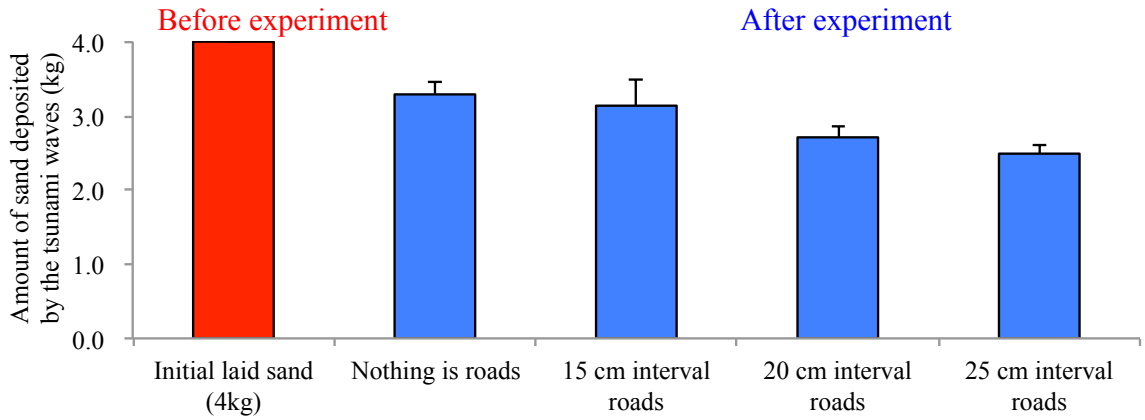
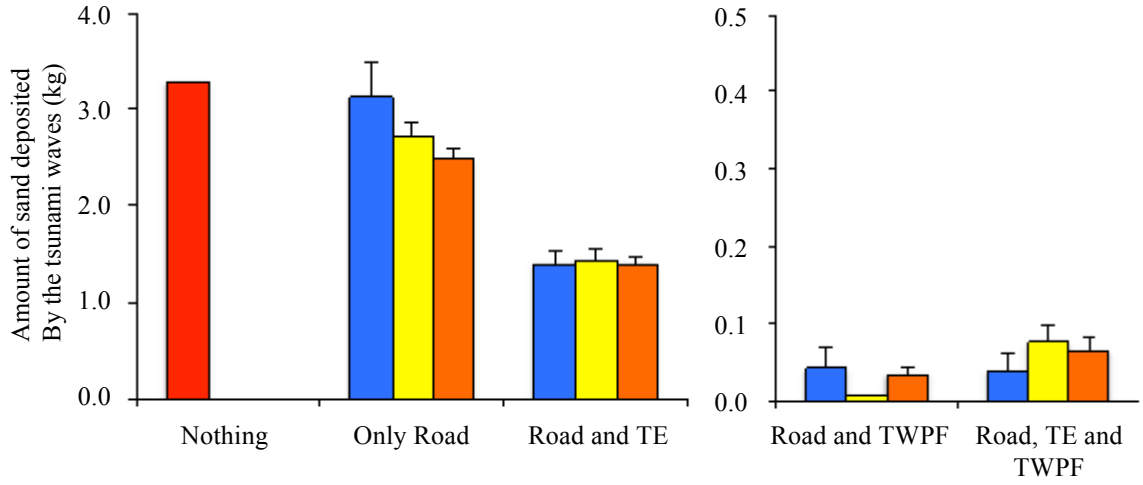


Fig. 2 Relationship between the road interval and the amount of sand deposited by the water flow in the experiment



TE and TWPF means tide embankment and tidewater embankment.
Red indicates the result of tsunami experiment without any structures. Blue, Yellow and Orange also shows the results of 15 cm, 20 cm and 25 cm interval three roads, respectively.

Fig. 3 Result of experiments with five different conditions

As the result of experiments, it was clarified that when the spaces between the roads were wide, the amount of deposited sand was controlled in better way. It was also clarified that the amount of sand deposition at the time of a tsunami in a coastal area could be controlled effectively by combining roads with wide spacing between them with a tidewater control forest or a tide embankment.

CONCLUSION

In this study, the effect of roads and each additional measure in controlling sand deposition caused by tsunami was examined and the effective interval of roads installed parallel to the coastline in mitigating tsunami damages was explored.

It was clarified that the amount of sand controlled by the roads increases with increases in the road interval and that a reduction of 98% or more was achieved in the condition with control measures compared to without control measures, assuming that a tidewater control forest of 200 cm in width (200 m in field-scale) was installed in each case.

However, these results are from laboratory flume experiments that did not consider the topography of the sea bottom or of coastal areas. The similarity of sand was also ignored in this study. To further study measures against sand deposition damage by tsunamis, it is necessary to conduct experiments that consider the similarity of sand and the topography of the sea bottom and the coastal areas in question.

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Research article

Possibility of Participatory Evaluation for Promoting Sustainable Agriculture Project in Samroung Commune of Cambodia

JUN FUJIHIRA
Institute of Environment Rehabilitation and Conservation, Tokyo, Japan

MACHITO MIHARA*
Faculty of Regional Environment Science, Tokyo University of Agriculture, Tokyo, Japan
Email: m-mihara@nodai.ac.jp

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Abstract In all over the world, many organizations implement project from a viewpoint of sustainable development. In case of Japan, 10.5 billion USD is used for Official Development Assistance (ODA) in 2012. Projects were not only implemented but also evaluated by donors, experts and implementers such as NGO and universities. This kind of conventional project evaluation is designed mainly by implementer side and local people regarded as just informants. But criticisms for conventional project evaluation were also studied by other researchers. In 2000, previous study stated that thinking of experts often different from that of people in developing country. Other studies also mentioned that, for improving quality of assistance, it is necessary to conduct project evaluation by adding the point of view of local people and feedback results of project evaluation to local people. However,implementation of participatory evaluation also has difficulties such as resource limitation and conflict of interest. So, this study dealt with the possibility of implementing participatory evaluation for project from a viewpoint of sustainable development in Samroung commune of Cambodia. The study was advanced through comparing evaluation result of conventional evaluation and model participatory evaluation. Result shows that result of two evaluation approaches has some differences because of resource limitation and less objectivity. Therefore, this study concluded that project evaluation better to be done not only by experts but also by local participants. This study proposes different approach of participatory evaluation for evaluating the project properly with more local voice in shorter time and less expense. This approach has potential to enhance accountability toward stakeholdersof Japanese ODA because result of evaluation is led with more local voices with objectivity of experts. Process of this approach also has potential as capacity building for stakeholders including local people in Cambodia.

Keywords participatory evaluation, conventional evaluation, participation level, sustainable development, Japanese ODA

INTRODUCTION

In all over the world, many organizations implement project from a viewpoint of sustainable development. In case of Japan, 10.5 billion USD is used for Official Development Assistance (ODA) in 2012 (Ministry of Foreign Affairs, 2014). Projects were not only implemented but also evaluated by stakeholders such as implementer, donor and expert. This kind of conventional project evaluation is designed mainly by implementer side and local people regarded as just an informant. By framework of ladder of participation that is considered as one of the classic and most influential participation theories, this participation level is evaluated less than placation under degree of tokenism. It is because that the ground rules allow people to advice but retain for the power holders the continued right to decide (Arnstein, 1969).

Criticisms for conventional project evaluation were also studied by other researchers. Chambers (2000) stated that thinking of experts often different from that of people in developing

country. Other studies also mentioned that, for improving the quality of assistance, it is necessary to conduct project evaluation by adding point of view of local people and feedback of the results. Participation of stakeholders for evaluation is recognized to have benefit not only for improving their knowledge and technique related to evaluation but also for their capacity development on development management. For JICA (2001), the participatory evaluation has 4 objectives: 1) building management capacity, 2) promoting ownership, 3) enhancing effective feedback, and 4) advancing accountability for donor and Japanese citizens. So, participatory evaluation can be considered as one method for capacity building and for expecting sustainability of future activities on project site because stakeholders learn method of project evaluation, strengthen ownership of projects, and improve their management skills in project implementation. Although participatory evaluation does not have a fixed and agreed-upon definition, this study applies the definition of Cousins and Earl (1999) who defined participatory evaluation as applied social research that involves a partnership between trained and practice-based decision makers, organization members with program responsibility, or people with a vital interest in the program. But it also has difficulties to implement. For example, to make reasonable evaluation result without conflict of interest seems to be difficult to make because this evaluation system involves more stakeholders as evaluator. If there is no conflict of interest, result of evaluation will be trustable and carry out positive impact for accountability toward donor and citizens. So, for implementing sustainable development positively, this study dealt with the possibility of implementing participatory evaluation for project from a viewpoint of sustainable development in Samroung commune of Cambodia.

Study Site

Study covered 11 villages which are located in Samroung commune, Phrey Chhor district, Kampong Cham province, Cambodia. These villages consist of Bonteay Thmey, Takrit, KondalKoang, TompangRisey, Svayprey, Samroung, Sodey, Thmey, Veal, Smei and Preykhcheay village. This commune is located at the distance of 83 kilometers from Phnom Penh cityand 8,111 people are living in 2011 (Fig. 1). In Samroung commune, conventional farming system is mainly applied for production in order to increasing yield. For promoting sustainable farming systems through sustainable agriculture based on natural resource circulation, Institute of Environment Rehabilitation and Conservation (ERECON) and Tokyo University of Agriculture has been implementing a projectt itled project on promoting sustainable agriculture in Samroung commune of Kampong Cham province, Cambodia since April 2011.

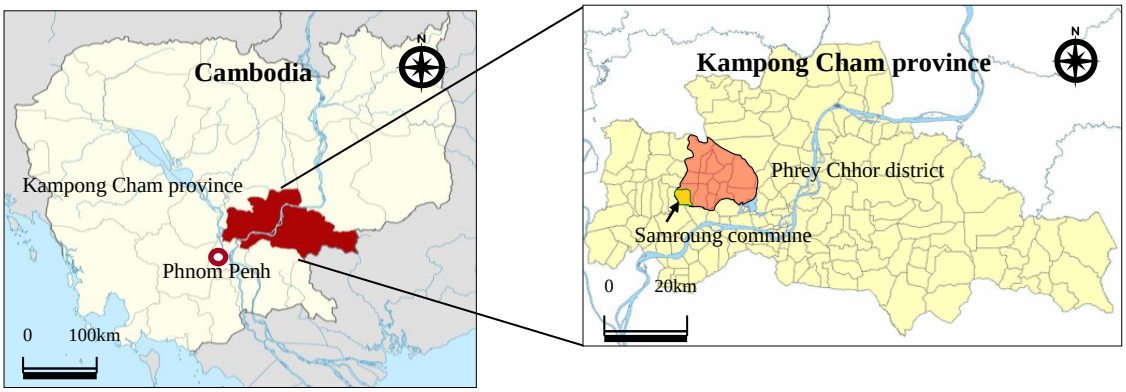

Fig. 1 Location of Samroung commune in Kamong Cham Province

METHODOLOGY

For achieving objective, the study was advanced through model participatory evaluation, focus group discussion, with 6 committee members of farmers' group and a school director on 27

September, 2013. In model participatory evaluation, definition of evaluation, criteria for evaluation, and basic information and activities of the project were shared in order to implementing adequate evaluation. Result of evaluation was answered by score on five points Likert Scale along the continuum of not satisfied at all to very satisfied. For avoiding conflict of interest, researcher acted just as facilitator encouraging participants to answer their opinions without hesitation.

In the project, 17contents were implemented from April 2012 to March 2013, Japanese financial year of 2012. For evaluating activities in 2012, researcher explained contents under 5 activities briefly and form question with participants. Then, participants evaluated these activities based on OECD criteria for evaluation such as relevance, efficiency, effectiveness, impacts and sustainability (Fig. 2).

Fig. 2 Materials for explaining process of participatory evaluation (left) and model participatory evaluation with local participants (right)

Conventional Evaluation Approach and Results in 2012

From the 1st year of the project, implement organization named Institute of Environment Rehabilitation and Conservation (ERECON) organize evaluation meeting as mid-term evaluation at the end of each financial year. The evaluation team comprised eight experts from Thailand, Cambodia and Japan having expertize in evaluation of international cooperation activities.The team visited project site in Samroung commune from 6 to 7 March, 2013. In the observation, meetings were held for direct interviews by evaluators to farmers, school teachers and concerned government officers in farmlands, elementary schools and market. The evaluation team also observed farmers group meeting as well as workshop on promoting sustainable agriculture.Through the observation in site, every team member evaluated project achievements by using evaluation sheets based on OECD criteria for evaluation. Finally, the team concluded "Summary of Evaluation" at the evaluation meeting on 8th March where 31 participants from collaborated organizations attended.At the end of the evaluation meeting, summary of evaluation was submitted from leader of evaluation team to representative of project implementer. Evaluation team evaluated the project as satisfactory in terms of activities for farmers, but could not evaluate impact of activities in elementary schools because they could not observe activities for this criterion.

RESULTS AND DISCUSSION

Comparing Results of Conventional Evaluation and Model Participatory Evaluation

Table 1 shows contents and evaluated activities done by evaluation team on March and local participants on September 2013. Contents of activities which has asterisk were observed and evaluated by evaluation team on March, 2013.

As Table 1 shows, project team could observeonly 7 contents in 5 activities at project site because of the time limitation. They evaluated almost all of activities as satisfactory and few

activities were evaluated as the highest or the second highest score through observation.

Yet, local participants evaluated 17 contents. Besides, as different from evaluation team, they evaluated not only activities but also individual content as possible as they could.

Table 1 Result of evaluation by evaluation team and local people

Contents of activity in 2012 (From April 2012 to March 2013) * Activities which evaluation team observed	Criteria of evaluation	Evaluation by evaluation team (March 2013)	Evaluation by farmers (September 2013)
Activity 0			
1. Conduct evaluation meeting for 2011	1. Relevance	-	Very satisfied
2. Distribute materials for 139 farmers	2. Effectiveness	-	Very satisfied (For 2, satisfied)
	3. Efficiency	-	Very satisfied (For 2, satisfied)
	4. Impact	-	Very satisfied
	5. Sustainability	-	Very satisfied
Activity 1			
1. Set 33 model farms*	1. Relevance	Satisfactory	Very satisfied (For 2 and 3, normal)
2. Select core members for farmers' group in each village	2. Effectiveness	Satisfactory	Very satisfied (For 2 and 3, normal)
3. Form group on Samroung Safe Agricultural Products (SSAP) and select committee members	3. Efficiency	Satisfactory	Satisfied (For 4, very satisfied)
4. Conduct technical training at Thailand			
5. Conduct workshop for local farmers who do not belong to the farmers' groups by SSAP*	4. Impact	Satisfactory	Very satisfied
	5. Sustainability	Satisfactory	Very satisfied
Activity 2			
1. Establish Pellet Compost Center*	1. Relevance	Satisfactory	Very satisfied
2. 22 rear cars were distributed	2. Effectiveness	Satisfactory	Very satisfied (For 2, satisfied)
	3. Efficiency	Satisfactory	Very satisfied
	4. Impact	Satisfactory	Very satisfied
	5. Sustainability	Satisfactory	Very satisfied
Activity 3			
1. Hold meeting for project teams of surveying agricultural product market	1. Relevance	Satisfactory	Very satisfied
	2. Effectiveness	Satisfactory	Very satisfied
2. Hold meeting for project team of products with less chemical input sales*	3. Efficiency	Satisfactory	Very satisfied (For 3, normal)
3. Register to Cambodian Organic Agriculture Association (COrAA)	4. Impact	Satisfactory	Very satisfied (For 3, normal)
	5. Sustainability	Satisfactory	Very satisfied
Activity 4			
1. Promote the food, agriculture and environment education through activities at organic farm*	1. Relevance	Highly satisfactory	Satisfied
2. Conduct rice growing experiment with different three formulas were conducted at each school as the food, agriculture and environment education. *	2. Effectiveness	Satisfactory	Very satisfied
	3. Efficiency	Satisfactory	Very satisfied
	4. Impact	-	Very satisfied (For 3, normal)
3. Conduct training on the food, agriculture and environment education for school teachers	5. Sustainability	Potentially satisfactory	Very satisfied
Activity 5			
1. Organize evaluation meeting on 2012*	1. Relevance	Highly satisfactory	Very satisfied
2. Publish and distribute newsletter which includes the contents of activities and the outcomes as well as project evaluation	2. Effectiveness	Satisfactory	Very satisfied (For 2, satisfied)
	3. Efficiency	Satisfactory	Very satisfied
	4. Impact	Satisfactory	Very satisfied
	5. Sustainability	Satisfactory	Very satisfied

Source: Summary of Evaluation for Year 2 and focus group discussion in 2013, ERECON

As same as Chambers (2000) mentioned, result done by evaluation team and local people showed some differences.

Firstly, local participants evaluated activity 0 which evaluation team did not evaluate. Also,

they recognized not completely satisfactory toward effectiveness and efficiency on distributing materials to 139 farmers. It is because that some farmers did not practice adequately even they received materials for practicing the learnt techniques such as compost and bio-pesticide making. Some farmers seem to busy with other tasks and less motivation for practicing the learnt techniques.Distributing 22 rear cars were also regarded low effectiveness and efficiency at the moment because some farmers not yet use for the intended purpose and just keep these at their house.

Secondly, local participants evaluate low on selecting core members and forming farmer's group. Forming farmer's group is not special for farmers. Reason of low evaluation was that the group was not registered as agricultural cooperative to the Cambodian government. However, registration of farmer's group to government is not included as project purpose.

Thirdly, activities at elementary schools were evaluated very high by both of evaluation team and local people. Butparticipants especially teacher regarded impact of the rice experiment was normal.They regarded it was just beginning and they would like to continue experiment with vegetable in order to teach advantages of sustainable agriculture to students.

At last, it was also revealed through focus group discussion that some farmers did not know attached newsletter named Sustainable Agriculture in each village. It was attached on information board in each village in order to share result of activities and evaluation meeting on previous year.

Discussion

JICA (2001) mentioned participatory evaluation is needed in JICA project because sustainability of project will be improved, and beneficiaries can understand project and accept them more readily. It applied same in Samroung commune because local participants mentioned they could understand project design and activities well through model participatory evaluation. But, through model participatory evaluation, it was considered that farmer's tend to evaluate contents of activities positively. It may cause conflict of interest on result of evaluation. Facilitator needs to consider the way to prevent conflict of interest carefully.

Meanwhile, evaluation by experts did not evaluate the project properly because time limitation did not allow them to observe all of activities and process of implementation. Opinions of the entire range of beneficiary local people were also difficult to be involved because the evaluation team could discuss with only some of farmers who were selected by implementer. As Beatrice (2008) stated, proper information and feedback may only be obtained through interactive participation and required involvement of relevant stakeholders in the project at Samroung commune.

Normally, participatory evaluation was conducted with participation of experts and local participants at the same time. But, as same as JICA (2001) studied, not enough time and money can be considered as limitations for implementation.

So, this study would like to propose different approach of participatory evaluation for mid-term and terminal evaluation as experienced from the case of Samroung commune.In detail, local participants evaluate contents of activities through observation and focus group discussion with project implementer. It is similar to monitoring but its purposes are not only checking progress and adjustment points of the project activities but also its impact and sustainability based on OECD criteria. Tentative summary of the earlier evaluation should be shared with the evaluation team as their reference. Evaluation team conducts observation after checking tentative summary of earlier evaluation that is made by local evaluators. Under this approach, experts can understand voice of local people properlywith shorter time and less expenses if they would read tentative summary of earlier evaluation before their observation. In addition, sustainability can be evaluated from contents of tentative summary because management capacity of local people will be shown on summary. JICA (2012) wrote some project conclude that they have sustainability if there were no problems when evaluation conducted. But, in fact, it seems not proper way to evaluation sustainability.

It was also considered that facilitator needs to improve knowledge related to evaluation and facilitation for improving effectiveness and efficiency of participatory evaluation. Their facilitation seems essential for conducting proper participatory evaluation without conflict of interest.

Besides, this study could not check possibility of improving ownership of local people through participatory evaluation because it needs to be studied by how their involvement changed, and how their participation level improved in future activities. It needs to be studied in future studies.

CONCLUSION

According to the result and discussion done in this study, it can be concluded that Samroung Commune has possibility of implementing participatory evaluation. Result of the study shows that conventional evaluation done by only experts seems not evaluate the project properly because of time limitation and less involvement of local people. In addition, result of evaluation done by experts and local participants has some differences. However, local participants seem to evaluate the project positively and they may evaluate some points which are not included as project purposes. From these points, evaluation seems better to be done not only by experts but also by local participants. So, this study proposes different approach of participatory evaluation for evaluating the project properly with more local voice in shorter time and less expense. This process also seems able to evaluate sustainability of the project properly. In addition, this study could not check possibility of improving ownership of local people through participatory evaluation. So it needs to be studied in future studies.

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Research article

Canal Water Level as a Canal Water Management System: Case Study of Klong Rangsit, Phathumthani, Thailand

KAMONSORN THANWISET*
Faculty of Architecture, Rajamangala University of Technology Thanyaburi, Thailand
Email: kamonsorn_t@rmutt.ac.th

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Abstract This research paper deals with the management of the canal water level (CWL) of *Klong Rangsit Canal* (KRC) as a canal water management system (CWMS) by relevant local government units and the CWL impacts on the livelihood of local residents. The relevant local agencies responsible for the CWMS in the area under study are the Royal Irrigation Department (RID) Area 11, the *Bungyeetho* municipality (BYM) and the *Phachatiphat Sub-District* municipality (PSM). The officials and personnel tasked with the CWMS responsibility were interviewed. In addition, the collection of field data was carried out. The findings indicate that attempts have been made by both municipalities to improve the living conditions and livelihood of the local residents. However, the local administrations lack the proper knowledge and skills to operate the floodgates. The municipalities operate the floodgates according to the demands of local residents. It is thus possible to draw a conclusion that most local-level state agencies give their own remit the first priority while the overall efficiency or cooperative efforts with other stakeholders are given a second priority.

Keywords canal water, management, government, responses

INTRODUCTION

Many CWL problems arise from ineffective management or a lack of participation and cooperation among stakeholder groups in the CWMS (Hearne and Torpen, 2010). Some canals are long, complex and connected to main rivers, the characteristics which influence the water flow in the canals. In addition, misuse and overuse of canal water resources occurs, especially when there is a water shortage. Construction projects and canal gates slow canal water flow. In addition, floods could be influenced by rising sea levels, land subsidence and variation in the levels of rainfall (Chyan-Deng et al., 2007). Variation in canals and soil loss during land clearing affects low-lying areas and those with poor drainage (Casadio et al., 2010). The relevant government agencies in Thailand that are responsible for management of natural resources, including the CWMS, have been classified into two levels: the National Government (NG) and the Local Government (LG) levels, as shown in Figure 1.

At the NG level, this research paper is concerned with two key state agencies, i.e. the Ministry of Agriculture and Agricultural Cooperatives of Thailand and the Ministry of Interior of Thailand. The agriculture ministry is tasked with the duties and powers with respect to agriculture, water sourcing and irrigation development, agriculturist promotion and development, cooperative system promotion and development. In addition, under the Ministry of Agriculture and Agricultural Cooperatives, the Royal Irrigation Department (RID) of Thailand is a national-level state body mainly responsible for the irrigation management in Thailand (Ministry of Agriculture and Agricultural Cooperatives, 2011). On the other hand, the interior ministry is responsible for the livelihood of citizens and the social, economic and environmental developments through district and *tambon* (sub-district) administrations. At the level of LG, the focus is on the Royal Irrigation Department's Area 11, which is a local government agency directly responsible for Klong Rangsit Canal (KRC), the canal under study. The RID's Area 11 is tasked with surveillance of water levels in KRC and prevention of flooding to the agricultural lands and communities near and along the

canal. The LG-level units are structured to enable a close collaboration with local residents to build a correct understanding of the area characteristics and thereby allow for timely response. This is the goal impossible to achieve with the NG-level state agencies. KRC is located in Thanyaburi district of Phathumthani province north of Bangkok. The district covers the municipalities of BYM and PSM, both of which are responsible for the areas along Klong (canals) 1-5.

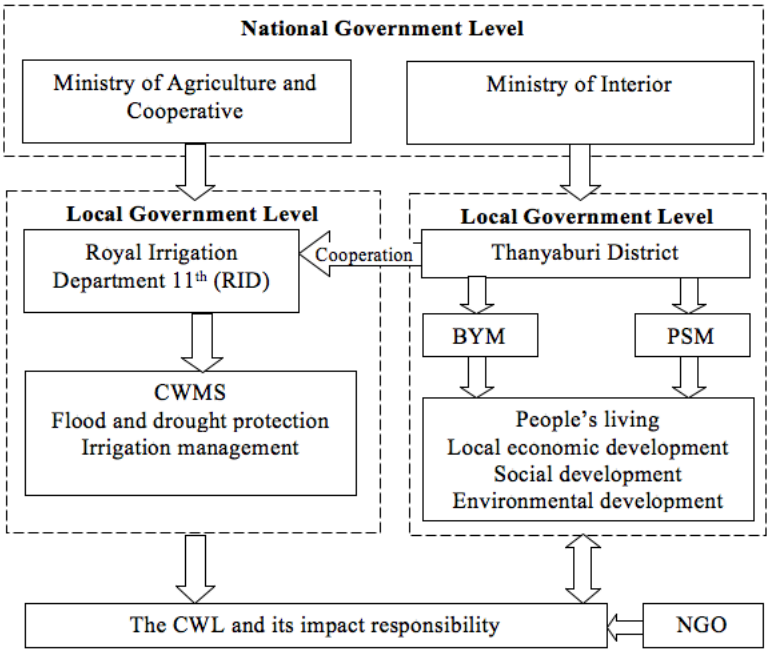

Fig. 1 The NG-level and LG–level state agencies

OBJECTIVE

The objective of this research is to study the CWMS of the relevant local government units and the environmental impacts and effects on local residents of the CWMS implementation.

RESEARCH METHODOLOGY

This research work relies on two sources of data: the primary and secondary sources. The primary data sources include interviews with the local residents along the canal and with relevant authorities as well as questionnaires. The secondary sources are reviews of books and journals, official records of the relevant government agencies, and from other stakeholders. The government agencies from which the official records were obtained are Bungyeetho Municipality (BYM), Phachatiphat Sub-District Municipality (PSM) and the Royal Irrigation Department (RID) Area 11. The officials and personnel responsible for the CWMS of the area under study were interviewed. In addition, field data were gathered from interviews with local residents and observations. The interview sessions enable a correct understanding of the present conditions, the CWMS implementation and its impacts on the livelihood of the local residents.

RESULTS AND DISCUSSION

The data from the RID Area 11 shows the impacts of changing precipitation on the CWL. Figure 2 depicts the relationship between the CWL in KRC and the average monthly rainfall from four irrigation stations located in the lower North region from 1998 through 2010. A maximum average rainfall was observed in September, one month before the CWL in KRC reached its annual peak in

October. This is because following heavy precipitation water from the North region slowly flows south and thus increases the CWL in Bangkok and its nearby areas. December had the lowest precipitation level and subsequently a lower CWL in the following months.

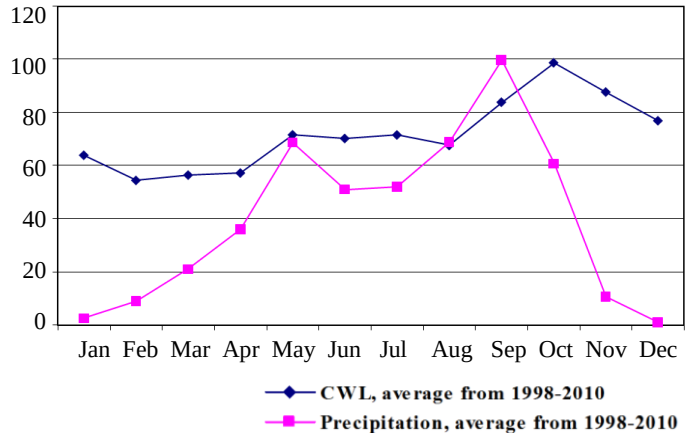

Fig. 2 Precipitation and CWL from 1998 to 2010 by percent of peak value

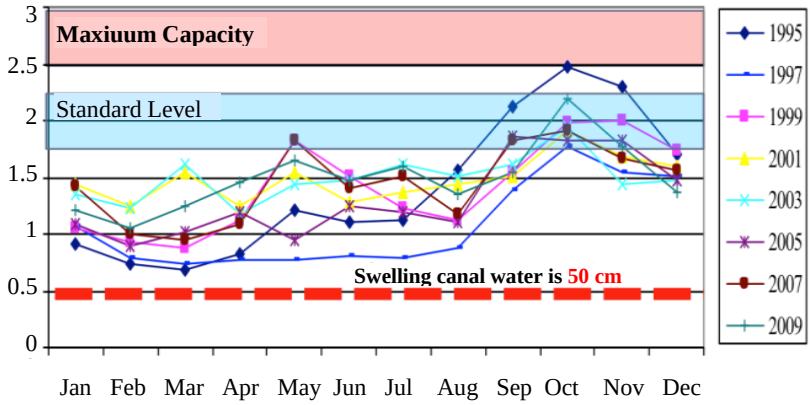

Fig. 3 Levels of canal water of 1995-2009

As seen in Fig. 3, the CWL could drop below 1.50 meters for up to 8 months of a year during the period of 1995 to 2009. Ideally, the CWL should be in the range of 2.00-2.50 meters. Especially from April to July, the canal water quality failed to meet the Biological Oxygen Demand (BOD) standard and the CWL was the lowest during the period (Doungdearn, J. et al, 2002). In addition, it is possible to conclude that the levels of canal water downstream are directly influenced by the variability of precipitation in the North region of Thailand. The CWL in KRC was relatively stable at approximately 0.5-0.9 m. Annual variable precipitation results in changes in the CWL (Thai Meteorological Department, 2010). This fact is confirmed by Fig. 3, which illustrates the differences in the CWLs from 1995 to 2009. From 1995 to 1998, there were greater differences between the highest and lowest CWLs, compared to from 2003 to 2009. The same figure also shows that the CWL was below 1.50 meters for up to 8 months of a year during the dry season. An ideal CWL should be in the range of 2.00 to 2.50 meters. In addition, the canal water quality failed to meet the BOD standard and the CWL was at its lowest during the period of April through July. A low and stable CWL of 0.5-0.9 meter was observed for most of the year. As indicated in Fig. 3, the RID maintains a minimum CWL at no less than 0.50 meter or 50 cm in order to control the pollution level and maintain the water aeration in KRC. A lower CWL could affect the water aeration in the canal since water inflow is insufficient to replenish oxygen in the water. Furthermore, the lower CWL makes it impossible to flush waste water in KRC into the main river.

CWMS Evaluation

The KRC canal flows and discharges into the Chao Phraya River. The water level of KRC is subject to the water levels of the Chao Phraya River and the water from the northern region. In a high CWL in KRC, the Chulalongkorn main floodgate would be opened to discharge the canal water into the Chao Phraya River to prevent flooding. In the dry season in March and April, when the CWL is low, the main floodgate would be opened to drain the water from the river into the KRC canal. However, in case that the water level in the Chao Phraya River is lower than that in KRC in any dry season, the river water would be pumped into KRC to maintain the canal water quality and appropriate CWL. The minimum and maximum of CWL of KRC are 50 cm and 2.50-3.00 meters, respectively. According to the RID Area 11, there are many floodgates along KRC to regulate the CWL. When a demand for water arises, the RID 11th would be notified either by local residents or by the BYM or PSM local administration to operate the floodgates. To efficiently manage the CWL of KRC, the local RID launched the Operation and Maintenance South Rangsit Irrigation Canal Project. The aims of the project are flood prevention and better water management for agriculture. In addition, during the rainy season, the local RID closely monitors the CWL situation of KRC and updates other relevant agencies for a timely decision and effective operation of the floodgates.

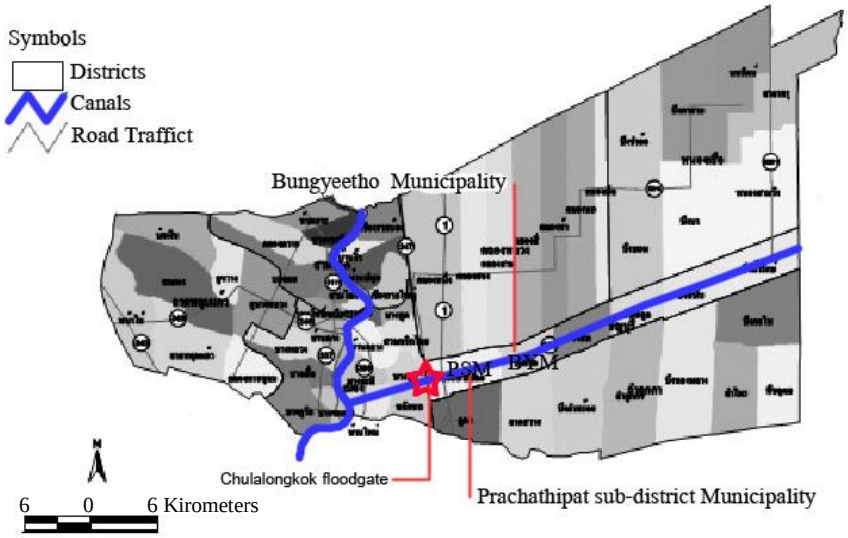

Fig. 4 Location of the Chulalongkorn main floodgate

Government Responses

According to an interview with Mr. Nithaklon Yentakoun, head of the Canal Water Management Division of KRC, the canal water flows both upstream and downstream depending on the water level of two rivers on either side of KRC in different seasons. The rivers are the Chao Phraya River and the Bang Phrakok River. The BYM municipality is responsible for the canal cleanliness and quality and the provision of assistance to the local residents affected by floods. In addition, the municipality collaborates with local leaders and community members to improve the condition and sustainability of the canal, e.g. the clean canal campaigns, landscape improvement projects and the programs to address environmental impacts from the industrial development in or around the area.

Figure 5 illustrates the cooperation between the relevant local government agencies and local residents to address the problems and impacts arising from the CWL. When a CWL problem arises, the RID Area 11 and the relevant municipalities would be alerted. The local RID would operate the canal water floodgates according to the requirements, while the municipalities provide the local residents with food, sanitation and basic accommodations. Occasionally, community leaders alert the local RID to operate the floodgates or request assistance from a community closer to the local

RID to alert the local state body to operate the floodgates. According to Thaweewong Sriburi, a vice president of the Thailand Environment Institute (TEI) (2003), Thailand has at least 30 state agencies under eight different ministries, other than two independent committees, responsible for or tasked with canal water-related projects or duties. This unnecessarily complicates the efficient and successful national-level implementation of the CWMS policies and practices in the country. In addition, the inputs from local residents are usually excluded from the formulation of the national-level CWMS policies and practices. This leads to ineffective implementation of the CWMS policies in the local level. The issues must be addressed urgently by which the local inputs are included and more cooperation of various relevant agencies is encouraged in the policy setting.

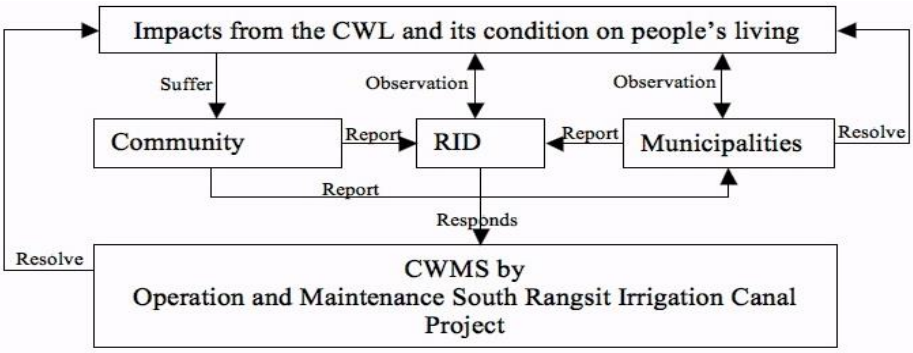

Fig. 5 Schematic of the operation and maintenance South Rangsit Irrigation Canal Project

Implementation of CWMS

(A) Alleviation measures in case of floods and droughts: According to an interview with the mayor of BYM, the municipality would take necessary measures to alleviate the suffering of the residents affected by floods or droughts. For instance, local residents whose houses are flooded would be provided with safe temporary shelters and evacuated if required. In addition, they would be provided with foods and medicines. However, some flood victims fail to receive the aids as their residences were illegally built on the state land and thereby are not shown in the local demographic census.

(B) Preventive measures to wastewater: The illegal settlers were found to fail to care for the environment and thus dump household wastewater into KRC (Sajor, E.E. and Ongsakul, R., 2007). In addition, our survey found that household wastewater from these illegal settlements is untreated since the area is outside the municipalities' jurisdiction. Nevertheless, the educational campaigns have failed to instill in these settlers a sense of responsibility and cooperation. Thus, both municipalities of BYM and PSM have taken other necessary steps to improve the condition of the canal and its CWL with such a project as the canal cleaning and dredging project which is held once or twice annually. The project is supported by non-governmental organizations (NGOs) and local schools that send volunteers to help with the project.

(C) Assessment and treatment of canal water: When the CWL of KRC is low, the PSM municipality would replenish the oxygen level in the canal water, especially in the area where many restaurants and floating markets are located, i.e. Klong (canals) 1 and 2. The oxygen replenishing machines are scheduled to run every day during 2.30 p.m. - 5 p.m. Although the municipality has four machines under its care, only one is functional.

(D) Recovery of environmental degradation: Both BYM and PSM municipalities constructed a canal embankment along one side of the KRC canal and converted the other side into a small avenue for walking and bicycles. In addition, improvements have been made to the landscape along the canal. The developments are intended to prevent new illegal settlement along the canal and to evict the illegal settlers in a most ingenious and diplomatic manner.

Ineffective CWMS of Relevant Local Government Units

The study results reveal a lack of cooperation between the local government units in charge of KRC in tackling the CWL and pollution problems in an efficient and sustainable fashion. An interview with the mayor of BYM indicated that three main agencies are tasked with the CWMS responsibility of KRC, i.e. the engineering division of the municipality, the environment division of BYM and the RID 11th. For example, construction of a bridge is the responsibility of the municipality's engineering division or the local RID or other local state units since the activity affects land use and the canal characteristics. In addition, an interview with Mr. Nithaklon Yentakoun, an official stationed at the RID Area 11, revealed that no standard operating procedure of the floodgates exists. Another interview with community leaders of the Klong Rangsit 3 market showed that the local residents require the canal water for both agriculture and drainage to flush water contaminants. The municipality sometimes involuntarily operated the floodgates to flush waste water following the local community leaders' requests.

The local municipalities operate the floodgates and manage the CWL of KRC in accordance with the demands of local residents since the local administrations lack the proper knowledge and skills to operate the floodgates. The municipalities would tackle the problem only when it arises. It is also found that most local-level state agencies give their own remit the first priority while the overall efficiency or cooperative efforts with other stakeholders are given a second priority. According to Chitradon (2009), the key to a successful CWMS is the adaptive capability and the collaboration and participation of all concerned parties, i.e. local governmental agencies, cities, and communities.

CONCLUSION

The findings indicate a lack of regular and systematic monitoring of the quantity and quality of water in KRC. This contributes to a severe water shortage in dry seasons and to high pollution and low oxygen in the water. Since the dredging of KRC a hundred years ago, the RID has been a key government unit responsible for the CWMS of the canal. However, the agency has focused its tasks on the prevention of flooding and maintaining of adequate water in the canal (i.e. a minimum of 50 cm); but has never assessed the quality of the water in KRC. The local RID operates the water floodgates according to the needs of local residents who are affected by contamination or pollution in the canal water. In addition, it is found that the ineffective implementation of CWMS could possibly be attributed to an ambiguous division of CWMS responsibility between various local government units.

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Research article

Survey Analysis of the Characteristics of Greenhouses in Korea

MANKWON CHOI
Institute of Agriculture and Life Science, Gyeongsang National University, Jinju, Korea

SUNGWOOK YUN
Institute of Agriculture and Life Science, Gyeongsang National University, Jinju, Korea

YONGCHEOL YOON*
Dept. of Agricultural Engineering, Gyeongsang National University (Institute of Agriculture and Life Science), Jinju, Korea
Email: ychyoon@gnu.ac.kr

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Abstract The purpose of this study is to collect basic data (using a questionnaire survey) to inform the establishment of structural safety guidelines and the standardization of greenhouse design in order to determine a standard model for the development of greenhouses on reclaimed land. To collect this data, 148 farms were visited across Korea, and were administered a questionnaire survey. The survey included items on greenhouse facilities, foundations, covering material, and irrigation type. Results revealed that greenhouses were nearly evenly split between single- and multi-span structures. Most were arch or 1-2W types. Single-span greenhouses tended to use pipe foundations, while most multi-span greenhouses used concrete foundations, and most foundations were buried deeply (50-59 cm). Nearly all greenhouses (95.3%) used plastic film as a covering material as opposed to glass; the same percentage used groundwater for irrigation. These results could potentially be utilized as basic data to develop a standard model for greenhouse design in Korea.

Keywords greenhouse structure, greenhouse covering material, greenhouse foundation, survey data, greenhouse irrigation

INTRODUCTION

The total area dedicated to greenhouse cultivation of vegetables in Korea occupied about 47,924 ha at the end of 2012 (MAFRA, 2013). This area is expected to increase gradually in the future following the Korean government's announcement of a development plan to build a research center on reclaimed land in Saemangeum, an estuarine tidal flat on the Yellow Sea coast. The construction of a seawall in April 2006, after a long fight between the government and environmental activists, allowed the land to be reclaimed. Since the establishment of the seawall, Saemangeum has been scheduled for conversion into either agricultural or industrial land (Choi et. al., 2013). As such, the planned research center is slated to incorporate a high-tech greenhouse and large-scale agricultural complex that covers a large percentage of the reclaimed land. Additionally, a greenhouse is currently under development at other reclaimed land at Hwang (MIFAFF, 2010).

When building a greenhouse on reclaimed land, land settlement, structures and potentially dangerous exposure to strong wind should be considered, because reclaimed land (due to its proximity to the coast) is softer than general farmland. In considering the characteristics of reclaimed land, there are many greenhouse construction requirements with regard to maintenance, repair, reinforcement, structural design criteria, and deformation.

Many studies have investigated the actual conditions of various greenhouses. Suh and Yoon conducted a survey analysis that collected data on heating method, gutter connection, capacity of heating systems, type of crop cultivation, dimensions, etc. (Suh and Yoon, 1997). Studies have also

been conducted on the actual state of the structures and environmental control facilities for tomato greenhouses in the Chungnam region (Nam and Kim, 2009), as well as on the utilization of irrigation systems for greenhouse farming (Lee et al., 1998). However, to date, no one has yet conducted a nationwide study of greenhouses in Korea.

OBJECTIVE

This study's aim is to provide basic data for the development of greenhouse maintenance guidelines. This was accomplished by conducting a questionnaire survey on the structure, covering materials, irrigation, and foundations of greenhouses in Korea.

METHODOLOGY

A questionnaire survey was conducted to investigate the actual state of greenhouses in Korea. Regional investigations were conducted in eight of Korea's nine provinces (Jeju was excluded). Most greenhouses were selected and investigated via Agricultural Research Services, while large, complex greenhouses were examined using satellite images. Greenhouses on a total of 148 farms were investigated (Fig. 1): 63 for Gyeongsangnam-do (Gyeongnam); 15 for Jeollanam-do (Chonam); 11 for Kangwon-do (Kangwon); 10 for Gyeonggi-do (Gyeonggi), 10 for Chugcheongbuk-do (Chungbuk), 10 for Chugcheongnam-do (Chungnam); 10 for Jeollabuk-do (Chonbuk); and 19 for Gyeongsangbuk-do (Gyeongbuk). The following aspects of each greenhouse were investigated: type, specifications, foundation type, irrigation type, and depth of foundation. Additionally, questionnaire surveys were conducted during farm visits from July to September 2013. Survey data were analyzed using SPPS (IBM SPSS Statistics Version 20).

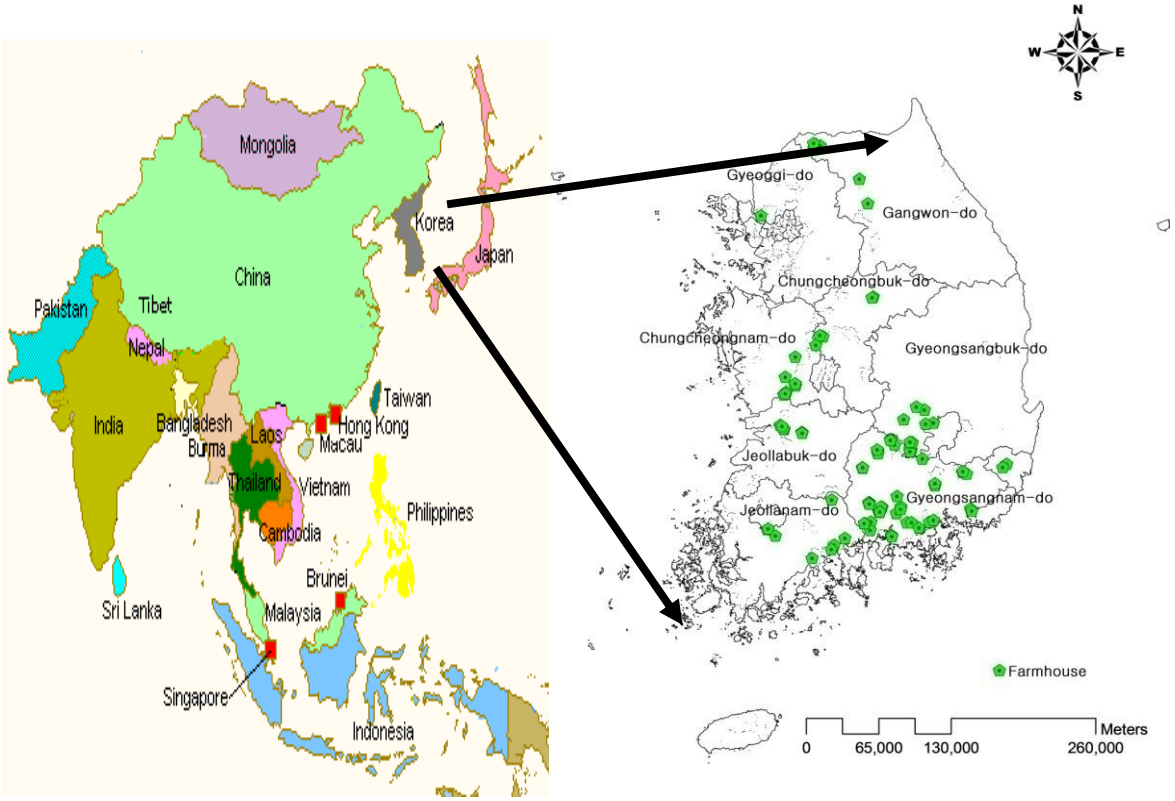

Fig. 1 Locations of surveyed greenhouses

RESULTS AND DISCUSSION

Of the 148 farms investigated, a total of 148 valid questionnaires were received. Data collected from these questionnaires were analyzed using SPSS.

Greenhouse Types

Figure 2 shows the number and percentage of single- vs. multi-span greenhouses 72 (48.6%) for the former, and 76 (51.4%) for the latter. Table 1 shows the types of greenhouses investigated. According to the survey, 51 (34.5%) for arch greenhouses, 56 (37.8%) were 1-2W, 11 (7.4%) were Venlo, 6 (4.1%) were Miryang, 3 (2.0%) were three-quarter, 1 (0.7%) were even-span, 2 (1.4%) were peach-type, 6 (4.1%) were long-span, and 12 (8.1%) were other, respectively ("Other" includes greenhouses without columns, Mammoth-type greenhouses, and so on). The most common type of greenhouse was the 1-2W, which, along with the arch type, accounted for 72.3% of all surveyed greenhouses. The even-span type was the least common, accounting for less than 1.0% of all surveyed greenhouses. From this result, it is clear that most farms in Korea prefer the arch style for single-span greenhouses, and the 1-2W style for multi-span greenhouses.

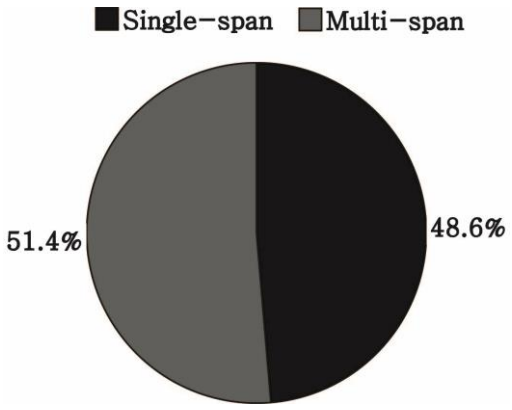

Fig. 2 Percentage of single- vs. multi-span greenhouses

Table 1 Types of greenhouse by region

Classifications	Type									Total
	Arch type	1-2W type	Venlo type	Miryang type	3/4 roof type	Even type	Peach type	Long span type	Others	
Gyeongnam	21	22	5	6	3	1	0	2	3	63
Chonnam	0	6	4	0	0	0	0	3	2	15
Kangwon	2	2	0	0	0	0	2	0	5	11
Gyeonggi	0	8	2	0	0	0	0	0	0	10
Chungbuk	5	5	0	0	0	0	0	0	0	10
Chungnam	7	2	0	0	0	0	0	0	1	10
Chonbuk	4	6	0	0	0	0	0	0	0	10
Gyeongbuk	12	5	0	0	0	0	0	1	1	19
Total	51	56	11	6	3	1	2	6	12	148
(%)	(34.5)	(37.8)	(7.4)	(4.1)	(2.0)	(0.7)	(1.4)	(4.1)	(8.1)	(100.0)

Foundation Type

Table 2 shows the results for foundation type according to region. The survey found that 47 (31.8%) greenhouses used pipes, 25 (16.9%) used strip foundation of pipe (surface), 8 (5.4%) used strip foundation of pipe (inner), 16 (10.8%) used concrete (trapezium), 24 (16.2%) used concrete

(columns), 18 (12.2%) used concrete (THP), and 10 (6.8%) used other foundation types. Further, it is apparent that foundation type is related to greenhouse type: single-span greenhouses tended to feature any of the three types of pipe foundation (pipes burial, strip foundation of pipe (surface), and strip foundation of pipes (inner)), while multi-span greenhouses tended to feature any of the three types of concrete foundation (trapezium, columns, and THP). Of the 148 greenhouses investigated, nearly half used one of the three types of pipe foundation (commonly associated with single-span greenhouses); this is likely because single-span greenhouses are easier and cheaper to install than multi-span greenhouses. After pipes burial (31.8%), the most popular type of non-pipe foundation was concrete (columns) at 16.2%. Regional characteristics that could account for these preferences were not observed.

Depth of foundation results by region shows in Table 3. The survey found that 6 (4.1%) foundations were buried < 30 cm, 17 (11.5%) were 30-39 cm, 27 (18.2%) were 40-49 cm, 53 (35.8%) were 50–59 cm, 33 (22.3%) were >= 60 cm and 12 (8.1%) for other, respectively. Of the greenhouses surveyed, most (53, or 35.8%) had foundations buried 50-59 cm deep. For most greenhouses in general, which factor a wind speed of up to 30m/s into their design, 30 cm is a sufficient foundation depth. However, regions with wind speeds of at least 40 m/s have been reported to require a foundation embedment depth of at least 50 cm (Kim and Nam, 1995). Thus, greenhouse designs must take regional wind speeds into account. In all cases, the embedment depth was determined to be appropriate to regional wind speed, except those foundations buried 30 cm deep or less in Gyeongnam and Chonnam provinces.

Table 2 Types of foundation by region

Classifications	Types of foundation							Total
	Pipes burial	Strip of pipe (surface)	Strip of pipes (inner)	Concrete (trapezium)	Concrete (columns)	Concrete (THP)	Others	
Gyeongnam	27	6	0	7	9	8	6	63
Chonnam	1	0	2	2	6	2	2	15
Kangwon	6	1	0	1	1	2	0	11
Gyeonggi	1	4	1	0	3	1	0	10
Chungbuk	1	4	2	0	2	1	0	10
Chungnam	2	5	0	0	0	1	2	10
Chonbuk	0	1	3	2	2	2	0	10
Gyeongbuk	9	4	0	4	1	1	0	19
Total	47	25	8	16	24	18	10	148
(%)	(31.8)	(16.9)	(5.4)	(10.8)	(16.2)	(12.2)	(6.8)	(100.0)

Table 3 Depth of foundation embedment by region

Classifications	Embedment depth						Total
	<30cm	30~39cm	40~49cm	50~59cm	>=60cm	Others	
Gyeongnam	5	4	17	18	12	7	63
Chonnam	1	2	1	3	6	2	15
Kangwon	0	2	2	3	4	0	11
Gyeonggi	0	1	1	4	4	0	10
Chungbuk	0	1	0	4	2	3	10
Chungnam	0	1	2	5	2	0	10
Chonbuk	0	0	4	5	1	0	10
Gyeongbuk	0	6	0	11	2	0	19
Total	6	17	27	53	33	12	148
(%)	(4.1)	(11.5)	(18.2)	(35.8)	(22.3)	(8.1)	(100.0)

Covering Material

Table 4 shows the greenhouse covering material by region. The survey found that 141 (95.3%)

greenhouses used plastic film, while 7 (4.7%) used glass. Regardless of region, most installed plastic film, likely because it is far less expensive.

Results regarding greenhouse irrigation type are given in Table 5. The survey found that 141 (95.3%) used groundwater, 5 (3.4%) used stratum water, 1 (0.7%) used a combination of ground and stratum water, 1 (0.7%) used other types of irrigation, and 0 (0.0%) used rainwater. It is interesting to note that the overwhelming majority of greenhouses used groundwater, while none used rainwater.

Table 4 Greenhouse covering material by region

Classifications	Covering materal		Total
	Plastic film	Glass	
Gyeongnam	59	4	63
Chonnam	13	2	15
Kangwon	11	0	11
Gyeonggi	9	1	10
Chungbuk	10	0	10
Chungnam	10	0	10
Chonbuk	10	0	10
Gyeongbuk	19	0	19
Total	141	7	148
(%)	(95.3)	(4.7)	(100.0)

Table 5 Greenhouse irrigation type by region

Classifications	Irrigation water					Total
	Ground water	Rian water	Stratum water	Ground+Stratum water	Othres	
Gyeongnam	61	0	2	0	0	63
Chonnam	15	0	0	0	0	15
Kangwon	8	0	3	0	0	11
Gyeonggi	9	0	0	0	1	10
Chungbuk	10	0	0	0	0	10
Chungnam	10	0	0	0	0	10
Chonbuk	10	0	0	0	0	10
Gyeongbuk	18	0	0	1	0	19
Total	141	0	5	1	1	148
(%)	(95.3)	(0.0)	(3.4)	(0.7)	(0.7)	(100.0)

CONCLUSION

This study presented the results of a detailed questionnaire survey on the types of form, foundation embedment depth, covering material, and irrigation water of greenhouses in Korea. The results obtained can be summarized as follows:

1) Of the 148 farms surveyed, 48.6% used single-span greenhouses, and 51.45% used multi-span.
2) Most greenhouses were the arch or 1-2W type.
3) Most greenhouse foundation types were pipe foundations for single-span greenhouses and concrete foundations for multi-span greenhouses.
4) Embedment depth indicated that 88.4% of surveyed foundations were buried deeper than 40cm.
5) Most of the greenhouses examined (95.3%) used plastic film (PE) as a covering material.
6) Most of the greenhouses (95.3%) irrigated using groundwater.

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Research article

Verification of Drainage with Biotope Placed on Artificial Floating Island Using *Phragmites australis* (Cav.) Trin. for Water Purification

MASATO KIMURA*
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan
Email: masa-k@obihiro.ac.jp

OSAMU TSUJI
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

TOSHIMI MUNEOKA
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

HIROTO OTE
Hokkaido Government, Hokkaido, Japan

RYUICHIRO NAKAGAWA
Hokkaido Government, Hokkaido, Japan

YURI YAMAZAKI
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

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Abstract Soil and fertilizer runoff from farms causes water pollution and eutrophication of streams and lakes. A method for cleaning the polluted water is the placement of artificial floating islands of *Phragmites* on the water surface. *Phragmites* plants absorb nitrogen dissolved in water, promoting lateral bud sprouting. The grown lateral buds are then cut, removing the pollutants. This purification method is suitable for cold regions such as Hokkaido. We devised a drainage system with a biotope to apply this purification method with a minimum of effort. The advantage of the method is that because the artificial floating islands of *Phragmites* after sprouting are placed in the drainage and streams, no *Phragmites* nursery is required. In this study, to determine the effectiveness of this method, *Phragmites* plants after sprouting or in the 3rd year of growth were placed in a stream in Biei Town, Hokkaido and were observed every 2 weeks. In the 3rd-year *Phragmites* plants, terrestrial stems were lying on the ground after a month, but new lateral buds grew from the culms of fallen stems and underground stems. Thus, if *Phragmites* grown to a certain stage could be used, this method is a promising approach to improve water quality. In contrast, in *Phragmites* plants after sprouting, the number of terrestrial stems continued to decrease during the observation period because no underground stems were established by running water and accreted sand. The method should therefore be investigated in other locations, such as wide river channels and stable streams.

Keywords *Phragmites australis* (Cav.) Trin., water purification, drainage system with a biotope, stream

INTRODUCTION

Hokkaido is located in the northernmost part of Japan and covers the largest area in the country. Land-extensive farming is practiced in this area. This area plays an important role as a food supply area for Japan. However, because large amounts of fertilizer are applied to fields to increase yield, soil and fertilizer run off into streams, lakes, and marshes after heavy rains. This runoff is the most

important cause of water contamination and eutrophication. Given that pollutant loads from farm fields have recently been increasing, it is desirable to investigate methods and strategies for improving and maintaining the water quality of streams, lakes, and marshes.

One method to clean eutrophic water is to place the artificial floating islands of *Phragmites australis* (Cav.) Trin. on the water surface (Uchida et al., 1999, 2001; Uchida and Maruyama, 1998; Tazaki, 2002). This method comprises three steps. First, the artificial floating islands are placed on the surface of a eutrophic water body, and lateral buds sprouting from nods of *Phragmites* plants are inserted into a drain mat. Second, after the lateral buds have sprouted, they grow and absorb large amounts of nitrogen, including nitrogen from the eutrophic water. Finally, in autumn, *Phragmites* plants that have accumulated nitrogen are cut and removed from the system. The artificial floating islands are left in place during the winter and reused in the following year. To investigate the suitability of this method in cold regions such as Hokkaido, Tsuji et al. (2009) and Kimura et al. (2012) placed the artificial floating islands on a biotope developed adjacent to Lake Mizusawa in Hokkaido and observed the growth of *Phragmites*. The result was that the plants grew steadily and were not damaged by cold during the following winter. Thus, water quality in cold regions could be improved by this method.

In this study, to assess a drainage system with a biotope using the artificial floating islands of *Phragmites*, we placed two *Phragmites* at different growth stages in a stream flowing into Lake Mizusawa, Hokkaido and observed their growth. The two kinds of *Phragmites* are following: one is the *Phragmites* in the 1st year after sprouting, another is the *Phragmites* in the 3rd year which the rhizome fully grew in the site for breeding of *Phragmites*. If the 1st-year *Phragmites* grew successfully, water quality improvement employing the drainage system with a biotope using the artificial floating islands of *Phragmites* would be more efficient, given that a *Phragmites* nursery would not be required.

METHODOLOGY

Study Area

Fig. 1 Study area: Mizusawa Lake in Biei-cho, Hokkaido

The study area was in one of the three streams flowing into Lake Mizusawa (Fig. 1), a manmade lake at latitude 43 ° 32 ′ 14 ″N and longitude 142 ° 29 ′ 41 ″ E located in Biei-cho in central Hokkaido. The terrain around these streams and lake is hilly and comprises mostly farm fields (293.8×10^{-2} km^2) for wheat, corn and so on. During the growing season, large amounts of fertilizer are applied to the fields to increase yield. According to Ote et al. (2011), the amount of nitrogen applied to these hillside farms was 1.8×10^3 kg in 2010. However, following heavy rains, soil and fertilizer flowed into the streams and lake from the water catchment area. In 2010, the rate of nitrogen runoff from farms was 11% (Ote et al., 2011). Thus, the nitrogen loading of the three streams and Lake Mizusawa was estimated to be 2.0×10^3 kg. This is the most important cause of eutrophication of the streams and lake and leads to the occurrence of blue-green algae and

unpleasant smells. To preserve the local environment, it is desirable to improve water quality.

Growth of *Phragmites*

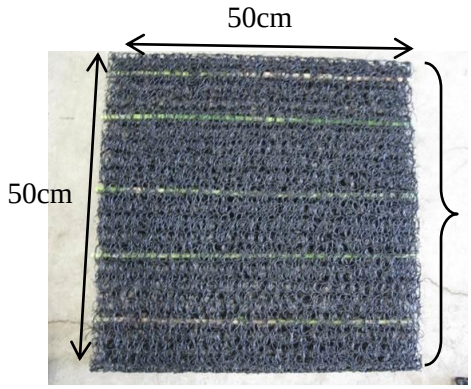

Fig. 2 Drain mat used to make artificial floating islands for water purification

As shown in Fig. 2, the artificial floating island of *Phragmites* comprises a drain mat (Yoshiharakakou Co., Ltd.) and five stems of *Phragmites*. First, the mats are placed on the water surface until sprouting from the stems occurs. The mats are then transferred to the nursery and left there until the rhizome grows to maturity.

Fig. 3 Aerial parts and rhizomes of 1st-year *Phragmites*

Fig. 4 Aerial parts and rhizomes of 3rd-year *Phragmites*

Figures 3 and 4 show the artificial floating islands of 1st- and 3rd-year *Phragmites*, respectively. The 1st-year *Phragmites* was placed on the water surface of Lake Mizusawa on July 5, 2012 and then sprouted. The 3rd-year *Phragmites* was transferred to the nursery on September 25, 2010. These *Phragmites* overwintered and the rhizomes grew as shown in Fig. 3.

These two types of the artificial floating island of *Phragmites* were transferred to the stream shown in Fig. 1 on August 24, 2012. Figure 5 shows the arrangement of the artificial floating

islands of *Phragmites*. As shown in this figure, the artificial floating islands of 1st- and 3rd-year *Phragmites* were placed alternately in the stream at 1-m intervals from upstream to downstream. Moreover, each one was placed on the stream at 0.3 m intervals from water route and sandbank. All the artificial floating islands of *Phragmites* were rooted to the bottom of the stream by anchor pins. The number of stems was recorded every 2 weeks.

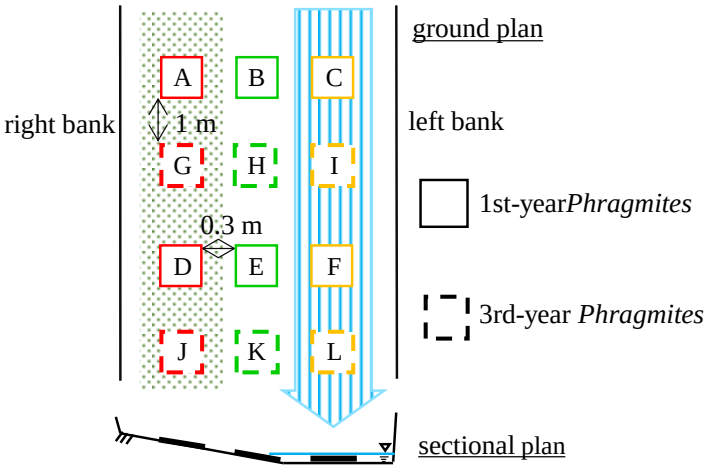

Fig. 5 Arrangement of artificial floating islands of 1st- and 3rd-year *Phragmites* in a stream

RESULTS

Figures 6 and 7 show changes in the number of stems of 3rd- and 1st-year *Phragmites*, respectively. Each line in the two plots represents the total number of stems of the artificial floating islands of *Phragmites* that lay in the same column, namely "A" and "D," "B" and "E," "G" and "J," or "H" and "K." However, because the artificial floating island of *Phragmites*, "F" and "L" were flown to downstream, the line, "C" or "I" represents the number of stem of the artificial floating island of *Phragmites*, respectively.

As shown in Fig. 8, in most 3rd-year *Phragmites*, the aerial part fell over and was partly covered with sand on September 5, 2012. However, the number of stems increased steadily in all positions, especially from September 5 to September 28, as shown in Fig. 6. The number of stems in "A" and "D," "B" and "E," and "C" was 104, 105, and 64, respectively, on September 28. The reason for the increase in the number of stems was the extension of lateral buds from stems that fell over and the appearance of sprouts from the rhizomes, as shown in Fig. 8. After September 28, because the air temperature dropped, the increase in the number of stems ceased.

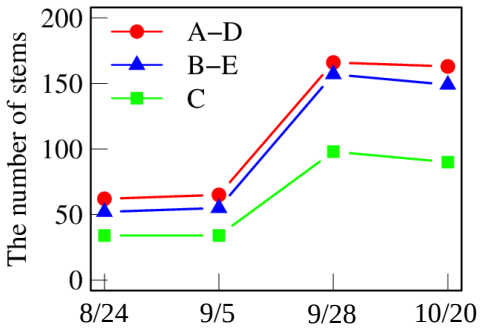

Fig. 6 Change in the number of stems of 3rd-year *Phragmites* placed in a stream

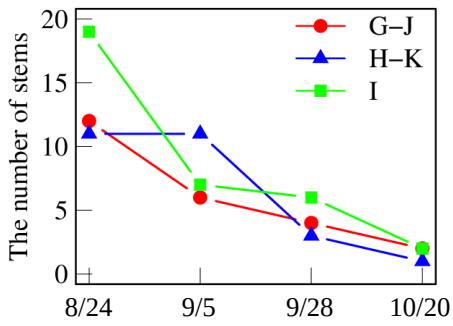

Fig. 7 Change in the number of stems of 1st-year *Phragmites* placed in the stream

In contrast, as shown in Fig. 7, the number of stems of 1st-year *Phragmites* continued to decrease in all positions. Two months after placing in the stream, the number of stems decreased to 10 in "G" and "J," 10 in "H" and "K," and 17 in "I" because of the deposition of sand on *Phragmites*.

Fig. 8 Growth of *Phragmites* in the 1st year, September 28, 2012

DISCUSSION

Growth of 1st- and 3rd-year *Phragmites* showed opposite behavior. The number of stems of 3rd-year *Phragmites* increased steadily (Fig. 6), whereas those of 1st-year *Phragmites* decreased (Fig. 7). We speculate that this difference was associated with rooting of the rhizome.

The aerial parts of 3rd-year *Phragmites* fell over in 2 weeks after placement in the stream, and sediment deposits were observed. However, because the rhizomes had matured in the nursery (Fig. 4), they rooted readily in the stream bed after transplanting. Therefore, the lateral buds and sprouts could be stretched and appeared because of capable of absorbing nourishment from the rhizome (Fig. 8).This result suggests that if artificial floating islands of 3rd-year *Phragmites* are used, the drainage system with a biotope can be used practically. However, because in this case a breeding nursery of *Phragmites* will be required, land must be reclaimed.

As shown in Fig. 3, rhizomes did not grow to maturity. We infer accordingly that they could not root in the stream bottom. In addition, sediment deposition was observed. From this result, we infer that *Phragmites* does not readily grow in streams with irregular flow such as the stream studied here. However, given an environment in which the rhizome can grow to maturity, we suggest that 1st-year *Phragmites* can grow steadily in a stream. In future, for practical application of a drainage system with a biotope, we plan to determine the locations to which 1st-year *Phragmites* can adapt and observe *Phragmites* growth again.

CONCLUSION

The drainage system with a biotope using the artificial floating islands of *Phragmites* was suggested to improve the water quality of Lake Mizusawa, Biei-cho, which has been made eutrophic by an influx of soil and fertilizer from surrounding farm fields. To investigate the practicality of this method, 1st- and 3rd-year *Phragmites* were placed in a stream flowing into Lake Mizusawa and their growth was recorded at 2-week intervals. The 3rd-year *Phragmites* grew steadily because nutrients could be absorbed via rhizomes rooted in the stream bed. Thus, if the artificial floating islands of 3rd-year *Phragmites* are used, a drainage system with a biotope can be used practically. In contrast, the number of stems of 1st-year *Phragmites* decreased because their rhizomes did not mature and nutrients required for growth could not be absorbed. However, in an environment where rhizomes can mature, we suggest that 1st-year *Phragmites* may also be used in a drainage system with a biotope. It is necessary to investigate the growth of 1st-year *Phragmites* transplanted to floating islands.

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Research article

Effect of Groundwater Level on Cadmium Uptake and Yield of Soybean from Cadmium Polluted Soils

MD. ZAHIDUL HAQUE*
United Graduate School of Agricultural Sciences (UGAS), Iwate University, Iwate, Japan
Email: mzhaque81@gmail.com

CHOICHI SASAKI
Faculty of Agriculture and Life Science, Hirosaki University, Hirosaki, Japan

NOBUHIKO MATSUYAMA
Faculty of Agriculture and Life Science, Hirosaki University, Aomori, Japan

TAKEYUKI ANNAKA
Faculty of Agriculture, Yamagata University, Yamagata, Japan

KIICHI SASAKI
United Graduate School of Agricultural Sciences (UGAS), Iwate University, Iwate, Japan

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Abstract Human uptake of Cadmium (Cd), a toxic heavy metal that can cause kidney damage and other physiological disorder, takes place mainly through food. In some regions of Japan, the agricultural land area was polluted with heavy metals especially Cd. Management of groundwater level can be effective method for minimization of Cd uptake in plant at large scale agricultural field. In this greenhouse experiment, we investigated two constant groundwater levels; 10cm groundwater level model (M-10) and 40cm groundwater level model (M-40) on Cd uptake in Soybean plant in Cd polluted soils (3.39 $mgkg^{-1}$). The redox potential of soil layer was measured from seed sowing to harvesting. Thickness of gravel layer, non-polluted soil and polluted soil was 14, 15 and 25cm respectively. The soil layer (10-40 cm) of M-10 was always measured in reduction condition and 0-40cm layer of M-40 was always in oxidation condition. Cd concentration of Soybean seed was significantly lower in M-10 (0.92 ± 0.1 $mgkg^{-1}$) than that of M-40 (1.31 ± 0.2 $mgkg^{-1}$). Cd concentration of stem was also found significantly lower in M-10 (0.82 ± 0.1 $mgkg^{-1}$) than that of M-40 (2.34 ± 0.2 $mgkg^{-1}$). In the other hand, main stem height of soybean plant of M-40 (111.6 ± 5.1 cm) was significantly higher than that of M-10 (100.5 ± 3.6 cm). In vegetative stage (first 50 days) the SPAD-value was observed higher in M-40 (about 46.5) and lower in M-10 (about 31.3). Branch number, 100 seed weight and seed yield were also found significantly higher in M-40 than those of M-10. The result revealed that, reduction condition was effective for minimization of Cd uptake in Soybean plant whereas, oxidation condition was favorable for seed yield.

Keywords cadmium uptake, groundwater level, soybean yield

INTRODUCTION

Many heavy metals exist in minute amounts in natural agricultural soil. However, when the amounts exceed a certain level due to pollutants brought from outside, soil contamination occurs and agricultural products become contaminated. It poses a great threat to the environment and human health worldwide due to the persistent nature and toxicity and their accumulation in the food chain (Bahadir et al., 2007). Cadmium (Cd) is one of the most harmful heavy metals. Cd occurs naturally in the environment in its inorganic form as a result of volcanic emissions and weathering of rocks. In addition, mining, modern industrialization, use of fertilizers and Cd

containing sludge has led to an increase in levels of Cd in soil, water and living organisms.

Several possible methods of minimizing absorption of Cd by agricultural crops exist mainly, 1) soil dressing, 2) water management (paddy field), 3) chemical cleaning of soil, 4) phytoremediation and 5) use of different varieties and rootstock. But most of these methods are very costly and time consuming for effective minimization. A further possible mechanism of reducing Cd uptake may be via groundwater level management. In this process, oxidation-reduction condition of root zone is controlled by groundwater level management. In oxidation conditions, Cd converts to a soluble form that plants can uptake easily. On the other hand, in reduction condition it is not in available form for the plant. Furthermore, the environmental and economic benefits of groundwater level management through reduced pollution and increased yields have been documented (Kalita and Kanwar, 1993).

Soybean is one of the world's major and fastest expanding crops in terms of both calorie and protein intake. Soybean is an important traditional food, and sauce and paste made from it are intrinsic to the Japanese gastronomic culture. A large-scale domestic agricultural products survey in Japan showed that the Cd concentration in one-sixth of the total soybean seed exceeded 0.2 $mgkg^{-1}$, the international allowable limit proposed by the Codex Alimentarius Commission (MAFF, 2002). It is important to increase the yield as well as minimization of Cd from polluted soils. The objective of the study is to find out the relation between groundwater level on cadmium uptake and soybean yield. This will help to minimize uptake of heavy metals especially Cd in different grain crops.

MATERIALS AND METHODS

Soil Properties

In this study, we used polluted soil from Eastern Japan (we kept the place secret) and non-polluted soil from Kanagi, Aomori prefecture. The physio-chemical properties of the soil were measured by the standard methods of analysis (Table 1).

Table 1 Soil physical and chemical properties (Paul et al., 2011)

Sample	Density (g/cm^3)	Soil texture	MgO *	Na_2O *	CaO *	K_2O *	Total Fe *	Cd *	T-N (%)	T-P (%)	OM (%)
Polluted soil	2.453	L	496	114	2909	311	2820	3.39	0.40	0.15	4.80
Non Polluted soil	2.592	SCL	918	84	1530	159	5683	0.14	0.44	0.60	6.00
Gravel	2.680		147	18	539	58	600	0.13	0.00	0.35	0.05

Note: Soil texture is based on the International Soil Society classification. L: Loamy; SCL: Silty Clay loam. $mgkg^{-1}$ dry soil. Gravel diameter size 2-4mm*

Experimental Design

The experiment was conducted in green house of Hirosaki University at Aomori prefecture. Two plastic containers were used for two groundwater level treatment model; 10 cm (M-10) and 40 cm (M-40). Both containers were filled with gravel (small stone; 14 cm), non-polluted soil (15 cm) and polluted soil (25 cm) shown in Fig. 1. After filling soil, Eh sensor and temperature sensor was set up for every soil layer of the box.

Cultivation Procedure

Before seeding the groundwater level was set up as 10cm for both treatments for 12 hours to moist the soil. After 12 hours of seeding the groundwater level was set up as per treatment. Groundwater level was maintained by Mariotte bottle arrangement which supplied water through the bottom of the plastic box. Fertilizer (N,P,K) was applied as per recommended rate for Rhyho variety. The seeds of soybean plants (*Glycine max* (L.) Merr.cv. Rhyho) were sown in four points of every box at 4 seeds/point at 1st June 2012 about 2-3 cm depth of soil. After emergence, (15 days after sowing) soybean plants were thinned to 2/point as well as 8/box. In every 4 days, 2000 ml water was supplied in every box that is equal to rainfall of 4 days in this location. The plants were periodically sprayed with insecticide.

Measurement Procedure

Oxidation-reduction potential (ORP) of each soil layer was measured by electrometrically using ORP meter (Central Science Co., Ltd., model UC-203) from vegetative to harvesting period. Leaf color measured using chlorophyll meter (Minolta Co. Model SPAD-502) from first trifoliate leaf stage. The latest fully developed trifoliate leaf was used for leaf color measurement. Cd content of seed, stem and root was measured after harvesting and drying and then extracted by nitric acid and sulfuric acid and the analyzed by Atomic Absorption Spectrophotometer (Model Z-2000, Hitachi Corporation) as described by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF ,1979).

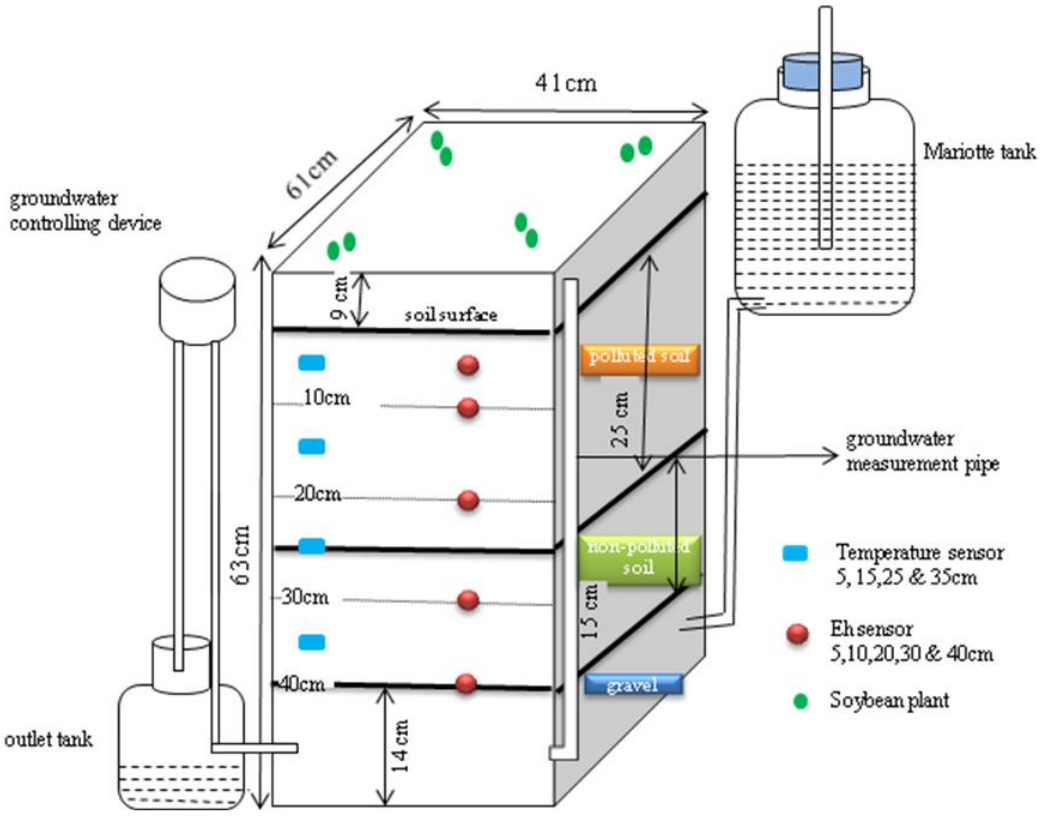

Fig. 1 Layout of plastic container used in the experiment

RESULTS AND DISCUSSION

Redox Potential of Soil Layers (Eh)

Oxidation-Reduction potential (ORP) condition is known as a redox potential (Eh). The Eh value in soil more than 300 mV is an indicator of oxidation condition and lower than 300 mV indicates

reduction condition (Iimura, 1981). Eh value varied in two boxes for two different groundwater level treatment model. Eh value is less than 300 mV in below 10cm (from soil surface) in M-10 for saturated condition by groundwater level (Fig. 2). In case of M-40, soil layer (0-40 cm) was remaining in oxidation condition at about 700 mV Eh value (Fig. 3).

So it means reduction condition remained through crop life time of M-10 and oxidation condition occurred in M-40. The proportion of soluble cadmium decreases abruptly with the decrease of soil redox potential (Iimura, 1981). So, Cd dissolute decreased comparatively in M-10 than M-40.

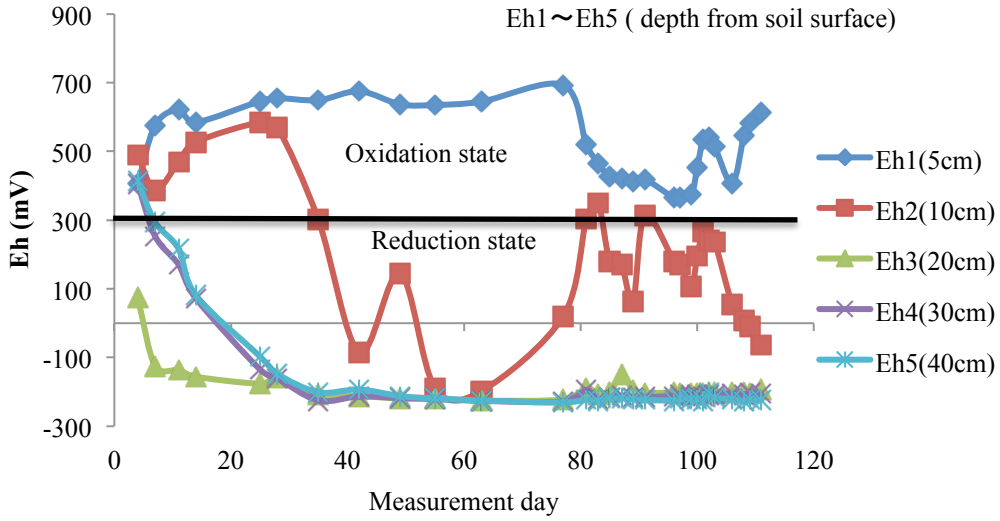

Fig. 2 Eh value of soil layer of 10 cm groundwater level model

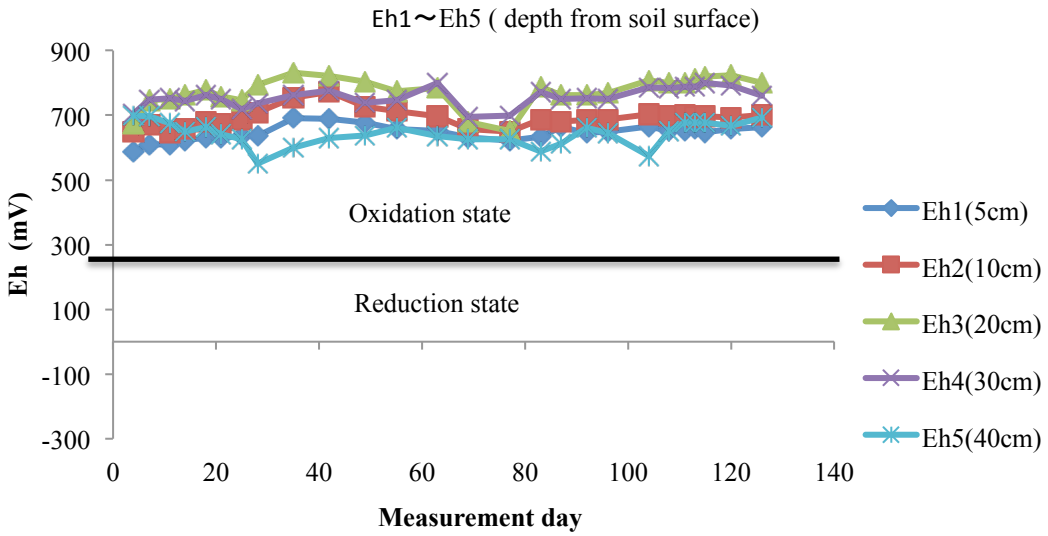

Fig. 3 Eh value of soil layer of 40 cm groundwater level model

Cadmium Concentration in Soybean Plants

Cadmium concentration of different parts of soybean plant was found higher in M-40 than M-10. Accumulation of Cd uptake in seed by soybean plants was significantly higher in case of M-40 (1.31 ± 0.2 mgkg^{-1}) than M-10 (0.92 ± 0.1 mgkg^{-1}) at $p > 0.001$ (Fig. 4).

The reason was that, reduction condition occurred in M-10 for high groundwater level and M-40 caused oxidation condition for lower groundwater level. Absorption and accumulation of Cd

was significantly reduced with diminishing Eh in reductive conditions formed by flooding rice fields (Lu et al., 1992). Previous researchers showed that in soil reduction condition, the presence of sulphate ion can be converted to sulfide ion which reacts with Cd and produce relatively insoluble Cadmium sulfide (Ono et al., 2003). This mechanism supported to the M-10 and that is why the Cd uptake by soybean plants was low. Cd uptake of soybean stem was also significantly higher in M-40 than M-10 (Fig. 5). The average value of stem Cd uptake of M-40 and M-10 were (2.34 ± 0.2 mgkg^{-1}) and (0.82 ± 0.1 mgkg^{-1}) respectively. It showed that Cd concentration was found 3 times higher in M-40 than M-10. This result revealed that redox condition of soil influences the uptake of Cd and mobilization in soybean plants. Accumulation of Cd in roots of soybean plants in M-10 (5.92 ± 0.5 mgkg^{-1}) had no significant difference ($p = 0.875$) with that of M-40 (6.08 ± 2.2 mgkg^{-1}) shown in Fig. 6. The Cd Concentration of soybean root was found higher than that of stem and seed.

These happened due to the apparent free space (it represents the intercellular space freely accessible to ions) of plant tissues were much greater in root tissue than other parts. In M-10, the Cd concentration of root found about 7 times higher than that of stem and seed; and in M-40, the Cd concentration of root found about 3 times higher than that of stem and seed. Accumulation of Cd in root was the highest of the total Cd in the plant (Jarvis and Jones, 1976; Cui et al., 2008) which is similar to this study.

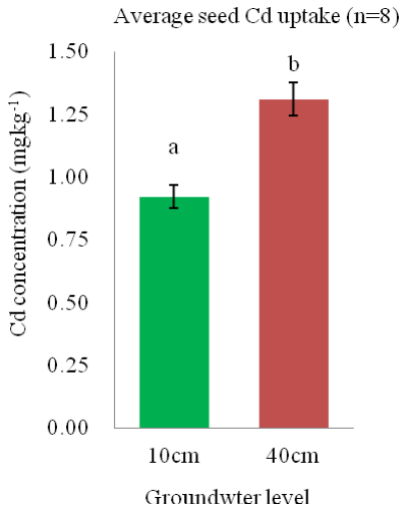

Fig. 4 Cadmium concentration in seed

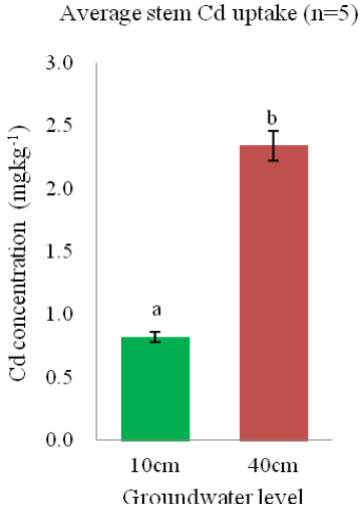

Fig. 5 Cadmium concentration in stem

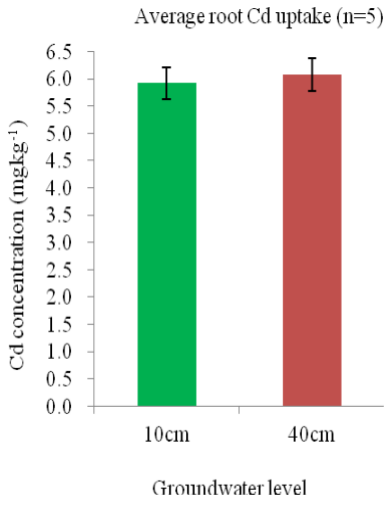

Fig.6 Cadmium concentration in root

Soybean Yield Components

The average main stem height in M-40 (111.6 ± 5.1 cm) was significantly higher than that of M-10 (100.5 ± 3.6 cm) shown in Table 2. This result might be occurred due to high groundwater level effect in M-10. In M-10, first 30 days vegetative growth was affected due to the excessive moisture in the soil which was clearly visible in our experiment. Vegetative growth was inhibited following shorter stem (Garside et al., 1992a) by the effect of excess moisture which is supported to the present study. Main stem length was found higher with lower water table treatment (Shimada et al., 1995) which is also similar to M-40.

There was a significant difference happened in case of soybean yield due to groundwater level difference in this experiment. The average good seed weight per plant was 68.1 ± 14.6 g in M-40 and 35.1 ± 13.8 g, in M-10 (Table 2). Effects of groundwater level on soybean yield have been observed by many researchers. The optimum groundwater table depth for getting highest yield little differs from researcher to researcher; that is 20cm (Abe et al., 1981), 40cm (Ishibashi et al., 1982), 30cm to 50cm (Ueno, 1979) and 50cm (Shibata and Endo, 1976). In our experiment, we found higher yield in M-40 than M-10. Another researches showed that, soybean gave high yield when

grown at around 10cm depth groundwater table in the saturated soil culture at the semi-arid tropical region in Australia (Garside et al., 1992b). In Japan most of the high yielded records were obtained on a drained paddy field where the water table maintained at around 50cm from the soil surface.

100 seed weight and branch number plant^{-1} were found significantly higher for M-40 than M-10. In M-40, 100 seed weight was found 39.2 ± 2.8 g and in M-10 was 30.9 ±1.7 g (Table 2). It showed that Soybean seed of M-40 was good quality. In M-40 showed higher (7.9 ± 0.9) branch number than M-10 (5.9 ± 1.6) (Table 2). Previous researches found 100 seed yield decreases for excess moisture in the soil at the ripening stage (Sugimoto et al., 2000). The average stem diameter and seed/pod were not significantly differing in M-40 to M-10.

Table 2 Soybean yield components of two different groundwater levels

	Yield components					
Ground-water level	Stem height (cm)*	Stem diameter (mm)	Branch No.*	Seed/pod	100 seed wt.[1] (g)*	Good seed wt.[1] (g)*
10 cm	100.5 ± 3.6	7.3 ± 1.9	5.9 ± 1.6	1.94 ± 0.08	30.9 ± 1.7	35.1 ± 13.8
40 cm	111.6 ± 5.1	9.0 ± 0.9	7.9 ± 0.9	1.92 ± 0.05	39.2 ± 2.8	68.1 ± 14.6

*Note: * means significant according to ANOVA at 0.05 level. 1- Seed weight at 15% moisture. In all cases (n=8)*

Leaf Color (SPAD-Value)

The chlorophyll meter provides a simple, quick, portable and non-destructive method for estimating leaf chlorophyll content. In SPAD-value graph (Fig. 7) we can clearly see the effect of groundwater level on leaf chlorophyll content. In M-10 model, vegetative state (up to 50 days after sowing) the leaf chlorophyll content was lower (about 31.3) whereas M-40 model was higher (about 46.5). It happened in M-10 model because of high groundwater level. But, after 50 days it recovers by its adaptation quality. We know that, soybean plant has high range of adaptation quality in high range of groundwater level. In previous study, (Garside et al., 1992a) reported that temporary chlorosis occurred when saturated-soil-water culture was given to soybean plants and that caused a reduction of leaf nitrogen content (Sugimoto et al., 1988). So it is clear that groundwater level has an effect on leaf chlorophyll content. Chlorophyll contents decrease as well as decrease seed yield in lower water table treatment (Shimada et al., 1995) that is similar to this experiment.

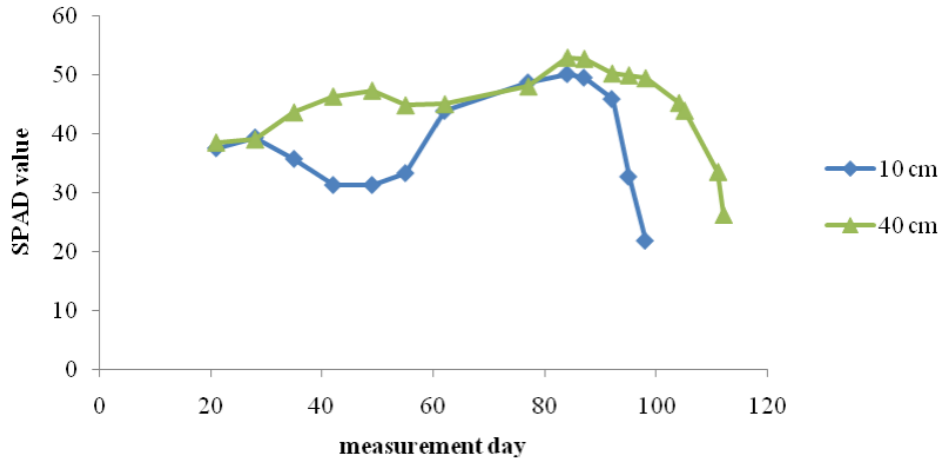

Fig. 7 SPAD value of soybean plant grown in two different groundwater level

CONCLUSION

The accumulation of Cd in soybean plants was significantly affected by groundwater level. Groundwater level controls the oxidation-reduction status of soil, consequently uptake of heavy

metal by soybean plants. In oxidation condition of soil, plants uptake more Cd than reduction condition of soil due to increase of soluble Cd. This result suggested that low groundwater level as well as oxidation condition promotes Cd uptake in soybean plant and high groundwater level as well as reduction condition inhibits the Cd uptake. This could be an effective technique for minimization of Cd and other heavy metal uptake from polluted soils and it can be improve the management of polluted soil in many countries. We need more research about various ranges of groundwater level and various stage of soybean to develop agronomic management of soybean cultivation in polluted soil.

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Research article

Investigation Species of Edible Tree and Medicinal Plants in Faculty of Agriculture, Khon Kaen University

NARUEMOL KAEWJAMPA*
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
Email: knarue@kku.ac.th

TIPA JANDAKORN
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

JARUNYA RATTANAWAN
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

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Abstract The objective of this study was conducted in Faculty of Agriculture, Khon Kaen University to investigate species, distribution and the usage of edible trees and medicinal plants and finding some guideline to conservation. The Check-List Survey was used and only more than 1.30 m. of height and more than 4.5 cm. of diameter at breast height (DBH) in both of edible trees and medicinal trees were identified and documented. The results showed that the overall of tree species in Faculty of Agriculture, Khon Kaen University are 57 species and 28 families which divided to edible trees 37 species, 12 families and medicinal trees are 55 species, 26 families. In addition to edible part are fruit, leaf, flower, inside-outside seed, bark and root. While, whole plant part including bark, leaf, root, stem, fruit, flower, seed, resin, petiole and polen was used as medicinal trees useful in the treatment of illness and any diseases. The distribution of edible trees and medicinal trees in this area varied primary forest (dry dipterocarp forest and dry evergreen forest) which no reforestration and conservation. This study indicated that edible trees and medicinal trees are valuable resources for improving not only food and nutritional security of households living but also ecological system. Therefore, more concern and should be enhanced the *In-situ* conservation of edible trees and medicinal trees through the participation of both faculty members and university members.

Keywords species and distribution, edible tree, medicinal tree

INTRODUCTION

Forest is an important productive sector effects on the natural balance of the remaining ecosystems and improvement of rural livelihoods (Sarma et. al., 2010; Mbuvi and Boon, 2009). Many plant species in the forest provide an adequate level of nutrition, food security, medicine and also income generation. In recently, the natural resources of Thailand are decreasing in every year, especially forest areas. Rapid environment changes typically cause extinctions, the species diversity of Thailand forest ecosystems. The forest ecosystems should be maintained by managing the sustainable management strategies to protect forest biodiversity which understood on the structure, ecology, behavior and reproduction of dominant tree species (Lamotte et al., 1998).

In the university area; Khon Kaen University, Thailand, the trend of the forest land was decreased causes of university development strategies with lack of good maintain and management, which affect to change of forest structure and endanger plant species in primary forest; dry diperocarpt forest and dry evergreen forest. Biodiversity survey in many natural locations such as national park, conservation forest and community forest area were done by many researchers but biodiversity or species inventory of university area is still neglected.

Therefore, the aim of the present study was to surveying the plant diversity, distribution and valuable of plant in Faculty of Agriculture, Khon Kaen Universtiy, Thailand, used the forest

inventory technique to highlights the edible and medicinal tree resource and finding some conservation guideline would be help to maintain ecosystem, food security and also reduced global warming.

METHODOLOGY

Study area: The study site is located in Faculty of Agriculture, Khon Kaen University, Khon kaen province Thailand at zone 48N with UTM coordinate 18° 22′ 78.4″ N and 26° 75′ 04″ E, 224 meters above sea level. The area encompasses 0.08 km^2 with two dominant forest type which are dry dipterocarp forest (DDF) and dryevergreen forest (Fig. 1).

Tree measurements: Trees with a diameter –dbh-at breast height more than 4.5 cm. and more than 1.3 m of height were numbered, recorded its name and measured or estimated its height. The diameter at breast height (DBH) was measured using a girth measurement. Height was measured using a hypsometer when necessary. Photographs of trees habitat were taken and geographic coordinates of each tree was also recorded using global positioning system (GPS; Garmin 60 CX).

The identification of trees was done through various available resources including World Wide Web and expertise available in the department of national parks, wildlife and plant conservation.

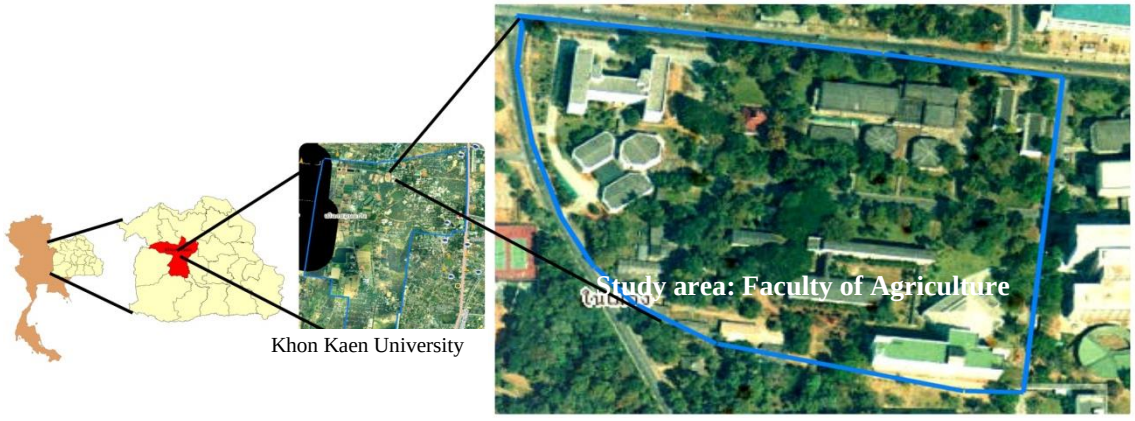

Fig. 1 Study area of faculty of agriculture, Khon Kaen University, Thailand

RESULTS AND DISCUSSION

The Forest inventory at Faculty of Agriculture, Khon Kaen University, Thailand indicated that, two types of forest; dry dipterocarp forest (DDF) and dry evergreen forest (DEF) was found. In over all, 57 species belonging to 28 families were observed and arranged according to their forest type consisting of 51 species were found in DDF, whereas DEF has only six specific species (Table 1). The value products that are used from these tree species include fruits, seeds, leaf, bark, flower, root, stem, petiole, pollen and resins. Of these, 37 species belong to 12 families of edible trees were reported to be used as vegetables, food and fruits. Fruits and leaves are the most dominant parts as found from 23 and 12 species, respectively (Fig. 2). While, the medicinal trees were found 55 species belong to 26 families which have potential value for traditional medicine of northeast region of Thailand. Bark is the most dominant part use as a medicine source which found in 34 species. Leaves placed in the second positions next to the bark that have been reduced by 25 species (Fig. 2).

Besides, the distribution of all trees both edible and medicinal tree on study area varied primary forest (dry diperocarp forest). South area of Faculty of Agriculture is rich in medicinal trees such as *Shorea obtuse*, *Xylia xylocarpa*, *Morinda coreia* and *Pterocarpus indicus*. While, tree which identified as both edible and medicine tree was found around Faculty of Agriculture (Fig. 3).

Table 1 Valuable tree species at the Faculty of Agriculture, Khon Kaen University, Thailand

Species	Family	Local uses*	Edible	Medicinal
DDF				
Lannea coromandelica (Houtt.) Merr.	ANACARDIACEAE	Lf, Br, Rt	Yes	Yes
Mangifere indica L.	ANACARDIACEAE	Lf, Fl, Fr	Yes	Yes
Buchanania latifolia Roxb.	ANACARDIACEAE	Fr, Sd, Rt, La	Yes	Yes
Melodorum fruticosum Lour.	ANNONACEAE	Lf, Sd, Rt, Po	No	Yes
Canaga odorata Hook. f & Th	ANNONACEAE	Lf, Fl, S	No	Yes
Polylthia longifolia (Benth.) Hook.f.	ANNONACEAE	Lf	No	Yes
Wrightia arborea (Dennst.) Mabb.	APOCYNACEAE	Lf, Br, Fl, Rt, La, S	Yes	Yes
Alstonia scholaris (L.) R.Br.	APOCYNACEAE	Lf, Br, Rt,	No	Yes
Millingtonia hortensis L.f.	BIGNONIACEAE	Lf, Fl, Rt	Yes	Yes
Oroxylum indicum (L.) Kurz	BIGNONIACEAE	Lf, Br, Fl, Fr, Rt, Sd	Yes	Yes
Crescentia cujete L.	BIGNONIACEAE	Br, Fr	No	Yes
Bombax anceps Pierre var*anceps* .	BOMBACACEAE	Br, Fl	Yes	No
Canarium subulatum Guillaumin	BURSERACEAE	Fr, S	Yes	Yes
Terminalia cacappa L.	COMBRETACEAE	Lf, Br, Fr, Sd	Yes	Yes
Shorea obtusa Wall.ex Blume	DIPTEROCAPACEAE	Br, Fl	Yes	Yes
Dipterocarpus intricatus Dyer	DIPTEROCAPACEAE	Br, Fl, La	Yes	Yes
Phyllanthus acidus (L.) Skeels	EUPHORBIACEAE	Lf, Fr, Rt	Yes	Yes
Calophyllum inophyllun L.	GUTTIFCEAE	Fl, Sd, La	No	Yes
Mammea harmandii Kosterm.	GUTTIFERAE	Fl, Fr	Yes	Yes
Tectona grandis L.f.	LABIATAE	Lf, S	No	Yes
Caesalpinia coriaria Willd.	LEGUMINOSAE	Fr	No	Yes
Albisia lebbeck (L.) Benth.	LEGUMINOSAE–MIMOSOIDEAE	Lf, Br, Sd	Yes	Yes
Senna siamea (Lam.) Irwin & Barneby	LEGUMINOSAE-CAESALPINIOIDEAE	Lf, Br, Fl, Rt	Yes	Yes
Tamarindus indica L.	LEGUMINOSAE-CAESALPINIOIDEAE	Lf, Br, Fl, Fr	Yes	Yes
Sindora siamensis Teijsm. & Miq.	LEGUMINOSAE-CAESALPINIOIDEAE	Br, Sd	Yes	Yes
Afzelia xylocarpa (Kurz) Craib	LEGUMINOSAE-CAESALPINIOIDEAE	Br, Sd, S	Yes	Yes
Bauhinia purpurea L.	LEGUMINOSAE-CAESALPINIOIDEAE	Lf, Br, Fl, Rt, Sd	Yes	Yes
Cassia bakeriana Craib	LEGUMINOSAE-CAESALPINIOIDEAE	Br, Fr, Sd	Yes	Yes
Cassia spectabilis DC.	LEGUMINOSAE-CAESALPINIOIDEAE	Rt	No	Yes
Cassia fistula L.	LEGUMINOSAE-CAESALPINIOIDEAE	Lf, Br, Fl, Fr, Rt, Sd	No	Yes
Phyllocarpus septentrionalis Donn.Sm	LEGUMINOSAE-CAESALPINIOIDEAE	Lf, Br, Rt	No	Yes
Erythrina variegate L.	LEGUMINOSAE-PAPILIONOIDEAE	Lf, Br, Rt	Yes	Yes
Pterocarpus indicus Willd.	LEGUMINOSAE-PAPILIONOIDEAE	Lf, Br, Sd, S, La	No	Yes
Pterocarpus macrocarpus Kurz	LEGUMINOSAE-PAPILIONOIDEAE	Lf, Br, S	No	Yes
Lagerstroemia floribunda Jack	LYTHRACEAE	Br, Rt	No	Yes
Lagerstroemia speciosa (L.) Pers.	LYTHRACEAE	Lf, Br	No	Yes
Lagerstrooemia loudonii Teijsm. & Binn	LYTHRACEAE	Br	No	Yes
Michelia champaca L.	MAGNOLIACAE	Lf, Br, Fl, Rt, S	No	Yes
Swietenia macrophylla King	MELIACEAE	Lf, Br, Fl	Yes	Yes
Azadirachtaindica A.Juss. var. *siamensis* Valeton	MELIACEAE	Lf, Br, Fl, Fr, Rt, Pt,	Yes	Yes
Xylia xylocarpa (Roxb.) Taub. Var.	MIMOSACEAE	Br, Fl, Sd	Yes	Yes
Artocarpus heterophyllus Lam.	MORACEAE	Lf, Fr, Sd, S, La	Yes	Yes
.Roxb *Artocarpus lacucha*	MORACEAE	Br, Rt, S	Yes	Yes
Averrhoa carambola L.	OXALIDACEAE	Lf, Br, Fr, Rt,	Yes	Yes
Morinda coreia Ham.	RUBIACEAE	Lf, Fr, S	Yes	Yes
Haldina cordifolai (Roxb.) Ridsdale	RUBIACEAE	Lf, Rt	No	Yes
Schleichere oleosa (Lour.) Oken	SAPINDACEAE	Br, Fr	Yes	Yes
Lepisanthes rubiginosa (Roxb.) Leenh.	SAPINDACEAE	Fr, Rt, Sd	Yes	Yes
Litchi chinensin Somn	SAPINDACEAE	Fr, Sd	Yes	Yes
Mimusops elengi L.	SAPOTACEAE	Lf, Br, Fl, Fr, Rt	Yes	Yes
Strychnos nux-vomica L.	STRYCHNACEAE	Br, Fr, Sd	Yes	Yes
DEF				
Peltophorum pterocarpum (DC.) Backer ex K.Heyne	CAESALPINIACEAE	Lf, Br	Yes	Yes
Dipterocarpus alatus Roxb.	DIPTEROCAPACEAE	Lf	No	Yes
Dipterocarpus tuberculatus Roxb.	DIPTEROCAPACEAE	Lf, Rt, S	No	Yes
Sandoricum koetjape (Burm.f.) Merr.	MELIACEAE	Lf, Br, Fr, Rt	Yes	Yes
Syzygium cumini (L.) Skeels	MYRTACEAE	Br, Fr	Yes	Yes
Grewia eriocarpa Juss.	TILIACEAE	Fr	Yes	No

** Br: Bark, Fl: Flower, Fr: Fruit, La: Latex, Lf: Leaf, Po: Pollen, Pt: Petiole, Rt: Root and tuber, S: Stem, Sd: Seed*

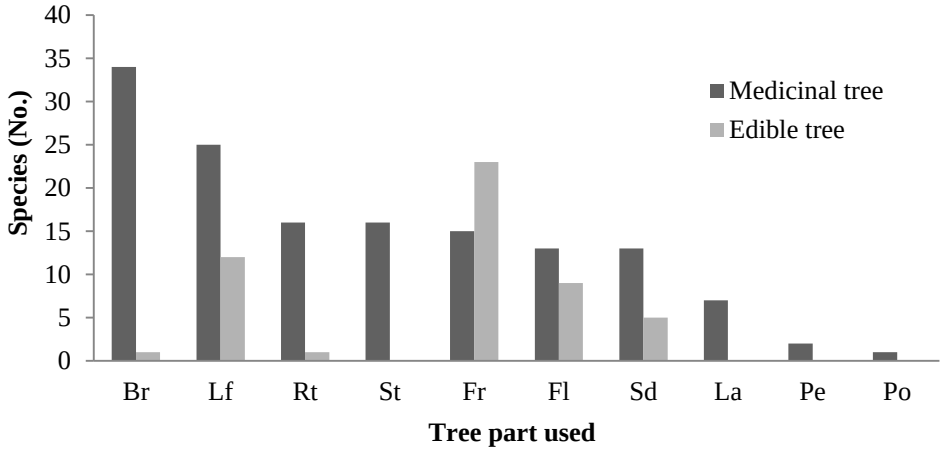

Fig. 2 Different usable parts of trees of Faculty of Agriculture, Khon Kaen University, Thailand

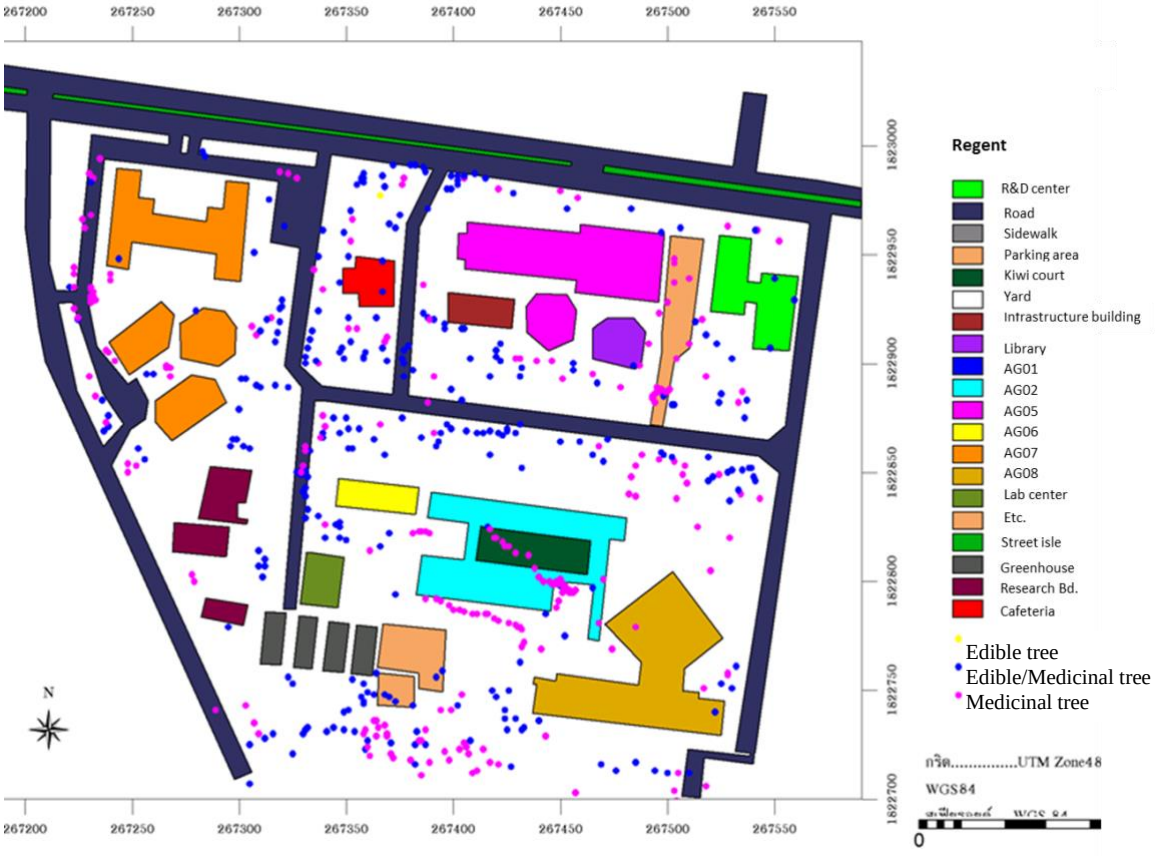

Fig. 3 The distribution of edible and medicinal tree in Faculty of Agriculture, Khon Kaen University, Thailand

In northeast region, the DDF and the DEF are two important of the forest dynamics in dry forests of Thailand with very different ecosystems while existing in similar climatic regions (Lamotte et. al., 1998). Chantaranothai and Sanoamuang (2002) found that the most of forest type in Khon Kaen Univesity area is DDF which fertile and high biodiversity and more than 80% of DDF tree species was found in this area. However, deforestation for various reasons was occurred during the university development system. Therefore, many valuable trees were extinct from this area. Similar to this study which forest inventory and identify trees in Faculty of Agriculture, Khon Kaen Universtiy was divided into DDF and DEF. The DDF species was higher than DEF species

because the DDF as being strongly adapted phonologically, physiologically and physiologically, to the dry season burns which so characterize their environment (Stoott, 1988).

This study revealed also a need for controlling forest conservation in the university area in term of plant biodiversity. Planting of edible and medicinal tree should be promoted, strongly encouraged and supported from the university and faculty board and also all of university and faculty members.

CONCLUSION

The natural ecosystems hold important plant genetic resources of edible and medicinal tree in Faculty of Agriculture, Khon Kaen University, which if good management can serve a sustainable resources include food security, good environmental would be reduced as climate change. An urgent need, for conservation of both edible and medicinal tree species in two forest types, their habitats, indigenous knowledge and member's participatory, is required.

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Research article

Effect of Fallow on Arbuscular Mycorrhizal Fungi under Maize Cropping System

PHAKPEN POOMIPAN*
Faculty of Science and Technology, Thammasat University, Phatum Thani, Thailand
Email: phakpen@tu.ac.th

Received 29 October 2013 Accepted 1 March 2014 (*Corresponding Author)

Abstract Fallow had been reported to decline survival of arbuscular mycorrhizal (AM) spore. The effect of fallow on AM fungi under maize cropping system was studied to evaluate its effects on population of AM fungal species in community, AM spore abundance and biodiversity. A pot experiment was undertaken over two successive crops. The crop 1 was maize planting in all pots for establishing a uniform AM community. The crop 2 was maize planting and leaving pot soil as fallow. At the start of the crop 2, the AM community in both topsoil and subsoil was composed of 12 species in 4 genera: 2 species of *Acaulospora*, 2 species of *Entrophosphora*, 7 species of *Glomus* and 1 species of *Scutellospora*. *Glomus* spp. was dominant in the AM community. The spore number of *Glomus* spp. was approximately 70 and 80% of total spore number in topsoil and subsoil, respectively. The AM fungal biodiversity was 0.94 and 0.91 in topsoil and subsoil, respectively. The AM spore abundance was approximately 1,600±50 and 750±70 spores per 100 g^{-1} of soil in topsoil and subsoil, respectively. There were no differences in AM spore abundance of all pots at the start of crop 2. The data collection at the end of the crop 2 was compared to those at the start of crop 2. The results showed that the population of AM fungal species in community, the AM spore abundance and the biodiversity in the topsoil and the subsoil did not change under maize crop. However, fallow treatment had decreased the AM spore abundance by 30% and 15% in the topsoil and the subsoil, respectively. It had greatly affected on spore number of *Glomus* spp. than the other AM genera. The AM fungal biodiversity had declined to 0.79 and 0.84 in topsoil and subsoil, respectively. Therefore, the results indicated that fallow had negative effect on AM fungal community in soil. This may be due to life cycle of AM fungi was disturbed by absence their host during fallow period.

Keywords arbuscular mycorrhizal fungi, fallow, *Glomus*, maize

INTRODUCTION

Symbiotic associations between arbuscular mycorrhizal (AM) fungi and plant roots are widespread in the natural environment. It can provide a range of benefits to the host plant, soil and environment. These include improved plant nutrient uptake (Marschner and Dell, 1994), enhanced tolerance to drought and salinity of soil (Schreiner et al., 2007), enhanced tolerance to nematode and soil-borne pathogen (Sylvia and Chellemi, 2001), and provided stability of soil structure (Bedini et al., 2009). In addition, AM extraradical hyphae itself and glomalin producing by the hyphae have highly correlated with soil organic carbon and are the major component of soil microbial biomass (Rillig et al., 2002). These are resulted in an important role of AM fungi in regulating carbon fluxes between the biosphere and the atmosphere under climate change.

Thailand is an important country in South-east Asia for production of feed maize The global feed maize demand will increase to around 50% by 2020 (FAO, 2004). This is due to increasing in consumption of red and white meats which has resulted in an increase in demand for maize as feed for livestock. Otherwise, some maize is also used industrially for ethanol production. Therefore, research on enhancing sustainable maize yield in Thailand has value more broadly in the world. However, the production of maize for animal feedstock occurs in more than 40 provinces in 3 regions: Central, North-eastern and Northern parts of Thailand. Nakhonratchasima is particularly

important production areas. On Pak Chong soil, high phosphorus (P) fixation presently limits productivity, as many farmers do not have the finances to apply rates of fertilizer required for optimum yields. Application of AM fungi might become a solution in this case. Due to AM fungi are well known to enhance the P nutrition of crop plants and the importance of AM fungi for maize production in Thailand has been discussed (Na Bhadalung et al., 2005).

However, the fallow period is another farming practice which can reduce the population of AM propagules in soil. Harinikumar and Bangyaraj (1988) and Thompson (1994) observed that low AM abundance following fallow led to reduced AM sporulation and colonization in the succeeding crop. Otherwise, fallow is widely practiced in central Thailand and maize farmers also are interested in crop rotation. Therefore, the pot experiment was undertaken to evaluate effects of fallow on populations of indigenous AM fungi.

OBJECTIVE

To evaluate effect of fallow on population of AM fungal species composition in community, AM spore abundance and biodiversity in topsoil and subsoil of Pak Chong soil series under maize cropping system in Thailand.

METHODOLOGY

An experiment was conducted in large pots using a completely randomised design with 4 replications. The treatments were maize-maize crop and maize-fallow crop. The experiment was conducted with two successive crops. In crop 1, all pots were planted with maize for 4 months. In crop 2, maize and fallow were randomly applied to 4 replicate pots for 4 months.

The soil sample belonged to the Pak Chong soil series: clay-loam, kaolinitic, isohyperthermic, Typic Paleustults (Soil survey staff, 1998). The soil was collected from field plots (14˚ 38´ N, 101˚ 19´ E; elevation 354 m above sea level; National Corn and Sorghum Research Centre, Amphur Pak Chong, Nakhonratchasima Province, Thailand) at two depths, 0-15 cm topsoil and 15-30 cm subsoil. The soil was allowed to air-dry before use. The soil chemical properties are given in Table 1. The soils before potting were analysed for soil pH, soil organic matter (OM) (Kjeldahl method), available P (Bray II method) and exchangeable K, Ca and Mg (1N NH_4OAc) using Black et al. (1965)

Table 1 Chemical property of the topsoil and subsoil

Soil layer	pH	OM	P	K	Ca	Mg
	1:1 soil:H_2O	%	mg kg^{-1}			
Topsoil	7.0±0.0	2.6±0.1	9.8±0.6	160.0±9.1	1920.0±32.7	225.0±5.0
Subsoil	6.8±0.0	1.1±0.1	4.8±0.5	57.5±4.8	1620.0±75.7	175.0±5.0

The soil was crushed with a mallet, roots removed by hand and then well mixed. Five kg coarse washed river sand was placed into glazed clay pots (32 cm diameter at the top, 25 cm diameter at the bottom and 30 cm in height) to enhance drainage and then 7 kg subsoil and 13 kg topsoil were placed, respectively. Each pot had a single, central drainage hole sealed to a U-shaped drainage pipe (1.3 cm diameter) with the free end of the pipe being slightly below the bottom of the pot to reduce air flow into the pot base. Between the crop cycles, the pots were left uncovered and exposed to rain. Vertical plastic sheets (1.5 m high) were placed between pots to prevent rain-splash.

In crop 1, all pots were cropped with maize (*Zea mays* L., cv. Suwan 4452), one plant per pot. This was undertaken to produce a uniform population of AM fungi under maize for testing agronomic practices. N fertilizer was applied to the soil surface three times at the rate of 2.52 g of urea per pot (on a soil weight basis, equivalent to 112 kg N ha^{-1}), split equally at D7, D30 and D45. This rate was used to ensure normal grain production since the volume per plant of the pot soil was about a half of that in the field. P fertilizer was applied as triple super phosphate (TSP) at the rate of 1.67 g TSP per pot (equivalent to 32.75 kg P ha^{-1}) by surface banding on one side of the plant at

D14. Zinc (Zn) fertilizer was applied at the rate of 0.38 g of Zn per pot as Zn-EDTA (equivalent to 30.4 kg Zn ha^{-1}) at D40. Other nutrients were not applied as previous studies had shown that maize growth in this soil is limited by N, P and Zn (Suwanarit et al., 1992).

In crop 2, maize and fallow were randomly applied to 4 replicate pots. In the cases with crops, one plant was grown per pot. Fertilizer was applied for maize cropping; N fertilizer was applied two times at the rate of 1.12 g urea per pot (equivalent to 50 kg N ha^{-1}), equally split at D14 and D40. P fertilizer was applied as TSP at the rate of 1.12 g TSP per pot (equivalent to 21.8 kg P ha^{-1}) by surface banding on one side of the plant at D14 and Zn fertilizer was applied at the rate of 0.38 g of Zn per pot (equivalent to 30.4 kg Zn ha^{-1}) at D40. The rates of fertilizers, lower than that used in the preliminary crop but adequate for maize, was used to minimize the difference in nutrient status in soil among cultural practices. Fallow treatment was not fertilised but was exposed to the weather (infrequent rain events).

Soil samples were collected from 0-15 cm depth for topsoil and 15-20 cm depth for subsoil using a 2 cm diameter steel auger, 3 augers per pot at the start and the end of crop 2. The holes were filled with sterilized Pak Chong soils that were stored at room temperature in laboratory before use. The soil samples were left to air-dry for determining the AM spore number. The AM spores were sorted into group using morphology and size traits and identified using the INVAM species guide and manual for AM fungal identification (Schenck and Perez, 1988). The AM spore of each species was counted for calculating AM biodiversity using the Shannon-Wiener index (Pielou, 1975).

All data were checked for normal distribution by Levene's test. ANOVA was used to determine effect of treatments. Duncan's Multiple Range Test at $P<0.05$ was used for post hoc testing.

RESULTS

The AM community in the soil (both topsoil and subsoil) at the start of crop 2 was composed of 12 species in 4 genera: 2 species of *Acaulospora*, 2 species of *Entrophosphora*, 7 species of *Glomus* and 1 species of *Scutellospora*. The 12 AM species were described in Table 2.

At the start of crop 2, there were 1,637 and 765 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. *Glomus* spp. was dominant. It contributed 73 and 78% of the total spore number in topsoil and subsoil, respectively. The spore of *Glomus* spp. was 1199 and 599 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Acaulospora* spp. was 232 and 94 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Entrophospora* spp. was 188 and 56 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Scutellospora* sp. was 18 and 16 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The AM spore number of each species was shown in Fig. 1. The AM fungal biodiversity was 0.94 and 0.91 in topsoil and subsoil, respectively.

At the end of crop 2, total spore number, spore number of each AM species and AM biodiversity did not change under maize-maize treatment. However, under maize-fallow treatment, there were 1166 and 649 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. Comparing to the AM spore number at the start of crop 2, fallow treatment had decreased the AM spore abundance by 30% and 15% in the topsoil and the subsoil, respectively. It had greatly affected on spore number of *Glomus* spp. than the other AM genera. The spore of *Glomus* spp. was 838 and 455 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Acaulospora* spp. was 190 and 140 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Entrophospora* spp. was 128 and 42 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The spore of *Scutellospora* sp. was 10 and 12 AM fungal spores 100 g^{-1} in topsoil and subsoil, respectively. The AM spore number of each species was shown in Fig. 2. The AM fungal biodiversity of fallow treatment had declined to 0.79 and 0.84 in topsoil and subsoil, respectively.

Table 2 Characteristics of the AM fungal taxa and their codes

AM fungal species	Spore characteristic
Acaulospora sp. 1 (A1)	Globose shape, 76-112.5 µm, white to orange, soporiferous succule (80-100 µm). Two layers of spore wall, combined thickness 3-7 µm.
Acaulospora sp. 2 (A2)	Globose shape, 100-120 µm, yellow to orange, soporiferous succule (120-130 µm) and fine spines present. Two layers of spore wall, combined thickness 5-10 µm.
Entrophospora sp. 1(E1)	Globose shape, 165-208 µm, orange to dark orange, hyaline outer layer, and hyaline, subglobose soporiferous succule (180-220 µm) and thick spines present. Three layers of spore wall, combined thickness 15-17.5 µm.
Entrophospora sp. 2 (E2)	Globose shape, 60-80 µm, hyaline colour and hyaline subglobose soporiferous succule (60-80 µm). Three layers of spore wall, combined thickness 2-5 µm.
Glomus sp. 1 (G1)	Globose shape, 80-125 µm, white to cream colour, single chlamydospore. Four to five layers of spore wall, combined thickness 4-8 µm.
Glomus sp. 2 (G2)	Sporocarp formation without peridium (200-1500 x 200-2000 µm), globose (80-140 µm) or subglobose (80-96 x 120-140 µm) chlamydospore, pale yellow, forms spores in roots. Three layers of spore wall, combined thickness 4-5 µm.
Glomus sp. 3 (G3)	Sporocarp formation without peridium (200-800 x 200-1000 µm), globose (60-120 µm) or subglobose (40-112 x 96-188 µm) chlamydospore, pale yellow to yellow, forms spores in roots. Two to three layers of spore wall, combined thickness 2-4 µm.
Glomus sp. 4 (G4)	Sporocarp formation without peridium (1-3 mm), globose (80-100 µm) or subglobose (60-100 x 90-140 µm) chlamydospore, yellow to orange. Three layers of spore wall, combined thickness 3-5 µm.
Glomus sp. 5 (G5)	Sporocarp without peridium, globose chlamydospore (92-112 µm), white to cream. Three spore wall layers, thickness 5-7 µm.
Glomus sp. 6 (G6)	Globose shape, 120-300 µm, pale yellow to yellow, recurved septum. Two layers of spore wall, combined thickness 4-5 µm.
Glomus sp. 7 (G7)	Globose shape, 124-180, yellow-brown to dark orange-brown, shiny and containing lipid content. Two to three layers of spore wall, combined thickness 4-8 µm.
Scutellospora sp. (S)	Globose shape, 168-240 µm, white to cream colour, germination shield and auxillary cell. Five layers of spore wall, combined thickness 4-8 µm.

DISCUSSION

Fallow had negative effect on AM fungal community in soil. The fallow period reduced AM fungal spore number in the topsoil by 30%. This finding is consistent with many previous studies that have been undertaken in containers or in the field. For example, in a field study (acid to neutral soil), one year of bare fallow treatment reduced AM density by 80% compared to continuous maize cropping for a range of sites in Iowa, USA (Troeh and Loynachan, 2003). Similarly, in Queensland, Australia, viable propagules of AM fungi declined in cracking clay soils during long periods of fallow (>1 year) resulting in poor root colonization and symbiotic effectiveness of subsequent crops (Thompson, 1994). Ryan and Angus (2003) observed that the percentage of root colonization of wheat and field pea grown after fallow in South-Eastern Australia was depressed compared to those grown after clover, an AM host. One possibility for the reduction in AM populations during fallow is a lack of host plant roots necessary to maintain viable spore populations for the next crop. Alternatively, Pattinson and McGee (1997) suggested that periodic wetting and drying of soil during fallow periods in agro-ecosystems may also reduce AM fungal propagules during the fallow period.

Fallow affected the proportion of species composition in the AM community. *Glomus* species were more sensitive to fallow than species of other AM genera. In general, AM fungal spores are able to germinate in the absence of host-derived signals. Soil edaphic conditions, such as moisture, temperature and pH, promote AM spores from a dormant to a germinating state, but they are unable

to complete their life cycle without their host plant (Giovannetti, 2000). Therefore, the decrease in spore number in fallow treatment was likely the consequence of failure to establish a functional symbiosis with a host plant during the fallow period.

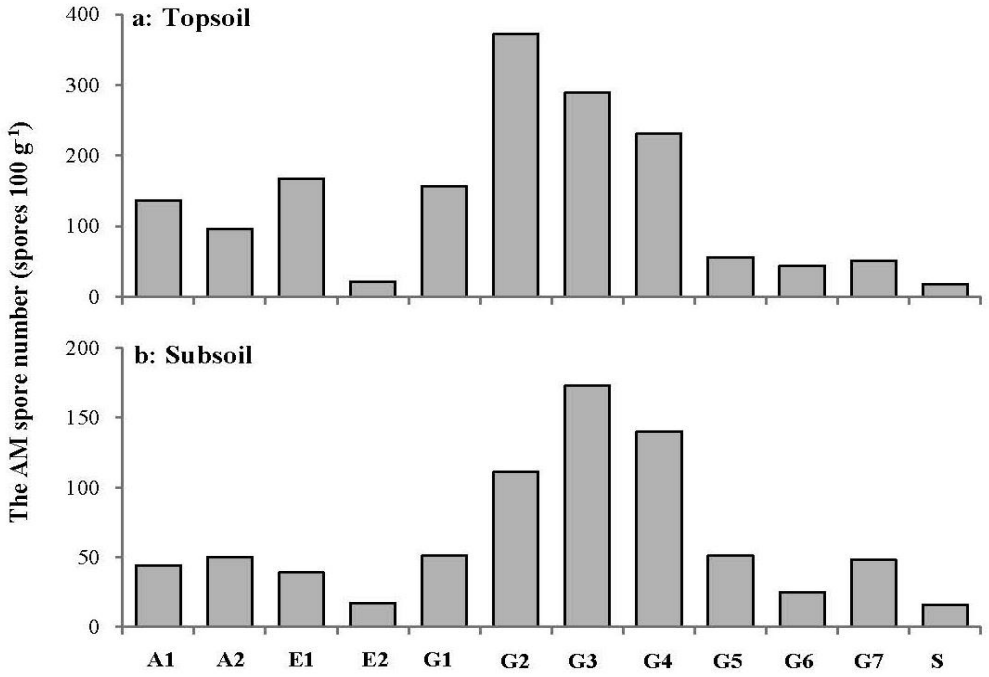

Fig. 1 AM spore number in topsoil (a) and topsoil (b) at start of crop 2

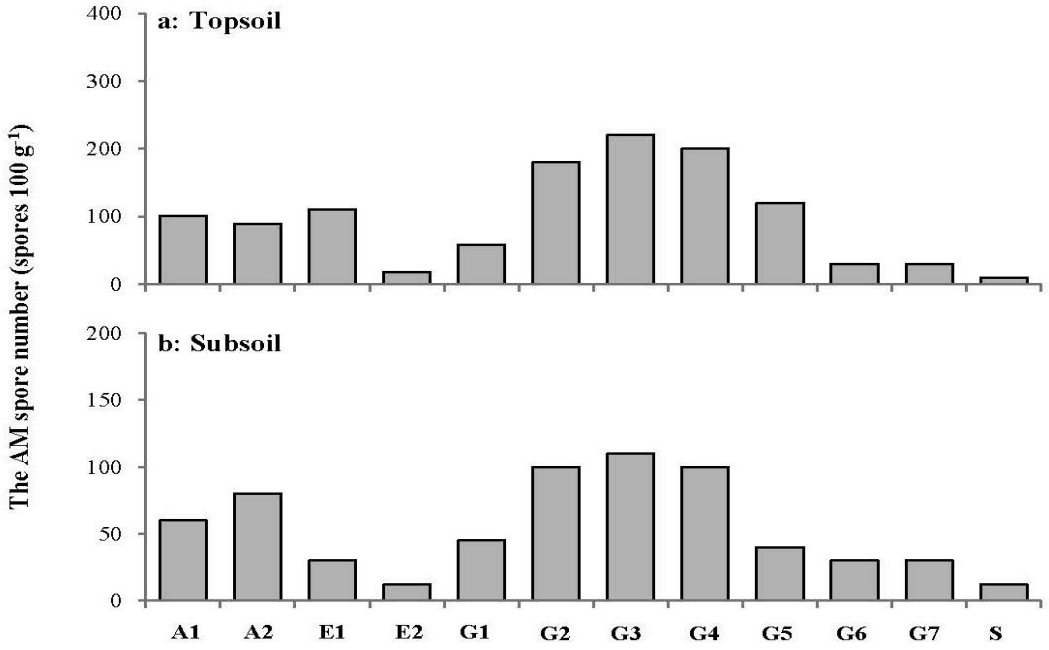

Fig. 2 AM spore number of fallow treatment in topsoil (a) and topsoil (b) at end of crop 2

CONCLUSION

Fallow had negative effect on the proportion of species composition in the AM community. *Glomus* species were more sensitive to fallow than species of other AM genera.

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Research article

Effects of Pesticide on Phenotypic Characteristics of Plant Growth - Promoting Rhizobacteria (PGPR) in Cassava Production Systems

PIMUPSORN PANOMKHUM
Faculty of Agriculture, Khon Kaen University, Thailand

RATTIYAPON RUNGTHONG
Faculty of Agriculture, Khon Kaen University, Thailand

TIPPAYA NITTAYACHIT
Faculty of Agriculture, Khon Kaen University, Thailand

CHULEEMAS BOONTHAI IWAI
Faculty of Agriculture, Khon Kaen University, Thailand

MONGKON TA-OUN
Faculty of Agriculture, Khon Kaen University, Thailand

PHRUEKSA LAWONGSA*
Agricultural Biotechnology Research Center for Sustainable Economy: (ABRCSE),
Faculty of Agriculture, Khon Kaen University, Thailand
Email: phrula@kku.ac.th

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Abstract Cassava (*Manihot esculenta* Crantz) is an important economic crop in Thailand. Nowadays, insect pest is the major problem that causes severe damage to cassava leading to considerable yield losses. Since, using chemical pesticide is always presence of chemical residues on soil and may affect the population and diversity of soil microorganism. Therefore, the aim of the study was to determine the effect of thiamethoxam on plant growth promoting rhizobacteria (PGPR) population in cassava production system. A total of 400 bacteria were isolated from 4 sites, including 1 (cassava production system without thiamethoxam and fertilizer application 2 (cassava production system with thiamethoxam application 3 (cassava production system with thiamethoxam and organic fertilizer application 4 (cassava production system with thiamethoxam and chemical fertilizer application. These isolates were screened for their plant growth promoting factors like production of indole-3-acetic acid (IAA), phosphate solubilizing activity and their ability to grow in N-free medium. In addition, their biocontrol activity like protease and chitinase enzyme production and siderophore production as well as antagonistic activity against *Fusarium* sp. were investigated. The findings of this study indicated that the application of thiamethoxam in cassava production system can affect PGPR population. In this study, numbers of bacterial isolates demonstrate that they are a potential source to be used as microbial inoculant for crop production system.

Keywords Plant growth promoting rhizobacteria (PGPR), thiamethoxam, cassava

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the most important economic crops in Thailand. Cassava can be used for various food products, animal feed, raw material to produce ethanol etc. In addition, an increasing demand for alternative energy products will increase the market value of cassava in the near future.

Nowadays, insect pest is the major problem that caused damage of cassava production. In particular, the most of farmers prefer to use of chemical pesticide such as thiamethoxam, insecticide in the group of neonicotinoids which is one of the most widely used, is resulting in chemical residue in soil. This may disturb the soil environment by affecting microorganisms in soil, and also the physical -chemical properties of soil leading to infertility of soil. Biological control is thus being considered as an alternative or a supplemental way of reducing the use of chemicals in agriculture.

The using of introduced microorganisms with induced systemic resistance against plant disease and stimulate plant growth has been extensively studied (Compant et al., 2005; Welbaum et al., 2004). The introduction of plant growth promoting rhizobacteria (PGPR) offers a promising alternative to manage plant pathogen and enhance plant growth. PGPR can directly benefit plant growth by increasing nitrogen and phosphorus uptake (Rodriguez et al., 1999) and indirectly by increasing resistance to pathogen. PGPR may suppress plant pathogens by producing antimicrobial metabolism (Duffy, 2004) and also by producing enzymes and/or fungicidal compounds (Bloemberg and Lugtenberg, 2001; Haas and Défago, 2005). This study was designed to investigate how chemical pesticide shaped the bacterial populations as well as plant growth promoting activities for successful application of PGPR in cassava production systems to reduce the use of chemical pesticide and soil fertility could be maintained.

OBJECTIVE

The purpose of this study was to investigate the influence of chemical pesticide on the population and phenotypic characteristics of PGPR in cassava production system.

METHODOLOGY

Study Sites and Soil Sampling

Study sites used in this study were selected from Khon Kean province and Kalasin province (N 16° 28' 43", E 102' 49 and 37" N 16° 38' 3", E 103° 15' 15", respectively). Soil samples were collected from rhizosphere of cassava cultivar Rayong 11 with three replications of each treatment was collected at 0-15 cm depth. Pesticide used in this study for cassava stake priming was thiamethoxam 25 WG. Four treatments used in this study, including 1) cassava production system without thiamethoxam and fertilizer application 2) cassava production system with Thiamethoxam application 3) cassava production system with thiamethoxam and organic fertilizer application, 1000 kg/1,600 Square meter 4) cassava production system with thiamethoxam and chemical fertilizer application 15-7-18, 100 kg/1,600 Square meter. The rhizosphere samples were placed in plastic bags and stored at 4 °C for further microbial analysis. In addition, soil samples were collected from 0-15 cm depth for the examination of physical and chemical properties of soil.

Isolation of PGPR from Cassava Rhizosphere

Bacterial strains were isolated from cassava rhizosphere by serial dilution plate technique on nutrient agar medium (NAM) (Dubey and Maheshwari, 2002). The bacterial colonies were isolated and maintained on NAM slants at 4 °C. One hundred isolates obtained from serial dilution plate technique of each treatment were screened for their plant growth promoting factors like production of indole-3-acetic acid (IAA), phosphate solubilizing activity and their ability to grow in N-free medium. In addition, their biocontrol activity like protease and chitinase enzyme production and siderophore production as well as antagonistic activity against *Fusarium* sp. were investigated.

Phenotypic Characterization of PGPR

Indole-3-acetic acid (IAA) production: IAA production was determined using the method described by Lawongsa (2008) with slight modification. Bacteria isolates were cultured in Tris-TMRT (D-mannitol 10 g, yeast extract 0.2 g, $CaCl_2.2H_2O$ 0.2 g, $MgSO_4.7H_2O$ 0.25 g, Tris-base 1.21 g, pH 6.8) supplemented with tryptophan 0.5 mM for 48 h. The measurement of IAA was done by adding 2 ml of 0.01 M $FeCl_3$ in 35 % $HClO_4$ into 1 ml of Tris-TMRT culture broth. The mixture was incubated in the dark at 30 °C for 30 min. The detection of IAA was determined by the development of pink color.

Phosphate solubilizing assay: Solubilization of tricalcium phosphate was detected in national botanical research institute's phosphate growth medium (NBRIP) agar plate supplemented with 1.5% (w/v) agar (Nautiyal, 1999). Five microliters of each bacterial culture was dropped on NBRIP agar plates. The development of halo zone around the bacterial colony indicated phosphate solubilizing activity.

Nitrogenase activity: For rapid determination, nitrogenase activity was assayed after bacterial strains were streaked onto N-free minimal medium supplemented with 1.5% (w/v) agar and incubated at 28 ± 2 °C for 3 days (Desnoues et al., 2003). Bacterial growth indicated nitrogenase activity.

Protease assay: Bacteria were isolated for protease enzyme (casein degradation) using a method described by Sjödahl et al. (2002). Samples were inoculated on LB agar plates containing skim milk (20 %), then incubated at 28 ± 2 °C for two days (Uyar et al., 2011). The development of clear zone around the bacterial colony indicated protease enzyme activity.

Chitinase assay: Chitinase activity was determined using colloidal chitin (Cattelan et al, 1999). Five microliters of each bacteria culture were dropped on colloidal chitin agar (Colloidal Chitin 10 g, K_2HPO_4 0.5 g, $MgSO_4$ $7H_2O$ 0.5 g, Na_2HPO_4 0.5 g, $NaNO_3$ 3.0 g, Yeast extract 1 g, Agar 20 g, pH 7) and incubator at 28 °C for 7 days. The development of halo zone around the bacterial colony indicated chitinase activity.

Siderophore assay: Siderophore was determined by chromazurol sulphonate agar (CAS) using the method described by Clark and Bavoil, 1994. Bacterial inoculum was spotted into the center of a CAS agar plate. After incubation at 28 °C for 5 days, siderophore production was assayed by clear zone formation around the cell.

Antagonistic activity: An inhibition of phytopathogen by bacterial strains on potato dextrose agar (PDA) plates was performed as detailed in previously study (Keel et al., 1996) with slight modification. Briefly, bacteria was grown overnight in NB (Nutrient broth) medium, and 5 µl of each culture was spotted 2 cm from the edge of the plate (four spots per plate) and 0.3 cm square plug from a culture of *Fusarium* sp. was placed at the center of the plate. The results were assessed after 5 days by measuring the distance between the edges of the bacterial colony and the fungal mycelium.

Statistical analysis: The data collected was analyzed statistically using Analysis of variance (ANOVA) along with least significant differences (LSD) by analytical software STATISTIC 8.

RESULT AND DISCUSSION

Soil Analysis

The data of physical and chemical properties of soil are shown in Table 1. The results showed that soil samples of all treatment were sandy soil and contained low fertility.

Effect on Bacterial Population of Rhizospheric Soil of Cassava

Total count of bacteria was found to decrease with the application of thiamethoxam (Table 2). Interestingly, when the experimental plot received organic fertilizer as well as chemical fertilizer,

there was slight increase in the bacterial count as compared to cassava production system without any fertilizer.

Table 1 Physical and chemical properties of soil

Treatment	1	2	3	4
Organic matter; OM (%)	0.227 c	0.360 b	0.432 a	0.368 b
Total N (%)	0.014 a	0.009 b	0.013 a	0.009 b
Available P (mg/kg)	7.230 c	16.793 bc	51.890 a	26.330 b
Exchangeable K (mg/kg)	31.470 ab	24.037 b	33.057 ab	43.870 a
Organic carbon (%)	0.132 c	0.209 b	0.250 a	0.213 b
Soil pH	4.411 a	3.553 b	4.556 a	3.450 b
Electrical conductivity (dS/m)	0.045 a	0.026 b	0.029 b	0.032 b
Cation exchange capacity (cmol/kg)	1.725 b	5.433 a	3.333 ab	6.000 a
Bulk density (g/cm^3)	1.504 a	1.411 a	1.353 a	1.442 a
Soil moisture (%)	3.372 a	2.935 a	3.396 a	3.009 a
Soil texture	sand	sand	sand	sand

Treatment: 1) cassava production system without thiamethoxam and fertilizer application. 2) cassava production system with Thiamethoxam application. 3) cassava production system with thiamethoxam and organic fertilizer application, 1000 kg/1,600 Square meter. 4) cassava production system with thiamethoxam and chemical fertilizer application 15-7-18, 100 kg/1,600 Square meter. Means values followed by different letters are significantly different (ANOVA; LSD test, P<0.05)

Table 2 Effect of pesticide application on bacterial population

Treatment	Bacterial count (cfu/g soil)
1	5.94 x 10^{11} a
2	4.51 x 10^{10} b
3	5.42 x 10^{10} b
4	4.78 x 10^{10} b

Treatment: 1) cassava production system without thiamethoxam and fertilizer application. 2) cassava production system with Thiamethoxam application. 3) cassava production system with thiamethoxam and organic fertilizer application, 1000 kg/1,600 Square meter. 4) cassava production system with thiamethoxam and chemical fertilizer application 15-7-18, 100 kg/1,600 Square meter. Means values followed by different letters are significantly different (ANOVA; LSD test, P<0.05)

Phenotypic Characterization of Bacterial Isolates for Plant Promotion and Biocontrol Traits

A total of 100 cultivable bacterial isolates of each treatment obtained after serial dilutions and plating onto NAM were screened for plant growth promoting traits through growth promoter assays and biological control assays.

The bacterial ability to produce IAA in presence of L-tryptophan as precursor was tested. A total of 305 isolates showed the ability to produce IAA, 60%, 64%, 89% and 92% of isolates that have ability to produce IAA were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

Phosphate solubilizer produce clear zone around the bacterial colonies on media containing insoluble mineral phosphate. A total of 245 isolates showed the ability to solubilize tricalcium phosphate, 60%, 64%, 77% and 44% of isolates that have ability to solubilize phosphate were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

A total of 310 isolates showed the ability to grow in nitrogen-free medium, 55%, 75%, 98% and 82% of isolates that have ability to grow in nitrogen-free medium were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

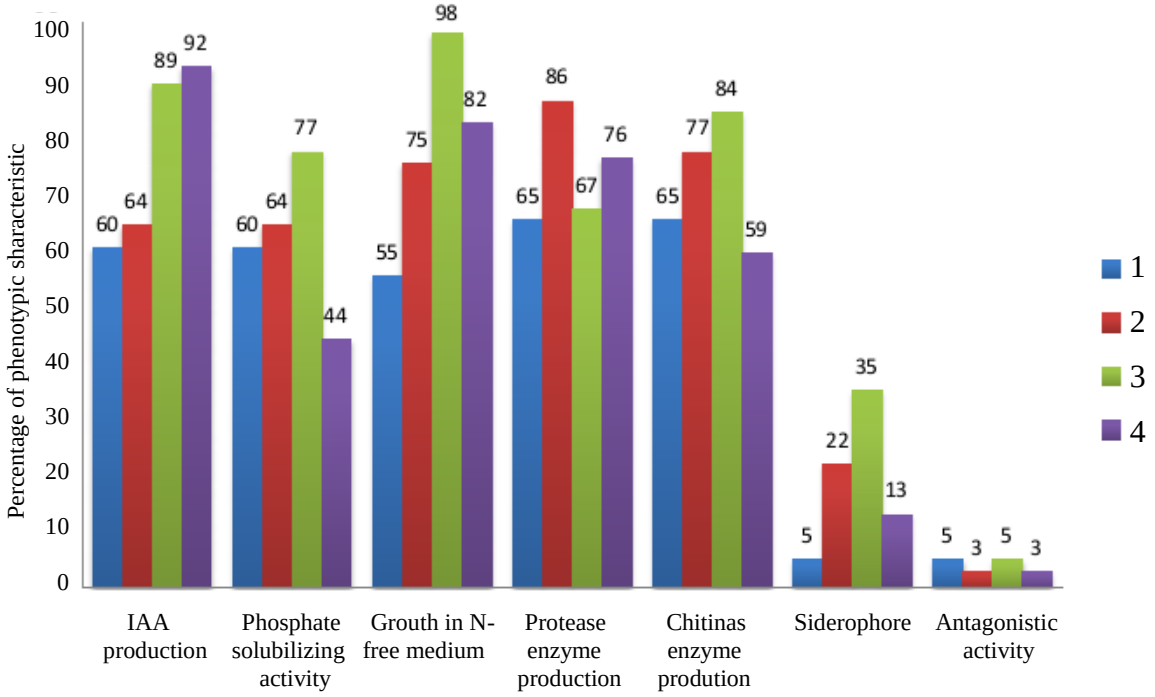
Production of fungal cell wall degrading enzymes (protease and chitinase enzymes), an important mechanism of fungal inhibition, was analyzed. A total of 294 isolates could produce halo zone on skim milk agar that showed protease activity, 65%, 86%, 67% and 76% of isolates that have ability to produce protease were obtained from treatment 1, 2, 3 and 4, respectively. A total of 285 isolates could produce halo zones on colloidal chitin agar that showed chitinase activity, 65%, 77%, 84% and 59% were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

Bacterial isolates which have the ability to produce siderophore and showed clear zone on CAS agar were considered as positive isolate. A total of 75 isolates could produce clear zone that

showed siderophore production, 5%, 22%, 35% and 13% were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

In vitro antagonistic activity against *Fusarium* sp. was investigated. The result revealed that only 16 isolates showed the ability to control *Fusarium* sp. growth among 400 isolates, 5%, 3%, 5% and 3% of isolates were obtained from treatment 1, 2, 3 and 4, respectively (Fig. 1).

From this present study, the results showed that bacteria showed variation in their growth promoter and biocontrol characteristics. Numbers of bacteria still showed the ability to promote plant growth directly and indirectly way even in the presence of pesticide. This could be certified to the fact that certain soil bacteria can degrade pesticides (Sethunathan, 1973). In addition, certain soil bacteria might have utilized pesticide as energy sources (Ahemad and Khan, 2011). Furthermore, the results showed that the application of organic fertilizer can promote plant growth promoting activities of bacteria.



Treatment: 1) cassava production system without thiamethoxam and fertilizer application 2) cassava production system with Thiamethoxam application 3) cassava production system with thiamethoxam and organic fertilizer application, 1000 kg/1,600 Square meter 4) cassava production system with thiamethoxam and chemical fertilizer application 15-7-18, 100 kg/1,600 Square meter.

Fig. 1 Number of bacterial isolates showing phenotypic characteristic at each sampling site displayed as a percentage of the total site number

CONCLUSION

This study has shown that thiamethoxam not only affect the bacterial population but also have an impact on their plant growth promoting activities. In addition, the use of organic fertilizer can slight increase the number of bacteria that exert the positive effects on plant growth promoting via direct and indirect mechanisms. The higher numbers of bacterial isolates which have the ability to produce IAA, solubilize phosphate, grow in nitrogen-free medium, produce chitinase enzyme and produce siderophore were found in cassava production system with thiamethoxam and organic fertilizer addition when compared to control with thiamethoxam. Therefore, it can be concluded that the use of pesticides should be applied with organic fertilizer, to maintain the biodiversity of soil microorganisms. Further study should be carried out with such efficient PGPR isolates to achieve the successful cassava management.

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Research article

Appropriate Chemical Fertilizer Application Rates on Yield and Yield Components of Red Roselle, Cultivar: Surin

RATCHATA TONWITOWAT*
Rajamangala University of Technology Thanyaburi, Pathumtani, Thailand
Email: ratchatatonwitowat@yahoo.com

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Abstract The experiment of appropriate chemical fertilizer application rates on yield, yield components, dry calyx acid and seed oil contents in red roselle (*Hibiscus sabdariffa*) cultivar: Surin with 4 chemical fertilizer rates (16-16-16: 0, 25, 50 and 75 kg/rai; 1 rai = 1,600 m^2) was conducted at Faculty of Agricultural Technology; Rajamangala University of Technology Thanyaburi; Pathumtani province, during late July to December 2010 by RCB design 4 replications. The results indicated that some agronomic characteristics, yield and yield components of all red roselles with applied in any rate of the chemical fertilizer were higher than the non-applied one. The rate of 75 kg/rai brought red roselle not only got better in growth of vegetative parts (192.2 centimeters of plant height, 10 main branches), faster in 50% first flower blooming date (only 100 days after planting), longer periods of flowering and maturation of the first fruit (22 and 23 days after the first bloom flower) but also gave greater in yield components (38.8 fresh fruits, 179.2 and 24.1 grams fresh and dry calyx , 31.1 grams of seeds/plant), these supported the roselle to get the highest yield (764.8, 103.0 and 132.8 kg/rai of fresh calyx, dry calyx and seed weight respectively). Nevertheless when considering to the harvest index, the highest rate of fertilizer applied roselle plot was equal to that non-applied plot (0.36). Regarding to the analysis of dry calyx acid and seed oil contents in red roselle, all treatments by average contained 13-16% of acid and 20-21% of seed oil.

Keywords red roselle, chemical fertilizer rates, yield, yield components, dry calyx acid, seed oil contents

INTRODUCTION

Roselle (*Hibiscus sabdariffa*), a member of Malvaceae family, is a tropical crop which has the various uses, started from home consumption to medicinal and industrial uses. Red calyxes are utilized as reagent for jelly, jam, beverages, sauces and food preserves (Abo-Baker and Mostada, 2011). Fresh calyxes are filled with greater amount of ascorbic acid and also rich in riboflavin, niacin, carotene, calcium and iron while dry calyxes presents antimicrobial as well as antioxidant activities due to its phenolic compounds: flvanoids, gossypetine, hibiciscetine and saddaretine. Seeds of roselle have been found to be a good of protein (Anokwuru et al., 2011 and Qi et al., 2005). Furthermore, the calyx extraction had a great therapeutic action for curing heart and nerve diseases and high blood pressure (Hassan, 2009).

Roselle is one of the target medicinal herbs that Thai government desired to push their products to share in the international markets. Thailand used to be the outstanding exporter of high quality dry roselle calyxes before the occurrence of economic crisis. From the analytic report of roselle production, market and processing, OAE (2007) had concluded that despite roselle products have a big chance for markets but there are some obstructions: in part of production, most plantations are in small scale (only 5-6 rai/grower) with using the local growing practices, lacking of good varieties and agricultural practicing, then led to low productive efficiency. Indeed, systematic cultivation of this medicinal plant needs specific cultural, management practices and agronomical recommendations. Fertilizer is a major factor affecting crop production, to search for

optimum rate of application being one important cultural practice needs to be standardized. Unfortunately, until now there is very few of available research papers that could be supported the roselle production in commercial scale.

OBJECTIVE

This investigation was aimed to find the response of red roselle to 4 chemical fertilizer rates (16-16-16 : 0, 25, 50 and 75 kg/rai; 1 rai = 1,600 m^2) on yield, yield components, acid content in dry calyxes and oil content in seeds.

METHODOLOGY

Field trial was carried out at the Agronomic field of Agricultural Technology Faculty, RMUTT, during late July to December 2010. Before planting, the soil sample from field was taken and sent to Soil and Plant Laboratory of Rice Department of Thailand for properties analysis (the results were Sandy clay loam texture, pH 6.3, Organic matter 2.23%, Total N 0.11%, P_2O_5 123 ppm, K_2O 241 ppm, CEC 9.76 meq/100g). Simultaneously the compost and manure samples were brought to analyse for NPK contents in Soil and Plant Laboratory at Kasetsart University (compost: 1.12%N; 0.46% P_2O_5 and 1.03% K_2O, manure: 1.49%N; 0.57% P_2O_5 and 1.30% K2O). At the land preparation time or two weeks before planting, one tons of farmyard manure mixed with one ton of compost per rai were uniform applied to all plots as basal application.

The experiment was arranged in RCB design with 4 replications and 4 level of chemical fertilizer application rates (formula 16-16-16: 0, 25, 50 and 75 kg/rai) which were applied at 3 weeks after planting. Two-three seeds/hill were sown (two weeks later thinned to one plant/stand) at 75x50 centimeters, 5 rows in 21 square meters of plot size. Ten sample plants in the middle rows of each plot were observed for agronomic characteristics: plant height, number of main branches, 50 % of 1st flower blooming date, flowering periods and 1st fruit maturation date. At maturity, dark red fresh fruit of ten sample plants in each plot were harvested for collecting yield and yield components data : number of fresh fruits/plant, fresh calyx weight/plant, dry calyx weight/plant, seed weight/plant, 1000 seeds weight, fresh and dry calyxes yield, seed yield and harvest index. The 200 g of dry calyxes and seeds of each treatment were taken to Agricultural and Agro-Industrial Product Improvement Institute at Kasetsart University for analysed the contents of dry calyx acid and seed oil.

RESULTS AND DISCUSSION

Some Agronomic Characteristics

Highly significant increase in plant height and number of main branches/plant was observed with chemical fertilizer application by the 120 days after planting when compare with the control treatment (2 tons of compost mixed with manure only). The plant height varied from 145.9 cm in non fertilized plants to 191.2 cm in plant that received the highest rate of chemical fertilizer (75 kg/rai). In case of number of main branches/plant, it seems that all fertilized plants progressively increased their number of main branches/plant from 3 branches of control treatment to 8-10 branches/plant. Generally, fertilized plants would perform better than non fertilized one. (Akanbi et al., 2009)

When considering to the data analysis of 50 % of 1st flower blooming date, flowering periods and 1st fruit maturation date, it showed that the highest rate of application plant took shortest time to reach 50% of 1st flower blooming, equal to 3-11 days faster when compared with the lower rates and control treatments. Moreover, it spent a little longer period of flowering (since the first to last flower blooming) and 1st fruit maturation (duration between flower blooming and mature fruit). Plants in higher fertilizer rate flowered earlier might be because of the vigorous and rapid growth

of plants which brought them to attain the competent stage of flowering. Oyewole and Mera (2010) reported that manure application promoted vegetative growth in roselle, while nitrogen had elongated the juvenile stage in plant, thus delaying crop maturity.

Table 1 Some agronomic characteristics of red roselle "Surin" at different rates of chemical fertilizer

Fertilizer (16-16-16) (kg/rai)	Plant height at 120 day after planting (cm)	No. of main branches/plant	50 % of 1st flower blooming date (days)	Flowering periods (days)	1st fruit maturation date (days)
Control	145.9b	2.8c	111.0a	19.3b	21.8c
25	186.9a	8.3b	104.2b	20.8ab	22.6b
50	186.4a	9.3ab	103.0b	22.3a	22.7b
75	191.2a	9.8a	100.2c	21.8a	23.3a
F test	**	**	**	**	**
CV.(%)	6.44	9.75	1.24	4.59	1.19

Means followed by the same letter at the same column were not significantly different by LSD
**, ** significant at P<0.05 and 0.01, respectively and ns not significant*

Yield and Yield Components

Different chemical fertilizer rates had significant effect on yield and yield components of deep red roselle "Surin". Application of 75 kg/rai plots gave the highest number of fresh fruits, fresh and dry calyxes weight/plant/rai, seed weight/plant and seed yield/rai. Meanwhile the application in 50 kg/rai plants had all components and yield which were at par with the 25 kg/raI ones. Nevertheless, both got in higher values than control treatment equal to 1.3-1.4 times. However, increased in application of the chemical fertilizer rates did not show the significant affect on the 1000 seed weight. Okosun (2006) reported that the 20 kgN/ha did enhance the number of fruits and seed/fruit. Furthermore, Haruna et al. (2011) found that the application of 60 kg/ha of nitrogen fertilizer and 5 tons/ha of poultry manure significantly increase calyx yield and profitability of roselle. Oyewole and Mera (2010) observed that for the calyx, pod and seed production, the application of manure at 7.5 tons/ha or nitrogen at 75 kgN/ha gave the best yield. Anyinkeng and Mih (2011) concluded that 20 tons of poultry manure significantly increase growth, biomass and economic yield of roselle. In case of the harvest index (calyx plus seed yield), it was found the significant effect on. The increased fertilizer rate from control to 50 kg/rai had reduced the harvest index value. However, when topped up to 75 kg/rai, the value was speed up but not over the control. Atta et al. (2010) also discovered that the supplying 50-100 kgN/ha significantly decreased seed and calyx harvest indexes relative to control (0 kgN/ha).

Table 2 Yield components of red roselle "Surin" at different rates of chemical fertilizer

Fertilizer(16-16-16) (kg/rai)	No.of fresh fruits/plant	Fresh calyx weight/plant (g)	Dry calyx weight/plant (g)	Seed weight/plant (g)	1000 seeds weight (g)
Control	10.8c	47.5c	8.2c	10.3c	37.5
25	27.9b	126.1b	16.8b	22.5b	37.8
50	28.5b	133.5b	18.4b	23.1b	37.5
75	38.8a	179.2a	24.1a	31.1a	37.5
F test	**	**	**	**	ns
CV.(%)	11.62	14.88	13.5	10.66	3.31

Means followed by the same letter at the same column were not significantly different by LSD
**, ** significant at P<0.05 and 0.01, respectively and ns not significant*

Data from Table 4 revealed that the pH of dry roselle calyxes were decreased after applied higher chemical fertilizer rates which would be correlated with the gradually increased of acid content (titratable acidity percentage) that ranged from 13.21-16.06%. This is in accordance with that obtained by Abo-Baker and Mostada (2011). Nevertheless, at any rates of fertilizer did not

affect to the oil content in roselle seeds, the approximate value of seed oil content was equal to 20-21%.

Table 3 Yield of red roselle "Surin" at different rates of chemical fertilizer

Fertilizer (16-16-16) (kg/rai)	Yield of fresh calyx (kg/rai)	Yield of dry calyx (kg/rai)	Seed yield (kg/rai)	Harvest Index
Control	202.6c	35.2c	44.0c	0.36a
25	495.6b	68.6b	96.0b	0.32b
50	555.5b	78.1b	98.6b	0.32b
75	764.8a	103.0a	132.8a	0.36a
F test	**	**	**	*
CV.(%)	12.99	12.28	10.67	6.51

Means followed by the same letter at the same column were not significantly different by LSD
**, ** significant at P<0.05 and 0.01, respectively and ns not significant*

Table 4 pH, dry calyx acid content and seed oil content of red roselle "Surin" at different rates of chemical fertilizer

Fertilizer (16-16-16) (kg/rai)	pH	Dry calyx acid content (%)	Seed oil content (%)
Control	2.96 ± 0.02	13.21 ± 0.29	19.71±0.18
25	2.96 ± 0.01	14.16 ± 0.41	21.43±0.04
50	2.93 ± 0.01	14.01 ± 0.20	19.95±0.49
75	2.82 ± 0.02	16.06 ± 0.13	19.83±0.90

CONCLUSION

For producing roselle to reach better yield and yield components, two tons of organic fertilizer (compost mix with farmyard manure) as basal application and 75 kg/rai of chemical fertilizer application formula 16-16-16 are recommended.

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Research article

Acceptability of Value Added Products from Giant Swamp Taro (*Cystosperma chamissonis*) Corm

REGUCIVILLA A. POBAR*
Bohol Island State University, Bohol, the Philippines
Email: regupobar@gmail.com

EMMYLOU BALO
Bohol Island State University, Bohol, the Philippines

MARIA SHELANIE POBAR
Bohol Island State University, Bohol, the Philippines

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Abstract Giant Swamp Taro "*Cyrtosperma chamissonis*" is a native plant in the Philippines. It can also be found in Bohol, Philippines especially in swampy coastal areas. It is used as food and is prepared in several ways like roasting, grating, or baking the corm whole. Giant Swamp Taro has traditionally been an important emergency crop in times of natural disaster and food scarcity. It is rich in calories, fibre, calcium, iron, zinc, β-carotene, thiamine and Vitamin C. This study ventured to produce T1- Taro Espasol with Young Buko, and T2- Taro Espasol with Peanuts; to determine its acceptability; and to promote the product to the rural community. This is an experimental study using parallel group design with sixty panelists assessing the product in six sensory attributes; appearance, texture or mouthfeel, cohesiveness, odor, taste and general acceptability, utilizing Hedonic Scale. It was found out that T2 or Giant Swamp Taro with peanuts ranked first in four sensory attributes; cohesiveness (tie with T0) - Crumbly, Odor - Very Pleasant, Taste - Moderately Palatable, and in General Acceptability-Very Much Acceptable. T2 ranked second in texture-Less Soft and third in Appearance - Very Attractive. On the other hand, T1 or Giant Swamp Taro with Young Buko got the highest in Appearance-Very Attractive, cohesiveness (tie with T2)- Crumbly, second in taste-Moderately Palatable, and in 'general Acceptability- Very Much Acceptable and third in Texture and Mouthfeel- less soft, and odor - Very Pleasant. Meanwhile, T0 ranked first in texture and mouthfeel - less soft, second in appearance - Very Attractive, Odor - Very Pleasant and third in Cohesiveness - Crumbly, Taste - Moderately Palatable, and General Acceptability - Very Much Acceptable. It can be concluded that the three treatments of Giant Swamp Taro Espasol are generally acceptable. It is easy for the rural people to prepare the recipe since it is cooked using carajay and tools which are available in rural communities. Giant Swamp Taro flour can substitute glutinous rice in recipes.

Keywords giant swamp taro, corm, espasol, hedonic tasting, taro flour, glutinous rice

INTRODUCTION

Giant Swamp Taro (*Cyrtosperma chamissonis)* is a native plant of the Philippines that has dozens of varieties thriving on most of three tropical islands in the Pacific (Hopkins, 2012). It is one of the few subsistence crops that grow well within swampy areas. It may be field stored in the ground for very long periods (up to 30 years or more) and has traditionally been an important emergency crop of times of natural disaster and food scarcity. In fact in Tonga and some other island, this is considered as famine food (Manner, 2011).

Englberger and Levendusky of the Island Food Community of Pomhpei promote giant swamp taro along with other local foods can protect against many serious diseases such as Vitamin A

deficiency, anemia, diabetes, heart disease and cancer (Wagner, 2006). It is rich in minerals (zinc, calcium and iron), β-carotene, and fiber (Manner, 2011).

Giant Swamp Taro is highly valued but consumption is infrequent. It can be eaten to replace other crops like breadfruit when not in season, it can withstand strong winds and hurricanes, thus providing food security (Englberger et al., 2004).

The main product of Giant Swamp Taro is the corm which can be roasted, boiled, baked, mashed, grated and combined with other starches for eating. The leaves and inflorescences can be eaten as vegetables and the petioles yield a fiber suitable for weaving. The big leaves are used as food wrapper and also to cover the earth oven (Hopkins, 2012).

In the Philippines, especially in Bohol, Giant Swamp Taro are not given much value as food, it is only eaten when nothing can be eaten anymore, when there are still other food to eat, Giant Swamp Taro is forgotten. In Anda, Bohol for example many Giant Swamp Taro are dying because it is not taken as food. So to promote Giant Swamp Taro, the researcher thought of making recipes out of taro so that it can be fully utilized. The researcher believed that there is enough supply of Giant Swamp Taro since in the eastern part of Bohol, around 15 hectares are planted with Giant Swamp Taro which according to the President of the Cooperative producing taro flour cannot cause its extinction but can save the dying taro since the cause of its death is the non-consumption of the mother corm. So, that 15 hectare taro farm is more than enough to supply the raw material if a huge volume is needed in the production of more taro products.

This study ventured to produce Espasol utilizing Giant Swamp Taro flour as the main ingredient. Espasol is a type of rice cake made out of rice flour cooked in coconut milk, sweetened and dusted with toasted rice flour. It originated in Laguna, Philippines and popularly sold in major thoroughfares, bus stops and specialty shops in Laguna (Merano, 2009). The researcher assumed that Giant Swamp Taro flour can replace malagkit/glutinous rice flour in the recipe.

The researchers believed that in this study the Giant Swamp Taro farmers can get benefit from the new recipes, their taro corms can be utilized as a snack item and not be left behind unconsumed or unutilized or just as food for hogs. The rural community can also get benefit because they can use the new recipe as new addition to their snack or dessert. The entrepreneurs can mass produce these recipes and sell them for another income.

OBJECTIVE

The study aimed to produce Espasol from Giant Swamp Taro; to identify the ingredients, tools, equipment and the procedure in producing the three treatments of Giant Swamp Taro Espasol; to determine the acceptability of the product; to promote the products to the local community and to encourage them to use the products. The products were developed at Bohol Island State University, Main Campus, Tagbilaran City, Bohol, Philippines for Academic Year 2012-2013.

METHODOLOGY

This study is experimental using parallel group design and utilizing five-point Hedonic Scale. The finished products were subjected to sensory appraisals of sixty panelists consisting of twenty community people, thirty students and ten Food Technology instructors. Sensory appraisal is a scientific method used to evoke, measure, analyze and interpret reactions to those characteristics of food materials as they are perceived by the senses of sight, smell, touch and hearing (ASTM MNL 14).

This study was conducted in the Food Technology Laboratory of Bohol Island State University Main Campus, Tagbilaran City. The sixty panelists broken down as follows: twenty-five community people, twenty-five Food Technology students and ten Food Technology instructors. They were chosen to make sure that each must free from taste perception disorders, odor perception disorders, color blindness and denture defects which might affect their judgment of the product (Hashimi, 2007).

The researchers formulated the four recipes utilizing Giant Swamp Taro flour in three

treatments; first is the Plain Swamp Taro Espasol as treatment, second is the Giant Swamp Taro with Young Buko as treatment 1 and the third is Giant Swamp Taro with Peanuts for Treatment 2. The products were evaluated two times, first in the afternoon and the other in the following day, since according to Panlasang Pinoy, Espasol has best result if consumed the next day as it will firm-up. The five point Hedonic Scale was used with the following range and descriptive rating.

Table 1 Descriptive rating

Numerical Rating	Descriptive Rating					
	Appearance	Texture	Cohesiveness	Odor	Taste	General Acceptability
4.50-5.00	Most Attractive	Soft	Tender	Most Pleasant	Highly Palatable	Most Acceptable
3.50-4.49	Very Attractive	Less Soft	Crumbly	Very Pleasant	Moderately Palatable	Very Much Acceptable
2.50-3.49	Attractive	Firm	Grainy	Pleasant	Palatable	Acceptable
1.50-2.49	Less Attractive	Less Hard	Fibrous	Less Pleasant	Less Palatable	Less Acceptable
1.00-1.49	Not Attractive	Hard	Coarse	Unpleasant	Not Palatable	Not Acceptable

RESULTS AND DISCUSSIONS

The researchers found out that the following are the ingredients of the three treatments of Giant Swamp Taro Espasol.

Table 2 Ingredients

Ingredients	To Plain Giant Swamp Taro Espasol	T1 Giant Swamp Taro Espasol with Young Buko	T2 Giant Swamp Taro Espasol with peanuts
2 cups Giant Swamp Taro flour	√	√	√
2 cups coconut milk	√	√	√
¾ cup centrifugal sugar	√	√	√
¼ cup brown sugar	√	√	√
1 cup Taro flour for dusting	√	√	√
1 stalk pandan tied to knot	√	√	√
1 cup young buko, shredded		√	
½ cup peanuts, toasted and crushed			√
1 sheet water cellophane for wrapping	√	√	√

The three treatments of Giant Swamp Taro used Giant Swamp Taro flour, coconut milk, centrifugal and brown sugar, pandan leaves for flavoring, young buko for treatment 1, crushed peanuts for treatment 2 and water cellophane for wrapping for the three treatments.

Tools/equipment needed: The preparation of the three treatments of Giant Swamp Taro recipes required the use of the following tools and equipment: flour sifter, spatula, rubber spatula, measuring cup, measuring spoon, coconut grater, strainer, wooden ladle, tin sheets, carajay, stove.

Procedure: The procedure used in preparing the three treatments of Espasol are as follows: Heat the carajay, add the Giant Swamp Taro flour. Cook in medium heat until toasted or golden brown while continues mixing. Turn off heat, set aside. This will be used for dusting. In a mixing bowl, put together coconut cream, sugar and pandan. Mix and transfer to a carajay. Bring to a boil then lower the heat to medium. Remove pandan leaves and continue boiling, add the flour until thick. Place in a tin sheet dusted with flour then flatten with a rolling pin. Slice into long strips. Roll it to form a cylindrical shape cake. Roll each in toasted flour. Wrap in water cellophane.

The three treatments were then subjected to sensory evaluation by the panelists. First was right after cooking and the second was a day after it was prepared. The panelists were asked to take a glass of water in between tasting of the product so as not to mix the taste of the products. Likewise

they were also blindfolded when evaluating the taste and the odor of the three treatments of Giant swamp Espasol so that their judgment of the product will not be affected by the appearance of the product.

Table 3 Result of sensory evaluation

Attributes	Treatments	Trial 1	Trial 2	Average	Rank	Descriptive Rating
	T0	4.29	4.1	4.20	2	Very Attractive
Appearance	T1	4.24	4.5	4.37	1	Very Attractive
	T2	4.28	3.9	4.09	3	Very Attractive
	T0	4.29	4.65	4.47	1	Less Soft
Texture/ Mouthfeel	T1	4.18	4.5	4.34	3	Less Soft
	T2	4.22	4.55	4.38	2	Less Soft
	T0	4.36	4.4	4.38	3	Crumbly
Cohesiveness	T1	4.5	4.4	4.45	1.5	Crumbly
	T2	4.4	4.5	4.45	1.5	Crumbly
	T0	4.43	4.2	4.32	2	Very Pleasant
Odor	T1	4.24	4.1	4.17	3	Very Pleasant
	T2	4.4	4.5	4.45	1	Very Pleasant
	T0	4.38	4.25	4.32	3	Moderately Palatable
Taste	T1	4.31	4.55	4.43	2	Moderately Palatable
	T2	4.59	4.3	4.44	1	Moderately Palatable
	T0	4.3	4.3	4.3	3	Very Much Acceptable
General Acceptability	T1	4.27	4.45	4.36	2	Very Much Acceptable
	T2	4.34	4.6	4.47	1	Very Much Acceptable

Result of the First Trial

As shown in the result of the first trial, in appearance, T0 or the Plain Giant Swamp Taro Espasol ranked first while T1 or Giant Swamp Taro Espasol with Young Buko ranked third but all the treatments received a descriptive rating of Very Attractive. When comes to texture, still T0 ranked first while T1 ranked third with a descriptive Rating of Less Soft. For cohesiveness, T1 got the highest rating with a descriptive rating of Tender while T0 got the lowest with a Descriptive Rating of Crumbly. For Odor**,** T0 has the highest rating while T1 got the lowest; Taste, T2 got the rating of 4.59, described as Highly Palatable and T2, the lowest has a rating of 4.31 Moderately Palatable. Result disclosed that T2 ranked first in General Acceptability with T1, the lowest, the three treatments received a Descriptive Rating of Very Much Acceptable.

Result of the Second Trial

As manifested in the result of Second Trial, T1 got a rating of 4.5 or Most Attractive in Appearance while T2 got 3.9 or Very Attractive in the same Attribute. On the other hand, T0 got 4.65 or Soft while T2 got 4.55 both described as Soft in Texture and Mouthfeel. For cohesiveness, T2 has the highest rating of 4.5 with a descriptive Rating of Tender and T0 and T1 got a tie rating of 4.4 described as Crumbly. In odor, T2 has a rating of 4.5 or Most Pleasant while T1 has 4.1 or Very Pleasant. For Taste, T1 has a rating of 4.55 or Highly Palatable and T0 has 4.25 or Moderately Palatable and for General Acceptability, T2 has the highest rating of 4.6 or Most Acceptable and T0 has 4.3 or Very Much acceptable. The result of the second trial affirmed that Espasol has better result when allowed to firm up since in the General Acceptability T2 is rated Most Acceptable and the other two treatments were rated Very Much Acceptable while in the texture and mouthfeel the three treatments were rated soft.

Average Rating of First and Second Trial

The overall rating disclosed that T2 or Giant Swamp Taro Espasol with peanuts ranked first in four attributes, Cohesiveness, (tie with T1), Odor, Taste and General Acceptability. The result is in consonance with the theory of Gatchialan which states that when the Odor and Taste of the product

are acceptable, the product is generally acceptable. T0 on the other hand got the highest rating in Texture and mouthfeel while T1 ranked first in appearance and cohesiveness (tie with T2).

Shelf Life

Samples of the products were allowed to stand at room temperature to observe the changes that may take place, it was observed that T0 and T2 lasted for 6 days while T1 lasted only for three days. The addition of young buko caused the Espasol to spoil earlier than the other treatments which were T0 Plain Giant Swamp Espasol and T2- Giant Swamp Espasol with Peanuts. The addition of peanuts in T2 had contributed the shelf life of the product and so it lasted longer.

Marketability

The three products were displayed at the university canteen other products were displayed at the cooperative store of Anda, Bohol where many Giant Swamp Taro can be found. After a week of display in the cooperative store, the three treatments were all sold out, while in the university canteen it took two weeks for the product to be sold out.

CONCLUSION

Giant Swamp Taro Espasol can be prepared using the taro flour. It can be used for food other than the usual boiling which rural people used to eat like the three treatments of Espasol in this study. The three treatments are all acceptable for food. It is easy for the rural people to prepare since it is cooked using carajay and tools which are available in the rural communities. Giant Swamp Taro flour can substitute glutinous rice in recipes.

It is recommended that information dissemination be done to promote the use of Giant Swamp Taro Espasol as snack items; preparing these value-added products from giant Swamp Taro be extended to rural community so that these nutritious snack items can be used as part of their meals; value-added products from Giant Swamp Taro be introduced to the entrepreneurs so that these can be mass produced and sold in the community; and other food technologists be inspired to experiment other products using Giant Swamp Taro with a hint that this could be used as substitute for glutinous rice.

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Research article

Effect of Ethanol-Blended Gasoline on the Concentration of Polycyclic Aromatic Hydrocarbons and Particulate Matter in Exhaust Gas of Motorcycle

SOMPORN PLEANJAI*
Rajamangala University of Technology Thanyaburi, Pathumthani, Thailand
Email: Spleanjai@gmail.

ITTIPOL PAW-ARMART
Automotive Air Pollution Division, Pollution Control Department, Bangkok, Thailand

THERDSAK PETBLENGSI
Automotive Air Pollution Division, Pollution Control Department, Bangkok, Thailand

SINGTO SAKULKHAEMARUETHAI
Rajamangala University of Technology Thanyaburi, Pathumthani, Thailand

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Abstract This study focuses on the characteristics of polycyclic aromatic hydrocarbons (PAHs) and fine particulate matter (PM) in six four-stroke motorcycle exhaust emissions. Blend gasoline contains 85% (vol) ethanol (Gasohol E85) and 10% (vol) ethanol (gasohol 91) was used as test fuels. The test motorcycle was driven on a Chassis dynamometer to evaluate the effect of ethanol-gasoline blend on gaseous pollutant emissions. The dynamometer system comprised a cooling fan, a dynamometer, a dilution tunnel, a constant-volume sampler (CVS) unit, a gas analyzer and a personal computer. The exhaust from the test motorcycle was passed to the dilution tunnel. The emissions of PAHs and criteria air pollutants (THC, CO, and NOx) were measured. Measurements were performed on a standard driving cycle. The results show that in comparison to gasohol 91 fuels, the use Gasohol E85 fuels achieved reduction of THC and CO emissions. The emission of THC from gasohol E85 reduced by 4-60% (average 43%) compared with those of gasohol 91 fuels. CO emissions also showed a reduction by 40-95% (average 75%). The concentrations of naphthalene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, and Benzo(g, h, i)perylene were also determined.

Keywords ethanol-blended gasoline, polycyclic aromatic hydrocarbons (PAHs), particulate matter (PM), exhaust emission

INTRODUCTION

Increasing industrialization and motorization have turned polycyclic aromatic hydrocarbons (PAHs) into omnipresent environmental pollutants. PAHs are organic compounds, the derivatives of which are widespread and harmful compounds formed by incomplete combustion. Some PAHs are potential mutagens and carcinogens, and are probably a significant cause of allergic responses and cancer**.** In addition, the oxidized and nitrated reaction products of these compounds have been found to be more potent carcinogens and mutagens than their parent PAHs. Motor vehicles are known to represent a significant source of PAH emissions. Most carcinogenic PAHs have been found to associate with particulates, predominately with fine particulates.

The effects of ethanol-gasoline blend on air pollutant emissions had been investigated in many studies (Al-Hasan, 2003; He et al., 2003; Hsieh et al., 2002; Yüksel and Yüksel, 2004). Most of the studies indicated that ethanol-blended gasoline produced lower CO and THC levels than unleaded gasoline on SI engines. Ethanol-blended gasoline also decreased emissions of air toxic, such as benzene, 1,3-butadiene, toluene, and xylene, with ethanol levels increasing. Air quality issue

caused by emissions from motorcycle in urban area is critical in Asian cities: China, India, Taiwan, Thailand, and Vietnam. Such as motorcycles contributed up to 30% of CO and 70% of THC among all gasoline powered vehicles in Bangkok (Xie et al., 2004), and account for 28% of CO, 52% of THC, and 19% of NOx in Taiwan (TEPA, 2011). Emission from motorcycle correlates with many parameters, such as fuel property, engine type, driving mode, and exhaust catalyst. However, to our knowledge, there are no data on the particulate matter and PAHs distribution pertaining to emissions from motorcycles for Bangkok and the surrounding province of Thailand in current literature.

This study investigated the effects of ethanol-gasoline blends applied in four-stroke motorcycle on engine exhaust emissions. The Gasohol E85 (E85) and Gasohol 91 (E10) were used as test fuels. The study was to measure only mass of PM and selected gaseous pollutants (THC, CO, CO_2 and NOx). PAHs in the exhaust are also discussed. Emissions inputs are calculated from Thailand's PCD (Pollution Control Department).

OBJECTIVES

1. To analyze PAHs from Gasohol E85 and Gasohol 91 in four-stroke motorcycle exhaust
2. To measure mass of PM and THC, CO, CO_2 and NOx emissions

METHODOLOGY

Table 1 Emission analysis system

Measurement	Pollutants	Analyzer
Direct Measurement	CO/CO_2	Non-Dispersive Infrared(NDIR)
	HC	Non-Dispersive Infrared(NDIR)
	NOx	Chemiluminescence Detector(CLD)
CVS Measurement	CO/CO_2	Non-Dispersive Infrared(NDIR)
	THC	Flame Ionization Detector(FID)
	NOx	Chemiluminescence Detector(CLD)
Weighing	Particulate Matter(PM)	Micro Balance

Blend gasoline contains 85% (vol.) ethanol (Gasohol E85) and 10% (vol.) ethanol (gasohol 91) was used as test fuels. These fuels are a commercial fuel in Thailand. There are 6 motorcycles were selected. The selected four-stroke motorcycles were without any engine adjustment. The motorcycle was placed on chassis dynamometer. The chassis dynamometer was located in a certified laboratory within the motorcycle manufacturer. The main dynamometer system comprises of a dilution tunnel, a constant volume system (CVS) unit, an exhaust gas analyzer and a personal computer. Exhaust samples were collected for the entire cycle; the exhaust gas was initially mixed with air, directed to the CVS unit, and then connected to the sampling bags and analyzer. In this study, the carbon monoxide (CO), unburned hydrocarbons (THC), and oxides of nitrogen (NOx) in the exhaust filtered samples were measured using a non-dispersive infrared analyzer, a flame ionization detection analyzer, and a chemiluminescence detection analyzer, respectively. Particulate matter (PM) emissions were sampled on fiber filters and measured by means of weighing (see Table 1).

PM and particulate PAHs were collected by quartz microfiber filters (diameter 70 mm, flow rate 60 liter per minute for 20 minutes). Two sets of filter holders were employed in this system. Back-up filters were used in each holder downstream the sampling filters to check the breakthrough effects. Two glass cartridges containing polyurethane foam (PUF) plug and XAD-16 resin were used to collect the gaseous PAHs. Before taking the samples, the cleaned filters were stored in a desiccator for at least 8 h for moisture equilibrium before weighing. After the experiments, the filters were brought back to the laboratory and put in a desiccator for 8 h to remove moisture. They were weighed again to determine the net mass of particles collected. After final weighing (only for filter samples), each PAH-containing sample was extracted with a mixed solvent (acetonitrile:

dichloromethane = 10: 90% v/v) by accelerated solvent extractor (ASE). The extract was then concentrated by purging with ultra-pure nitrogen 130 psi for 60 second to 2 mL for cleanup procedure and re-concentrated to 1.0 mL by evaporator. The concentrations of the following PAHs were determined by a high performance liquid chromatography (HPLC DAD/FLD).

RESULTS AND DISCUSSION

All motorcycles fueled with gasohol 91 (E10) and gasohol E85 (E85) were tested. The results are shown in Fig. 1-Fig. 5 and Table 2. Figure1 shows that a quantity of PM content in the test motorcycle exhaust decreases when adding more ethanol in fuel.

Figure 2 shows that THC emission from all motorcycles fueled with E85 decreases by 4-60% compared to E10 and it was found that the THC emission decreases when adding more ethanol in fuel. Figure 3 shows that CO emission from the motorcycles fueled with E85 decreases around 40-95% compared to fueled with E10 and it was found that E10 has CO more than E85 because incompletely burning of oil unfit engine makes more exhaust emission. The result of CO_2 emission is not significant difference as shown in Fig.4. Figure 5 shows that NOx emission from all motorcycles fueled with E85 is 50-400% higher than E10.

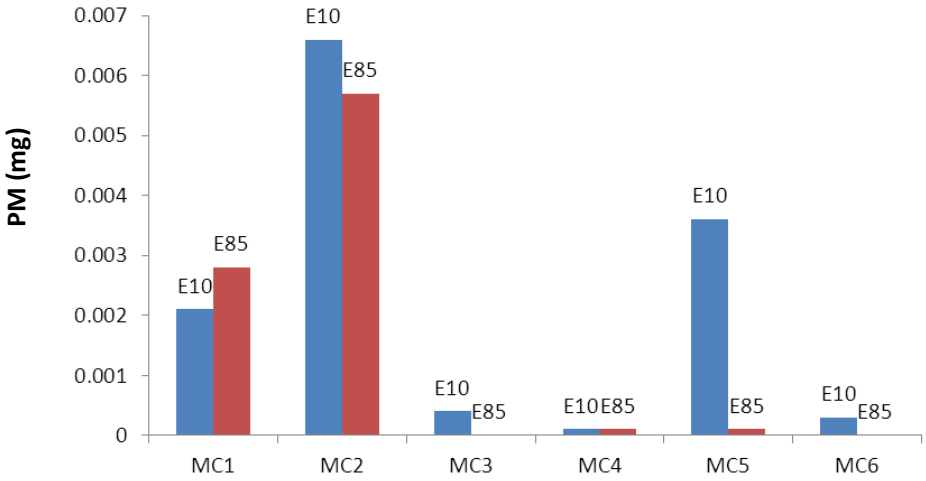

Fig. 1 Emission of PM from four-stroke motorcycle with different fuels

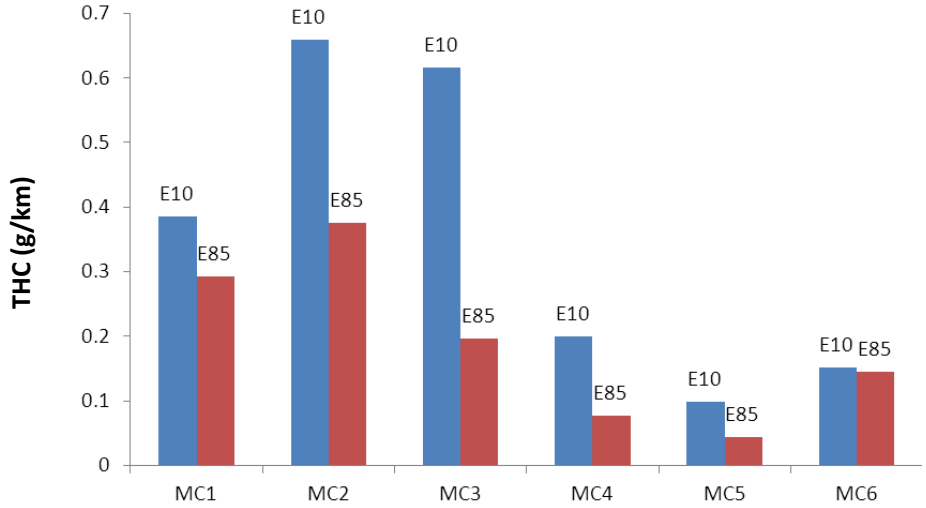

Fig. 2 Emission of THC from four-stroke motorcycle with different fuels

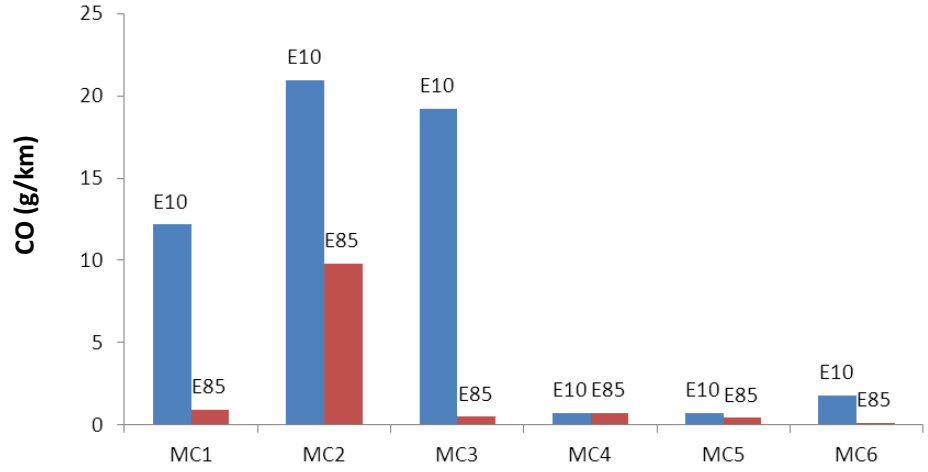

Fig. 3 Emission of CO from four-stroke motorcycle with different fuels

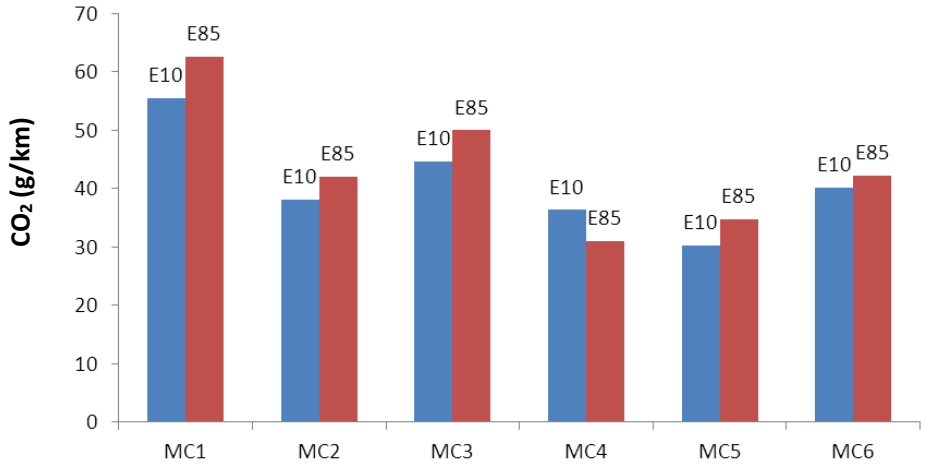

Fig. 4 Emission of CO_2 from four-stroke motorcycle with different fuels

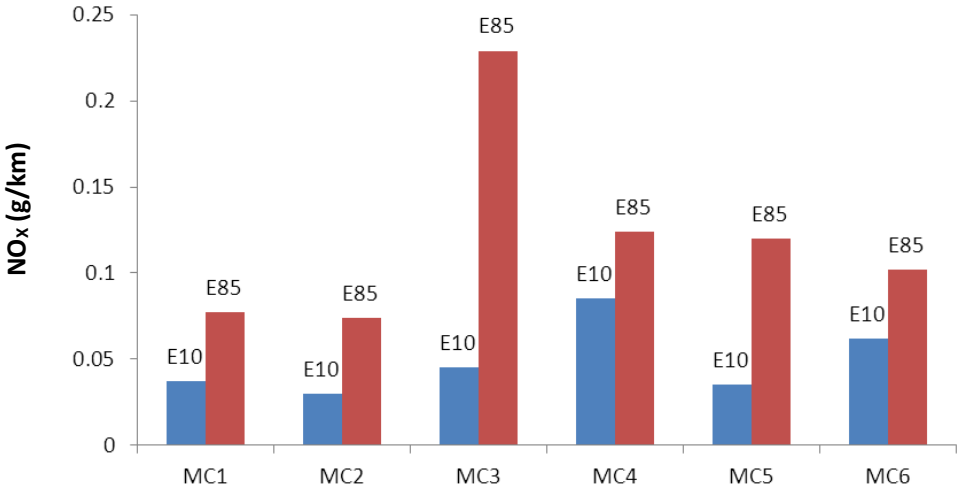

Fig.5 Emission of NOx from four-stroke motorcycle with different fuels

Our findings according to previous studies, it was found that ethanol-gasoline blended fuels (3-30 vol.%) and pollutant emissions are correlated. In general, exhaust HC and CO emissions are lower with oxygenated fuels, but comparable or higher NOx emissions are produced (Furey and

King, 1980; Hsieh et al., 2002; He et al., 2003). The extent of pollutant reduction depends on ethanol content, air-fuel ratio (AFR), engine operating conditions, type of cars and whether closed-loop fuel is used (Zervas et al., 2002; Al-Hasan). The effect of using an ethanol gasoline blend fuel (ethanol 10 vol.%) on four-stroke motorcycle exhaust emission using chassis dynamometers had been investigated that indicate reductions in CO and HC emissions with an insignificant effect of ethanol on NOx emission(Jia et al., 2005). In addition, the high ethanol-gasoline blend ratio (20%) resulted in a less emission reduction than those of low ratio blends (<15%)(Yao et al., 2009). Furthermore, the effect of ethanol blended gasoline fuel on emission was investigated in Thailand (Sukajit et al., 2011). The exhaust emissions tests on four-stroke motorcycle fueled with E0, E10 and E20 results show that the ethanol blended gasoline fuel results in decreasing of CO emission by 40-70% and it was found that CO emission decreases when adding more ethanol in fuel. Other emissions show no difference.

According to Table 2, it could be seen that many compounds were detected in the exhaust emissions tests on four-stroke motorcycle fueled with E10 and E85. In this study, based on emission amount, the top-5 aromatic hydrocarbons detected were as follows: Naphthalene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene and Benzo(g, h, i)perylene. It was found that ethanol of E10 fuel plays insignificant effect on aromatic emissions, as compared to E85.

Table 2 Emission of PAHs from four-stroke motorcycle with different fuels

PAHs(mg/m^3)	Gasohol 91(E10)					
	MC1	MC2	MC3	MC4	MC5	MC6
Naphthlene	0.03	0.05	0.04	0.04	0.03	0.03
Chrysene	‹0.025	1.51	0.15	‹0.025	‹0.025	0.05
Benzo(a)anthracene	‹0.025	1.3	0.03	ND	ND	0.03
Benzo(b)fluoranthene	‹0.025	1.33	0.14	ND	‹0.025	0.04
Benzo(g,h,i)perylene	0.06	1.87	0.47	ND	‹0.025	0.05
	Gasohol E85 (E85)					
PAHs(mg/m^3)	MC1	MC2	MC3	MC4	MC5	MC6
Naphthlene	4	0.1	‹0.025	0.06	0.04	0.04
Chrysene	<0.025	1.25	ND	0.04	ND	ND
Benzo(a)anthracene	ND	0.96	ND	<0.025	ND	ND
Benzo(b)fluoranthene	ND	1.33	ND	<0.025	ND	ND
Benzo(g,h,i)perylene	ND	2.16	ND	ND	ND	ND

CONCLUSION

This study investigated the emissions of THC, CO, CO_2 and NOx emissions for four-stroke motorcycles using E10 and E85 gasoline/ethanol blended fuels. In comparison with E10, using E85 as fuel reduces the emission of THC and CO by 4-60% and 40-95% respectively. In contrast, the emission of NOx emission is increased by 50-400% using E85. The CO_2 emissions are not significant difference. The PM and PAHs were analyzed. The results were found that PM decreases when fueled with E85 and PAHs: Naphthalene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene and Benzo(g, h, i)perylene emissions for four-stroke motorcycles using E10 and E85 as fuels are not significant difference.

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Research article

Factors affecting paddy landscape from the perspective of landscape structure

YAMAMOTO TADAO*
Research Faculty of Agriculture, Hokkaido University, Hokkaido, Japan
Email: tady@env.agr.hokudai.ac.jp

NOMOTO KEN
Foundation of Hokkaido Agricultural Modernization Technology Research Center, Hokkaido, Japan

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Abstract The current landscape was constructed by the first settlement in approximately 120 years at the Shinotsu region located in the Ishikari River Basin, Hokkaido. The objective of this study was to investigate landscape elements and factors found during landscape changes as well as the problems associated with future developments. Data regarding landscape changes during each period were collected using topographic maps, and changes because of human actions and related projects in this region were recorded from town history and other related documents. Landscape changes occurred through the following steps: (a) primal natural landscape (peatland, primarily occupying the landscape); (b) natural and partial agricultural landscapes occurred during only good settlement conditions (alluvial plain); (c) decrease in natural landscape and gradual development of a dry field landscape with drainage of peatland (farmland expanded in hockmoor from niedermoor); and (d) paddy field landscape established using an advanced agricultural water-use system. From these landscape changes, it was clear that the changes in elements and factors were primarily human plans (motive), peatland characteristics (depending of Fudo, which is a holistic phenomenon based on the complex of interactions between factors such as climate, geography, and soil) and agricultural water-use system (tools and facilities). In addition, these elements and factors interactively affected landscape changes; thus, evaluation using each element or factor alone is difficult.

Keywords drainage, peatland, colonization lot-plan, irrigation, landscape change

INTRODUCTION

A landscape is not simple scenery. An agricultural landscape is formed by interactions between the ecosystem, climate, geomorphology, and human actions (Forman & Godorn, 1986). Any particular rural area (farming village) is composed of various combinations of farmlands and land improvement facilities, including production facilities, homes for living space, rivers, ponds, forests, and other natural environmental elements. Most studies have evaluated rural areas primarily on the basis of their production function or structure and function as individual elements because production was considered the first priority in rural areas. However, sustainable development is expected because of recent changes in circumstances surrounding life in rural areas as well as agriculture. Thus, natural environments can provide a fulfilling environment based on agricultural production, which generally indicates ecosystem stability. So, the holistic evaluation considering the relationship between each element is necessary for sustainable development. There are few evaluations like this in actually. Therefore, we suggest the landscape evaluation is effective.

A landscape is formed in a rural area by various elements. Landscape evaluation is an effective method to understand the relationships among the natural environment, life, production, and other elements. We can regard the landscape as an interaction between the visible phenomena on the land surface and the land-use pattern, which exhibits a material circulation and human interaction between natures in this region. Furthermore, evaluation of these phenomena is an

effective method to understand the regional environment.

The objective of this study was to investigate landscape elements and factors observed during landscape changes as well as the problems associated with future developments.

METHODOLOGY

The target area of the study was the Shinotsu region located downstream of the Ishikari River Basin. In this area, the landscape represents the overview of pattern of land use.

We considered that investigation of land use and its patterns is an effective way to analyze the landscape. The distinguishing landscape forms and elements during each period were identified using Hokkaido soil maps (1985) and topographic maps issued by the Geographical Survey Institute as well as human actions and related projects for this area that were collected from town history and other related documents, including the history of irrigation, drainage and reclamation engineering in Hokkaido (1984), Shinshinotsu town history (1975), Tobetsu town history (1972), and others. Subsequently, a conceptual diagram was prepared from the collected data.

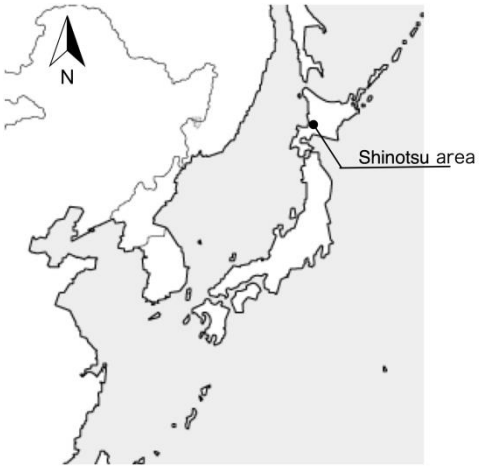

Fig. 1 Location of Shinotsu region

RESULTS

At present, an approximately homogeneous landscape, i.e., paddy fields, with a few land-use changes can be observed in the Shinotsu area. During each period, the natural landscape condition gradually changed because of policies, social and economic conditions, and progressive agricultural technology. Based on this developmental process, we considered that gradual development, factors restricting development, and human activities in the landscape differed during each period.

The elements and changing factors during each period are described as follows.

Landscape Changes, Elements, and Factors before the 1870s

Before reclamation and settlement, the region comprised a wilderness landscape with alluvial plains, hockmoor and niedermoor, forest, and river landscapes. The forest landscape was located on a neighboring hill and was characterized as a mixed forest with needleleaf and broadleaf trees. The wilderness landscape, located in the lower area, was characterized as the hinterland of the natural river basin. The wilderness landscape was formed by meandering rivers, floods, and sedimentation; thus, was considered an extension of the river landscape. This regional landscape was divided into hockmoor, niedermoor, and an alluvial plain based on its vegetation and pedogenesis.

The niedermoor formed the hinterland because of the effects of the Ishikari River. The hockmoor was formed and recharged by rain. The landscape change depends on the altitude of

hockmoor, which was relatively higher than that of the other wilderness landscapes. The alluvial plain expanded along the Ishikari River and primarily comprised fluvial deposits; the primary vegetation was broadleaf forest. The alluvial plain landscape was characterized by the positional relationships among the river, soil, and vegetation.

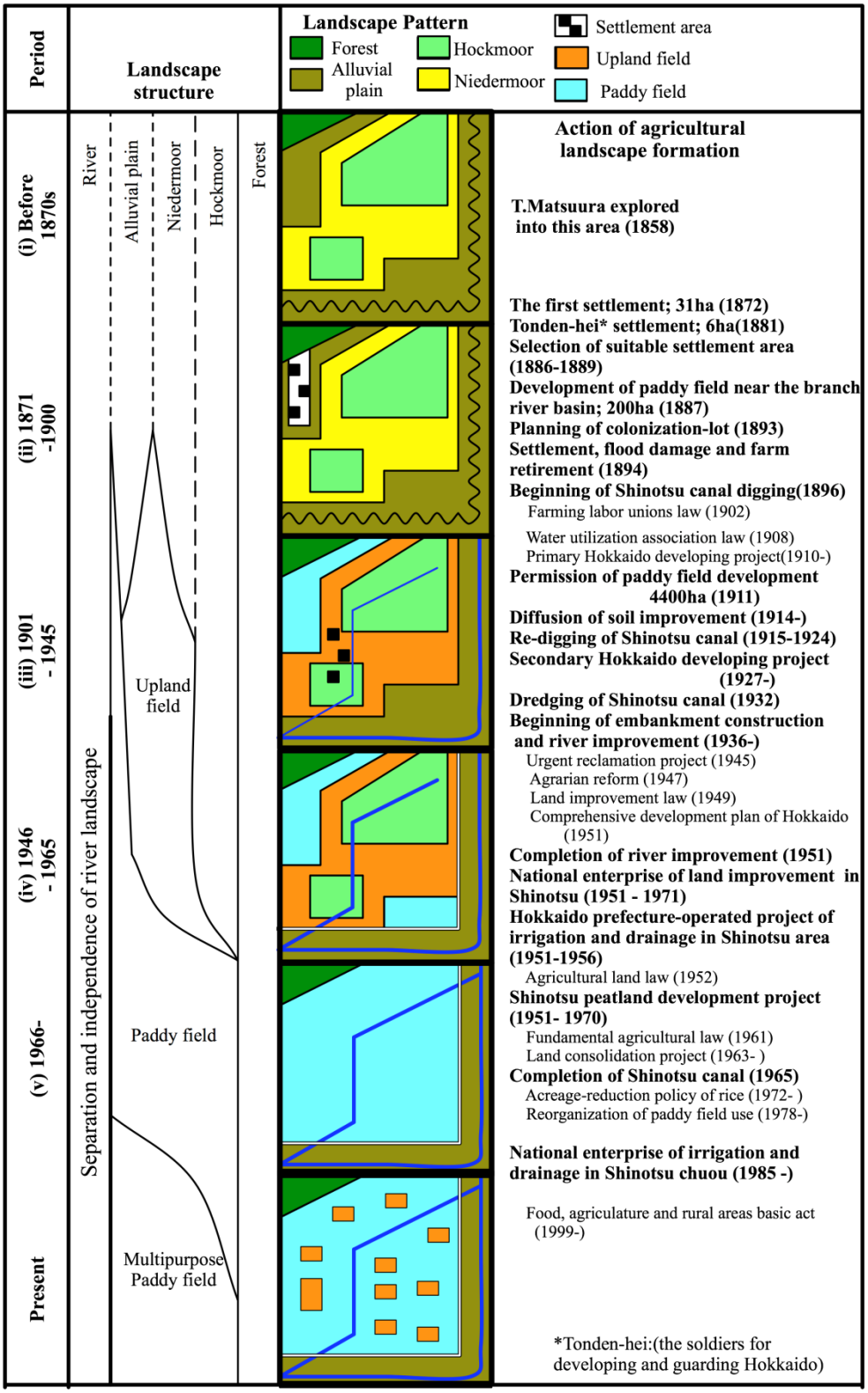

Fig. 2 Overview of landscape pattern changes

The river landscape was characterized as a primeval river with spatiotemporal changes including natural levees and former river channels.

This landscape was stable as a natural ecosystem because of an absence of human activities.

Landscape Changes, its Elements, and Factors from the 1870s to 1900

During this period, the landscape largely comprised forest, wilderness, and river landscapes. An agricultural landscape formed by settlement was observed in a part of the landscape. With the exception of the agricultural landscape, each landscape element and the interrelationships are essentially similar to those of the former period.During this period, the agricultural landscape appeared in a part of the alluvial plain forming the wilderness landscape. However, it had not widely expanded yet. Moreover, it had a small impact on the natural landscape because the settlement comprised reclaimed land and houses. Although the colonization-lot plan had been planned by the government, it is yet to be regulated.

Landscape Changes, its Elements, and Factors from the 1900s to 1945

The regional landscape included forest, wilderness, agricultural, and river landscapes. It was characterized by paddy and upland spreads. The partial paddy landscape occurred under only good settlement conditions on the wilderness landscape, and sustainable upland field landscapes were present. The paddy landscape, with intake from natural rivers, was at the border of the wilderness landscape at the foot of a hill or an alluvial plain near river branches. The paddy landscape had not expanded at this time. However, the upland field landscape had increased gradually from an alluvial plain to the boundary between niedermoor and hockmoor. A large part of hockmoor remained devoid of human intervention.

The upland field landscape expanded in the wilderness by channeling the Shinotsu Canal for drainage to dry the peatland, and constructing a grid-like road, drainage ditch, and houses designed on the basis of the colonization-lot plan. Although these fields were upland fields, the current basic constitution, such as grid-like lots and scattered houses, appeared at this stage. This upland field landscape was influenced by floods and snowmelt run off from the river and wilderness landscapes.

Landscape Changes, its Elements, and Factors from 1946 to 1965

During this period, the regional landscape was characterized by forest, wilderness, extended agriculture, and disconnected river landscapes. The river landscape was separated from the alluvial plain and the agricultural landscape was improved with embankments. The agricultural and alluvial plain landscapes were affected by hydrological influence due to advancing river water drainage caused by construction. Moreover, preventing the damage from floods by improving river embankments has enabled sustainable agricultural production; however, it requires further upgrading.

In the beginning of this period, a large part of hockmoor comprised the wilderness landscape. After drainage, land reclamation and paddy construction were enhanced. Then, the alluvial plain area decreased and changed to a paddy landscape. In addition, the upland field landscape was present with large qualitative changes. The paddy landscape appeared close to the Ishikari River and the upland field landscape decreased in size because of paddy construction on the alluvial plain. Niedermoor was used as an upland field.

Landscape Changes, its Elements, and Factors after 1965: Quantitative Changes in the Paddy Landscape

During this period, the regional landscape comprised forest, paddy, and river landscapes. The paddy landscape was homogeneous and the low-lying area was developed. Thus, most of the upland field and hockmoor landscapes changed to paddy landscape. Moreover, the wilderness

landscape disappeared during this period. The paddy landscape was formed by grid-like drainage as well as irrigation channels and roads regulated by colonization-lot planning; Houses and facilities filled these lots. The Shinotsu Canal, a dual-purpose canal, was located at the center of this area. The establishment of an irrigation system and reinforcement of the regional drainage system maintained the landscape.

This mixed area of paddy fields and upland fields changed by creating multipurpose paddy fields in the paddy landscape.

The paddy landscape has been primarily sustained by a drainage and irrigation system, which is centered on the Shinotsu Canal and takes water from the Ishikari River. Because such a system created a new watershed, a new independent landscape appeared in the low-middle part of the Ishikari River Basin.

DISCUSSION

Landscape Forming Elements and Factors

The pattern changes [from (i) to (ii)] in Fig. 2 characterize the appearance of an artificial landscape and disappearance of the natural wilderness landscape. The artificial landscape formed by reclaiming farmlands and houses appeared along the reclamation settlements. This landscape is limited to appear in a relatively convenient location that is easier and effective in the development of an alluvial plain. Moreover, it is less common in inferior drainage areas such as peatlands and lower alluvial plains. This land condition makes it easier to reclaim settlements as well as set-up water for agricultural use and houses as regulated factors of the landscape changes.

The changes from (iii) to (iv) in Fig. 2 were characterized as advanced systematic reclamation and the appearance and expansion of large-scale agricultural landscape in the niedermoor and alluvial plains. Social factors for landscape changes such as planning and implementation of colonization-lot plan form a base of agricultural development. This agricultural landscape expanded with the advancement in drainage for using the alluvial and niedermoor areas. Subsequently, the drainage specified the landscape changes during this period.

The changes from (iv) to (v) in Fig. 2 indicate a sustainable agricultural landscape which has been unaffected by floods due to river improvement, thereby upgrading the condition for agriculture with an advancement in river water drainage. Therefore, the factors specified for the maintenance of the Shinotsu Canal by the systematic improvement projects of agricultural production base are implementation or advancement of regional drainage, soil dressing in peatland, and improvement of agricultural water management systems.

CONCLUSION

We evaluated the changes in regional landscape structure from the perspective of social and natural factors. The current Shinotsu area landscape was built based on the regional natural, social, and technical conditions in a low-lying area on the Ishikari River Basin. The landscape developed because of the interaction between human actions and previous conditions. From the beginning of the settlement to the present, the regional landscape has changed gradually due to systematic and large-scale human actions. The changes in the natural and agricultural landscape structures influenced by human action were specified by the niedermoor characteristics. These changes depended on land drying by drainage. The changes to farmlands and more sophisticated farmlands occurred because of enhanced drainage. Moreover, the sustenance of drainage function can be further advanced to drain water from wilderness plain around the areas that have been drained before.

From these landscape changes, it is clear that the primarily changed elements and factors were the motivation (planning), the peatland characteristics (depending of Fudo, which is a holistic phenomenon based on the complex of interactions between factors such as climate, geography, and soil) and agricultural water-use system (tools and facilities). Furthermore, these influences are

affected by a difference in perspective or the time of evaluation. In addition, these elements and factors have an interactive effect; thus, evaluation using each element or factor alone is difficult.

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Research article

Application of Analytical Hierarchical Process Method to Select a Technology Option in Rural Settings

TUNG NGUYEN NHU*
International University - Vietnam National University, Ho Chi Minh, Vietnam
Email: nntung@hcmiu.edu.vn

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Abstract Selection of an appropriate technology in rural settings in developing countries contributes to the effective use of the scarce resources of the community and the sustainability of the system using that technology. Literature review shows that appropriate selected technologies suit difficult conditions of poor people, lessen their financial burdens, increase productivity and create wealth. This paper also introduces the application of Analytical Hierarchical Process (AHP) method in making decision on technology in rural settings. The eight-step process of AHP method is demonstrated with an illustration example of rural water supply investment based on the alternatives, criteria and priorities as judged. This new model, an application of mathematical methodology in social choice, would correct the shortcomings of other decision rules and improve the quality of decision-making process of a community in their initiatives to improve their livelihoods.

Keywords rural development, technology selection, analytical hierarchical process

INTRODUCTION

Nowadays about three quarters of 780 million people are drinking unsafe water and two thirds of this number are living in Africa and Asia (UNICEF, 2012). In order to achieve the Millennium Development Goal for Water Supply and Sanitation of the United Nations, more efforts need to be made to provide safe water to rural communities in these two continents. Fortunately, this mission is likely to be realized, at least in terms of technology as nowadays there are many water technology options, both traditional and modern. A collection of most recent water treatment technologies include solar water disinfection, coagulants/flocculants, ultraviolet treatment, reverse osmosis, ultra filtration, nanofiltration, to name some (Dalberg, 2013). Beside those advanced technologies, people can use traditional water treatment methods such as boiling water, chlorination, sand filters and ceramic filters. For each technology application, there is a corresponding type of water supply. Current popular types include piped water distribution, hand-pump well, rainwater guttering system which can be used in rural areas (Mekong Delta Water Project). Before selection of technology and water distribution type, it is important to know what community wants. How to relate the community's wants or criteria to technology options for optimal selection requires a quantitative decision model. This paper introduces the application of Analytical Hierarchical Process (AHP) technique for this purpose because the requirements for its application are met with available options and predictable criteria. With many choices presented, communities have great opportunities to make informed decision in a suitable water supply model to improve their health and even further, increase farming and irrigation productivity hence raise their income. Analytical Hierarchical Process (AHP) technique is presented as a quantitative decision technique in many operations research books and journal papers. The key to this method is pairwise comparison between alternatives in respect to each criteria and these comparisons are organized in the structural form of tree branches. The final goal is to calculate a weighted score total for each alternative and select the most optimal alternative. Saaty (1990) introduced clear basic guidelines for this calculation. Following him, some scholars proposed an extended AHN method, or fuzzy AHN technique (Abdel-Kader and Dugdale, 2001, Ertugrul Karsak and Tolga,

2001, Ordoobadi, 2012). The extended AHP method supplemented the short comings of failing to discuss uncertainties or risks in determining values for each alternative. Applications of AHN techniques can be found in much literature on investment selection, portfolio plans, technology choice, vendor or provider selection.

OBJECTIVE

The purpose of this paper is to introduce the application of Analytical Hierarchical Process (AHP) method in a decision on water technology in rural settings. This is a multi-criteria decision-making process which requires eight steps, as described in the next sections. A rural water technology is recommended as a result of applying this method given judgment values provided by top experts.

The limitation of this presented calculation is that its outputs are only accurate in case pairwise comparison is perfectly consistent. In practice, pairwise comparison is not perfectly consistent. Actually, consistency ratio should be calculated in any AHP matrices, whose calculation is explained in the work of Saaty (Saaty, 1990). The scope of this paper does not include the inconsistency ratio.

METHODOLOGY

Basic AHP methods are explained in the work of Nydick and Hill (1992). He showed calculation tables to describe step by step to reach to the final aggregated score for each supplier. Saaty (1990) listed AHP method steps as follows: 1 - identify potential alternatives; 2 - identify and classify selection criteria; 3 - Identify criteria/alternatives interdependence; 4 - Construct AHP Model; 5 - Perform pairwise comparisons to determine criteria priorities; 6 - Perform pairwise comparison to determine alternative priorities with respect to each criterion; 7 - Determine overall priority for each alternative; 8 - Select the technology alternative with the highest priority.

To illustrate this paper with a simple example, a list of three key criteria normally used for rural water supply technology selection, extracted from literature, is used. Next, from reading technical assessment on community-level water supply, three emerging rural water technology alternatives are selected based on the recommendations by water experts (Dalberg, 2013). They are solar water disinfection, coagulant/flocculants treatment and reverse osmosis. After the criteria and alternatives have been identified, top experts in rural water supply have been contacted for giving judgment values to the alternatives and criteria. This qualitative approach is called “jury of executive opinion” where the opinions of a small group of high-level managers are good enough for decision (Render, Stair, & Hanna, 2009). From personal working relationship, a UNICEF top water engineer and a former team leader of Mekong Delta Project Rural Water Project have been asked to answer the questionnaire using the survey website www.surveymonkey.com. Both of them worked as top experts in an Australia-funded water project in Mekong Delta. The team leader, who is a water engineer with more than 30 years of experience in rural water supply has responded. In the questionnaire, the respondent is asked to judge the importance level of each water technology and each criteria. The questionnaire uses 5-point Likert scale: 1 = very unimportant; 2 = unimportant; 3 = neutral; 4 = important; 5 = very important for criteria importance weights and 1 = very poor; 2 = poor; 3 = average; 4 = good; 5 = very good for other questions.

ILLUSTRATION EXAMPLE AND RESULTS

Let’s consider the following case. Suppose that a social enterprise wants to select an appropriate technology option to supply water to a community in rural Mekong Delta. This example excludes water provision at the individual household level hence eliminate technologies for this level including chlorination, sand filters, ceramic filters. A preliminary technical assessment filters out three technologies suitable to local conditions are solar water disinfection, coagulant/flocculants treatment and reverse osmosis. The overall objective is to identify the best technology which has

the highest evaluation score. Note that comparison values in the tables below are given by a top expert in rural water supply.

Step 1: Identified potential alternatives are solar water disinfection, coagulant/flocculants treatment and reverse osmosis).

Step 2, 3& 4: Criteria/alternative interdependence and AHP Model are established (Fig. 1).

Step 5: Criteria pairwise comparisons performed to determine criteria priorities (Tables 1, 2).

Let's sum up all the elements in each column to generate Column Total (Table 1). Then divide each value by its column sum. For example, the sum of all the elements in the column of item a – Low cost is 6.25. The value of the pairwise comparison between quality and itself is 1. To normalize this value, we divide 1 by the column total of 6.25 to result in 0.16 (Table 2). The last column of Table 3 shows the priority weight of each criterion, which is calculated by averaging all the values of the same row. For example, the criterion of item a - low cost is 0.16. The row average value is not different from the value previously normalized by column because the expert judgment is perfectly consistent.

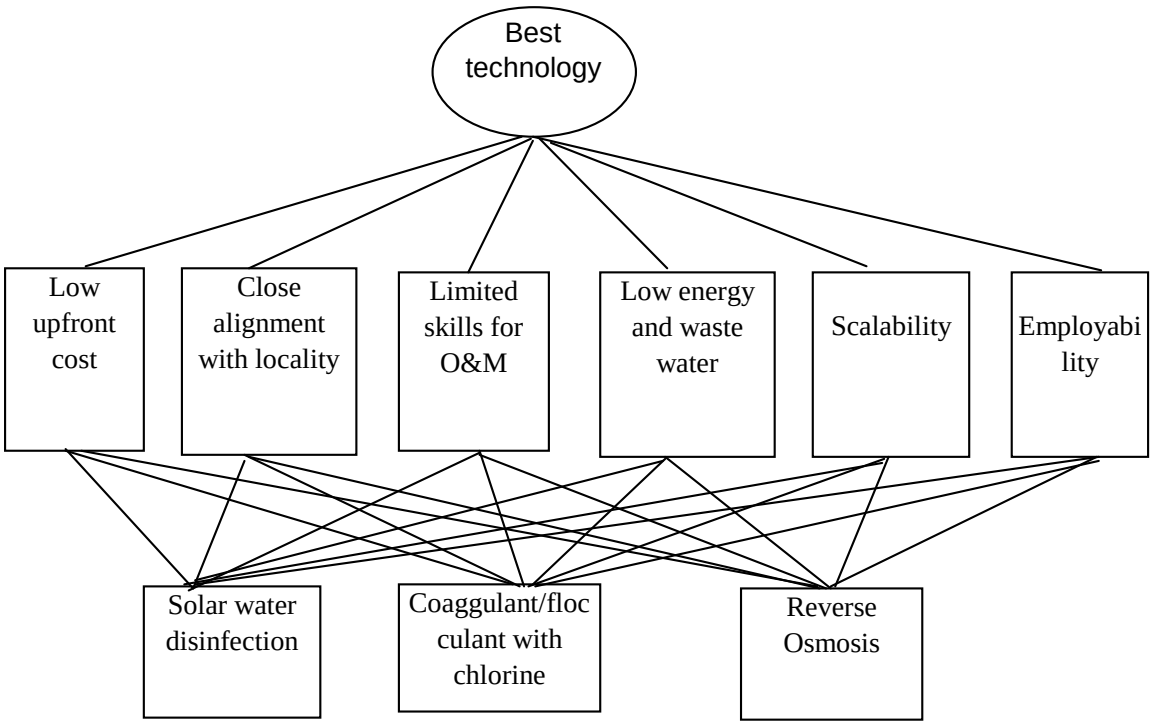

Fig. 1 The AHP model for technology selection

Table 1 Pairwise comparison of criteria - original matrix

	a	b	c	d	e	f
a. Low cost	1	4/5	4/4	4/4	4/4	4/4
b. Alignment with locality	5/4	1	5/4	5/4	5/4	5/4
c. Limited O&M skills	4/4	4/5	1	4/4	4/4	4/4
d. Low energy and waste water	4/4	4/5	4/4	1	4/4	4/4
e. Scalability	4/4	4/5	4/4	4/4	1	4/4
f. Employability	4/4	4/5	4/4	4/4	4/4	1
COLUMN TOTALS	6.25	5.0	6.3	6.3	6.3	6.3

Read: take the example of the 2nd row. The pairwise comparison between alignment with locality (item b) and low cost (item a) is 5/4. It means that the expert judged 5 points for alignment with locality versus 4 points for low cost.

Table 2 Pairwise comparison of criteria - adjusted matrix

	a	b	c	d	e	f	Priorities (Row average)
a. Low cost	0.16	0.16	0.16	0.16	0.16	0.16	0.16
b. Alignment with locality	0.20	0.20	0.20	0.20	0.20	0.20	0.20
c. Limited O&M skills	0.16	0.16	0.16	0.16	0.16	0.16	0.16
d. Low energy and waster water	0.16	0.16	0.16	0.16	0.16	0.16	0.16
e. Scalability	0.16	0.16	0.16	0.16	0.16	0.16	0.16
f. Employability	0.16	0.16	0.16	0.16	0.16	0.16	0.16
						TOTAL	1.00

Step 6: Pairwise comparison to determine alternative priorities with respect to each criterion. After we make comparison between criteria, we continue with pairwise alternative comparison. Table 3a and Table 3b show the results of priority weights after we have taken Step 5 above. For example, after column value normalization and row average, the priority weight for solar water disinfection option relative to other option is 0.396 in respect to Low cost (Table 3a).

Table 3a Supplier pairwise comparison in respect to cost, alignment to locality, O&M skills

	Cost			Alignment to locality			Limited O&M skills		
	A	B	C	A	B	C	A	B	C
A. Solar disinfection	1	5/3	1/3	1	1	4	1	5/3	5
B. Coagulant/flocculants plus chlorine	3/5	1	3	1	1	4	3/5	1	3
C. Reverse Osmosis	1/5	1/3	1	1/4	1/4	1	1/5	1/3	1
Weight	0.396	0.453	0.151	0.444	0.444	0.111	0.556	0.333	0.111

Read: Take the example of the judgment value of 1/5 between C and A in the 3rd row. It means that C is 5 times less preferable than A in respect to Cost.

Table 3b Supplier pairwise comparison in respect to low energy/waste water, scalability and employability

	Low energy and water waste			Scalability			Employability		
	A	B	C	A	B	C	A	B	C
A. Solar disinfection	1	5/3	5	1	3/4	3	1	1/2	2/3
B. Coagulant/flocculants plus chlorine	3/5	1	3	4/3	1	4	2	1	4/3
C. Reverse Osmosis	1/5	1/3	1	1/3	1/4	1	3/2	3/4	1
Weight	0.556	0.333	0.111	0.375	0.500	0.125	0.222	0.444	0.333

Table 4 Computation of overall weights

Option	Low cost	Alignment with locality	Limited O&M skills	Low energy and water waste	Scalability	Employability	Overall Weights (row total)
	0.160	0.200	0.160	0.160	0.160	0.160	
A	(0.396)(0.160)	(0.444)(0.2)	(0.556)(0.16)	(0.556)(0.16)	(0.375)(0.16)	(0.222)(0.16)	0.426
B	(0.453)(0.160)	(0.444)(0.2)	(0.333)(0.16)	(0.333)(0.16)	(0.5)(0.16)	(0.444)(0.16)	0.419
C	(0.151)(0.160)	(0.111)(0.2)	(0.111)(0.16)	(0.111)(0.16)	(0.125)(0.16)	(0.333)(0.16)	0.155

Step 7: Determine overall priority for each alternative.

After we have known the priority for each criteria and alternative, we generate the overall priority weight by making a product of these two priorities and sum all the values of the same row (Table 5). For example, Option A gets an overall priority weight of 0.426.

Table 5 Overall priority weight ranking

Alternative	Overall priority weight
A – Solar disinfection	0.426
B – Coagulant/flocculants plus chlorine	0.419
C – Reverse Osmosis	0.155

Step 8: Select the technology alternative with the highest priority: the final step is to sort the overall weights by descending order and select the alternative with the highest weight (Table 5).

The above calculated result from AHP method yields the highest overall priority weight for solar disinfection for rural water technology (overall priority weight of 0.426). This is because the expert assessed that this alternative receives the highest values for three out of six assessment criteria, i.e. alignment to local conditions, limited requirements for O&M skills, low energy and waste water, with the largest importance weight loaded on the alignment to local conditions.

In the Mekong Delta Water Project (2002-2008) all piped water schemes in communes use flocculant/coagulant technology. Several reasons can be given. Traditionally, local preliminary technical assessment engineers did not include emerging technologies like solar disinfection or reverse osmosis, in the feasibility study phase. It was because of limited capacity of local rural water centers, their ignorance of other better technologies and project time constraint, to name some. Besides, local partners are inclined to prefer a familiar technology like flocculant/coagulant technology with chlorine rather than take time to study the feasibility of a new technology which requires much time and expertise. As a result, beneficiary communities in the project are introduced with familiar coagulant technology whereas our computations show solar disinfection is better.

CONCLUSION

The AHP method is recommended for use as a multi-criteria selection model by any community committee composed of members of diverse expertise, background and possibly interests. For example, an engineer may prefer operations feasibility while a community representative favours affordability and employability. The remaining issue is how to reach this consensus among these members. Future studies need to introduce a method by which committee members can come up with a consensus. Group preference decision technique is one method of this kind. Besides, the conditions for applying this model include prior identification of suggested choices and ability of committee members in determining criteria relevant to the proposed investment, which would be a challenge in rural areas. It is strongly suggested that social enterprises use this selection approach as quantitative management. In a context where stakeholders need to know justifications of any choice made by the social enterprise in option selection, the results of this approach would show clear and scientific evidence to convince them. The limitations of this approach include a short list of alternatives meaning that if the number of alternatives and criteria is too large, it is too complex to calculate priority weights manually. In this case, it is suggested to use a specializing software Expert Choice. It is possible to properly apply the AHP method in selecting water technology because of some reasons. Firstly, the nature of a water project requires preliminary technical investigation for available water sources, normally done as part of feasibility study. As a result, a short list of technology alternatives would be proposed. It should be avoided that a project presents too many alternatives without prior technical screening step and consequently community select an option which subsequently turns out to be technically unfeasible. Secondly, the list of evaluation criteria can be enriched by consulting community members. Thirdly, for community-level water schemes, different views from engineers, community development consultants, planning experts, etc should be considered in making decisions. The AHP is a suitable and fair process to synergize these diverse but important points of view. Lastly, with emerging advanced technologies in water treatment and distribution, a community should be wise to take advantage of a technology which can help enhance farming productivity hence reduce poverty. Future studies should explore how some technologies can create employment for local people.

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Research article

Evaluation of the Ion Components for the Estimation of Total Nitrogen Concentration in River Water based on Electrical Conductivity

YURI YAMAZAKI
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

TOSHIMI MUNEOKA*
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan
Email: muneoka@obihiro.ac.jp

SACHIYO WAKOU
Department of Agriculture, Forestry & Fishery, Ibaraki Prefectural Government, Ibaraki, Japan

MASATO KIMURA
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

OSAMU TSUJI
Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan

Received 30 October 2013 Accepted 1 March 2014 (*Corresponding Author)

Abstract It is generally known that the nitrogen concentration in river water is higher in agricultural areas. However, measurement of the nitrogen concentration is time- and cost-intensive. This study estimated total nitrogen (T-N) concentration based on electrical conductivity (EC) in river water at two agricultural watersheds area which are the Tokachi area, the main land uses are upland and daily farming and the Nemuro area, the main land use is daily farming. The ion components in river water were also considered. The investigation was carried out from August to early September in 2003 to 2006 and in 2012, and T-N concentration, EC and ionic components in river water were measured. In the two areas, there was a positive correlation between T-N concentration and EC in the river water. From this result, T-N concentration was able to be estimated from EC. However, the slope of the regression line differed between the two areas. It is causally related to the effect of the ionic components, because there was a very strong correlation between the concentrations of cationic and anionic components in river water and the EC. In the Tokachi area, SO_4^{2-} and NO_3^- account for a high percentage of the anionic components. These derive from fertilizer, which correlates positively with T-N concentration. In the Nemuro area, Na^+ accounts for a high percentage of the cationic components. In comparison with sea salt, the Na^+ concentration is higher than Cl^- concentration. In addition, there was no correlation between Na^+ and T-N concentration. In the Nemuro area, the outflow of ion component of geological origin affects EC. In light of the above, T-N concentration was able to be estimated based on EC; however, it is necessary to consider the difference in the concentrations of water quality components for each region.

Keywords T-N concentration, EC, cationic components, anionic components

INTRODUCTION

Large-scale farming has long prospered in Eastern Hokkaido, whose natural environment differs from those of other Asian monsoon regions. In recent years, water contamination, including nitrate pollution of river water and groundwater, has been pointed out there (Tabuchi et al., 1995; Matsumoto and Tou, 2006).

The authors investigated the long-term river water quality in the Tokachi area and the Nemuro area, where the agricultural land use is mutually different. It was shown that the trend of nitrogen concentration in the river water differed between the two areas because of their mutually different agricultural land use (Yamazaki et al., 2013, Muneoka et al., 2013).

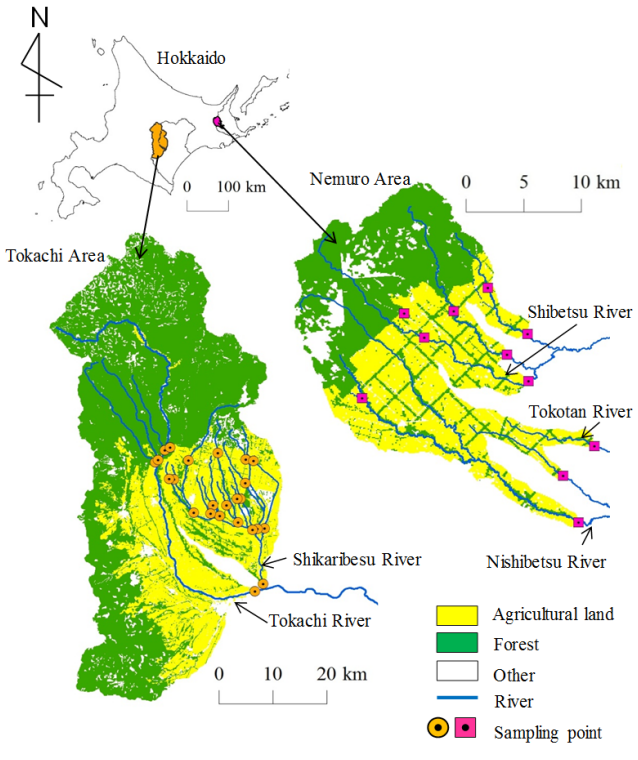
The nitrogen concentration in river water is usually measured by ion chromatography and spectrophotometry, which are time- and cost- intensive. In contrast, electrical conductivity can be measured relatively easily in the field.

This study estimated the total nitrogen (T-N) concentration based on the electrical conductivity (EC) of the river water. EC had been used to estimate the T-N concentration in irrigation water (Tomita et al., 2008). However there are not many examples of applying the method to river water.

In this study, we examined whether the T-N concentration could be estimated from EC values. To do this, based on the results of water quality investigations (2003 - 2012) in the Tokachi area and in the Nemuro area of Eastern Hokkaido, the relationship between T-N concentration and EC was expressed by using a linear regression. In addition, we considered the impact of the ionic components in river water on the coefficients of the regression line.

METHODOLOGY

The study sites are outlined in Fig. 1. The Tokachi area, which consists of 24 watersheds in the Tokachi river system and the Shikaribetsu river system (No. 1 to 24), is in the northwestern part within jurisdiction of the Tokachi General Subprefectural Bureau. It is an area of upland and dairy farming. The Nemuro area, which consists of 11 watersheds in the Shibetsu river system, the Tokotan river system and the Nishibetsu river system (A to K), is in the western within jurisdiction of the Nemuro Subprefectural Bureau. It is an area mainly of dairy farming. In both of these areas, large-scale farming has been pursued, and there have been no considerable changes in agricultural land use in either area since 1985.



Sampling Point	River name	Bridge name	Area (km^2)	Land use (%)	
				Agricultural land	Forest
Tokachi area					
1	Tokachi	Oojika	632	1	94
2	Penkenai	Pennai	23	0	98
3	Penkenikorbetsu	Penkenikorobetsu	48	2	96
4	Penkenikoro	Minamiiwamatsu	72	2	97
5	Tokachi	Nakajima	1798	21	70
6	Shikaribetsu	Urimaku	217	4	91
7	Sikanosawa	Kikuchi	5	83	13
8	Kamihoronai	Kamihoronai	3	88	12
9	Shikaribetsu	Momiji	256	13	81
10	Minami1sen	Nakashikakann2gou	13	72	17
11	Iketo	Minamisawa	9	95	2
12	Pankebibaushi	Kousui	27	90	7
13	Urimaku	(no bridge)	9	13	66
14	Poronai	(no bridge)	3	90	7
15	Urimaku	Mutsu	49	58	32
16	Penkeutorei	Honnmaki	3	88	11
17	Pankeutorei	(no name)	5	93	6
18	Pankeutorei	Komadome	17	65	25
19	Penkechin	Okuyama	26	22	49
20	Ponchin	Kamimaki	13	75	18
21	Penkechin	Isami	63	46	33
22	Pankechin	Sinnei	10	52	32
23	Pankechin	Taneuma	72	72	15
24	Shikaribetu	Kunimi	667	48	45
Nemuro area					
A	Kanjiushi	Yourouushi	11	4	71
B	Keneka	Minori	41	7	81
C	Keneka	Hakuyou	82	32	57
D	Shibetsu	Nagori	54	3	91
E	Shibetsu	Kamisibetu	82	22	72
F	Masu	Masukawa	10	32	64
G	Masu	Kenebetsu	28	49	46
H	Tokotan	Houtoku	12	81	14
I	Nishibetsu	Kousai	19	10	60
J	Nishibetsu	Nishisyunnbetsu	149	54	32
K	Pononnebetsu	Akashi	19	73	21

Fig. 1 Outline of the Tokachi and Nemuro areas

For the years 1981 to 2010, the annual mean air temperature and the yearly precipitation were 5.9 ˚C and 840.7 mm at Komaba in the Tokachi area, and 5.4 ˚C and 1158.0 mm at Nakashibetsu in the vicinity of the Nemuro area. Both areas have a relatively cold climate with less rainfall than other agricultural areas in Japan.

The investigation of the river water quality was conducted at the normal water level at 35 sampling points. EC and water temperature were measured using a digital conductivity meter at sampling points. Discharge was also measured on the rivers in small watersheds (varying between 22 and 25 by year). The investigations were carried out from late August to early September in 2003 to 2006, and in 2012. River water samples were analyzed for T-N concentration with spectrophotometer using the cadmium reduction method and chromotropic acid method.

In addition, in late August 2005, ion components of river water were analyzed. These components were Cl^-, NO_3^-, NO_2^-, SO_4^{2-}, HCO_3^-, CO_3^-, PO_4^{3-}, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+}. They were analyzed by liquid chromatography.

RESULTS AND DISCUSSION

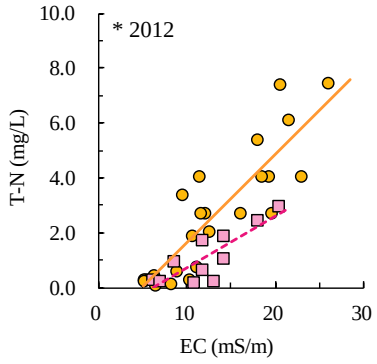
The results of the relationship between T-N concentration and EC in river water for each year in two areas are shown in Fig. 2. The graph is an example of the results for 2012 (Fig. 2(a)).

Since there was a positive correlation between T-N concentration and EC in river water through the study period in the two areas, it was possible to estimate the T-N concentration from the EC of the river water in these agricultural watersheds. The slope and intercept of the regression line were virtually constant throughout the study period in the Nemuro area. In the Tokachi area, the slope and intercept of the regression line were increased from 2005. After the full implementation of "The Law on Animal Waste Regulation" in 2004, significant increases in nitrate nitrogen concentration in river water from some sampling points in the Tokachi aera were confirmed (Yamazaki et al., 2013). The increasing trend of the slope and intercept since 2005 is considered to reflect the changes in the behavior of farmers.

The slope of the regression line is small in the Nemuro area through the study period comparing the two areas. This indicates that the increase in the EC due to change in the T-N concentration in the Nemuro area is higher than in the Tokachi area.

The coefficients of the regression line for estimating the T-N concentration from the EC in both areas were different. As reasons for the differences, the influence of the ionic components other than inorganic nitrogen can be considered. Therefore, cationic and anionic components in river water were analyzed.

In the two areas, there was a very strong correlation between the cations and anions in the river water and the EC (Fig. 3). The percentages of the cationic and anionic components in river water are shown in Fig. 4(a), (b) and Fig. 5(a), (b).



Investigated year	Tokachi area (Y = *a* X + *b*)			Nemuro area (Y = *a* X + *b*)			N.B.
	a	*b*	*r*	*a*	*b*	*r*	
2003	0.24	-0.96	0.85 ※※	0.17	-1.00	0.87 ※※	
2004	0.24	-1.25	0.80 ※※	0.17	-1.19	0.79 ※※	
2005	0.38	-1.92	0.87 ※※	0.17	-0.97	0.83 ※※	
2006 ≈ 2012	0.37	-1.65	0.92 ※※	0.19	-1.02	0.85 ※※	
	0.32	-1.60	0.87 ※※	0.19	-1.13	0.82 ※※	*

※※significnace of 1%

Fig. 2 Relationship between T-N concentration and EC in river water

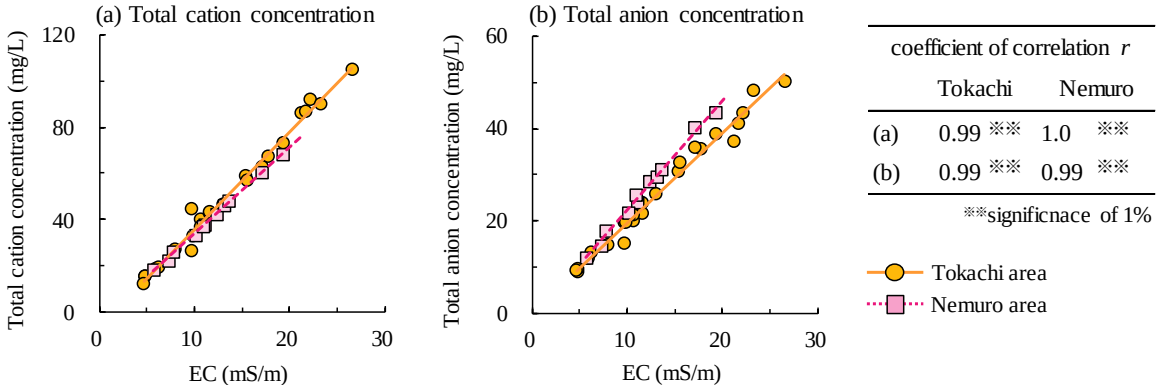
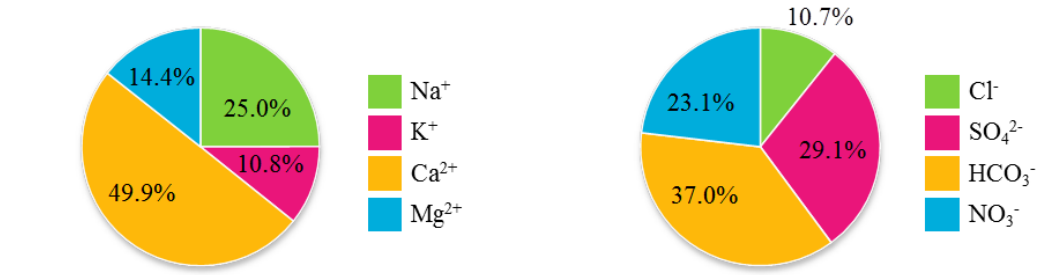


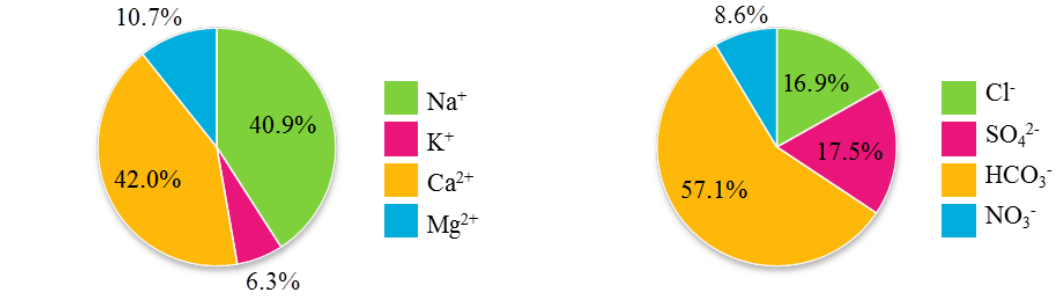
Fig. 3 Relationship between ionic components and EC in river water

Ca^{2+} and HCO_3^- are the main ionic components in the river water. The trend of the percentage of the ionic components differed between the two areas. The percentage of SO_4^{2-} and NO_3^- were higher in Tokachi area (Fig. 4(a), (b)). These components correlated positively with T-N concentration. They are derived from the outflow of fertilizer component. The runoffs of SO_4^{2-} and NO_3^- were increased, because upland farming has been practiced on a large scale in the Tokachi area. In the Nemuro area, the percentage of Na^+ is comparable with the percentage of Ca^{2+} (Fig. 5(a), (b)). In general, most of the Na^+ and Cl^- are supplied from sea salt, and the ratio of Na^+ concentration to Cl^- concentration in sea salt is 1:1.16. However, in comparison with sea salt, Na^+ concentration is higher than Cl^- concentration in the Nemuro area. In addition, the Na^+ in the Nemuro area had no correlation with T-N concentration. From the above results, why the slope of the regression line of T-N concentration and EC in the Nemuro area is smaller than in the Tokachi area, because the outflow of ionic components derived from the geological features of each area rather than agricultural origin affect the EC.



(a) Percentage of the cationic components (b) Percentage of the anionic components

Fig. 4 Percentages of the ionic components in river water in Tokachi area



(a) Percentage of the cationic components (b) Percentage of the anionic components

Fig. 5 Percentages of the ionic components in river water in Nemuro area

CONCLUSION

The relationship between T-N concentration and EC was examined for two areas of eastern Hokkaido with mutually different agricultural land use. Since there was a positive correlation, T-N concentration in river water was able to be estimated from EC, and comparing the slope of the regression line, it is different in two areas. When the ion components of river water are compared between the two areas, the percentages of SO_4^{2-} and NO_3^- in the fertilizer component are higher in the Tokachi area. In the Nemuro area, the outflow of ion components of geological origin affects EC. From the above consideration, T-N concentration was able to be estimated based on EC; however, it is necessary to consider the difference in the water quality components of each region.

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Research article

Assessment of Economics and Water Productivity of Four Crops Grown after Wet Season Rice under Differing Water Availability Conditions in Northeast Thailand

ARUNEE PROMKHAMBUT*
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kean University, Thailand
Email: arunee@kku.ac.th

JOHN S. CALDWELL
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kean University, Thailand

ANAN POLTHANEE
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kean University, Thailand

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Abstract The economic profitability and water use productivity of four crops grown after rice harvest were assessed in two sub-districts, Dong Klang (DK) with limited water availability for irrigation, and Tung Pra (TP) with greater water availability, in Kornsarn District, Chaiyapoom Province, Northeast Thailand. Three households growing dry season rice, soybean, chili and field corn were purposively selected for each crop in each area. Higher crop yields were found in TP than DK for dry season rice, soybean and field corn (5000 vs 5513 kg/ha, 1646 vs 1971 kg/ha, 3633 vs 4563 kg/ha, respectively), while chili yield was higher in DK (14917 vs. 9083 kg/ha). Fertilizer cost was the main cost for dry season rice in both areas (39-42% of total production cost), followed by labor (27-38%), but irrigation cost was higher in DK than TP (21% and 9%). Seed cost was the main cost for soybean production in DK (43%), but combined harvester was highest in TP (41%). Labor for fruit picking was the main cost for chili in both areas (80-81%), and fertilizer was the main cost for field corn (36-53%). Net returns in both areas followed a similar pattern, chili> dry season rice > soybean ≥ field corn (18,838>1,880>827>598 USD/ha in DK; 15,462>1,512>540≈585 in TP), with higher net returns in TP due to lower costs. The benefit-cost ratio was highest for dry season rice in both areas; 4.06 and 4.86 in DK and TP, respectively. However, water productivity on a yield basis was lowest for rice in both areas (0.68 and 0.75 kg/m^3 in DK and TP, respectively), and highest for field corn (0.98 and 1.23 kg/m^3 in DK and TP, respectively). Measures to reduce water use for rice, and reduce costs and improve market access of other crops could improve water productivity and farmer income.

Keywords dry season rice, soybean, chili, field corn, benefit-cost ratio, water productivity

INTRODUCTION

Rice is the main economic crop in Northeast Thailand. It contributes one third of the total national rice planted area and production. However, dry season rice production in the northeast region covered only 19% of total dry season rice area and contributed only 13% of dry season rice production nationally in 2011 (Office of Agricultural Economics, 2012). Dry season rice is typically cultivated with water supplied from large or medium scale reservoirs. Lower rainfall during the wet season leaves less water in these reservoirs, leading to low yields, crop failures, and reduced income for farmers. Due to the drought in the 2012 wet season, the Office of Agricultural Economics (2012) has predicted that the harvested area of dry season rice in the Northeast will be

reduced by 50%, resulting in 43% lower yield, in contrast with relatively stable dry season production in other regions. In years with low levels water in reservoirs, the Royal Irrigation Department (RID) warns farmers that it may not have sufficient water for late-planted dry season rice. The Department of Agriculture has promoted change to non-rice crops with lower water requirements, but many farmers continue to grow dry season rice. However, the reasons why farmers continue growing dry season rice have not been reported. In this paper, we focus on economic returns and water use productivity of rice compared to the most important non-rice crops as possible key factors in farmer crop choice decision-making. Assessment of these two factors may suggest possible ways to improve the profitability of non-rice crops.

OBJECTIVE

To compare the economics and water use productivity of 4 different crops grown after wet season rice under different water availability conditions.

METHODOLOGY

Four crops (dry season rice, soybean, chili and field corn) grown under irrigation after wet season rice harvesting were assessed based on household surveys in 2 sub-districts, Dongklang (DK) and Tungpra (TP), Kornsarn District, Chaiyaphum Province, Northeast Thailand, during 2013. These sub-districts were selected based on their higher diversity of crops grown after main season rice in a preliminary field survey of 4 sub-districts.

DK was located at a higher elevation and had limited access to irrigation water from small streams. TP was situated near the Chern River, one of the main rivers in the Northeast. Irrigation was provided by publicly-financed electric pumps along the river. Soil is finer in TP (Sandy loamy) than DK (Loamy sand). Rice is the main crop grown in the dry season in both areas.

Three households growing dry season rice, soybean, chili or field corn were purposively selected for each crop in each area, 12 farmers per sub-district and 24 farmers total. Structured questionnaires were employed to interview each farmer regarding the farmer's age and education level, types of dry season crops grown, cultural practices, yields, production costs, prices, markets, and reasons for crop selection. Group interviews with key informants (village headman, village committee members, and leading farmers) were done to obtain general village information. Descriptive statistics were calculated using the statistical package SPSS Ver.13.0 (SPSS Inc.). Spreadsheet software (Microsoft EXCEL) was used for percent analysis.

Water use productivity was expressed on two bases: monetary value per unit cost, shown in Eq. (1), and yield per quantity of water used, shown in Eq. (2), according to Pereira (2007), as follows:

$$\text{Water cost productivity} = \frac{\text{Value of crops}}{\text{Irrigation cost}} \quad (1)$$

$$\text{Water use productivity} = \frac{\text{Crop yield}}{\text{Total seasonal water use crop}} \quad (2)$$

Water requirements for rice (http://www.rid.go.th/attatch_branch/qrice.html) and field corn (http://www.rid.go.th/attatch_branch/qcorn.html) were obtained from the Royal Irrigation Department, while the water requirement for soybean was taken from the Agricultural Research Development Agency (http://www.arda.or.th/kasetinfo/north/plant/soy_water.html).

RESULTS AND DISCUSSION

Farmer Characteristics

Farmer's average ages were similar in both areas (46 years in DK and 48 years in TP). Fifty-eight

percent of respondents in DK had finished elementary school, considerably less than 83% in TP. The average number of household laborers was 2.33 and 2.00 persons/household in DK and TP, respectively. These numbers are lower than average number of farm laborers per household of the province (2.86) and nationally (2.88) (Office of Agricultural Economics, n.d.).

Table 1 Planted area and yield of crops grown after wet season rice under irrigation in Dongklang (DK) and Tungpra (TP) sub-districts, Kornsarn Distict, Chaiyaphum Province, Northeast Thailand

Crops		Dongklang		Tungpra	
		Planted area (ha/household)	Yield (kg/ha)	Planted area (ha/household)	Yield (kg/ha)
Dry season rice	Average	0.91	5,000	0.85	5,513
	SD	0.24	1,875	0.49	642
	C.V.(%)	27	38	57	12
Soybean	Average	1.97	1,646	0.96	1,971
	SD	1.40	377	0.32	104
	C.V.(%)	71	23	33	5
Chili	Average	0.45	14,917	0.32	9,083
	SD	0.05	2,097	0.00	1706
	C.V.(%)	10	14	0.00	19
Field corn	Average	0.61	3,633	0.97	4,563
	SD	0.36	1,670	0.26	1,013
	C.V.(%)	59	46	27	22

Source: Field survey, 2013.

Yields and Planted Area of Crops Grown after Wet Season Rice

Higher planted areas per household of each crop except field corn were found in DK compared to TP (Table 1). This may be due to more labor availability, or because less favorable conditions in DK leads farmers to expand planted area in order to get more total production despite lower yields.

Yields of dry season rice, soybean and field corn were 10%, 20%, and 26% higher, respectively, in TP than DK (Table 1). This may be due to more favorable conditions in TP than DK. However, chili yield was 39% higher in DK than in TP. This is partly due to the longer harvest period of chili in DK due to its higher elevation. Farmers start growing chili soon after wet season rice and continue harvesting until rice planting in July for the next wet season in DK, while in TP farmer's have to stop harvesting chili in June due to excess soil moisture at its lower elevation.

Production Cost of Crops Grown after Wet Season Rice

Both sub-districts had similar patterns of production costs for all four crops. In both sub-districts, chili production cost was approximately 10 times or more higher than other crops, followed by field corn and dry season rice, and lowest in soybean (Tables 2 and 3). The fact that the production cost of soybean was lowest of the four crops contradicted farmer's stated expectations. A higher share of costs at the start of the season may influence farmer perceptions more than costs later in the season.

The factors contributing most to production costs differed among the four crops, but the patterns for each crop were similar between the two sub-districts. Fertilizer was the most important production cost for rice (42% of total cost in DK, 36% in TP) and field corn (36% in DK, 53% in TP). The greater proportion of cost allocated to fertilizer in TP indicated that field corn production was more intensive in TP than in DK, likely reflecting greater water availability in TP. Seed costs and land preparation were second and third in importance for field corn. More farmers indicated that good land preparation is crucial for seed germination. However, combined harvester was second in importance in contribution to rice production costs (27% in both DK and TP) (Tables 2 and 3).

Table 2 Production cost of crops grown after wet season rice under irrigation in Dongklang (DK) Sub-district, Kornsarn Distict, Chaiyaphum Province, Northeast Thailand, 2013

List	Dry season rice		Soybean		Chili		Field corn	
	Cost (USD/ha)	%	Cost (USD/ha)	%	Cost (USD/ha)	%	Cost (USD/ha)	%
Land preparation	36	7.3	1	0.3	208	2.9	102	19.7
Seed	-	-	177	43.5	239	3.3	104	20.1
Fertilizer	208	42.1	28	6.8	526	7.3	187	36.1
Fungicide/insecticide	-	-	-	-	218	3.0	-	-
Crop stimulants	-	-	-	-	82	1.1	1	0.1
Herbicide	8	1.7	-	-	6	0.1	14	2.6
Labor	-	-	-	-	5,775	80.0	32	6.3
Combined harvester	134	27.0	153	37.5	-	-	-	-
Irrigation	2	21.5	5	10.7	-	2.4	23	10.5
Transportation to market	106	0.5	44	1.2	169	-	54	4.4
Cost of production	495	100.0	407	100.0	7,223	100.0	517	100.0

**Production costs excluding family labor cost. Crop stimulants include plant growth regulators and liquid fertilizer. USD=US dollars*

Table 3 Production costs of crops grown after wet season rice under irrigated area at Tung pra (TP) Sub-district, Kornsarn Distict, Chaiyaphum Province, Northeast Thailand, 2013

List	Dry season rice		Soybean		Chili		Field corn	
	Cost (USD/ha)	%	Cost (USD/ha)	%	Cost (USD/ha)	%	Cost (USD/ha)	%
Land preparation	64	13.2	6	2.3	149	2.9	64	11.7
Seed	21	4.4	61	23.2	233	4.5	96	17.6
Fertilizer	190	39.1	4	1.6	297	5.7	290	52.9
Fungicide/insecticide	2	0.3	6	2.1	132	2.5	-	-
Crop stimulants	-	-	6	2.3	7	0.1	-	-
Herbicide	10	2.1	4	1.6	19	0.4	-	-
Labor	-	-	21	7.9	4,194	80.6	54	9.8
Combined harvester	132	27.1	88	33.1	-	-	-	-
Irrigation	24	9.1	11	21.8	-	3.3	7	6.8
Transportation to market	44	4.9	58	4.2	172	0.0	37	1.3
Cost of production	487	100.0	265	100.0	5,203	100.0	548	100.0

**Production costs excluding family labor cost. Crop stimulants include plant growth regulators and liquid fertilizer. USD=US dollars*

For soybean, seed and combined harvester costs were the two most important costs, with seed costs higher in DK but combined harvester higher in TP. In DK, farmers did not keep their own seed for next season, but in TP, one farmer used his own seed produced in an upland area. This indicates by saving their own seed farmers can lower production costs for soybean. Hired labor cost comprised approximately 80% of the cost of chili production in both sub-districts (Tables 2 and 3).

The sub-districts differed in the relative importance of irrigation water costs. In DK, with less water availability, the highest proportion of production cost spent for irrigation was for rice (21%). In TP, with greater water availability, the highest proportion spent for irrigation was for soybean (22%) (Tables 2 and 3). Higher water use for soybean in TP was reflected in higher yields (Table 1). This indicated that improved access to irrigation water can make non-rice crops more viable..

Returns of Crops Grown after Rice

In both locations, net returns was 10-fold or higher in chili (15,462-18,838 USD/ha), followed by dry season rice (1,512-1,880 USD/ha). In TP soybean was ranked third (827 USD/ha) followed by

and higher yield per area. The high returns of chili were due to its high price (Fig. 1). Nevertheless, using price as the major criteria for crop selection may not be appropriate, due to its greater price fluctuation as seen in Fig. 1. This may be the reason why farmers did not grow chili as their secondary crop, or grew chili as one of 2 or 3 crops.

The benefit-cost ratio (BCR) was highest for dry season rice in both areas, 4.06 and 4.86 in DK and TP, respectively. This was higher than chili despite its much greater net returns, reflecting the much lower production cost of rice. Nevertheless, all 4 crops had BCR values higher than 1, indicating that all crops were profitable for farmers.

However, among the 4 crops chili had the highest water cost productivity, with similar values in both areas (Table 4). Water cost productivities of the same crop differed between the two sub-districts, reflecting different costs of water. For example, with limited access to water and resulting higher cost (DK), rice had the lowest value (18.9) of the 4 crops. However, where water costs were less (TP), water cost productivity was higher (53.5). However, when the cost of water is disregarded and only the amount of water used is considered, water yield productivity was highest for field corn, followed by soybean, and lowest for rice in both areas. This finding confirms that dry season rice uses more water than other crops. Unfortunately, in the absence of data on the water requirements of chili, we cannot compare chili water yield productivity.

Table 4 Partial budgeting (USD/ha) of crops grown after wet season rice under irrigated area at Dongklang (DK) and Tungpra (TP) sub-district, Kornsarn distict, Chaiyaphum province, northeast Thailand

List	Dongklang				Tungpra			
	Dry season rice	Soybean	Chili	Field corn	Dry season rice	Soybean	Chili	Field corn
Total cost	495	407	7,223	517	487	265	5,203	548
Gross return	2,007	946	22,685	1,102	2,367	1,093	24,028	1,147
Net return	1,512	540	15,462	585	1,88	827	18,838	598
BCR	4.06	2.33	3.14	2.13	4.86	4.12	4.62	2.09
Water cost productivity	18.91	21.72	133.88	20.25	53.46	15.73	139.80	30.59
Water yield productivity	0.68	0.78	NA	0.98	0.75	0.94	NA	1.23

BCR= Benefit-cost ratio, water cost productivity =yield value (USD)/water yield productivity (USD), water use= crop yield (kg/area)/total water use (m^3/area), NA= not available and USD=US dollars

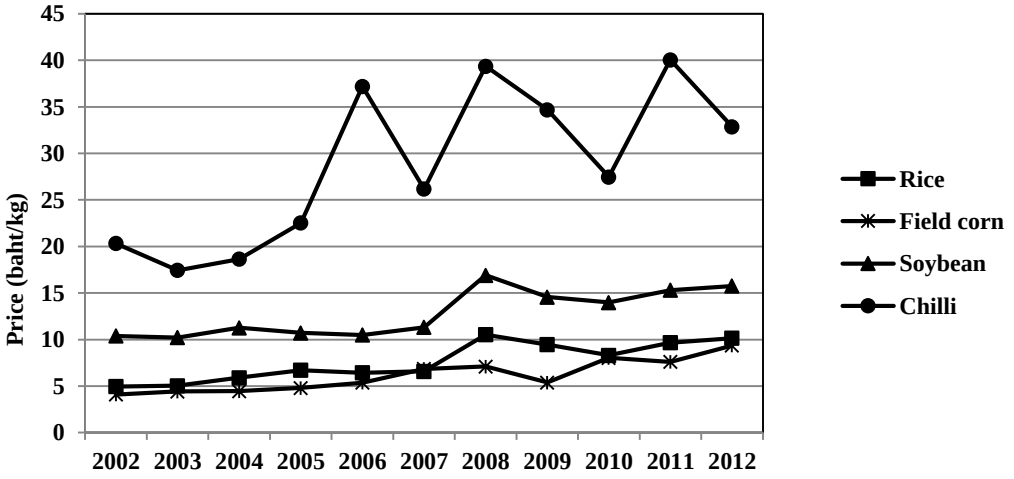

Fig. 1 Farm gate price of crops in this study in Thailand during 2002-2012
Source: Office of Agricultural Economic (n.d.)

CONCLUSION

In the introduction to this paper, we indicated that this study sought to answer the question, why do farmers continue to grow dry season rice despite the problems they faces due to insufficient water resulting from frequent droughts in the Northeast. Many factors may affect farmer's decisions to continuing growing rice. As a first step in identifying which factors are most important in crop choices, we assessed four dry season crops following wet season rice, dry season rice, soybean, chili, and field corn, using four measures: net returns, BCR, water cost and water use productivity. Net returns analysis indicated that chili was the most profitable, while dry season rice was second in net returns, exceeding soybean and field corn in both areas. However, BCR was highest in dry season rice in both areas compared to chili. The high BCR of rice thus may be the reason why farmers continue to grow dry season rice. However, in terms of water use efficiency, dry season rice is not the most efficient crop, and its water cost productivity is poorest when water costs are high. Measures to reduce water use in dry season rice in areas with poor water availability, and reduction of production and market constraints for other crops, may enable farmers to obtain higher water productivity and greater net returns from dry season second crop production. The effect of these measures should be assessed in relation to differences among farmer's in levels of education and household labor availability, those two factors which this study did not evaluate. Development of a decision-tree model based on BCR, water availability, and other potential factors could be a useful tool for extension and farmer group leaders.

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Research article

Effect of Calcium Ascorbate Treatments on Juice Leakage of Fresh Cut Watermelon (*Citrullus lanatus*)

INTIRA LICHANPORN*
Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, Phathum Thani, Thailand
Email: lintira@yahoo.com

NUNCHANOK NANTHACHAI
Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, Phathum Thani, Thailand

PALIDA TANGANURAT
Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, Phathum Thani, Thailand

UNCHALIN SINGKHUM
Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi, Phathum Thani, Thailand

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Abstract Before cutting, melons were washed with sodium hypochlorite (100 ml/l active ingredient) and water rinsed. Melons were cut longitudinally into four parts, cut into triangles 2 cm thick. A piece of watermelon was chosen from the center. Watermelon slice were dipped in calcium ascorbate (CaAsc; 0, 1, 5, 10 and 20%, w/w) for 2 minutes and drained. Fresh-cut watermelon was arranged in foam trays with 4 pieces per tray, covered with plastic polyethylene (LLDPE) film and stored at 10°C with relative humidity of 90-95%. At each storage interval, melon slices were evaluated for weight loss, changes in color (L*, a* and b*), total soluble solids and juice leakage. Dipping fresh-cut watermelon slices in 5, 10 and 20% CaAsc increased the weight loss up to 9.73 12.83 and 13.65% respectively, compared with watermelon dipped in 0 and 1% CaAsc, which only experienced 4.88 and 4.10% of weight loss after storage for 8 days. Percent juice leakage in fresh-cut watermelon dipped in 1 and 5% CaAsc was less than the other treatments. The effect of calcium ascorbate on the changes of color and total soluble solids were not significantly different. However, fresh-cut melon dipped in 1% CaAsc tended to reduce the changes of weight loss and juice leakage better than other treatments.

Keywords watermelon, calcium ascorbate, juice leakage

INTRODUCTION

Fresh-cut watermelon is sold as quarters and halves with rind, or as cubes without rind. Quality degradation of fresh-cut watermelon has been described as loss of texture, color, and sweetness (Rushing et al., 2001). Juice leakage in fresh cut watermelon can increase as a result of cube size, storage temperature, or modified atmosphere. Fonseca et al. (1999) found that cubes of length <1.9 cm had more juice leakage due to cut surface injury, while cubes >4 cm in length had more juice loss from compression. Water-soaked appearance of watermelon is an ethylene-induced phenomenon characterized by softening and maceration of the endocarp and the placenta tissues (Risse and Hatton, 1982; Elkashif and Huber, 1988a, 1988b). Water-soaked tissue is characterized by enhanced solute leakage, degradation of pectic polymers, cell separation, and loss of cell wall rigidity (Elkashif and Huber, 1988a, 1988b). The induction of water-soaking and the related increases in softening and cell leakage by ethylene parallel the role of this growth regulator in

ripening; Calcium plays a pivotal role in cell signals related to AOS (Bhattacharjee, 2005). Calcium dips have been implicated in enhancing membrane stability, slowing senescence, and improving the retention of membrane integrity (Picchioni et al., 1996). The softening rate is related to Ca levels in the fruit tissue (Fallahi et al., 1997). For this reason, Ca dips have been used as firming agents to extend post harvest life of several products. Firmness and resistance to softening, resulting from addition of Ca, have been attributed to the stabilization of membrane systems and formation of Ca pectate, which increases rigidity of the middle lamella and cell walls, leading to increased resistance to polygalacturonase (PG) activity and to improved turgor pressure (Mignani et al., 1995). Ca ions form intermolecular bridges by interaction with free car- boxyl groups of pectic acid polymers to form insoluble salts with ionic linkages between pectin molecules (McFeeters and Fleming, 1991). Ca application often results in reduced incidence of physiological disorders and decay (Garća et al., 1996). Therefore, in this study we determine the effects of calcium ascorbate (CaAsc) dips, subsequent storage time and a maintained modified atmosphere condition on juice leakage of fresh-cut watermelon.

OBJECTIVE

The objective of this study was to determine effects of calcium ascorbate treatments on juice leakage of fresh cut watermelon (*Citrullus lanatus*).

METHODOLOGY

Watermelon (*Citrullus lanatus*) fruit was purchased from a commercial market in Phathumtani province in Thailand. Before cutting, melons were washed with sodium hypochlorite (100 ml-*l^{-1} active ingredient) and water rinse. Melons were cut longitudinally into four parts, and then cut into triangles 2 cm thick. A piece of watermelon was chosen from the center. Watermelon slices were dipped in calcium ascorbate (CaAsc; 0, 1, 5, 10 and 20%, w/w) for 2 minutes then removed. Fresh-cut watermelon was arranged in foam trays with 4 pieces per tray and covered with plastic polyethylene (LLDPE) film and stored at 10°C with relative humidity of 90-95%. At each storage interval, melon slices were evaluated for changes in color (L*, a* and b*), total soluble solids, juice leakage and weight loss.

Watermelons from each treatment were weighed individually before and during the storage period, and the percentage of weight loss was calculated using the equation by:

$$\text{Totalweight loss}(\%) = \left[\frac{\text{initial weight of fruit - initial weight of fruit}}{\text{initial weight of fruit}}\right] \times 100 \qquad (1)$$

Colorimeter measurements were made at days 0, 2, 4, 6 and 8 on eight random cubes per container replicate using a chromameter with an aperture of 8mm diameter, D65 illuminant, and CIE *L**, *a**, *b** color scale, (Minolta CR200, Ramsey, NJ).

Percent juice leakage was determined by weight after each storage interval, using the formula

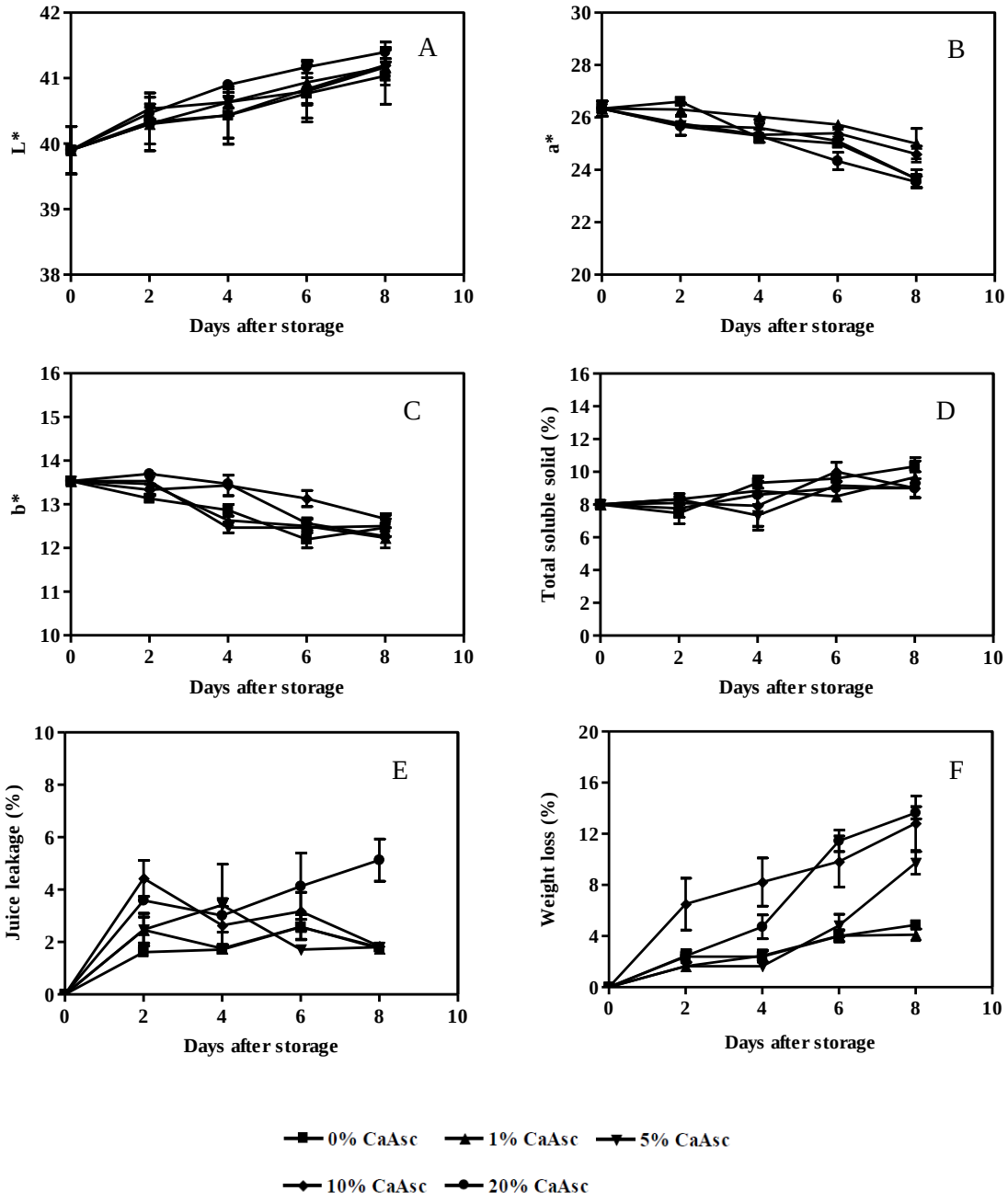
$$\text{Percent juice leakage}(\%) = \left[\frac{(\text{container} + \text{Juice wt.}) - \text{container wt.}}{(\text{container} + \text{fruit wt.}) - \text{container wt.}}\right] \times 100\ \% \quad (2)$$

Total soluble solid (TSS) from fruit juice was measured by a digital refractometer (PAL-1, Atago, Tokyo, Japan). The units of TSS were expressed as a percentage.

RESULTS AND DISCUSSION

Watermelon treatment dipped in 0, 1, 5, 10 and 20% CaAsc were not significantly different in regards to brightness (L*) throughout storage (Fig. 1A). The lack of predictive power using reflectance tristimulus colorimetry to determine lycopene content in watermelon flesh has been previously reported and is thought to be due to the lack of instrument sensitivity (Perkins-Veazie et

al., 2001). While, a* value is the redness, which was found to have decreased slightly during storage (Fig. 1B). The b* values, the blueness was reduced slightly as a result of the oxidation process and deterioration (Perkins-Veazie and Collins, 2004) (Fig. 1C). Fresh cut watermelon dipped in 0, 1, 5, 10 and 20% CaAsc showed a slight increase in the total soluble solid throughout storage (Fig. 1D). The total soluble solids in the range from 7.33 to 10.33%, is consistent with the research of Perkins-Veazie and Collins (2004). They found that the total soluble solids of watermelons, cv Summer Flavor 800 and Sugar Shack, that were cut into 5 cm pieces were in the range of 11.4 to 12.2%. The juice leakage of fresh cut water melon increased rapidly in the first 2 days (Fig. 1E), this may be a consequence of the increase of tissue decomposition.



L (A), a* (B), b* (C), Total soluble solid (D), Juice leakage (E), Weight loss (F)*

Fig. 1 Effects of calcium ascorbate on quality of fresh cut watermelons

Juice leakage is not a desirable characteristic in fresh cut watermelons, as the juice gives the tissue a water-soaked appearance, and provides an excellent medium for microbial growth (Cartaxo and Sargent, 1997). Juice leakage in fresh cut watermelon can increase as a result of cube size, storage temperature, or modified atmosphere. Fonseca et al. (1999) found that cubes of length <1.9 cm had more juice leakage due to cut surface injury, while cubes >4 cm in length had more juice loss from compression. Sargent (1998) found that fresh cut watermelon cubes held at 1°C had 50% more leakage than those held at 3 °C, and concluded that this difference was due to chilling injury. Cartaxo and Sargent (1997) reported that juice leakage increased from 10 to 20% in fresh-cut watermelon stored 5 days at 3 °C under actively maintained atmospheres of O_2, 3 kPa, plus CO_2, 5–20 kPa, compared to that stored in an ambient environment. The percent leakage found in our study was similar to that reported by Fonseca et al. (1999) for non-compartmentalized Sangria watermelon cubes. Although the 5% CaAsc treatment slightly decreased the percent juice leakage in fresh -cut watermelon, fresh-cut watermelon dipped in 1% CaAsc tended to reduce the changes of weight loss and juice leakage better than other treatments. The weight loss of fresh cut watermelon dipped in calcium ascorbate concentration of 1% was not significantly different from the control (Fig.1F). However, fresh cut watermelon dipped in 1 and 5% CaAsc had more weight loss than controls during the first 2 days of storage. The properties of calcium increased the firmness. Dipping in calcium ascorbate will reduce the loss of firmness in apples stored by approximately 13 % after 3 weeks at 10 ºC (Fan et al, 2005).

CONCLUSION

Calcium ascorbate affected the changes of color (L* a* b*) and total soluble solids in fresh cut watermelon. Dipping with 1% calcium ascorbate decreased the weight loss and juice leakage. A dipping treatment in 5, 10 and 20% calcium ascorbate increased the weight loss and juice leakage more than the control of fresh cut watermelon.

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Research article

Education for Sustainable Development in Agriculture at Primary Schools

VICHEKA LORN*
Graduate School of Agricultural Sciences, Royal University of Agriculture, Phnom Penh, Cambodia
Email: vichekalorn@yahoo.com

MOM SENG
Royal University of Agriculture, Phnom Penh, Cambodia

BUNTHAN NGO
Royal University of Agriculture, Phnom Penh, Cambodia

LALITA SIRIWATTANANON
Association of Environmental and Rural Development, Pathum Thani, Thailand

MACHITO MIHARA
Tokyo University of Agriculture, Institute of Environment Rehabilitation and Conservation, Tokyo, Japan

Received 1 October 2013 Accepted 20 March 2014 (*Corresponding Author)

Abstract Even a small plot or container garden applying sustainable agriculture can help children learn basic ecological principles. In urban living, a garden maybe the best connection for young people to nature; especially it may affect to their community, making the connection between suitable agriculture and their parents or their future activities. The study was conducted to access the perception of school children at primary school through the series of training provided towards sustainable agriculture and environmental education. Series of training were delivered to school children selected from five primary schools: two from Prey Chhor district, Kampong Cham province and other three from Phnom Penh. Totally, there were about 200 children that participated from the selected primarily schools in each training. Before and after the training provided, as well as interviews at each step, the understanding of school children on sustainable agriculture and environment was evaluated; the results showed that the understanding of composting materials were increased, also the perception and the motivation increased with the training including practical demonstration. Noticeably, after the training on compost making, school children had learned the ways of how the compost is made and what the chemicals meant to them and their communities. We also observed that a number of school children started to collect the organic materials for their school's compost boxes. Moreover, the results from their vegetable gardening gave evidence that the understanding of school children on agriculture and environment was increased and it was applicable to their villages and the communities close to their places. Based on the findings obtained and our observation, the series of training on sustainable agriculture and environment to school children at primary schools are effective to the rural villages for their livings and income generation. This may be also helpful to the community effort in sustainable agriculture and environment as a whole.

Keywords food safety, trained and non-trained pupils, knowledge transferring

INTRODUCTION

The effort towards the environment and sustainable agriculture has to involve all people in the community, experts and policy maker. Childrens knowledge on the subject plays an important role

by influencing the daily life and farm practices of their parents as well as their future activities. Even though, farmers still using chemical fertilizers and pesticides in farmlands to increase agricultural productivity. The application of chemical fertilizers and pesticides in developed countries and developing countries have been causing serious environmental problems for some time (Mihara and Fujimoto, 2007). Educators focused on schooling for sustainability, a vegetable garden is the best starting place. Children can care for other living things, learn ecological principles, experience the joy of nature, make connections between science and social studies and use all their senses, thus pupils will know the balance between living and surviving through a hands-on relationship with another living organism. Students gain a better understanding of how gardening and farming practices affect the environment, and how they can improve both soils and the quality of their food (Biological Farmers of Australia, 2009). It is a way to understand an educational process on a daily basis (Center for Ecoliteracy, 2004-2011). To conclude, the topic of this study is to investigate the children's acceptance of knowledge on sustainable agriculture and environment.

METHODOLOGIES

The study was conducted at 6 primary schools and was divided into two groups, the first (ReseySai, Prey Veng and Prey Sar) was accepted the training about sustainable agriculture and environment since 2006 until 2011, and the second (Prek Speu, Toul Rokakos and Tro Pangsela) was not accepted. These schools are located at the edge of Phnom Penh city, Prey Sar and Prey Veng commune, Dang kor district, Cambodia. These areas are capital cities of Cambodia and it has a largely free land to conduct agriculture. So people here can be called farmers. There were 363 pupils from six primary schools interviewed using structured questionnaires. Among them, 164 joined the training courses whereas the rest did not. Key questions were applied with the students are: the pupils acceptance of the knowledge of agriculture and environment; how this important knowledge for the pupils thinking, and how the pupils can be in the core play role of extension? During the study, some experimental materials were also provided by the trained schools, were seeds, compost boxes, and organic gardens.

RESULTS AND DISCUSSIONS

Rehabilitation and sustentation of the agriculture and environment, using the sustainability of natural resources, and reflecting very clearly on a good environment, explaining to farmers and pupils to understand the importance of agriculture is a measure in the conservation work. Practice of the organic agriculture was increased through creating a series of compost centers, model organic farming and training courses. Based on the study, the range of pupil's age is from 11-15 years old. The pupils are the future guardians of the world. Sharing the knowledge will provide the younger generation with the skills and they need to face the challenges of producing delicious and healthy food. There are many workshops at the trained school, namely: water quality control, agricultural land improving, planting technology, compost making and bio-extract making. Depending on the training of materials for making compost (Fig. 1), the trained group can make compost by themselves; they can practice at their house which opposite from the non-trained group.

Knowledge on suitable agriculture and environment shown in table 1, notified that the trained pupils have a high acceptance of agro-forestry, mixed cropping, rotation crop, benefit from using organic fertilizer and bio-extract (97%), whereas the non-trained pupils accepted the 26%. In addition to this, the trained pupils can get a lot of experiences about crop technology related soil quality by enjoying organic farming with their hand-plantings.

Beside the materials for making compost, each step for making fertilizer is also important (Table 2). Digging a pit or building a compost box, putting plant residues in the pit or compost box as a layer, putting farmyard manure in the pit or compost box alternative with plant residues layers, pouring water until the materials become moist, covering the pile with plastic or thatch to protect from rainfall, and mixing the materials in the pit every week are the necessary knowledge for how

compost can be made. The trained students gave the best answers, whereas the non-trained students even though chose the right answers it was limited.

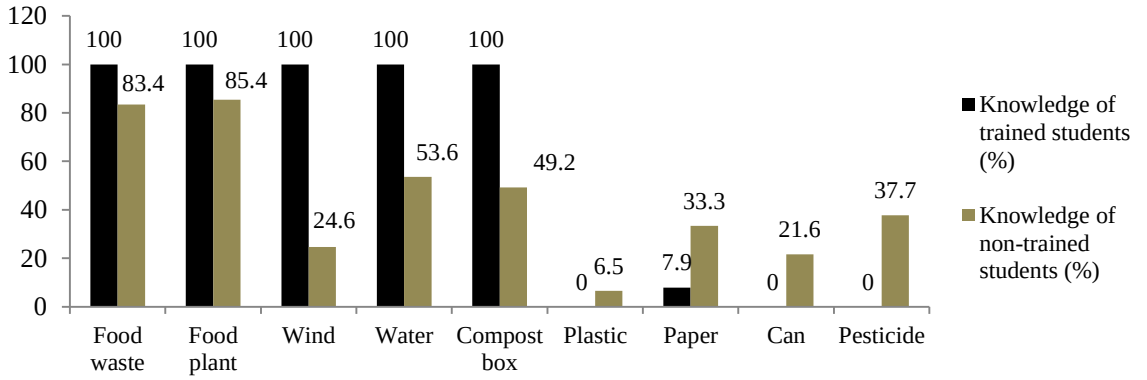

Fig. 1 Materials for making compost

Table 1 General education on suitable agriculture and environment

Description		Agro-forestry	Mixed crop	Rotation crop	Benefit from using organic fertilizer and bio-extract
Understanding of trained students (%)	Yes	95.1	95.7	98.8	100
	No	4.9	4.3	1.2	-
Understanding of non-trained students (%)	Yes	-	18.1	16.1	26.1
	No	100	81.9	83.9	73.9

Table 2 Each step for making compost

Each step for making compost	Understanding of trained students (%)	Understanding of non-trained students (%)
Dig a pit or build a compost box	100	100
Put plant residues in the pit or compost box as a layer	100	94
Put farmyard manure in the pit or compost boxalternative with plant residues layers	100	86.4
Put stone in the pit or compost box	-	30.2
Pour water until the materials become moist	100	-
Pour water until the materials become soaking wet	-	100
Cover the pile with plastic or thatch to protect from rainfall	100	44.7
Mix the materials in the pit or compost box every week	93.3	48.2

In addition to this, the trained group added that farmers should reduce the use of chemical fertilizer (100%) and use organic fertilizer instead of (100%) because when they apply organic fertilizer to the crop, there is no concern to their health. And non-trained group responded that reducing of chemical fertilizer will cause crops not growing well (81.9%). Moreover, 54% of the non-trained group answered that the application of chemical fertilizer will improve soil fertility while 93% of trained group mentioned that soil fertility will be degraded. Regarding to varieties of insect (for diversity of insect pest), the non-trained group showed that it is increase (65.3%), and the trained group also showed that it is decrease (93.3%). However both groups stated that it is not difficult to reduce the application of chemical fertilizer. This result can express that the trained group is easy to understand about disadvantage of chemical fertilizer while more higher understanding than the non-trained group. Acknowledgement of chemical disadvantage should be the best education for all people; it can lead farmers to lessen the amount of chemical fertilizer, and it can encourage customers to think about food safety. Relating to the effect of environmental pollution on public health, the trained group understands the effect whereas non-trained group only 54% of them understands. To reduce the amount of organic waste, recycling the waste into other materials is a main solution like recycling organic wastes into organic fertilizers. Farmers can apply organic fertilizers or compost fertilizers to the field to build a good soil quality and can bring the

food safety as well as the fresh environment. The farmers can have more benefits when they apply organic fertilizers because there is no need of much money like with chemical fertilizers, and all farmers can also learn how to produce high quality of organic fertilizer by themselves easily. Therefore, basing on safety feeling of using organic fertilizers, 100% from the trained students have a very strong confident on safe fertilizer because many theories were provide, it is an essential idea to promote their thinking at the present and in the future. Only 38.2% from the non-trained students have safety feeling. This understanding of organic fertilizer of non-trained students was got from outsides, including their families, friends and neighbors. The best information brings them to understand a lot about conservation of suitable agriculture and environment. The rest of non-safety feeling 61.8%, since they did not get a lot of information about a good practice of sustainable agriculture and environment so they always think if they apply organic fertilizer, the crop's yield will be decreased and will be also destroyed strongly from insect pest very quickly. Particularly, increasing the amount of trees around the house, school and community are very interested from trained students (100%) and non-trained students (55.8%). The reason is because; they can derive many benefits from the tree such as flood, building a house or making equipment, providing the shade and fresh air, especially the residue of the trees like leaves, bark or branch can be made into organic fertilizers as well. 44.2% the rest from non-trained students, they do not want to increase the trees. The reason when there are a lot of amounts of trees,it can cause the surrounding area dirty almost everywhere that can damage to environment and it can cause the serious accident. Futhermore, beside studying in the class, both trained and non-trained students also got the agricultural and environmental knowledge from outside (Fig. 2), were as followed: parents, teachers, classmates, friends at the schools, neighbors, NGOs, and the government. Even if the students can get the knowledge from outside, it is very limited. It means only sometime the students were involved; it is not like taking a class regularly.

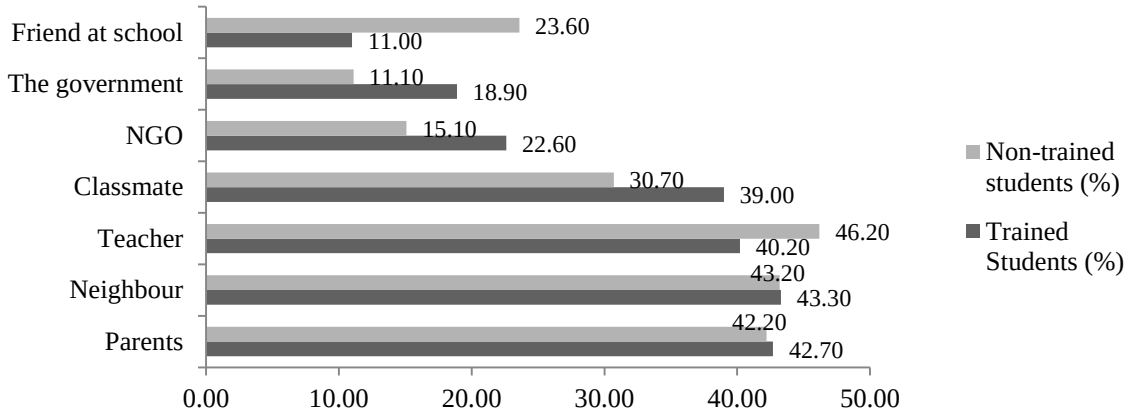

Fig. 2 Students knowledge on agriculture and environment getting from outside schools

Importantly, publishing books of agriculture and environment are also a main way to involve people especially students to learn the news and concerned issues in over the world. According to (Fig. 3) some students always do many researches by reading books in the school's library but some rarely and some never to read. Even though, the amounts of the trained students on book reading still bigger than the non-trained students.

After finishing the training, many trained students can conduct their own practices through learning and only a small amount could not because they are rare to join the training caused by supporting their parents for farm work. So they could not follow the lessons like the others (Fig. 4).

Encouraging people to understand the sustainable agriculture and environment through training series such as how to create appropriated practices, showing all difficulties related to any failure of applying the pollution on agriculture and environment and expressing clearly the benefit on sustainable agriculture, were focused as the most benefits for life skill from the trained students reason (Fig. 5).

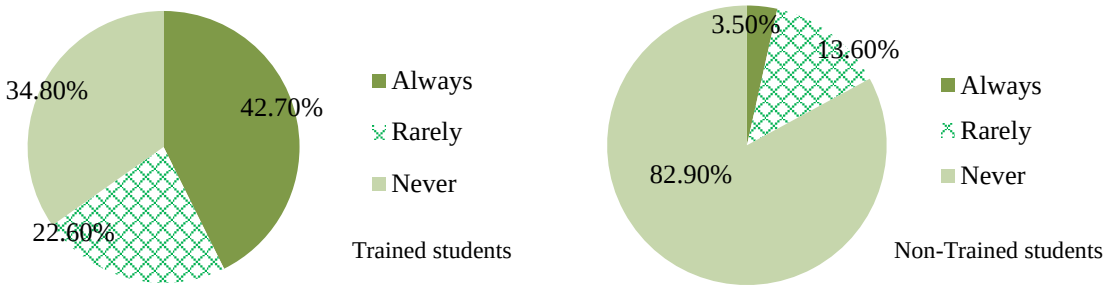

Fig. 3 Amount of students for reading books on agriculture and environment

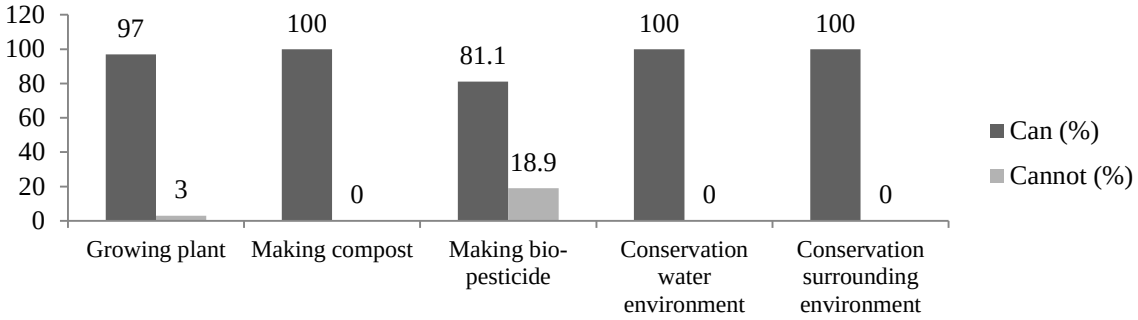

Fig. 4 Visibility of the trained students' practice after training

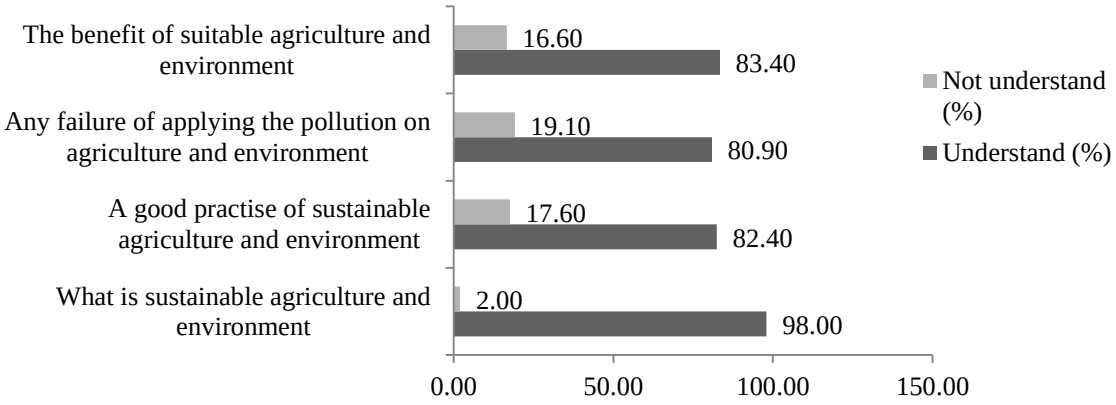

Fig. 5 Understanding of the trained students through training series

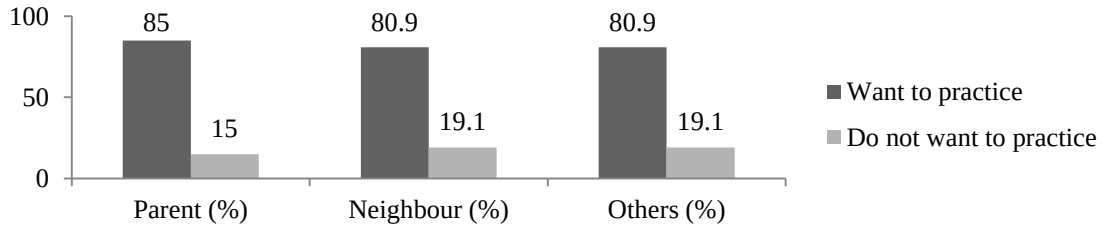

Fig. 6 Transferring of appropriated agriculture and environment to involvements

Many advantages derived from the training series not only provide the student knowledge, but also provide benefits indirectly to the student's parents or neighbors (Fig. 6). However, there is still limit of transferring because some involvements understood it takes time and it could not absolutely make a competition with foreign products.

Indeed, relying on the questionnaires of the trained students, there are many problems were occurred around people living area, they are water pollution, infertile productivity, air pollution, lacking of food safety and suitable agriculture. There are differences between before and after the training. After testing before training, it was explain there is only a little understanding on sustainable agriculture and environment for the trained students, and the understanding subjects in the interest of testing the children, namely: making compost (18.9%), sustaining water environment (18.3%), and sustaining surrounding environment (26.8%). Therefore, after training the students are really most understand and they can almost absolutely practice all the knowledge by themselves, especially they are a part of human resource and responsible for transferring this knowledge to the involvements.

Finally, the purpose of both groups, they would like to have a vegetable garden for their schools because they can improve planting crops, making compost fertilizer, making bio-extract, and they can have fun with their garden and learn new skills. The vegetable garden plays an important role to integrate the garden into the curriculum, including garden-based social studies. It encourages classroom teachers to participate with their students in the garden, especially to invite the local community to join together for growing plants year-round and can promote more and more the knowledge of sustainable agriculture and environment to the local community.

CONCLUSION

The trained pupils understood well about conservation of agriculture and environment, but non-trained pupils had a limit. All the pupils are very happy to join the program because they can learn and practice using of natural resource to get sustainability, and reflecting clearly of a good condition for environment. This study is very essential for pupils because it is a way to teach them to have a closely relationship with appropriated agriculture and environment in their future. Both groups would like to have organic vegetable garden for their school because they can enjoy with their garden and learn new skills. It is concluded that, there is still limited knowledge of the pupils on environmental and sustainable agriculture. They should be trained on the subject through formal educations, providing ready materials, practices and study tours.

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Research article

Changes in Cassava Yields with Trimmed Leaves for Eri-culture in Kampong Cham Province, Cambodia

KUMIKO KAWABE*
Graduate School of Agriculture, Tokyo University of Agriculture, Tokyo, Japan /
Research Center, Institute of Environment Rehabilitation and Conservation, Tokyo, Japan
Email: kumiko@khmergreennature.com

MACHITO MIHARA
Faculty of Regional Envrionment Science, Tokyo University of Agriculture, Tokyo, Japan

KEISHIRO ITAGAKI
Faculty of Internationl Agriculture and Food Stuides, Tokyo University of Agriculture, Tokyo, Japan

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Abstract Cassava (*Manihot esculenta*), a host plant of eri silkworm (*Samia Cynthia ricini*), is one of the main crops, followed by rice in Cambodia. As it was not long ago that eri-culture was introduced in Cambodia, the research related to eri-culture and eri silkworms in Cambodia has not been developed. Especially, trimming methods of cassava leaves have not been studied yet. Accordingly, attention has been paid to evaluate the suitable amounts of leaves trimmed for eri-culture without affecting cassava tuber yields. So, this study dealt with the potential percentage of cassava leaves trimmed for eri-culture in Cambodia. In the experimental field at Royal University of Agriculture located in Phnom Penh, cassava, variety called KM 94, was cultivated from November 2011 to July 2012 for 8 months. After 4 months passed from planting, the leaves were trimmed at 0%, 20%, 40%, 60%, 80% and 100%, respectively. At 8 months passed from planting, the yields were compared amongst plots of different trimmed percentage, and the suitable amounts of leaves trimmed for eri-culture without affecting cassava tuber yields were discussed. The experimental results showed that yields of 100% trimmed were significantly smaller than that of 0% to 80% trimmed. Additionally, there was no significant difference in yields amongst plots trimmed 0% to 80%. It was concluded that cassava leaves can be trimmed up to 80% without affecting cassava tuber yields.

Keywords eri-culture, eri silkworm, cassava, trimmed leaves

INTRODUCTION

Eri-culture, raising eri silkworms (*Samia Cynthia ricini*), has been conducting widely in Southeast Asia, such as southern China, Thailand, Vietnam and Cambodia. Although its origin is Assam province in India, eri silkworm became the only one kind among various wild silkworms which domesticated in the same manner of mulberry silkworm and it has introduced to many countries where host plant of eri silkworm can be found or cultivated (Photo. 1). Host plants of eri silkworm are the leaves of castor, cassava or papaya which are very easy to cultivate in the tropical or sub-tropical areas. The most attractive points of eri-culture for local farmers are that eri-culture can start with low input, for example the leave of cassava or castor is costless and rearing materials such as bamboo tray or net are easy to find in local areas, and eri-culture can provide local farmers not only cocoons but also pupae that includes high nutrition of protein.

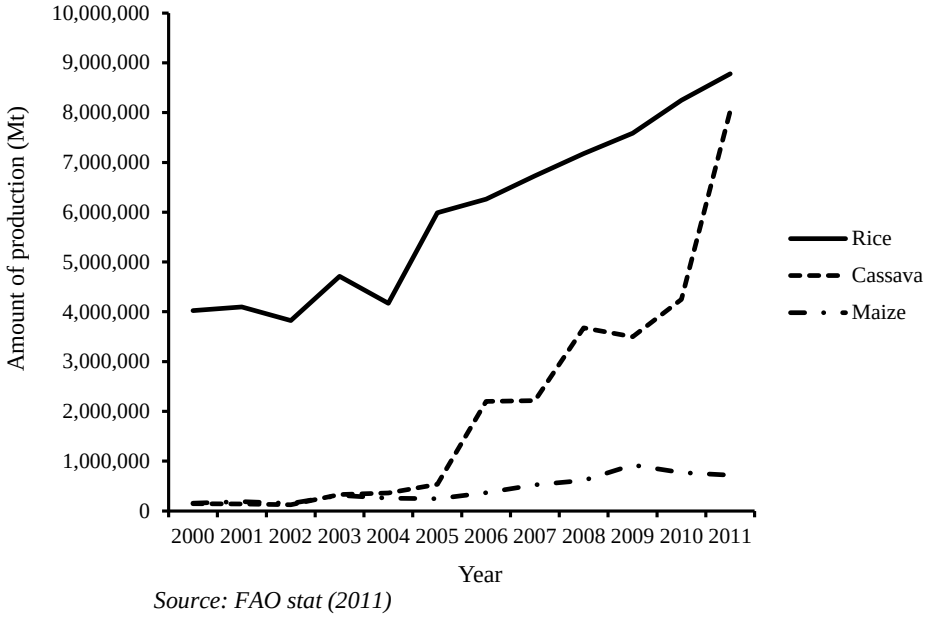
Eri-culture has introduced in local villages of Kampong Cham province, Cambodia in October 2010 by the international NGO for aiming to promote environmental awareness and income generation for local farmers to tackle with local problems regarding agriculture.

Agriculture is the main industry in Cambodia, and the statistics shows that 80% of total

population lives in rural areas and 70% of total population is engage in agriculture or related sectors (Central Intelligence Agency, 2011). The government places the first priority on agriculture, but at the same time it is very important for local people to sustain their living. However, local farmers in Cambodia still have difficulties to earn enough income from agriculture due to lack of infrastructure, knowledge, technology and information.

Cassava is one of the main crops followed by rice in Cambodia, and its yields has been increasing according to the statistics of FAO as shown in Fig. 1, due to the high potential of food security. In the research area, Kampong Cham province, the harvesting areas and yields of cassava have been increasing dynamically in recent years. Normally cassava farmers get income from tuber yields; however there may be high possibility to receive other income by using cassava leaves. So, eri-culture can be one of the options to utilize the leaves, and it can be useful for local farmers to generate more income from agriculture.

Photo. 1 Cultivating eri-silkworms



Source: FAO stat (2011)

Fig. 1 Trend of production in Cambodian top 3 crops

OBJECTIVE

The objective of this paper is to evaluate the suitable percentage of cassava leaves trimmed in mid-flow of cultivating without any effects on tuber yields of cassava in the research site. One of the main obstacles for local farmers to continue eri-culture was to gain enough amounts of fresh leaves for rearing eri silkworms during dry season. A host plant of eri silkworm, cassava leaf, has rarely been used after harvesting tubers in Cambodia. So, attention has been paid to the effect on cassava yields after trimming certain amounts of leaves during its growing period. As the appropriate

trimming methods have not yet been studied, the methods for eri-culture are also discussed in this study. It is expected that the results would be available to extend the utilization of cassava leaves for eri-culture in Cambodia.

METHODOLOGY

This experiment was conducted at the experimental field in the Royal University of Agriculture (RUA) located in Phnom Penh, Cambodia (Photo. 2). The variety of cassava named KM 94 was chosen for the experiment, as the variety has been widely cultivated by local farmers in Kampong Cham province. Each experimental plot was a 4 m x 4 m square at 30 cm of planting interval as shown in Fig. 2. There were 20 cassava trees in each of the 15 plots, so totally 300 cassava trees were planted and cultivated from November 2011. Numbering of the plots was done from the southwestern plot along west side as "a1" to "a5", from the southern plot to north for the middle lane as "b1" to "b5", and from the southeastern plot along east side as "c1 to c5".

Ensuring the growing conditions in each plot, all cassava trees were measured by height after 4 months of planting, and 48 cassavas in 6 plots with no significant difference in height were used for the further experiment (meshed plots in Fig. 2). Trimmed percentage was decided for each plot, "c5" for 0%, "c4" for 20%, "c1" for 40%, "b5" for 60%, "b1" for 80% and "a2" for 100%, respectively (Fig. 3). Also, meteorological conditions, such as temperature, humidity and rainfall, were observed at the experiment field in the Royal University of Agriculture during the experimental period.

Photo. 2 Experimental field at Royal University of Agriculture

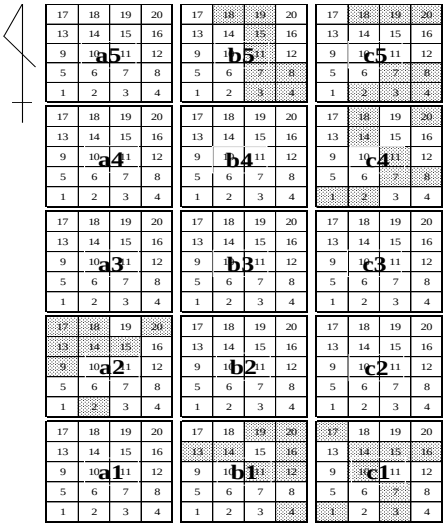


Fig. 2 Experimental plots at RUA, Cambodia

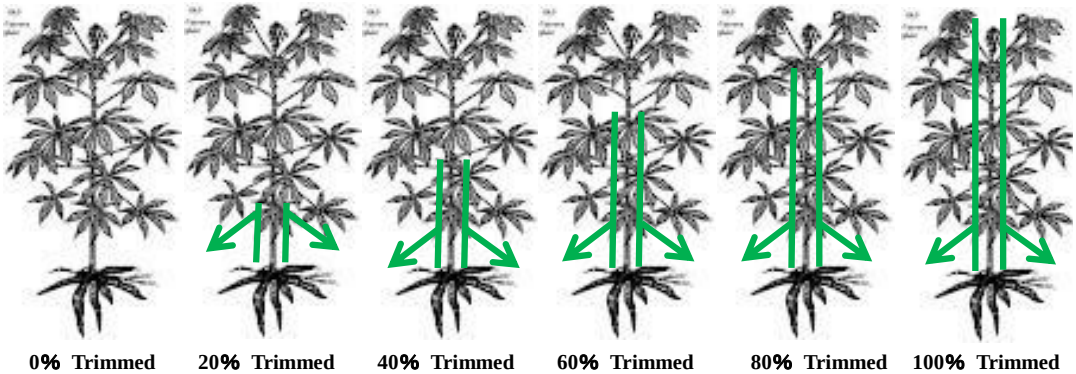


Fig. 3 Trimming methods from 0% to 100%

RESULTS AND DISCUSSION

Meteorological Data Observed during the Experiment

Meteorological conditions were observed from July 2010 to July 2012 at the experimental site in Royal University of Agriculture, Cambodia. The observed period covered whole the experimental period from November 2011 to July 2012. During the experimental period from November 2011 to July 2012, higher and lower temperature ranged from 30 degree Celsius to 37 degree Celsius and from 20 degree Celsius to 26 degree Celsius, respectively. Also, the monthly rainfall was from 0 mm to 190 mm. The trends of temperature and humidity from November 2011 to July 2012 were similar with that from November 2010 to July 2011. However, there was less rainfall from December 2011 to February 2012 comparing to that from December 2010 to February 2011 as shown in Fig. 4.

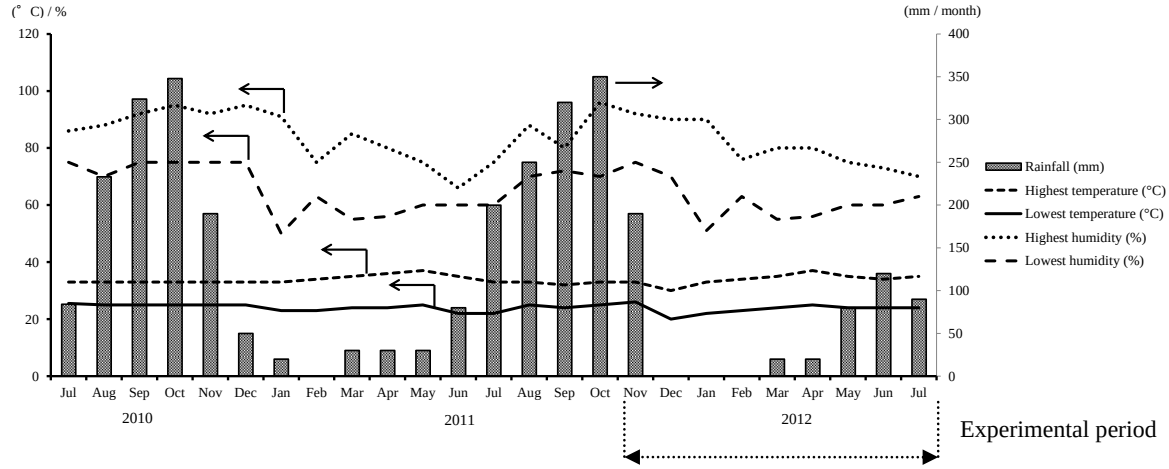


Fig. 4 Meteorological conditions observed at experimental field from July 2010 to July 2012

Table 1 Height of selected cassava trees in each plot

Name of plot	c5	c4	c1	b5	b1	a2
Height of each cassava tree (cm)	93	86	99	90	107	94
	109	94	102	100	96	112
	110	113	108	94	101	94
	93	102	103	91	90	104
	105	99	101	93	89	98
	113	113	101	105	101	96
	-	95	90	105	99	97
	-	105	102	100	88	91
Average	103.8	100.9	100.8	97.3	96.4	98.3

Selection of Cassava for Trimming

In March 2012, after 4 months passed from planting, the heights of 300 cassava trees were measured. Eight plants in each of selected 6 plots which indicated no significant difference in height were selected for further experiment (Table 1). This is to ensure that selected cassava trees grew similarly although there were various factors affecting to the growth of cassava trees such as soil nutrients, moisture, solar radiations, and other plants effects, so on.

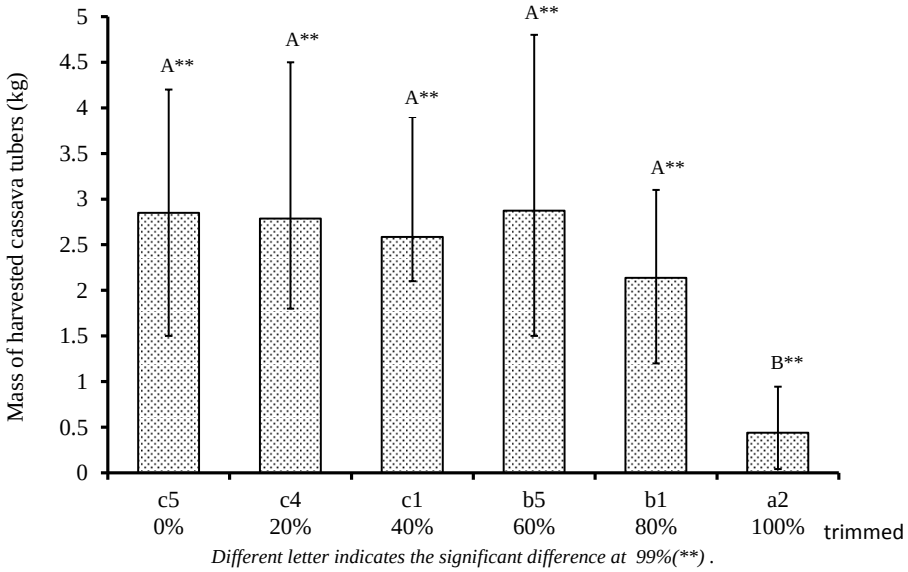
And then, amounts of cassava leaves from the lower part were trimmed at 0%, 20%, 40%, 60%, 80% and 100% (Fig. 3) in March 2012. The plot was selected as "c5" for 0%, "c4" for 20%, "c1" for 40%, "b5" for 60%, "b1" for 80% and "a2" for 100%, respectively (Fig. 2).

Changes in Cassava Yields with Trimmed Leaves

The leaves of selected cassava were trimmed at 0% (c5 plot), 20% (c4 plot), 40% (c1 plot), 60% (b5 plot), 80% (b1plot) and 100% (a2 plot), respectively (Fig. 3). After 4 months passed, cassava tubers were harvested and the mass of tubers in each cassava tree was measured in July 2012.

The experimental results were summarized in Fig. 5. It showed that the yield of 100% trimmed leaves was significantly smaller than that of 0% to 80% trimmed. Also, there was no significant difference in the yield among plots trimmed 0% to 80%. It was considered that trimmed cassava trees at 0% to 80% could recover the function of photosynthesis with reproducing cassava leaves. However, photosynthesis was not enough to grow cassava tubers for cassava trees trimmed at 100%.

Also, the fresh mass of trimmed cassava leaves at 0% to 80% was measured for cultivating eri-silkworms at middle flow of harvesting cassava as shown in Table 2. Apparently, there was a tendency for the fresh mass of trimmed cassava leaves to be larger with the increase in percentage trimmed. It indicated that 202.42 g of fresh cassava leaves were harvested from one cassava plant of 80% trimmed for cultivating eri-silkworms.



Different letter indicates the significant difference at 99%(**) .

Fig. 5 Effects of trimmed amounts of cassava leaves on mass of harvested cassava tubers

Table 2 Fresh mass of selected cassava leaves in each plot from 0% to 80% trimmed

Name of plot	c5 (0% trimmed)	c4 (20% trimmed)	c1 (40% trimmed)	b5 (60% trimmed)	b1 (80% trimmed)
	0	42.72	90.90	137.41	232.74
	0	28.98	55.80	281.20	185.21
Fresh mass of	0	35.39	62.88	169.51	290.75
cassava	0	13.92	106.92	159.19	129.42
leaves	0	45.58	84.99	79.81	163.67
trimmed (g)	0	23.25	92.51	191.71	220.66
	-	17.63	81.69	160.84	220.49
	-	34.09	111.89	145.82	176.44
Average (g)	0	30.20	85.95	165.69	202.42

CONCLUSION

Cassava (*Manihot esculenta*), a host plant of eri silkworm (*Samia Cynthia ricini*), is one of the main crops in Cambodia, and its harvested areas and yields have been increasing in the last five years and it is estimated to expand year by year.

Eri-culture, the raising of eri silkworm, a kind of wild silkworm originated in Assam province, India, was introduced to Cambodia in October 2010. Since then, farmers face the difficulty to ensure fresh leaves for feeding eri silkworm. So trimming methods of leaves should be studied. Accordingly, attention has been paid to evaluate the suitable amounts of leaves trimmed for eri-culture without damaging cassava yields.

KM 94, one of cassava variety that is widely adopted by local farmers in Cambodia, was cultivated from November 2011 to July 2012, a period of 8 months, at the experimental field in Royal University of Agriculture located in Phnom Penh. After 4 months passed from planting, the leaves were trimmed at 0%, 20%, 40%, 60%, 80% and 100%, respectively. At 8 months passed from planting, the yields were compared among plots of different trimming percentage and discussed the suitable amounts of leaves trimmed for eri-culture without damaging cassava tubers. The results showed that the yields of 100% trimmed were significantly smaller than that of 0% to 80% trimmed. Moreover, there was no significant difference in yields amongst plots trimmed 0% to 80%. Accordingly, it was concluded that cassava leaves can be trimmed up to 80% without damaging cassava yields.

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International Society of Environmental and Rural Development

Philosophy of ISERD:

Recently, in developing countries, subsistence agriculture is being converted to export-oriented mono-culture, and the amounts of agricultural chemicals applied to the farmland are increasing every year. The applied chemicals in farmland cause serious environmental problems downstream such as eutrophication, unusual growth of aquatic plants, decrease in dissolved oxygen and accumulation of bottom mud in water resources. Also, there seem to be many cases in which people apply agricultural chemicals without understanding its impact to health and food safety. Therefore, it is necessary to promote and enhance understanding of sustainable rural development among local stakeholders including farmers.

Sustainable rural development aims to meet human needs while preserving the natural environment. As it should cover not only social and economic development but also natural environment conservation, no single organization can achieve sufficiently the aspirations of sustainable rural development. Collaboration among international, governmental and non-governmental organizations, together with the academe and scientific sector, is indispensable.

The knowledge and intelligence accumulated in universities and research institutions are also expected to make the programs facilitated by the international, governmental and non-governmental organizations more adequately implemented and meaningful to societal development. However, these cases especially those implemented locally have been scattered without having been summarized well or recorded in annals academic or scientific societies.

So, the International Society of Environmental and Rural Development founded in 2010, aims to discuss and develop suitable and effective processes or strategies on sustainable rural development focusing on agricultural and environmental aspects in developing countries. The ultimate goals of the society are to contribute to sustainable rural development through social and economic development in harmony with the natural environment, and to support the potential or capacity building of local institutions and stakeholders in the rural area with academic background.

Purposes of ISERD:

The primary purposes of ISERD are to contribute to sustainable rural development through social and economic development in harmony with the natural environment and to support the potential or capacity building of local institutions and stakeholders in the rural area with academic background.

In order to enhance the realization of the primary purposes of ISERD, the secondary purposes are;

- to facilitate interaction among international, governmental, non-governmental organizations and local communities,
- to hold conferences or symposia on environmental and rural development,
- to publish the International Journal of Environmental and Rural Development, and
- to encourage and develop local awareness concerning sustainable rural development.

Membership:

There shall be two categories of membership.
(a) Individual
(b) Organizational
An application for membership of ISERD shall be submitted to the secretariat of ISERD, Institute of Environment Rehabilitation and Conservation (Japan) or Association of Environmental and Rural Development (Thailand) by writing or by other appropriate means.

Council of ISERD:

The affairs of ISERD shall be governed and managed by the ISERD Council. The councilors are as follows.
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ISERD Secretariat:

Institute of Environment Rehabilitation and Conservation (ERECON)
2987-1 Onoji Machida-Shi, Tokyo 195-0064, Japan
Tel/Fax: +81-42736-8972
E-mail: iserd.secretariat@gmail.com
Webpage: www.iserd.net

Collaborated with

Association of Environmental and Rural Development (AERD)
93/64 Moo.3, Sinsab village 2, Bungyeetho sub-district, Thanyaburi district,
Pathum Thani 12130, Thailand
Tel/Fax: +66-2957-8064
E-mail: iserd.secretariat@gmail.com
Webpage: www.iserd.net

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