ISSN 2185-159X

International Journal of

Environmental and Rural Development

Volume 2 Number 1

April 2011

International Society of Environmental and Rural Development

International Journal of Environmental and Rural Development

Official Journal of the International Society of Environmental and Rural Development

Aims and Scope:

The International Journal of Environmental and Rural Development, IJERD, is an interdisciplinary journal concerning environmental and rural development research in the education for sustainable development, ESD. The IJERD is devoted to publishing peer-reviewed research article, review article and technical report in the fields of environmental and rural development, such as education for sustainable rural development, rural development, environmental management or agricultural systems. Every article or report in IJERD must be accepted by at least 2 reviewers and an editorial member.

The aims of IJERD are to publish the latest research development and achievements, to strengthen education systems, to promote cooperation in environmental and rural development and to contribute to the progress in sustainable development. The editorial board of this journal covers a variety of scientific disciplines.

Thematic Areas:

The following areas are envisioned in IJERD.

Education for Sustainable Rural Development:

Environmental Education, Food and Agricultural Education, Participatory Approach, Capacity Building, Community Empowerment, Agricultural Extension, etc.

Rural Development:

Marketing, Partnership, Value Added Product, Community Development, Access to Technology, Cultural Preservation, etc.

Environmental Management:

Bio-Diversity, Soil Degradation and Land Conservation, Water Quality Conservation, Deforestation and Sustainable Forest Management, Environmental Management, etc.

Agricultural Systems:

Organic Farming, Conservation Tillage, Mechanization, Irrigation and Drainage, Nutrient and Pest Management, Cattle Breeding, Agro-Forestry, Indigenous Technology, etc.

Infrastructural Systems:

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

Contents

Research article

Research article

Effect of Land Use Change and Food Availability in Phatthalung Watershed, Southern Thailand

ANISARA PENSUK
Thaksin University, Phatthalung, Thailand
Email: anisara.pensuk@gmail.com

RAJENDRA SHRESTHA
Asian Institute of Technology, Pathumthani, Thailand

Received 30 November 2010 Accepted 21 February 2011

Abstract During the past few decades, land use change has been taking place over the Phatthalung watershed and the major change has been the replacement of paddy fields with rubber plantations. Those changes cause the reduction of paddy field and crop land area. Together with the population growth, urbanization and soil degradation, the food availability becomes a concerned issue. The food availability situation of Phatthalung watershed under different possible scenarios has been investigated as the major objective of this study. The scenarios developed in this study included the biophysical factors, socio-economic factors and policy factors. The projected food production of four scenarios except the worst case exceeded the local consumption rate and the high surplus of rice was found in the best case scenario. The projected food production from the baseline and the moderate case scenarios was medium, whereas the projected food production from the worst case scenario was lower than the household requirement, which can be interpreted as insufficient. These results from the four scenarios should be recognized in order to prevent and avoid the local and national food, especially rice, insecurity in the future.

Keywords biophysical factor, food availability, land use change, Phatthalung watershed, socio-economic factor, policy factor

INTRODUCTION

Food security is currently becoming a global concern due to the rapidly increasing population, the degradation of arable land and the conversion of food crop land into biofuel crop production which is resulting in the depletion of the fertile land for food production. The recent agricultural production data shows that the global cereal production is in decline (FAO, 2004). The assessment of the availability of food helps understanding the situation of food supply and food security. However, there are concerns that there are various factors besides land use which influences food production, e.g. water availability, land quality, the adoption of technology, commodity prices, population and its growth rate as well as the country's policy on promoting rubber plantation and the biofuel crops.

In Phatthalung watershed, the conversion of food production areas (e.g. paddy fields) to rubber plantation is the major land use change (Anisara and Shrestha, 2008). The increasing trend of paddy area conversion to rubber plantation has resulted in the decline of rice growing area and production in the watershed. Among several types of food items consumed by the population of Phatthalung watershed, rice is the major source of staple food. Thus, the decreasing rice production area is a serious concern in terms of food availability.

It is useful to realize the future food availability condition as we are able to prepare for uncertainty and ensure that local food production is sufficient for local people. Scenarios analysis, an environmental assessment tool, is useful to examine the future food availability. There are several scenarios related to food system including IPCC-SRES, GEO-3, Millennium Ecosystem Assessment, Global Scenarios Group, IFPRI 2020 and FAO (Monika, 2006). In this study, the

likely change in future food availability was assessed under four different scenarios involving variation in land uses, the quality of land and water, the commodity prices and the local and national land policy.

MATERIALS AND METHODS

Factors influencing food availability

The availability of food can be influenced by various biophysical, economic, social or policy factors. Fig. 1 presents various factors used in the study to simulate future food availability under different scenarios.

The biophysical factors were the factors which have influences on the rice production system e.g. land area, production rate, the technology input etc. The change in those factors can have positive or negative effect on the food availability. Among various factors, the factors considered in this study included rice production area, land quality and the availability of water. Major economic factors included the import and export of rice and those factors can have effects on the quantity of rice within the watershed, whereas commodity price of agricultural productions was another important economic factor which can have influences on farmers' land use decisions on crop selection to grow in their land. For example, the price of rubber was much higher than that of rice during the study period, hence farmers tended to convert their land to rubber plantation. Even though, the commodity prices did not have a direct effect on the availability of food, it can affect the production area. Population and population growth were the social factors considered in this study, higher population growth can reduce the food availability and hence, consequence to food insecurity as insufficient food supply. Furthermore, the increasing population can also reduce the production area due to agricultural land conversion to urbanization. Policy factors can play important roles indirectly via other factors which can have positive or negative effects on food availability. For example, policy can affect food availability via social factors by establishing the population control policy thus reducing the food demand. Similarly, land use policy can influence area dedicated for rice cultivation through commodity prices.

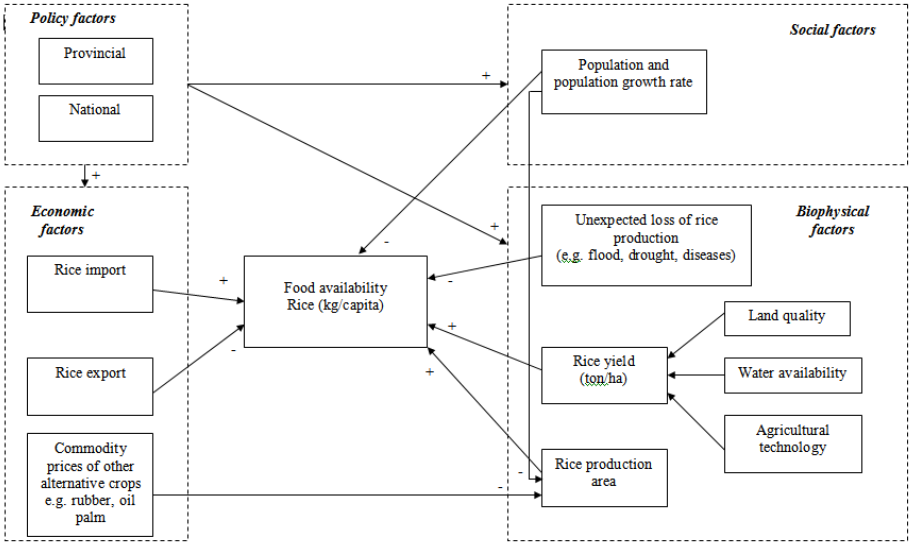


Fig. 1 Factors influencing food availability

Scenarios development

Scenarios are alternative possible outcomes in future, affected by different factors at different levels. Scenario analysis helps make better decisions in the context of uncertainty, particularly associated with future events. In this study, four potential scenarios were developed in order to

predict the availability of food in different situations. The influencing factors considered for developing the scenarios included population and its growth rate, the agricultural commodity prices and rice yield. The rice production area is influenced by agricultural commodity prices and the policy whereas the rice yield is influenced by land quality and water availability.

The availability of food assessed in this study was presented as quantity of rice per capita (kg/capita). There are four scenarios developed in this study, the criteria and assumptions for four scenarios are given in Table 1.

1) Baseline scenario (BL): It assumes a business-as-usual scenario. It is assumed that the current trend will continue in the future too. Hence, the assumptions are simply the extension of the past trend of different factors to continue in the future in the study area.

2) Best case scenario (BC): It assumes the synergy of the factors for the highest level of food availability in the area. The population of this scenario is assumed unchanged and it is under the assumption that the birth rate and the immigration are assumed equal as the death rate and the outmigration.

3) Moderate case scenario (MC): This scenario is less optimistic than best case scenario and assumes that policy intervention and technological development will be at the moderate level.

4) Worst case scenario (WC): This scenario assumes the worst possible condition with high rate of population growth and high decreasing rice production rate.

Table 1 Criteria and thresholds for assessing food availability under four scenarios

Scenario	Baseline (BL)	Best case (BC)	Moderate case (MC)	Worst case (WC)
Social factor				
Population	505,129	505,129	505,129	505,129
Population growth rate (%/year)	+0.26	0	+0.60	+1.09
Biophysical factor				
Rice production area changing rate (%/year)[a]	0	+4.76	+2.10	-16.80
Land quality (%/year)	-0.16	+0.30	+0.15	-0.30
Water availability (%/year)	-5.00	+15.00	+5.00	-6.00
Economic factor				
Commodity prices changing rate (%/year)[b]	0	+4	+15	+30
Policy factor (National/Provincial Plan)				
Land related policy (%/year)	0	+5% of rice production area	+3% of rice production area	-15% of rice production area

Note: [a] *Present paddy field area = 72,826.4 ha*
[b] *The average rubber price in 2006 = 61 Baht/kg*

Food availability projection

The relationships of the influenced parameters mentioned in Table 1 have been constructed in the STELLA environmental dynamic model in order to project the food availability in a 30-year time frame.

RESULTS

Food availability under the baseline scenario

The baseline scenario was projected based on the real situation. The projected population is showing the increasing trend with the moderate rate (Fig. 2). Even though, the area for rice production under this scenario is assumed unchanged (Fig. 3), the projected rice production shows the declining trend (Fig. 4) resulting in the decline of food availability. The present rice production is about 163,000 tons and it decreases to 130,000 tons in 2030. The decrease in rice production under this scenario mainly results from the decreasing of the rice yield; the current rice yield is 2.24

tons/ha/year and it became lower than 2 tons/ha/year in 2025 because the land and water resource is assumed to be left over without improvements.

The decline of rice production area resulting in the declining rice production and the increase in the population can lead to the declining of food availability (Fig. 5). The range of the projected food availability under baseline scenario was between 0.24 and 0.32 tons/capita/year with the average decreasing rate of 1% per year. The projected food availability is found slightly lower than the local rice consumption rate (336 kg/capita/year). Therefore, the Phatthalung watershed will be facing the problem of rice insufficiency in the near future under the current situation. There is the need of having appropriate policy and plan, both local and national, to increase the area under rice production in order to avoid the food insecurity problem in the study area.

Food availability under the best case scenario

Fully aware of the global food insecurity problem and the fact that Thailand is one of the biggest food exporters globally, the Thai government is establishing a policy of paddy area preservation in order to produce more food especially rice for the global market. The growing rice export can also contribute to the growth of national economy through agricultural development. Phatthalung watershed is considered as one of the most suitable area for rice production. The rice production area preservation policy is to turn the area which is suitable for rice but is being used to produce other types of crops (e.g. rubber plantation, oil palm, shrimp farms etc) to rice production area.

As described earlier, this scenario assumes strong policy intervention on rice area preservation, and improvement in land quality and water availability. The rice production of this scenario is increasing not only from the assumed enforcement of rice area preservation policy but also from the assumed very small rate of increase in the rubber prices, which in turn is expected to result in low economic incentives to convert rice production areas into rubber plantations. Fig. 3 shows a rapid increase of rice production area projected under this scenario; the increasing trend becomes stable in 2030 as it reaches the maximum suitable land area for rice production (at 150,000 ha).

Together with the improvement in land quality, the implementation of irrigation system, the projected amount of rice production under this scenario was the highest. The maximum and the minimum of the projected food production are over 640,000 and about 167,000 tons respectively (Fig. 4).

The predicted food availability under the best case scenario was substantially higher than the other three scenarios, because of the increased area under rice production and the increase in rice yield due to land and water improvement accompanied by decreasing of rice consumption due to the population control policy. The predicted annual food availability per capita of the best case scenario ranged between 0.32-1.21 kg (Fig. 5) and it is about double of the household consumption obtained from HH survey from the year 2023, implying sufficiency and surplus of food under this scenario.

Food availability under the moderate case scenario

In this scenario, the population is assumed to increase with moderate rate. Similarly, the rice production area and rice yield are assumed to increase at moderate rate due to the area preservation policy, with the smaller percent compared to the best case scenario, and ongoing land conversion because of the stable increase of rubber prices. The quality of land and the availability of water were assumed to slightly improve through fertilizer and irrigation water supply.

Similar to the best case scenario, the area for rice production was assumed to increase due to the policy even though at lower rate. Also, the economic factor, i.e., rubber prices, has been assumed to have lower influence in encouraging farmers to change the paddy field to rubber plantation.

In terms of social factors, population and its growth rate of this scenario are assumed to increase with the rate of 0.6% per year without population control policy (Fig. 2). The rice

production area of this scenario is projected to increase with the rate at 2.1% per year, the maximum projection area is nearly 136,000 ha (Fig. 3).

The amount of rice production projected under this scenario is increasing at the rate of about 2.8% per year (Fig. 4). The minimum projected amount of rice production under this scenario is about 163,000 tons and the maximum is nearly 379,000 tons (Fig. 4) due to the land and water is assumed to be improved under this scenario.

The projected annual food availability of this scenario ranged between 0.32-0.63 tons/capita. The projected results for first few years (2010-2017) are less than the local consumption rate obtained from the household survey but it rises afterwards (Fig. 5).

In this scenario, the food availability predicted under this scenario is showing sufficiency for local consumption for the next 30 years of the projection period (until 2040) but it is under risk if the population of this scenario keeps increasing without control, resulting in consumption of rice higher than its production.

Food availability under the worst case scenario

The worst case scenario assumed a greater decrease in rice production area, deteriorating land quality, water availability as well as the rice yield, along with the increase in the population and its growth rate. In terms of economic factors, the rubber price was assumed to increase by about 30% from the present one, which encourages farmers to convert rice paddies into rubber plantations.

The increasing population and the development of economic and industrial sectors are the dominant assumption of this scenario. Policy assumed in this scenario mainly focuses on economic development and the growing industrial sector together with the increasing population. Therefore, the paddy areas are encroached and replaced by human habitats and the infrastructures such as roads, buildings, and factories.

The high population growth rate without control and the high increase in rubber price drive to the worsening food availability. The projected population of this scenario shows a rapid increase (Fig. 2). On the other hand, the projected rice production and its area of this scenario are the lowest with the rapidly decreasing rate (Fig. 3-4). The projected area for rice production is found less than 50,000 ha in 2013, the rice production area kept deceasing over the years and it can be completely replaced by other types of land use within few decades. The area was rapidly decreasing to about 30,000 ha in 2015 (Fig. 3) which was the preserved area for rice production due to land properties constraints.

The degradation of land quality and the water insufficiency assigned for this scenario causes negative effects on the rice yield. The projected yield becomes lower with a high rate and it is found lower than 1 ton/ha/year within a decade. The decrease of rice yield causes the decrease of rice production amount and it is found nearly three times lower than the baseline scenario, only for the first decade of the projection.

The results of food availability showed a rapid decline until 2013 with a decreasing rate of about nearly 20% annually; the results ranged between 0.08-0.32 tons/year (Fig. 5) and lower than the local consumption rate (0.33 tons/capita/year) obtained from household surveys. The minimum amount of the projected results under this scenario is inadequate for people in terms of energy requirement from carbohydrate because the general minimum energy requirement from carbohydrate or rice is at about 73 kg/year (Anchanee, 2005).

According to the projected results under this scenario, the situation of food availability of Phatthalung watershed is in crisis as all rice production area can be completely replaced by other types of land use within the two decades.

The food availability of Phatthalung watershed will be insufficient and lead to malnutrition problem if the food production keeps reducing. In this scenario, the declination is resulting from the decreasing production area with the increasing demand for food due to the high population.

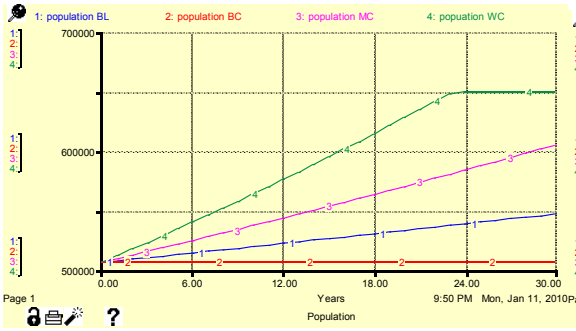


Fig. 2 Projected population for all scenarios

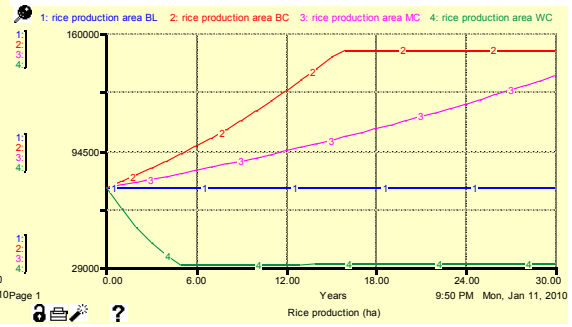


Fig. 3 Projected rice production area for all scenarios

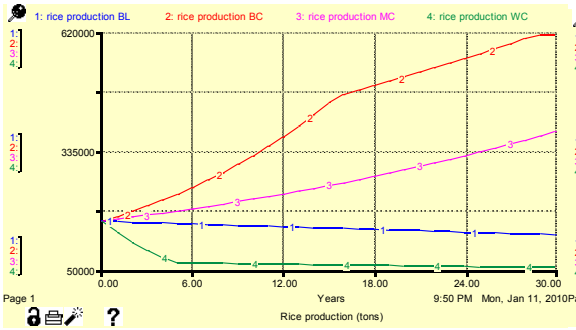


Fig. 4 Projected rice production for all scenarios

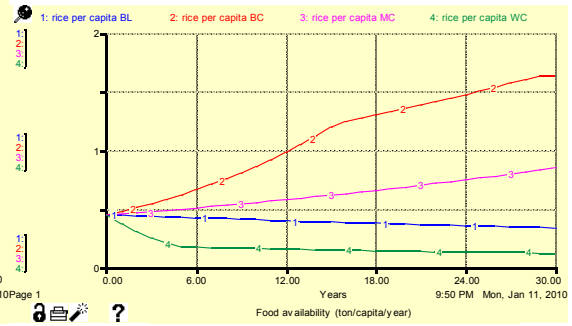


Fig. 5 Projected food availability for all scenarios

CONCLUSION

There are numerous factors which can have influences on the availability of food. In this study, population size, the area for rice production, rice yield, the condition of land and water resources, which are important factors for crop productions, and the policy were considered as the key factors affecting the food availability.

The 30 years projected food production of the four scenarios, except for the one worst case that exceeds local consumption and the minimum human energy requirement. The high surplus of rice was found in the best case scenario, whereas the projected production from the worst case scenario was the lowest and lower than the household requirement.

The promotion of rubber plantation can be good alternative sources of household income, since the economic return from cultivating rubber is higher than producing rice. However, it has to be ensured that the remaining area is capable to produce sufficient food for the local population. Otherwise local people have to purchase imported rice from neighboring countries which will affect the majority of household expenditure in the future.

REFERENCES

Anchanee, U. (2005) Thai food to the world: Weight control Thai food. http://www.thaifoodtoworld.com/home/recipediet.php?&language=TH&language=TH&language=EN.

Anisara, P. and Shreatha, R. (2008) Linking land use change and rural livelihoods: A study of Phatthalung watershed in Southern Thailand. APJORD, 18(2), 143-164.

FAO (2004) FAO Global information and early warning system on food and agriculture world food programme, Rome.

Monika, Z. (2006) A short review of global scenarios for food systems analysis. GECAFS, Rome.

Research article

The Rice Soil Fertility Capability Classification System

VO QUANG MINH
Department of Land Resources, Cantho University, Vietnam
Email: vqminh@ctu.edu.vn

Received 2 December 2010 Accepted 10 February 2011

Abstract The Rice Soil Fertility Capability Classification (RSFCC) is based on FCC (Fertility Capability Classification) system, with some modifications. The system deals with soil morphology, physics, and chemistry characteristics. Most of the class limits of modifiers are borrowed from soil taxonomy, others could be from field observation, which consists of 4 categories and based on three soil layers. The upper layer coincides with the top 20cm or Type (**C** for clay and **L** for Loamy). The soil below the upper layer from 20 to 50cm is referred to the Substrata Type (**C** for Clay and **L** for Loamy), and from 50 to 100cm is referred to Subsoil Type (**C** for Clay, **L** for Loamy, and **S** for Sandy). The condition modifiers, directly relevant to plant growth, include ***a***, ***a*** $^{-}$ ***c***, ***c*** $^{-}$, ***e***, ***f***, ***f*** , ***g*** $^{+}$, ***i***, ***n*** $^{-}$, ***s***, ***s*** $^{-}$, ***o***, ***p***. Some modifications and additions for classification are suggested, in which new modifiers of ***p*** (low P available), ***o*** (low organic carbon), ***c, c*** $^{-}$ (actual acid sulfate), ***f***, ***f*** (potential acid sulfate) are added, the former ***c*** condition modifier (sulfidic) divided into ***c*** (actual acid sulfate) and ***f*** (potential acid sulfate). Modifiers of ***a***, ***i***, ***n***, ***s***, are suggested with modifications from FCC system. The classes within each category and assigned modifiers for each soil type/substrata type/subsoil type are different, which is followed by modifiers presented.

Keywords FCC, fertility capability classification, modifier, rice

INTRODUCTION

Soil is a component of the natural medium that acquires its morphology and properties after a long and slow evolution after reaching equilibrium with environmental conditions. The data from field tests or from yield production provided by individual farmers records or else are usually local, spotty, and sometimes not reliable and are generally difficult to extrapolate. Therefore, the evaluation is normally conducted indirectly on the basis of the soil properties. The evaluations made should be validated finally with real constraints and yield data. According to Sanchez et al (2003), the problem with soil taxonomy is that it quantifies only permanent soil parameters, most of which are located in the subsoil. Soil taxonomy ignores many dynamic parameters crucial to crop productivity, which are mostly in the topsoil where the majority of plant roots are located, both in natural and agricultural systems. To overcome this limitation, a fertility capability soil classification system (FCC) was developed to interpret soil taxonomy and soil tests in a quantitative manner that is relevant to growing plants (Buol et al., 1975). It is now widely used and is included in the FAO soils database (FAO, 1995).

Based on the developed FCC system by Sanchez et al (2003), the research suggests the framework for developing the system for rice soil fertility classification and recommendation, where soil environment is effected such as soil acidity, agrochemical uses of fertilizer, pesticide, etc, and soil nutrient degradation. The recommended system is useful for farmers or agricultural extension workers to classify their soil, due to its simplicity and easy to apply by using simple lab analytical methods or field identification, with some recommendations for proper soil fertility improvement.

THE CONSTRAINS FOR RICE CULTIVATION RELATED TO SOIL MODIFIERS OR INDICATORS IDENTIFIED

The system was developed based on the soil constraints for rice cultivation, related to suggested system condition modifiers. The attributes used in the system are the lower-case letters of the constraints that have been identified for that soil, which recommended in the system description.

Constraints related to soil mineralogy

High leaching potential (e): Soils with a low cation exchange capacity (CEC) have topsoils with low organic matter content, low clay content, clay minerals with low CEC, or all these properties. These soils have a low inherent fertility and also a low capacity to retain nutrients added as fertilizers.
High phosphorus fixation (i): This is caused primarily by a high content of free ferric oxides (Fe_2O_3) in the clay fraction, which fix phosphate ions. It is a feature also found in strongly acid soils, and hence commonly associated with aluminum toxicity. High P fixation by Fe; P deficiency; Fe toxicity potential; these soils are difficult to puddle and will regenerate to their original structure rapidly.
Low Nutrient Capital Reserves (k): Low inherent fertility because of low inherent reserves of weatherable minerals; potential K deficiency depending on base contents of irrigation water.
Low organic matter status (o): N deficient; response to N fertilization very likely; low ECEC on sandy soils; N fertilizer should be applied in frequent, small doses.
Low inherent P content (p): Plant available P deficient; response to small additions of P fertilization.

Constraints related to soil reaction

Al toxicity, low pH (a, a^-): Aluminum toxicity will occur in aerobic layers; these are soils in which the exchange complex is dominated by alumina. The problem is strongly acid soils, which can be caused by strong leaching from high rainfall, and mainly from oxidation of sulfidic material.
Actual acid sulfate soils (c, c^-): Al and Fe toxicity, low pH, and P deficiency, which originated from oxidation of sulfidic material.
Potential acid sulfate soil (f, f^-): Potential acid-sulfate soils, causing Fe and S toxicity when anaerobic and Al toxicity when aerobic; depth at which sulfidic material occurs determines feasibility of rice production; Zn deficiency common; prevent seepage from these areas.
Constant saturation (g^+): Prolonged submergence causes Zn deficiency. N loss increased if soil is intermittently flooded and drained.
Saline (s, s^-): Defines saline soils; drainage needed but EC of irrigation water must be considered. .
Potential Sodic (n^-): This soil has a slightly high content of sodium but is low in calcium and magnesium salts causing soil dispersion, puddling, poor infiltration and poor aeration, and if sodium is high in the plow layer, probability of surface crust formation will be increased

METHOD FOR RICE SOIL FERTILITY CLASSIFICATION

Based on the soil constraints for rice cultivation, a method for rice soil fertility classification related to constraints recommended, on the basis of FCC system from Sanchez et al (2003) with some modifications, which are easy to apply and classify by using the simple methods for identification in the field or laboratory.

The term "FCC" is used to indicate adaptation of the Fertility Capability Classification, as developed by Sanchez and Buol (1985), and modified by Sanchez et al (2003), to the soil and rice growing conditions, which deal with soil morphology, soil physic, and soil chemistry characteristics. Most of class limits are borrowed from Soil taxonomy (Soil Survey Staff, 1994) or the FAO/Unesco soil classification system (FAO, 1974). The system consists of two categorical

levels. The first category; type/substrata/subsoil type - describes topsoil, substrata and subsoil texture at three soil depths and is expressed in capital letters. The second category; condition modifiers defined to delimit specific soil conditions affecting rice growth with quantitative limits. Each condition modifier is expressed as a lower case letter. The type/substrata type/subsoil type and condition modifiers are the soil attributes in terms of their capability for rice plant growth. Emphasis is placed on features that are easily detectable in the field, such as texture, color, depth of horizons, presence or absence of mottles, etc. Soil analytical laboratory data are only used to support the classification if available. This approach was chosen to enable people with little practical experience in pedology to easily identify soils in the field and classify them into one of the broad groups or phases.

Based on the FCC structure from Sanchez et al (2003), modifiers from system were used for rice soil. Based on the FCC structure from Sanchez et al (2003), modifiers from system were used for rice soil. We found the new structure system that can be used for classifying rice soils. Fourteen soil modifiers that affect rice growth were determined: **a**, **a$^-$**, **c**, **c$^-$**, **e**, **f**, **f$^-$**, **g$^+$**, **i**, **n$^-$**, **s**, **s$^-$**, **o**, and **p**. Among these parameters, **a**, **a$^-$** ,**e** , **g$^+$, i** , **k**, **n$^-$**, **o**, **p**, **s$^-$** for topsoil type, (which directly affects rice root), and **a**, **a$^-$**, **c**, **f**, **g$^+$, k**, **i**, **s**, **s$^-$**, **n$^-$**, for substrata type, which directly affects rice root, and **c$^-$,f$^-$**, **s**, **s$^-$** for subsoil type. There were 6 modifiers added to the system from Sanchez et al (2003), such as: **p**, **o**, **c**, **c$^-$**, **f**, **f$^-$**, in which superscripts **+** or **-** indicate a greater or lesser expression of the modifiers.

The structure of the soil names in the system were changed as follows: Soil texture of topsoil layer 0 to 20cm (**C**, **L**) plus modifiers of topsoil layer (**a**, **a$^-$**, **e**, **i**, **k**, **g$^+$**, **n$^-$**, **o**, **p**, **s$^-$**) plus soil texture of substrata topsoil; 20 to 50cm (**C**, **L**) plus modifiers of substrata topsoil (**a**, **a$^-$** ,**c** ,**f** ,**g$^+$** ,**k** ,**i**, **s** ,**s$^-$** ,**n$^-$**), plus texture of subsoil 50 to 100cm (**C**, **L**, **S**), plus modifiers of subsoil layer (**c$^-$, f$^-$**, **s**, **s$^-$**). The pertinent parts of the classification, which have relevance to rice growing, are described below.

System description

Type (Textute) at less than 20cm

L : Loamy : <35% clay but not loamy sand or sand.
C : Clayed : > 35% clay;
Modifiers:
a : Soil $pH_{H2O(1:1)}$ < 5.0 (or > 60% Al saturation),

a$^-$: Soil $pH_{H2O(1:1)}$ from 5.0 to 6.0 (or 10-60% Al saturation).

e : < 4 cmolc kg^{-1} soil as ECEC, or < 7 cmolc kg^{-1} soil by sum of cations at pH 7, or < 10 cmolc kg^{-1} soil by sum of cations $+Al^{3+}+H^+$ at $pH_{8.2}$

k : Exchangeable K < 0.2 meq/100g soil, or coarse texture (sandy) .

g$^+$: Prolong submergence more than 200 days/year, soil without clearly mottles represented for Fe^{3+} from less than 20cm.

n$^-$: Soil ESP from 6 to 15%.
o : < 0.75% Organic Carbon, and applied for top soil only.
p : (Applied for surface soil only). Available P < 2mg/100g (Olsen), or < 1mg/100g (Bray II).

s$^-$: ECe 2 - 4 mmhos/cm at 25^{O}C.
(Above types and modifers should be applied in this layer only)

Substra type (Textute) at 20 to 50cm

L : Loamy, <35% clay but not loamy sand or sand;
C : Clayed, > 35% clay
Modifiers:

a$^-$: Soil $pH_{H2O(1:1)}$ from 5.0 to 6.0 (or 10-60% Al saturation).

a : Soil $pH_{H2O(1:1)}$ < 5.0 (or > 60% Al saturation)

c : Soil $pH_{H2O(1:1)}$ < 3.5; Jarosite mottle with hue = 2.5Y or yellower, chroma 6.

f : Sulfidic material; pH < 3.5 after drying, without jarosite mottle with hue = 2.5Y at < 50 cm.
i : > 4% free Fe; or mottle with hue redder 5YR which > 35% clay.
k : Exchangeable K < 0.2 meq/100g soil, or coarse texture (sandy)
g^+ : Prolong submergence more than 200 days/year, soil without clearly mottles represented for Fe^{3+} from 20cm to 50cm.

n^- : Soil ESP from 6 to 15%.

s^- : ECe 2 - 4 mmhos/cm at 25^{O}C.

s : ECe > 4 mmhos/cm at 25^{O}C.
(Above Substrata types and modifers should be applied in this layer only)

Subsoil type (Textute) at 50 to 100cm

S : Sandy, loamy sands and sands
L : Loamy, <35% clay but not loamy sand or sand;
C : Clayed, > 35% clay
Modifiers:

c^- : Soil $pH_{H2O(1:1)}$ < 3.5; Jarosite mottle with hue = 2.5Y or yellower, chroma 6.

f^- : Sulfidic material; pH < 3.5 after drying, without jarosite mottle with hue = 2.5Y at > 50cm soil surface.

s^- : ECe 2 - 4 mmhos/cm at 25^{O}C.

s : ECe > 4 mmhos/cm at 25^{O}C.
(Above Subsoil types and modifers should be applied in this layer only)

Interpretation of system nomenclature

The whole idea of this system is that the soil 'name' as given by its system is meaningful for soil fertility management.

CAPITAL character*:* indicated for TYPE, SUBSTRATA TYPE, SUBSOIL TYPE according to soil depth.

Normal character: indicated for **Modifiers** and follows after above character

Example*:* Soil profile which has silt texture (**L**) at < 20cm, silt (**L**) and clay (**C**) at 20-50cm, and 50-100cm, and modifiers **a**, **p** at surface and **a**, **c**, **i** at subsurface and **f^-**, **s^-** at subsoil, which can be named as ***LapLaciCf$^-$s$^-$***.

Strategies for better utilization of soil and soil fertility conservation

The management requirements are given per interpreted soil property or group of properties. A complete listing of all possible combinations is not given because only a limited number of combinations of soil properties will be found in any area under consideration. On a large scale, however, interpretation of the soil properties in relation to farming systems, local expertise or rice varieties could be a valuable extension tool. The management requirements are based on Sanchez et al (2003), Smith (1989) and several experiments in the Mekong delta, Vietnam, on soil reclamation, etc. A description of each soil fertility or management constraint identified is given below.

Al toxicity, low pH (a, a^-): Soluble and exchangeable acidity should be removed as much as possible by leaching before applying amendments.

Actual acid sulfate soils (c, c^-): The free sulfuric acid dissolves clay minerals and produces large amounts of exchangeable aluminum. Iron and manganese toxicities and phosphorus deficiency are common. Physical properties are very poor. Jarosite occurs at 10 to 50 cm depth (**c**). Draining results in a dramatic decrease in pH. High liming rates (greater than 10t/ha every 3 to 4 years) or long term leaching would then be required for crop production (Breeman and Pons, 1978). The

most profitable practice is shallow drainage to grow one crop of a medium-term rice (Vo-Tong Xuan, 1997).

High leaching potential (e): The use of mineral fertilizers is not recommended in these soils in their natural state, as nutrients are not retained by these soils due to the low capacity to retain nutrients. In addition, leaching causes big nutrient losses when lime and fertilizers are applied; therefore, heavy applications of these nutrients and of N fertilizers should be split. Organic matter application is also recommended to increase soil cation exchange capacity. The practicality of adding high activity clays to increase permanent charge could be assessed (Noble et al., 2004).

Potential acid sulfate soil (f, f$^-$): When **f** soils are exposed to air and are low in calcium carbonate, FeS_2 is oxidized to ferric sulfate and free sulfuric acid, producing pH values on the order of 2 or 3. Drained acid sulfate soils are extremely infertile. Flooded rice is often grown, since under constantly reduced conditions, the pH is sufficiently high to eliminate aluminum toxicity.

High phosphorus fixation (i): These soils require high levels of P fertilizers or special P management Sources and a method of P fertilizer application should be considered. P fertilizer application should be split into several times as recommended by Đỗ Thị Thanh Ren and Nguyễn Mỹ Hoa (1998).

Low Nutrient Capital Reserves (k): Potassium fertilizers must be added. Generally, these soils have also limited capacity to retain nutrients and the potassium, calcium and magnesium added can be easily lost (Nguyễn Mỹ Hoa, 2003). The other source of nutrient capital reserves is soil organic matter, which contains all the nitrogen and much of the phosphorus and sulfur capital of soils. Potassium fertilizers or organic amendments with a significant content of K will need to be applied. Crops should be closely monitored for K deficiency symptoms (P. M. Moody et al, 2008).

Prolong submergence (g$^+$): Prolonged submergence causes Zn deficiency, especially on all year round cultivation soil remittently flooded and drained. H_2S toxicity symptom can occur if soil high in organic matter (Ponnamperuma, 1977)

Potential Sodic (n$^-$): Reclamation requires the replacement of Na^+ on the exchange complex by Ca^{2+} and leaching of Na^+ out of the root zone. Soil permeability and internal drainage must also be improved, so the displaced sodium ions can be leached out of the root zone.

Low organic matter status (o): Increasing the levels of organic matter in these soils would improve nutrient supply, increase CEC and water holding capacity. The management of soil organic matter involves mulching and incorporation of 'green manure' crops, retaining all crop residues in the field where the crop has grown, not burning crop residues, minimum or zero tillage farming systems, strip or alley cropping and application of organic materials such as animal manure, composted municipal waste, sewage sludge and locally available organic wastes obtained from off-site (P. W. Moody et al, 2008).

Low inherent P content (p): P management should be considered as a long-term investment in soil fertility, and it is more effective to prevent P deficiency than to treat P deficiency symptoms, because P is not easily lost or added to the root zone by biological and chemical processes that affect N supply. The residual effect of P fertilizer application can persist for several years, and management must emphasize the buildup and maintenance of adequate soil-available P levels to ensure that P supply does not limit crop growth and N use efficiency. Use rice cultivars that use P efficiently.

Saline (s, s$^-$): Presence of soluble salts requires drainage and special management for salt-sensitive rice varieties. Total reclamation of saline soils is often impractical because of the lack of high quality water for irrigation and leaching. Wetland rice production may be an economical alternative. Continuous flooding helps to leach salts out of the root zone. Where enough irrigation water of good quality is available, salts can be leached unless there are high percentages of sodium in the soil which will result in structure collapse and pan formation (Sombroek and nachtergaele, 1994).

Limitations of the method

Land use recommendations and soil improvement/reclamations were based on field survey, farmer interview and several field, lab experiments from several authors recommended, which needs to be tested and recommended for specific location. Modifiers on soil biology as recommended by

Sanchez et al (2003) is need to be added. Besides rice cultivation, other crops such as vegetable, upland, aquaculture, etc, were integrated to rice cultivation, since the system did not classify or recommend for all systems. There are some gaps in defining and identifying the indicators or modifiers. The developed system is used for classification of rice soil fertility at specific locations only.

CONCLUSIONS AND RECOMMENDATIONS

The soil fertility classification relies mostly on the topsoil and subsoils properties that indicate the soil fertility capability and affect rice production. The classification allows no specialists to classify the soil on which they are standing, in the field, even without the aid of a laboratory. The key to the success of the system will be its usefulness to agriculturalists or soil scientists working in the field.

The results are the first attempt to compare soil constraints using standardized data and methods. In order to develop sustainable systems, there must be reliable information on the constraints and potential of the soil and land resources. The principles of soil management are well known, but because climatic, soil and water conditions vary so widely, the design of land use systems, and particularly of conservation measures, must be site-specific. Details of the system for different levels of classification and recommendation should be studied for proper recommendation.

If a soil cannot be adequately classified, or depending on the scale of study, then it is possible to create a new phase or modifiers, because the system has been left "open-ended" to accommodate such modifications in the future, which can be classify the soil for better management and for getting more crop productions. There are some relations between modifiers definition with soil diagnostic horizons, properties, materials from FAO-WRB (World Reference Based) system, so it needs to study on those relationships for conversion from soil map to soil fertility map.

REFERENCES

Breeman, N.V. and Ponts, L. (1978) Acid sulfate soils and rice. Soils and Rice. International Rice Research Institute, 739-763, Philippines.

Buol, S.W., Sanchez, P.A., Cate, R.B. and Granger, M.A. (1975) Soil fertility capability classification, A technical soil classification system for fertility management. Soil Management in Tropical America, North Carolina State University, Raleigh, 126-145, USA.

FAO (1974) A framework for land evaluation. Soils Bulletin 32. FAO of the United Nations, Italy.

FAO (1995) Digital soil map of the world and derived soil properties. FAO, Rome.

Nguyễn Mỹ Hoa (2003) Soil potassium dynamics under intensive rice cropping. A case study in the Mekong Delta, Vietnam. Ph.D thesis Wageningen University, Netherlands.

Noble, A.D., Ruaysoongnern, S., Penning de Vries, F.W.T., Hartmann, C. and Webb, M.J. (2004) Enhancing the agronomic productivity of degraded soils in northeast Thailand through clay-based Interventions. ACIAR Proceedings, 116, 147-160.

Moody, P.W., Legrandl, P.T.J. and Chon, N.Q. (2008) A decision support constraints to upland soils. Soil Use and Management, 24, 148-155.

Ponnamperuma, F.N. (1977) Screening for tolerance to mineral stresses. International Rice Research Institute, Philippines, 6, 21.

Sanchez, P.A., Palm, C.A. and Buol, S.W. (2003) Fertility capability soil classification: A tool to help assess soil quality in the tropics. Geoderma, 114, 157-185.

Research article

Influences of Land Use during the Puddling Period on Water Balance and Quality in a Rice Farming Area

MOHAMMED KAMRUL HASAN
Hokkaido University, Sapporo, Japan
Email: hasan@env.agr.hokudai.ac.jp

YAMAMOTO TADAO
Hokkaido University, Sapporo, Japan

NAGASAWA TETUAKI
Hokkaido University, Sapporo, Japan

Received 3 December 2010 Accepted 28 January 2011

Abstract The study was carried out on the Shinotsu Canal agricultural watershed of Hokkaido, Japan from 2003 to 2008. This study was conducted to evaluate the nutrients fluxes after using irrigation into the paddy fields and the effectiveness of the paddy fields in removing nutrients load of the Shinotsu Canal watershed. Upper part of the Shinotsu Canal is dominated by paddy field and lower part is dominated by upland field. Water samples were collected with an automatic sampler at pump station (inflow) and end of drainage channel (outflow) of both block, and measured volume of inflow and outflow at puddling period (May). The concentration of suspended solids (SS) was determined by gravimetrically through suction filtration, total nitrogen (TN) and total phosphorus (TP) were determined by UV spectrophotometric methods, respectively. Water balance is higher at lower part of Mihara drainage block (MDB) than upper part of Tsukigata drainage block (TDB) due to high percentage of upland that caused losses of water by leakage and percolation. TN, TP and SS concentrations in drainage water are higher in MDB than that of TDB. The net loads of TN and TP are showed negative and lower values in TDB whereas MDB is positive and higher values, due to a combination of nitrification and denitrification, sedimentation reactions and sorption by soil is more in high percentage of paddy field in TDB. TN, TP and SS concentrations outflow load and net load are decreasing from 2003 to 2008 due to changed of water management by progress of pipe line. From the viewpoint of reducing the outflow of nutrients, it may be stated that the paddy field dominated area showed good performance in purification function for nutrients compounds.

Keywords land and water use, water balance, puddling period, water quality, Hokkaido

INTRODUCTION

In Japan, paddy fields cover 55% of the land used for agriculture. They require abundant water and account for 95% of the total agricultural water demand (Tabuchi and Hasegawa, 1995). Paddy fields therefore play a significant role in the overall agricultural watershed. Most paddy fields are located along lower reaches of rivers, use rivers as their main source of water, and discharge their outflow back into the river. The Shinotsu Canal watershed has a significant role in agriculture in Hokkaido, Japan. Water quality of the Shinotsu Canal is influenced by nonpoint source pollutants arising from land-based agricultural activities (Hasan et al., 2010). In some paddy fields along the lower parts of the Ishikari River basin in the Shinotsu Canal, irrigation water is reused as means of maximizing water utilization, and the water may contain higher levels of pollutants from surface and subsurface drainage compared with usual irrigation water. Several researchers have reported that cyclic irrigation may increase the hydraulic retention time of nutrients, and thereby, enhance

water purification in paddy field districts (Feng et al., 2004, 2005; Takeda and Fukushima, 2006). Cyclic irrigation may not only save water but also reduce the concentration of nutrients in agricultural areas (Kudo et al., 1995). The ability of cyclic irrigation to reduce nutrient load is directly proportional to the quantity of water reused (Kaneki et al., 2003). Tong and Chen (2002) examined the hydrologic effects of land use in Ohio and observed a significant relationship between land use and stream water quality, especially with respect to nitrogen and phosphorus.

In irrigation practices, especially puddling and transplantation period (May), require abundant water during the whole irrigation period (May to August) in paddy fields, and have strong influence on the water environment. Furthermore, many studies on nutrient fluxes in paddy fields have been outperformed in the irrigation period, but the flow of nutrients out of paddy fields has not been studied adequately in Hokkaido in instances of abundant water use. Therefore, this study aimed to assess the influences of land use and water management on water balance and quality during the puddling period at the Shinotsu Canal watershed in Hokkaido.

MATERIALS AND METHODS

The investigation was performed in the Shinotsu Canal in the Shinotsu district (43°57′N, 141°4′E), which is located at southern Ishikari River basin in west-central Hokkaido prefecture in northern Japan (Fig. 1). The Shinotsu Canal is 23 km long and passes through 10,864 hectares of agricultural watershed where the main cultivated crops are rice, wheat, corn, onions, and vegetables. Agricultural irrigation is controlled by five pumping stations from upstream to downstream. The lower stream pumping stations provide irrigation water derived through drainage channels from the outflow or runoff from upstream paddy fields. The study area comprised the Tsukigata drainage block (TDB) in the upper stream and Mihara drainage block (MDB) in the lower stream of the Shinotsu Canal (Fig. 2).The soil is peat-dressed mineral soil, and most land is flat. The annual average precipitation is 1024 mm, most is in the form of rain occurring from July to September. The annual temperature ranges from a minimum of −7.4°C in January to a maximum of 23°C in August. Fertilizer is applied to paddy fields in this region (N, 60–75 kg/ha; P, 80–90 kg/ha) during puddling to transplantation period (May) and the flowering stage (middle of July).

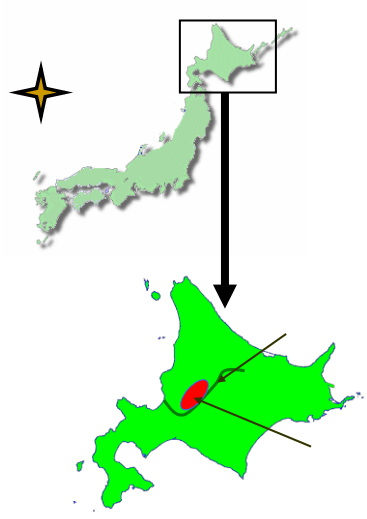


Fig. 1 Location map of study area

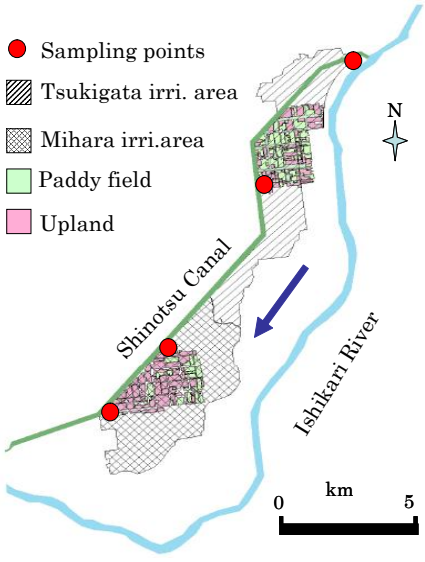


Fig. 2 Investigated area of Shinotsu

Inflow and outflow water samples (composite water samples) were collected from TDB and MDB. Composite water samples (two mixture samples obtained at intervals of 6 h for 24 h) were collected with an automatic water sampler (ISCO Model 3700) during the puddling and transplantation periods (May) in 2003, 2004, 2006, 2007, and 2008. Inflow water samples were collected at each pumping station, and outflow samples were collected at the end of the TDB and MDB drainage channels. Inflow water volume of TDB and MDB were calculated from data on

pump discharge and water level in the delivery tank; these data were collected from the management office of the Tsukigata and Mihara pumping stations (Shinotsu-chuoh Land Improvement District). Outflow water volumes were calculated from continuous records of water levels using an automatic water gauge, and flow velocity was measured when the water was sampled. Channel renewal (open to pipe) data were collected from the Shinotsu-chuoh Land Improvement District. Precipitation was estimated from the Shin-shinotsu and Tsukigata rainfall records using the Automated Meteorological Data Acquisition System (AMeDAS). Areas of paddy fields and uplands in the study watersheds were calculated using GIS Arc-View software from 1:25,000 scale digital maps. The concentration of suspended solids (SS) was determined gravimetrically by suction filtration, and total nitrogen (TN) and total phosphorus (TP) were determined by UV spectrophotometric methods. The concentrations of SS, TN, and TP were determined as described in the Japanese Industrial Standard (JIS).

RESULTS AND DISCUSSION

The Tsukigata and Mihara irrigation and drainage blocks were investigated from 2003 to 2008, and the areas of their paddy fields and upland fields were calculated. The Tsukigata pumping station irrigated 1948 hectares in the upstream agricultural watershed of the Shinotsu Canal (Table 1). TDB forms part of the irrigation area for Tsukigata pumping station and covers an area of 743 hectares (Table 1). Mihara pumping station lies in the downstream agricultural watershed of the Shinotsu Canal and irrigates 2018 hectares (Table 1). MDB is part of the irrigation area of Mihara pumping station and covers 747 hectares (Table 1). During the study period, the paddy field area was greater in TDB than in MDB, but the upland field area was greater in MDB than in TDB. A high percentage of the paddy field area was found in TDB (41–46%). In contrast, the percentage of upland was higher in MDB (56–63%) than in TDB (30–36%). TDB was dominated by paddy fields and MDB by upland fields; land use pattern did not change substantially during the study period.

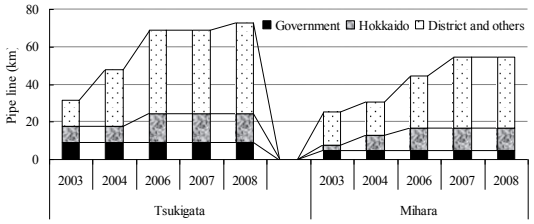


Fig. 3 Renewal of pipe line at Tsukigata and Mihara irrigation block

The form of irrigation channels is an important factor in water management in the agricultural watershed of the Shinotsu Canal. The pipeline irrigation channels are constructed from open channels in the Tsukigata and Mihara irrigation blocks. Lengths of the pipeline irrigation channels of the Tsukigata and Mihara irrigation blocks were calculated for every year from 2003 to 2008, except for 2005. The total pipeline length in the Tsukigata irrigation block was larger than that in the Mihara irrigation block for every year (Fig. 3). Pipelines are constructed as part of projects operated by the national government, the Hokkaido prefecture government, and the Shinotsu-chuoh Land Improvement District. The length of pipeline constructed under the national government project was constant during the study period, whereas the length of pipeline constructed under the Hokkaido project increased from 2003 to 2006 in both blocks. Pipelines constructed under other projects gradually increased in length from 2003 to 2008 in both blocks. The condition of these pipelines is evaluated at each drainage block. The water balance of each block was calculated using Eq. (1):

$$\textit{Water balance} = \textit{total inflow} - \textit{total outflow} \quad (1)$$

where *total inflow* is the volume of pumped water plus precipitation, and *total outflow* is surface plus subsurface drainage water per day. Inflow and outflow water volumes of TDB and MDB were calculated for the years 2003 to 2008. Irrigation water is distributed from about May 7 every year

in the Shinotsu district. Average daily inflow water volume was greater for MDB than for TDB for every year. In contrast, outflow water volume of MDB was lower than that of TDB. Inflow and outflow volumes gradually decreased due to increasing pipeline length in both blocks. The form of irrigation channel is changing gradually from open to pipeline, and farmers now control irrigation water for each paddy block to ensure proper water utilization. In contrast, the land use pattern of each block did not change significantly during the study period. The water balance of MDB was higher than that of TDB for every year (Fig. 4), because the percentage of upland was higher in MDB than in TDB, and paddy fields were scattered. Abundant water was therefore lost from the paddy fields to adjacent uplands by leakage and percolation. Water balance in TDB and MDB did not change significantly during the study years except in May, 2006 at MDB (Fig. 4).

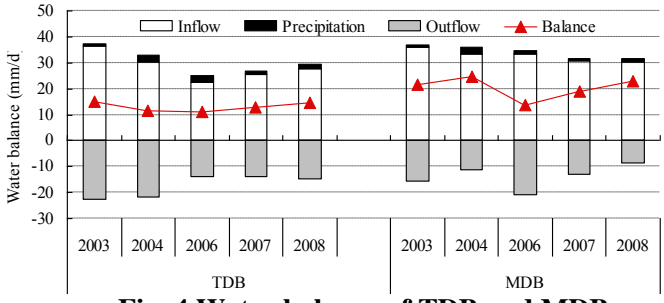


Fig. 4 Water balance of TDB and MDB

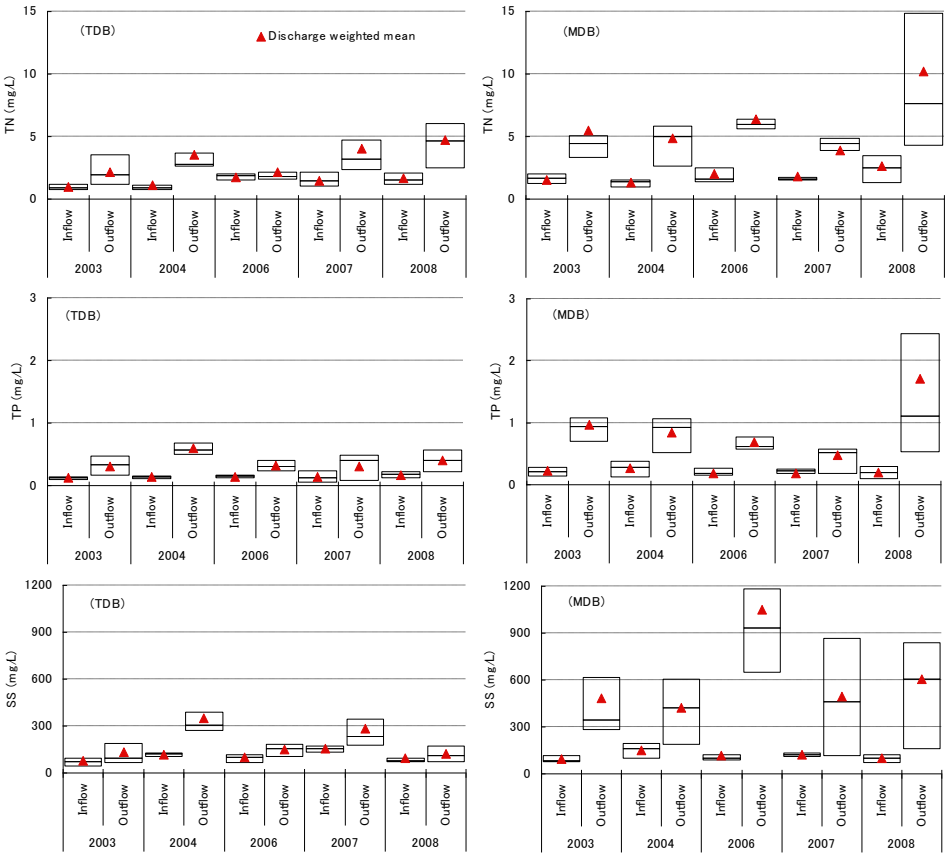


Fig. 5 Concentarions of TN, TP and SS in TDB and MDB in May

The discharge weighted mean concentrations of TN, TP, and SS of inflow and outflow water of TDB and MDB in May for every year are shown in Figure 5. The box plots of TN, TP, and SS concentrations represent 75% and 25% quartiles, medians, and weighted mean values for TDB and MDB. Mean TN, TP, and SS concentrations were higher in outflow than in inflow water in both drainage blocks. Variations in TN, TP, and SS concentrations were larger in outflow than in inflow water. These variations are thought to be caused by agricultural activities, i.e., puddling and

transplantation. In the initial stages of rice cultivation, abundant irrigation water is used in paddy fields for puddling, and it mixes with soil and fertilizer. Nutrient-rich flooded water is released through surface drainage before transplantation. A high load of pollutants accumulates through subsurface drainage and is subsequently discharged into drainage ditches. The concentrations of nitrogen and phosphorus in drainage water increase during puddling and transplantation, and also when fertilizer is applied (Takeda et al., 1997; Feng et al., 2004). Several studies of water quality indicators in drainage water from paddy fields in Japan showed that the concentrations of these contaminants increased significantly during puddling periods (Kondoh et al., 1992). Also, nutrient concentrations are generally higher in drainage water than in irrigation water (Takeda et al., 1997). In the present study the concentrations of TN, TP, and SS in outflow water were higher in MDB than in TDB due to the land use pattern, i.e., low percentage of paddy fields in every year (Table 1). Outflow discharge was lower in MDB than in TDB during the study period (Fig. 4), and nutrient concentrations were decreased by the high outflow discharge in the TDB drainage. Tabuchi and Takamura (1985) reported that outflows from paddy fields contained much less pollutants than upland fields because nutrients are easily absorbed by soil particles in paddy fields. The concentrations of TN, TP, and SS showed large variation due to puddling, transplantation, and initial use of fertilizers, which runoff by surface and subsurface drainage from paddy fields in both blocks. Nutrient concentrations of drainage water increased rapidly when the puddling process began, and high concentrations continued to be present during subsequent farming activities.

The net outflow nutrient load is one of the most important factors to consider when evaluating the role of paddy fields in reducing levels of pollutants from agricultural watersheds (Tabuchi and Takamura, 1985). The net nutrient load associated with irrigation is defined as the outflow nutrient load minus the inflow nutrient load (e.g., Takeda et al., 1997). The net load indicates increase or decrease in the nutrient load discharged from the paddy field when irrigation is compared with drainage water. A positive net load indicates that the paddy field area is a nutrient source, whereas a negative value indicates that the area is a nutrient sink, i.e., nutrients are absorbed by the paddy soil. The nutrient load is the product of average nutrient concentration and water flow volume. The daily nutrient load is calculated using the L-Q power Eq. (2):

$$L = aQ^b \tag{2}$$

where L is the load in kg ha^{-1} d^{-1}, Q is the flow rate m^3 ha^{-1}d^{-1}, and a and b are coefficients. Thus, the net nutrient load, L_{net} (kg ha^{-1}d^{-1}) is given by the following Eq. (3):

$$L_{net} = aQ_{out}{}^{b} - a'Q_{in}{}^{b'} \tag{3}$$

TN, TP, and SS loads were greater in MDB than in TDB for every year except for the outflow SS load of MDB. The net TN and TP loads were negative and lower values were found in TDB than in MDB (Table 2), because TDB contained a higher percentage of paddy field than MDB, causing greater nitrification and denitrification, sedimentation reactions, and sorption by soil. Misawa (1987) and Shiratani et al. (2002) reported that paddy field areas in Japan caused net removal of nutrients due to a combination of nitrification and denitrification, sorption by soils, and sedimentation reactions.

Table 1 Land use of research areas

Study block		Tsukigata	Mihara
Irrigation block (ha)		1948	2018
Drainage block (ha)		743	747
Paddy (ha)	2003	303 (40.8%)	161 (21.6%)
	2004	308 (41.5%)	208 (27.8%)
	2006	311 (41.9%)	184 (24.6%)
	2007	310 (41.7%)	188 (25.2%)
	2008	343 (46.2%)	177 (23.2%)
Upland (ha)	2003	269 (36.2%)	467 (62.5%)
	2004	264 (35.5%)	420 (56.2%)
	2006	261 (35.1%)	444 (59.4%)
	2007	262 (35.3%)	440 (58.9%)
	2008	224 (30.1%)	425 (56.9%)

Table 2 Nutrients loads of TDB and MDB in May

Load (kg ha^{-1})	Year	TDB			MDB		
		Inflow	Outflow	Netload	Inflow	Outflow	Netload
TN	2003	10.25	-11.86	1.61	18.21	-23.94	5.73
	2004	10.13	-11.48	1.36	15.35	-17.29	1.94
	2006	9.54	-9.21	-0.33	14.68	-33.53	18.85
	2007	10.03	-9.27	-0.77	13.76	-15.66	1.90
	2008	10.06	-9.49	-0.57	13.30	-13.28	-0.02
TP	2003	1.54	-1.24	-0.31	2.51	-3.78	1.26
	2004	1.23	-1.15	-0.08	2.06	-2.83	0.77
	2006	0.84	-0.48	-0.36	1.98	-5.07	3.09
	2007	1.04	-0.47	-0.57	1.81	-2.93	1.12
	2008	1.12	-0.55	-0.57	1.75	-2.25	0.50
SS	2003	105.39	112.35	6.96	61.33	26.22	-35.10
	2004	96.53	102.00	5.47	48.68	24.99	-23.69
	2006	92.51	56.57	-35.94	49.42	56.20	6.78
	2007	90.35	53.90	-36.45	40.67	23.97	-16.70
	2008	88.08	50.83	-37.26	33.09	21.04	-12.05

Net SS loads were negative in both TDB and MDB. TN, TP, and SS loads decreased between 2003 and 2008 due to changes in water management activities, i.e., progress in pipeline construction. However, progress in pipeline construction reduced outflow water volume, which affects the outflow and net load of nutrients. Water discharge is closely related to nutrient load. Our data on net nutrient loads indicate that areas dominated by paddy fields promote the purification mechanisms for nitrogen and phosphorus compounds in the water environment of agricultural watersheds.

CONCLUSION

In this study, we evaluated the land use pattern, renewal of irrigation channels by pipeline construction, water balance, water quality, and mass balance of nutrient loads in drainage blocks. The data on land use pattern indicated that TDB is dominated by paddy field areas whereas MDB is dominated upland fields. The water management system changed from open channels to pipelines in each block during the study period. Water balance was higher in MDB than TDB because MDB had a larger proportion of upland, which caused greater losses of water by leakage and percolation. The concentrations of TN, TP, and SS in outflow water were higher in MDB than in TDB, because pollutant outflow from paddy fields was much less than that from upland fields. Paddy fields act to purify pollutants such as nitrogen and phosphorus. The net loads of TN, TP, and SS were negative in TDB, where the lower values indicated nutrient uptake by TDB paddy soil, whereas MDB paddy fields had positive loads and higher values; i.e., they were nutrient sources. By reducing the outflow of nutrients, blocks dominated by paddy fields showed good purification performance for nutrient compounds. The reasons for this were the relatively low nutrient concentrations in irrigation water and the change in the water management system in TDB. Upstream (TDB) water is therefore cleaner than lower stream (MDB) water because of the effects of agricultural land use and the water management systems of the Shinotsu Canal watershed.

REFERENCES

Feng, Y.W., Yoshinaga, I., Shiratani, E., Hitomi, T. and Hasebe, H. (2004) Characteristics and behavior of nutrients in a paddy field area equipped with recycling irrigation system. Agric. Water Management, 68, 47-60.

Hasan, M. K., Yamamoto, T. and Nagasawa, T. (2010) Influences of land and water use on the water quality of Shinotsu Canals through agricultural areas. IJERD, 1-1, 174-179.

Kaneki, R. (2003) Reduction of effluent nitrogen and phosphorus from paddy fields. Paddy Water Environment, 1, 133-138.

Kondoh, T., Misawa, S. and Toyota, M. (1992) Characteristics of effluent loads of nutrient salts (N,P) from paddy fields located in the alluvial and lower area in Hokuriku District - research study on nutrient load in the low plain areas of Niigata. Trans. Jpn. Soc. of Irrigation, Drainage and Reclamation Engineering, 159, 17-27 (in Japanese with English abstract).

Kudo, A., Kawagoe, N. and Sasanabe, S. (1995) Characteristics of water management and outflow load from a paddy field in a return flow irrigation area. Jpn. Soc. Irrigation, Drainage Reclamation Engineering, 63-2, 179-184 (in Japanese with English abstract).

Misawa, S. (1987) Mechanism of water quality change in paddy field. Trans. Jpn. Soc. Irrigation, Drainage Reclamation Engineering, 127, 69-79 (in Japanese with English abstract).

Shiratani, E., Yoshinaga, I., Feng, Y.W. and Hasebe, H. (2002) Scenario analysis for reduction of effluent load from agricultural area by recycling use of the drained water. Proceedings of the Sixth International Conference on Diffuse Pollution, Netherlands, 331-338.

Tabuchi, T. and Hasegawa, S. (1995) Paddy Fields in the World. Jpn. Soc. of Irrigation, Drainage and Reclamation Engineering, 203-225.

Takeda, I. and Fukushima, A. (2006) Long-term changes in pollutant load outflows and purification function in a paddy field watershed using a cyclic irrigation system. Water Res. 40, 569-578.

Takeda, I., Fukushima, A. and Tanaka, R. (1997) Non-point pollutant reduction in a paddy field watershed using a circular irrigation system. Water Res. 31-11, 2685-2692.

Tong, S.T.Y. and Chen, W. (2002) Modeling the relationship between land use and surface water quality. Journal of Environmental Management, 66-4, 377-393.

Research article

Influence of Soil Salinization on Growth of Cotton in an Arid Area in Northwest of China

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

HASEGAWA SHUICHI
Research Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan

KAMIYA MITSUHIKO
Hokkaido Institute of Technology, Sapporo, Hokkaido, Japan

ABDISALAM JALALDIN
College of Resources and Environmental Sciences, Xinjiang University, Xinjiang China

ANWAIRE MAIMAIDI
Xayar Water Resource Agency, Xayar, Xinjiang, China

NAGASAWA TETUAKI
Research Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan

Received 8 December 2010 Accepted 28 January 2011

Abstract This paper discusses the influence of soil salinization on cotton plant growth and the factors that cause salinization in irrigated farmland located along the northern part of the Tarim River, Xinjiang Uygur Autonomous Region, China. A field survey was conducted in a cotton field in Nuerbake Township, Xayar County. The physical properties of the soil, fluctuations in groundwater level, the growth of cotton plants and electrical conductivity (EC) of the soil saturation extract were investigated. The quality of irrigation water and groundwater was also measured at the study area. The groundwater level was low in the summer and high in early spring; this high level was due to thawing of the soil and irrigation for planting. However, use of border irrigation temporarily raised the groundwater level. Even within the same field, the EC of the soil saturation extract differed depending on locations and soil depths. An EC of the surface soil exceeding 8.0 dSm^{-1} retarded cotton growth. We found that irrigation water quality did not affect the growth remarkably because the EC of the irrigation water was lower than 4.0–6.0 dS/m. On the other hand, the existence of a less permeable subsurface soil damaged cotton growth. The difference in hydraulic properties of the subsurface soil is influenced by the amount of clay that affects water and saline movement toward the surface.

Keywords electrical conductivity, soil saturation extract, salinization, irrigation

INTRODUCTION

The degradation of fields by soil salinization causes decrease in crop production. Soil salinization is a serious problem in arid and semi-arid regions (Jan van S., 1994), and it is a chronic problem in Xinjiang, northwest China. In Xinjiang, the agricultural field under salinization influence is about one-third of the total cultivated field (Hou, Z. et al., 2007). At the same time, soil salinization becomes a serious problem with the increase in irrigation agriculture (Yamamoto, T. et al., 2006).

The factors affecting soil salinization have been delineated in several past studies. In this area of China, soil salinization is the result of several factors, namely; 1) soil and groundwater contain

large amount of saline; 2) the groundwater level is kept high and 3) soil moisture and saline move to the surface by evapotranspiration under the above-mentioned conditions.

However, the groundwater level may not be a direct factor of soil salinization in Xayar, China, because salt accumulates in the farmland where groundwater level is sufficiently deep (Nagasawa, T. et al., 2008). Moreover, little research has been done on crop growth and soil salinization, and fundamental data are needed to counter this problem in the future. Therefore, in this study, we considered the factors involved in soil salinization and its influence on cotton growth in the Tarim River Basin.

METHODOLOGY

Outline of the investigation area

The investigation targeted Nuerbake Township of Xayar County, which is located in the Taklimakan Desert in the northern border region of Xinjiang Uyghur Autonomous Region. Xayar County is located downstream of the Ugen River, which is a branch of the Tarim River (Fig. 1). The temperature ranges from −30°C to 40°C, and annual precipitation is about 50 mm in this region. Here, soil freezes during the winter. The primary local crop is cotton, and irrigation water relies on the Kyzyl Dam located upstream of the Ugen River. The method of irrigation is mainly border irrigation.

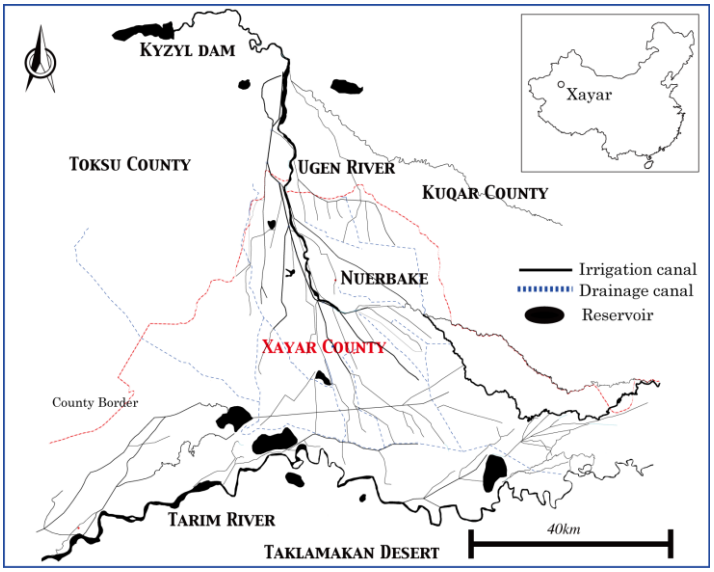


Fig. 1 Outline of Xayar County

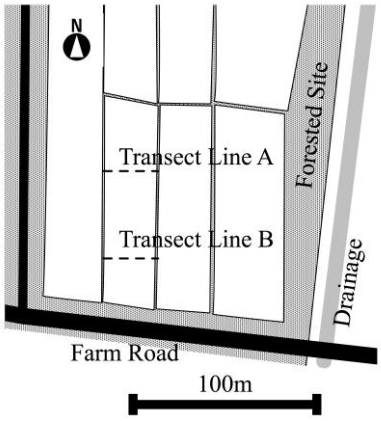


Fig. 2 Investigation field

The sampling of the irrigation, drainage, groundwater and well water was performed in Xayar, particularly in the Nuerbak Township in 2006–2010. The electrical conductivity (EC) was measured onsite, and water quality was analysed for anions and cations with Japanese Industrial Standards (JIS).

The EC of soil saturation extracts in a farmland damaged by salt accumulation was measured. In addition, a soil survey of the farmland and groundwater level measurement was conducted. The surveyed farmland was located near a drainage ditch and consisted of cotton fields where the growth of cotton was uneven and salt accumulation was relatively troublesome (Fig. 2). We measured plant heights and collected soil samples from this farmland. The survey was conducted during the flowering period in early August 2008 at two places, namely: along the A Line extending in the east to west direction at 40 m north of the farm road where the growth of cotton

flowers was uneven and sporadic bare areas could be seen on the ground; and, along the B Line extending in the east to west direction at 12 m north of the road where plant growth was relatively even. Along both the lines, from points 1.5, 4.5, 7.5, 10.5, 13.5, 16.5 and 19.5 m from the western end, soil samples were collected from the depth of 45 cm using a 50 cm long, thin steel pipe with an inner diameter of 2.7 cm at the tip and 3.0 cm along the rest of the pipe. At each point, soil samples were collected three times and divided them into five layers (0-5, 10-15, 20-25, 30-35 and 40-45 cm from soil surface); each layer was then collected in a separate plastic bag. These samples were transferred to a polyvinyl chloride container, saturated from the bottom with water taken from the main irrigation channel (EC value: 0.45 dSm^{-1}) and absorbed with an unglazed cup to measure the EC value. Soil samples were collected from the depth of 1.0 m in each line with a hand auger. Measurement of $EC_{1:5}$ values (1 part soil with 5 parts water) and screening tests were performed with these samples.

RESULTS AND DISCUSSION

Cotton growth and EC in the farmland

Along the A Line, 40 m from the road where the growth was bad (Fig. 3), there were sporadic bare areas on the ground and the heights of cotton flowers were uneven. In contrast, along the B Line, 12 m from the road side where the growth was relatively even, there were no bare areas on the ground and the plant heights were comparatively even, albeit with differences of approximately 10 cm. Cotton is a salt-tolerant crop, comparable to beet and alfalfa, and capable of producing a bumper harvest up to an EC value of 8 dSm^{-1}.

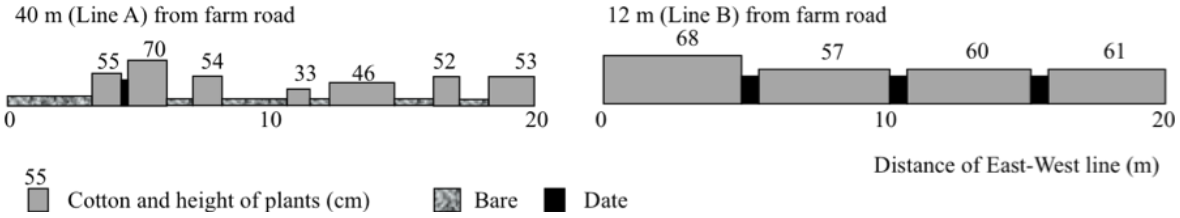


Fig. 3 Growth situation of cotton on each transect line

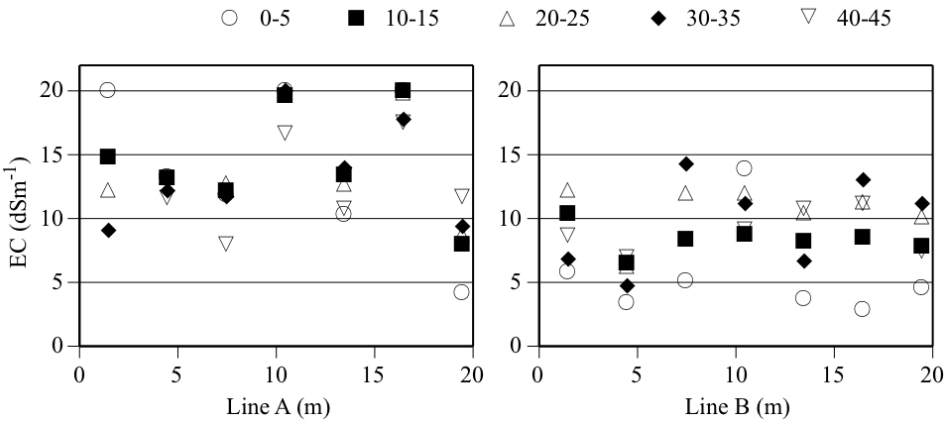


Fig. 4 EC of soil saturation extracts at each depth on farmland

Figure 4 shows the EC values along the A Line in parallel with the heights of cotton. At some points, the EC value exceeded 20 dSm^{-1}, which is the measurement limit of the EC metre used. In

such cases, the EC value was recorded uniformly as 20 dSm^{-1} on the figure. In the bare areas, in particular, the EC value of shallow parts exceeded 20 dSm^{-1}.

With the exception of the easternmost point, the EC value exceeded the threshold value for survival at all points and depths along the A Line. Besides, at most points, the shallower the depth, the higher the EC value tended to be, thus indicating an accumulation of salt near the ground surface due to evaporation. On the other hand, along the B Line where the growth of cotton was relatively even, the EC values fluctuated considerably even at the same point depending on the depth. However, the EC value never exceeded 15 dSm^{-1}. Furthermore, with the exception of one point, the EC value of the 0-5 cm layer was below the threshold value of 8 dSm^{-1}; however, at most points, the EC value of the 10-15 cm layer was in the vicinity of the threshold value. Therefore, the deeper the depth, the higher the EC value tended to be (Fig. 4). This suggests that unlike the A Line, the influence of eluviation by irrigation water was greater than that of salt accumulation caused by soil surface evaporation in the B Line.

Because EC is influenced by grain size composition in soil deeper than the target layer, we could not find a tendency in the relationship of the EC value and the percentage of a specific grain size ($<3.8 \times 10^{-5}$ m). However, in the relationship between the EC value of the 0-10 cm layer and the relative elevation of the ground on each sampling point, the $EC_{1:5}$ value increased as the relative elevation increased ($P<0.05$, Fig. 5). From this result, since the dissolved matters move with soil moisture by a capillary power with aridity, saline matters accumulation were estimated in the higher elevation point where is susceptible to such effect.

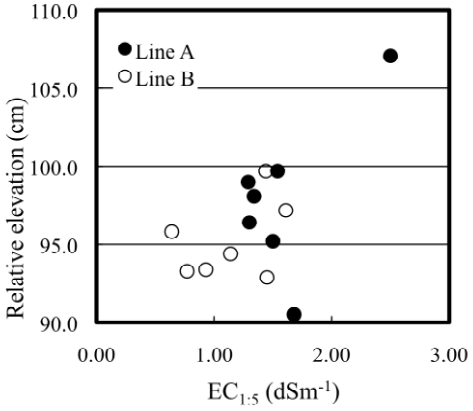


Fig. 5 Relationship of $EC_{1:5}$ and relative elevation of the farmland

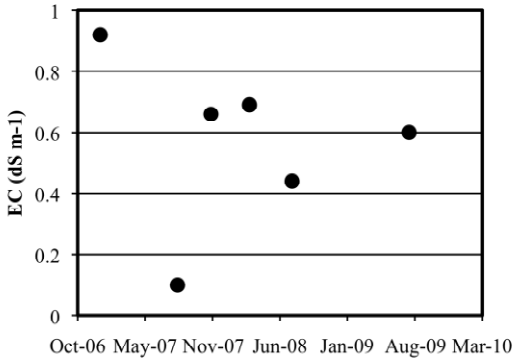


Fig. 6 Changes of EC in irrigation water

Table 1 Water quality of groundwater (Aug 2006)

No.	EC (dSm^{-1})	Cation (meq L^{-1})			Type
		Na^+	Ca^{2+}	Mg^{2+}	
1	4.6	16.0	13.7	15.1	Shallow groundwater (<4.0 m)
2	1.6	5.2	3.7	4.6	
3	2.2	6.4	7.9	9.2	
4	2.0	8.6	2.0	2.0	Well water (<30 m)
5	1.4	4.4	3.9	4.1	
6	2.6	10.8	4.2	7.4	
7	5.1	17.9	11.0	14.1	
8	4.0	12.3	12.9	14.8	
9	3.3	8.7	11.3	15.0	
10	0.6	2.9	1.4	0.0	Well water (120 m)

Water quality in the area

The EC value of irrigation water changes seasonally, and it ranged from 0.4 to 0.7 dSm^{-1} in this area (Fig. 6). According to the standard of United States Department of Agriculture (USDA) (Soil Survey Division Staff, 1993), this value shows an intermediate salt density disorder. The EC values of the groundwater were basically more than 2.0 dSm^{-1} in our research. This result is appropriate because Chen, W. et al. (2010) shows that the salinity levels of most of the shallow groundwater sources in Xinjiang are greater than 2.0 dSm^{-1}. Dissolved cations are shown in Table 1. It shows Na^+ value is higher at the time of EC is lower, and Mg^{2+} is higher as to be high value of EC. When the EC value of groundwater is compared, the tendency is for the EC value to be higher in the shallow groundwater of a field and to be lower in a deeper well. The influence of the leaching effect by irrigation is the likely cause that EC is higher in shallow groundwater.

Changing of groundwater level

In this area, it is assumed that a groundwater level of more than –2.0 m carry a high risk of soil salinization. The change of groundwater level in research target farmland is shown in Fig. 7.

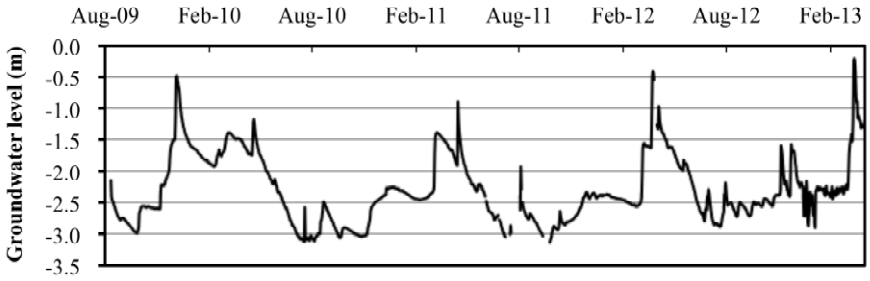


Fig. 7 Change of groundwater level in farmland

It shows groundwater level is higher in the winter and early spring and sufficiently lower in summer. Certainly, groundwater level is higher in the planting period (March to early April), but it is not high enough to be a problem during the cotton growing season.

Why does unevenness of soil salinization occur?

In the case wherein irrigation water was very saline, soil salinization may have occurred due to the salinity being supplied to the field by irrigation water. However, the EC of irrigation water was much lower than that of the groundwater in this study. This suggests that irrigation water is not a direct factor in soil salinization.

According to the USDA standard, the EC value of the irrigation water can be classified as causing moderate salinity damage. Nevertheless, when compared with the EC value and positive ions of shallow underground water, the effects of leaching are evident. This implies that the supply of salts by the irrigation water was not directly connected with salt accumulation. Saline in the soil of the farmland migrates by capillary attraction. In particular, it is believed that the presence of soil stratum containing clay beneath the A_p layer contributes to the maintenance of dampness in the soil, thereby promoting capillary attraction.

When the groundwater level is sufficiently deep, the supply of salts and water from beneath is scarce. However, in this region, irrigation and the thawing of ice in the soil, especially in early spring, causes the groundwater level to rise. Moreover, soil moisture is kept in the soil layer containing clay. In other words, the rise of shallow groundwater supplies the soil with saline from beneath in the annual groundwater fluctuation. This should be a major factor causing soil salinization, as the capillary action of the soil attracts the salts to the surface.

As for the unevenness of cotton growth that occurs in the same farmland, it was considered a waterlogging by inequality of ground surface during the planting period, partial difference of soil

structure (soil layer including large amount of clay exists in comparatively shallow depth) and deviation in fertilizer application could be the factors causing the same.

CONCLUSION

The influence of soil salinization on cotton growth in an arid area was observed. Based on the results, in the bare areas, the EC of soil saturate extract exceeded the threshold value (8 dSm^{-1}) for survival at all points and depths. In the area where the growth of cotton was relatively even, the EC values did not exceed the threshold value in 0–5 cm depth. In other words, it is clear that saline accumulation influences cotton growth. On the other hand, it was suggested that the causes of unevenness of soil salinization in the same farmland are soil composition (e.g. clay content) and microrelief (land elevation) on the farmland. Moreover, irrigation water was not a direct factor in soil salinization.

It is thought that soil improvement and the introduction of under-drainage in farmland would be an effective solution for the problem of soil salinization, but this is difficult when cost is considered. For realistic correspondence, it was suggested that crops are grown on furrow. This way should make saline matters beneath the plants move to the ridge direction. It is necessary to verify this hypothesis by further experiments.

ACKNOWLEDGEMENTS

Xayar County Government, Xayar Water Management Agency and Xinjiang Uyghur Autonomous Region Water Resource Management Bureau supported this research.

This study is a part of the academic research (No.21405031) supported by Grant-in-Aid for Scientific Research (B) from Japan Society for the Promotion of Science (JSPS), Japan.

REFERENCES

Jan van, S. (1994) Irrigation-a blessing or a curse. Agricultural Water Management, 25, 203-219.

Hou, Z., Li, P., Gong, J. and Wang, Y. (2007) Effect of different soil salinity levels and application rates of nitrogen on the growth of cotton under drip irrigation. China. Journal of Soil Science, 38, 681-686.

Chen, W., Hou, Z., Wu, L., Liang, Y. and Wei, C. (2010) Evaluating salinity distribution in soil irrigated with saline water in arid regions of northwest China. Agricultural Water Management, 97, 2001-2008.

Soil Survey Division Staff (1993) Soil survey manual, Soil Conservation Service. U.S. Department of Agriculture Handbook, 18, 108.

Yamamoto, T., Nagasawa, T. and Abudisalam. J. (2006) Irrigated agriculture and the environment in the Tarim River watershed: Case study of the Shaya irrigation district in the Ugen River basin. Sustainable Irrigation Management, Technologies and Policies, WIT press, 303-312.

Nagasawa, T., Yamamoto, T. and Abudisalam, J. (2008) Salinization of farmland in northern region of Taklamakan Desert, Relationship of salinization and agricultural wateruse in semi-arid zone (1). Conference Proceeding of Japanese society of Irrigation, Drainage and Rural Engineering, 808-809.

Research article

Soil Erosion Control by Coconut Husk Buffer Strip in Bohol Island of Philippines

JULIAN TORILLO JR.
Graduate School of Agriculture, Tokyo University of Agriculture, Japan
Email: juliantorillo@yahoo.com

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

Received 9 December 2010 Accepted 9 February 2011

Abstract Soil erosion causes serious environmental problems in Bohol Island, Philippines. Considering the agricultural socio-economic situation in the island, utilizing available materials in the region to mitigate soil erosion particularly in the upland fields have been focused. Thus, slope modeling experiments were conducted to evaluate the effects of coconut husk buffer strip on mitigating the losses of soil and nutrients. Based on the experimental results, the coconut husk buffer was effective to trap transported soils, however the nutrient losses from the plots with the coconut husk buffer were slightly higher than that from control plot without any treatments in the initial stage of rainfall events after the installation of coconut husk buffer strip.

Keywords coconut husk, buffer strip, trapping capability, soil and nutrient losses

INTRODUCTION

Parts of the land areas with 8-18% slopes in Bohol Province of the Philippines are covered with upland fields. Even in the mountainous areas with more than 18% in slopes, some portions have been exploited particularly for subsistence agriculture. Along with the higher intensity rainfalls in the interior mountainous areas, upland fields and other less vegetated areas on slopes are susceptible to soil erosion that causes rapid degradation of land (OIDC, 2006).

Upland fields with protruding stones and rocks on ground surfaces as well as abandoned farmlands are now dominant particularly in the southwestern part of the island. Thus, the strategies for rehabilitating and conserving these land resources are necessary where soil erosion is the prime problem to be mitigated. This study dealt with the strategic soil erosion control by utilizing coconut husk which is biodegradable, renewable and locally available material in the region. Considering the agricultural socio-economic situation in the island of Bohol, economical and easy application with high efficiency is also one of important scopes that should be focused. So, the objectives of this study are to observe the capability of coconut husk buffer to trap soil and nutrient losses with measuring the particle sizes that were trapped by buffer medium.

MEHODOLOGY

In order to evaluate the effects of coconut husk buffer on mitigating soil erosion, modeling experiments were carried out in the laboratory with artificial rainfall facilities at Tokyo University of Agriculture, Tokyo, Japan. The soil with clay percentage at 63.8%, silt at 8.1% and sand at 28.1% obtained from abandoned corn field in Tiptip District, Tagbilaran City of Bohol was used in the experiment.

Coconut husk was pounded by hammer to make it into a fibrous material and installed at the lower end of the slope model plots (130 cm long and 11 cm wide) in which around 7.5 kg of the soil was filled. Three plots were prepared as Plot I, Plot II and Plot III as the plot of control, the

plot with 2 rows of husk buffer and the plot with 2 rows of husk buffer in addition to 25 cm husk mulch, respectively as shown in Fig. 1. The prepared slope model plots were set up at 8 degrees in slope and simulated by artificial rainfall. Rainfall simulation was carried out for 2 hours at the intensity of 60 mm/h. The experiment was replicated 3 times in separate days. Surface water discharge (Point 1) from each plot was measured and the surface water was collected at every 15 minutes for the first hour and at every 30 minutes for the second hour.

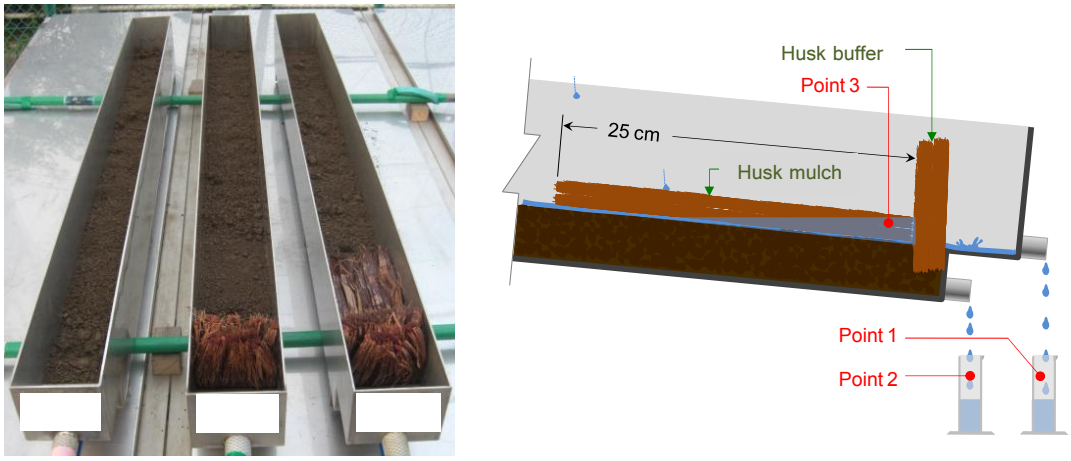


Fig. 1 Stainless slope model plots and installation of coconut husk buffer at slope toe

The amount of percolation water (Point 2) was measured and sampled after 24 hours from the end of each rainfall simulation. Both collected water samples at Point 1 and Point 2 were analyzed for total nitrogen (T-N) and total phosphorous (T-P). Also, the amount of soil losses were measured for collected water samples at Point 1. After the decomposition of water samples with sodium hydroxide (NaOH) and potassium peroxodisulfate ($K_2S_2O_8$), the concentrations of T-N and T-P were measured by spectrometric method (Mihara et al, 2000). Oven drying method was used to measure the soil loss concentration in the suspended water of surface runoff.

For comparing the particle sizes of soils eroded from each plot, the wet sieving method was applied using 106, 250, 500 and 1000 µm sieves (Ghadiri et al., 2001). One liter of suspended water was collected after passing through the sieves to determine the amount of <106 µm in diameters. Then the collected one liter suspended water was sampled by pipette method then filled into the weighing can and dried by oven together with the sieved soils from 106, 250, 500 and 1000 µm sieves.

RESULTS AND DISCUSSION

Soil losses

As shown in Fig. 2, the amounts of soil losses at Plot I as control dramatically increased with the repetition of rainfall simulation compared to that at Plots II and III with husk buffer. Also, there was a significant difference at 99% level between the amounts of soil losses at Plot I as control and that at Plots II and III with husk buffer in the second rainfall simulation test. During the first, second and third rainfall simulation tests, the 2 rows of husk buffer at Plot II could mitigate 36, 45 and 53% of soil losses at Plot I as control while the 2 rows of husk buffer with 25 cm husk mulch at Plot III could mitigate 50, 61 and 54%, respectively.

It was clearly observed that the coconut husk buffer worked to mitigate about 50% of soil losses. Meanwhile, the 2 rows husk buffered with mulch at Plot III had no significant difference in the amounts of soil losses with the 2 rows husk buffered at Plot II.

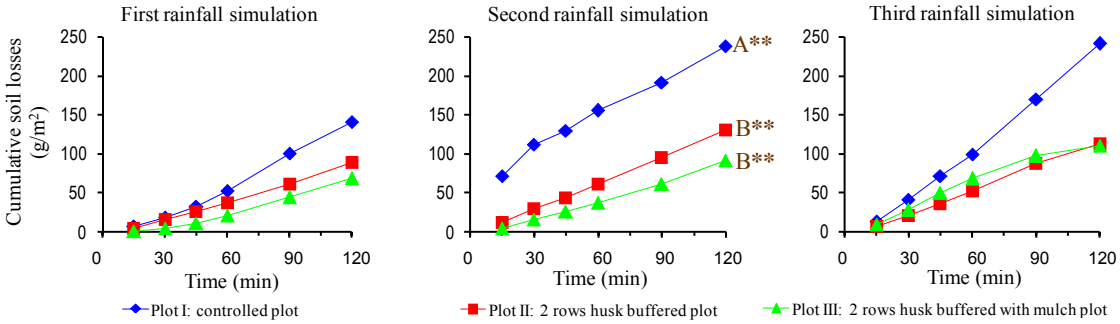


Fig. 2 Cumulative soil losses from Plots I, II and III in each rainfall simulation test

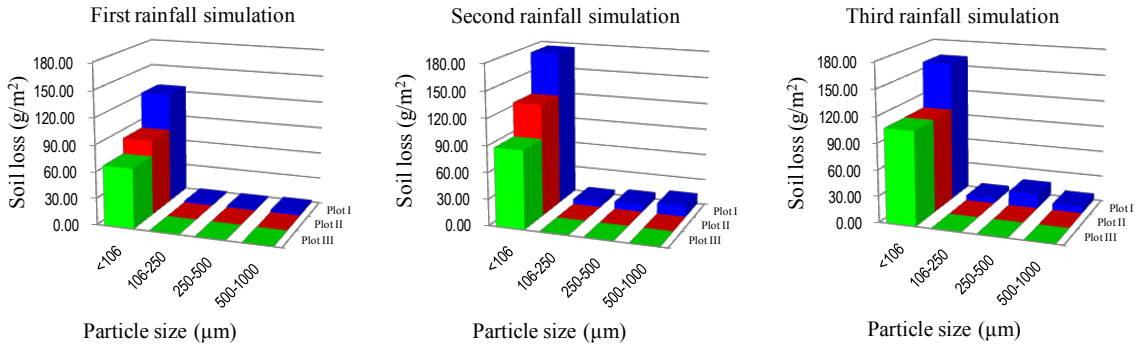


Fig. 3 Particle sizes of eroded soils from Plots I, II and III at first, second and third rainfall simulation tests

Coconut husk buffer strip trapping capability

The amounts of eroded soils from the plots in particle sizes of <106 µm in diameter were dramatically higher compared to the particle sizes of >106 µm (106 to 1000 µm) as shown in Fig. 3. Although coconut husk buffer could mitigate only around 25% to 35% of eroded fine soils in particle sizes of <106 µm, coconut husk buffer trapped 99% of eroded soils in particle sizes of >106 µm (106 to 1000 µm).

The experimental results showed the coconut husk buffer was highly capable to trap eroded soils larger than 106 µm in diameter, however less capable to trap fine soils in particle sizes of <106 µm.

Total nitrogen losses

As shown in Fig.4, the amounts of total nitrogen (T-N) losses through surface discharge from Plots II and III with husk buffer were slightly higher than that from Plot I as control in the first rainfall simulation test. It showed that coconut husk set in the plots released total nitrogen components. However, the amounts of total nitrogen (T-N) losses through surface discharge from Plots II and III became lower than that from Plot I in the second and third rainfall simulation tests.

Higher amounts of total nitrogen losses through percolation were observed at the husk buffered plots, particularly in Plot II (Table 1). The results clearly indicated that coconut husk set in the plots released total nitrogen components not only through surface runoff but also through percolation. In addition, there was a tendency for the amounts of total nitrogen losses through percolation to decrease with the repetition of rainfall simulation.

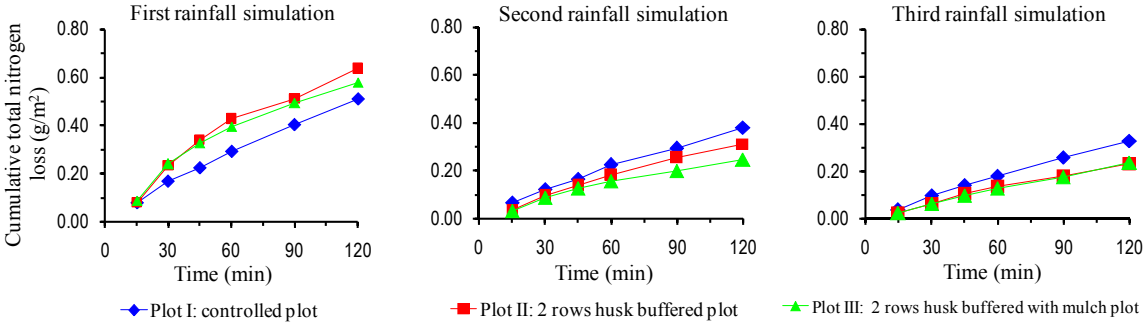


Fig. 4 Cumulative total nitrogen (T-N) losses through surface discharge from Plots I, II and III in each rainfall simulation test

Table 1 Total nitrogen losses through percolation ($x10^{-2}$ g/m^2)

	First rainfall simulation	Second rainfall simulation	Third rainfall simulation
Plot I	2.889	1.561	0.955
Plot II	3.066	1.983	2.500
Plot III	1.615	1.235	1.209

Total phosphorus losses

As shown in Fig. 5, there was a tendency that the amounts of total phosphorus (T-P) losses increased with the repetition of rainfall simulation. Also, the amounts of total phosphorus (T-P) losses from Plots II and III with husk buffer tended to be lower than that from Plot I as control, although a significant difference was not recorded.

As shown in Table 2, the amount of total phosphorus losses through percolation tended to increase with the repetition of rainfall simulation, although some fluctuations in amounts of T-P losses were observed.

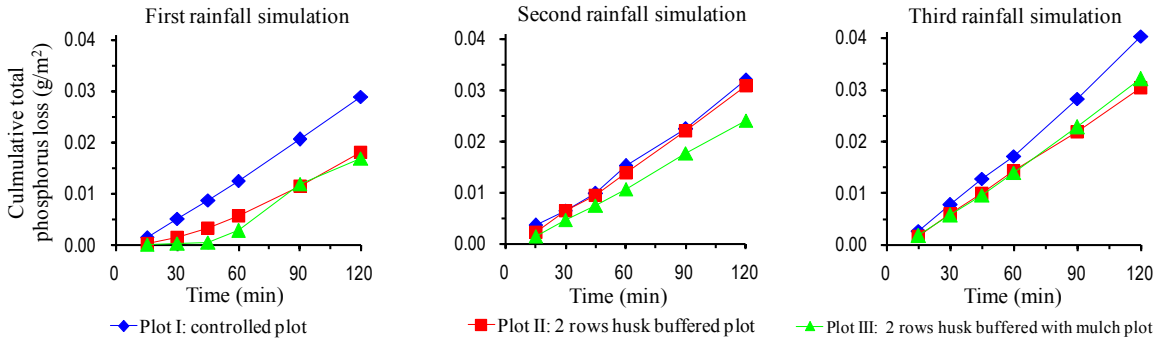


Fig. 5 Total phosphorus (T-P) losses through surface discharge from Plots I, II and III in each rainfall simulation test

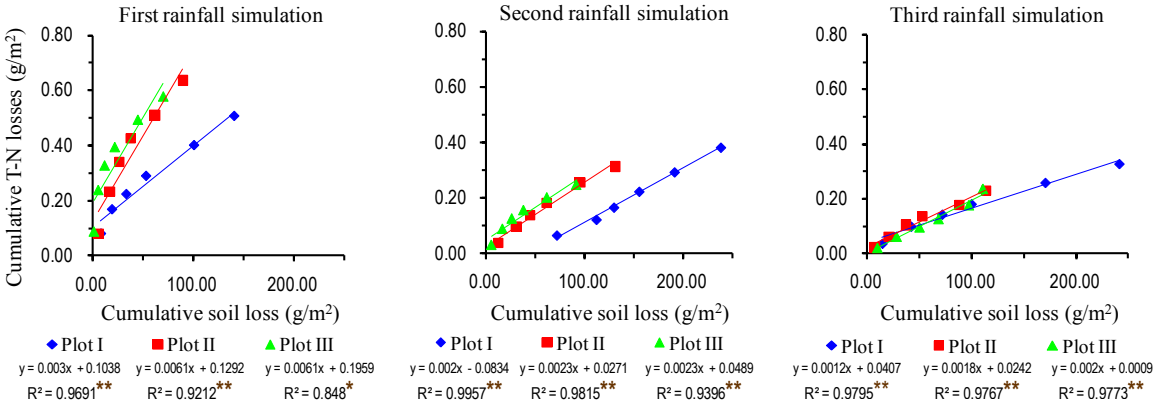
Table 2 Total phosphorus losses through percolation (x10^{-2} g/m^2)

	First rainfall simulation	Second rainfall simulation	Third rainfall simulation
Plot I	0.039	0.090	0.120
Plot II	0.052	0.058	0.054
Plot III	0.031	0.161	0.048

Relationship between soil and nutrient component losses

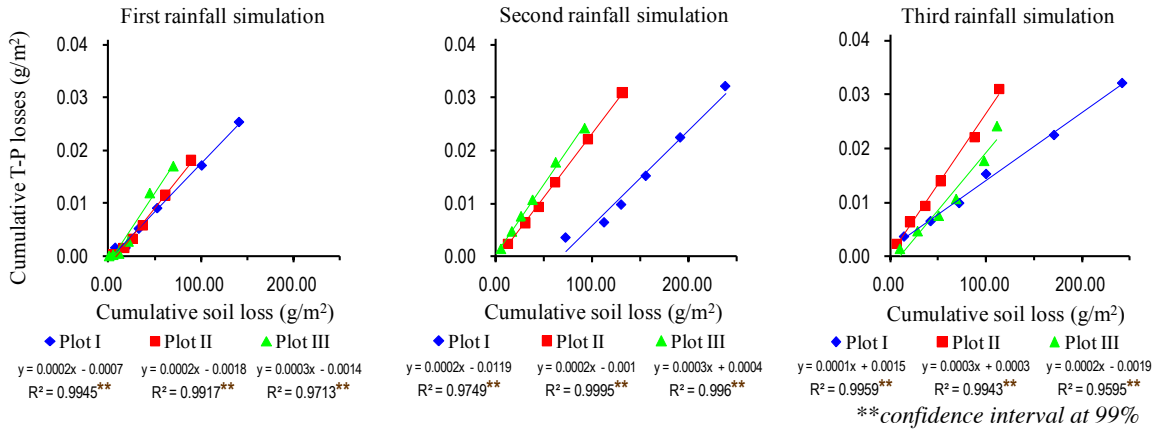
As shown in Fig. 6, the relationship between total nitrogen and soil losses changed remarkably during the first to third rainfall simulation tests. During the first rainfall simulation test, the amounts of total nitrogen losses rapidly increased with the amounts of soil losses. In the second and third rainfall simulation tests, the trend in the first rainfall simulation test became gentler, as the amounts of total nitrogen losses gradually increased with the amounts of soil losses.

The amounts of total phosphorus losses increased with the amounts of soil losses (Fig. 7). The increasing tendencies of total phosphorus losses from each plot changed slightly during the first to third rainfall simulation tests. However, there was a tendency that the amounts of total phosphorus losses from Plots II and III with husk buffer became higher than that from Plot I of control, especially in the first and second rainfall simulation tests. In the third rainfall simulation test, the difference in the amounts of total phosphorus losses among plots became small.



**confidence interval at 95%*
***confidence interval at 99%*

Fig. 6 Relationship between T-N losses and soil losses



***confidence interval at 99%*

Fig. 7 Relationship between T-P losses and soil losses

CONCLUSION

In Bohol Island of Philippines, soil erosion causes serious environmental problems. Considering the agricultural socio-economic situation in the island, utilizing available materials in the region to mitigate soil erosion particularly in the upland fields have been focused. So, this study dealt with the evaluation of the effects of coconut husk buffer strip on mitigating the losses of soil and nutrients.

The experimental results indicated that coconut husk buffer could trap 99% of eroded soils in particle sizes of >106 μm (106 to 1000μm), however less capable to trap eroded fine soils in particle sizes of <106 μm. In addition, the nutrient losses from the plots with the coconut husk buffer were slightly higher than that from control plot without any treatments in the initial stage of rainfall events after the installation of coconut husk buffer strip. It was considered that coconut husk set in the plots released nutrient components.

ACKNOWLEDGEMENT

I would like to acknowledge the support of President Dr. Elpidio T. Magante of Bohol Island State University for his meaningful guidance and advices.

REFERENCES

Hussein, J., Yu, B., Ghadiri, H. and Rose, C. (2007) Prediction of surface flow hydrology and sediment retention upslope of a vetiver buffer strip, Journal of Hydrology, 338, 261-272.

Mihara, M. and Ueno, T. (2000) Nitrogen and phosphorus transfer in soil erosion processes, IAHS Publication, No. 263.

Orient Integrated Development Consultants Inc. (2006) Bohol Agriculture Master Plan, CY 2006-2026.

Research article

The Social Economy - Key Element of Sustainable Environmental and Societal Development in Asia

FABIAN THIEL
University of Applied Sciences, Frankfurt/Main, Germany
Email: bodenrecht@fabian-thiel.de

Received 10 December 2010 Accepted 8 January 2011

Abstract Cooperatives, associations, partnerships, non-profit organizations (NPOs) and non-governmental organizations (NGOs) are core elements of the Social Economy. Social Economy as an economic and societal development approach could support the sustainable rural and environmental management in South East Asian countries. Examples for Social Economy enterprises are microlending institutions, fishing and rice cooperatives in Vietnam and Thailand, pepper and pottery associations in Cambodia or rural and small scale industry commodities and service associations. The Social Economy needs just and equal distribution of property, but also innovative property tax collection models in order to guarantee sustainable financial support by the governments. The implementation faces several challenges. Existing private property or leasehold rights and large agricultural investment funds could lead to the exclusion of small and medium landowners, family-based farmers and to a lack of institutional support from higher political levels. A system combining different forms of public and private property and good land governance may be the means to bridge the gap between the private right to acquire natural resources and the needs of the Social Economy. The division of agricultural land, natural commodities and the means of production in a comprehensive and equal way between the people is of fundamental importance for the Asian states.

Keywords social economy, property policy, secure land use rights, resource distribution, Asia

INTRODUCTION

The social economy serves as property policy, underlined by an interdisciplinary approach of good governance, law, economy, and land use planning. Asian societies should provide its citizens with opportunities to participate in community-oriented social economies. In developing and transformation of Asian countries, the social economy seeks to empower individuals in taking part of the general economic growth, poverty reduction, and social development particularly in the rural areas. Poverty reduction policies oriented towards sustainability and empowerment need a bottom-up approach where the people own and manage their businesses or communities and where they use the natural resources wisely. Hence, land and other non-renewable resources are essential and indispensable pillars of the social economy. But natural resources as the basic means for production and for any economic activities are limited and getting scarce. Many projects under the wide umbrella of the social economy, for instance the Federal Land Development Authority (FELDA) which initiated the pro-poor land reform, land distribution and cooperative projects in the Philippines, will have to contend with less suitable land for its cooperatives or infrastructure projects.

Challenges for community-based, socially well-balanced rural development and environmental management still remain in several Asian countries until today. The majority of agriculture producers are small and medium enterprises (SME). Respect for the vulnerable urban and rural poor or landless people calls for the bottom-up community organizing approach as an empowering instrument of the social economy. Experiences from the Philippines, Thailand, Vietnam and Cambodia showed that it takes approximately 10 years to organize people until they have built up a democratic, autonomous and self-reliant local community. In this given timeframe,

the social economy enables people to understand the reality of the nature as well as the created environment, to take steps towards effective changes for improving their livelihoods, and thus liberate people from dependency, especially from donor money or monopolistic market participants like agriculture product traders.

Theoretical regulatory framework for the social economy

Cooperatives, associations and independent organizations will be discussed whether these sectors might be used for participatory community environmental and societal development. Thus, this paper provides theoretical discussions and selected case studies of social economy projects. The social economy requires a firm land use planning system, socially well-balanced distribution of property rights and a fair, transparent property taxation to redistribute the revenues to the population in equal shares, particularly in rural areas. In Cambodia, tax revenue from transfer, leasing and selling of land properties rose to 19.51 million USD in 2010. This increased revenue could be used as subsidies for social economy companies or to support social initiative financials. As an innovative land use modality, associations and producer cooperatives for common property resources like land, forests, water and energy are additional instruments for securing existing land tenure of the farmers and SMEs. Land use planning, public land management and property taxation tools may be much more efficient if they are embedded within communal land ownership, land leasehold systems and similar bottom-up approaches to allow grass-root communities to empower collective action in their societies. Hence, the social economy strengthens local communities where people are enabled to share their knowledge and experience, for instance in agricultural extension and marketing. Social economy enterprises should consist of steering committees that will facilitate the framework of business' concepts and their strategy. In the case of operating on the local level, community leaders/managers should call for meetings and moderate the general assemblies. They have the task to communicate with the political authorities and sign documents or issue certificates containing legal registration processes. Moreover, the advantage of co-operation must be evident for every stakeholder in such an enterprise (Ostrom, 1990).

DISCUSSION

Collective action of vulnerable individuals has been of crucial importance for the social economy ever since (El-Ghonemy, 2010; Elsen, 2010). For instance, in the seventies, agriculture and producer cooperatives achieved impressive results in Asian countries like Japan, the Philippines, Sri Lanka, and Thailand, marking more than 400,000 cooperatives totalling 75 million members. At present, cooperatives work as a central element of the Thai and Vietnamese economies. Social economy sub-concepts and terminologies like social enterprises or social entrepreneurship are attracting an increasing interest in Asia, especially in South Korea, Japan, Taiwan, and recently Cambodia. Japan successfully adopted the cooperative idea and cooperative law from Germany in its efforts towards socially-balanced economic growth. In contrast, the historical experience of Cambodia during the Khmer Rouge period (1975-1979) makes it a special case indeed. Due to a private property-oriented, neoliberal land titling policy since 1995, attitudes towards the social economy are still limited. Links among NPOs, NGOs, cooperatives, associations and foundations engaging in rural development are weak in Cambodia. A significant amount of one billion USD as development money for Cambodia in key sectors like agriculture, trade, education, and governance was provided in 2010 by approximately 2,000 NGOs. Based on a lack of donor harmonization, cooperation amongst these NGOs or development aid agencies is still remarkably rare.

Future profits within the Social Economy should be made at organisational, at commune as well as individual levels. Cooperatives must be able to compete with other private market participants and state enterprises. Flexibility of each cooperative organization and adaptability to the changing market conditions as well as experienced, qualified leaders and/or managers are needed. Due to its agricultural potential, Southeast Asia (in compare with regions in southern Africa where numerous experiences with independent organizations exist) could serve as a role

model for the worldwide making of the social economy in order to resemble cooperatives and social movements (Defourny and Develtere, 2009).

Key principles of the social economy

Social and health independent organizations, producer cooperatives, associations, and collective entrepreneurs create the "homo cooperativus". They open a third way in using of land, commodities, and manpower resources beyond either private property or the planning economy. As an innovative land use alternative, (agricultural) associations and service/producer cooperatives or group rights on common property resources and collective entrepreneurship are additional and important instruments for secure land tenure (Olson, 1965). These entrepreneurs are part of social land policies on global scale in view of the social economy and the people-centred development context (Münkner, 1982; Elsen, 2010). Numerous social economy approaches like économia popular y solidaria, community economy or the économie solidaire base on similar key principles as listed below;

- Strictly voluntary membership and exit options
- Autonomy and solidarity (independent organizations as elements of subsidiarity)
- Democracy amongst the stakeholders (principle of "one member, one vote")
- Independence from the state
- Common public property for resources and other non-renewable means of production
- Equal distribution of profits and
- Self-organization

Public property or public enterprises which operate on state land are typical manifestations of the social economy since they are suitable for land, commodities, energy facilities, industries, service sectors such as banks or insurance companies. The transformation of private land property into public land property in favor of public enterprises and utilities is legally permitted by the majority of constitutions in Asian countries. Compensation for the loss of private property has to be provided to the previous owner(s) but the compensation does not necessarily have to be based on market value, money or on similar incentives. Public social or medical communities, trust arrangements, public funds, commons, public-private partnerships (PPPs) or cooperatives serve as social economy enterprises (see Figure 1 below).

Redistribution of land ownership through the social economy

Within the field of social economy, various definitions coexist like solidarity-based economy, économie sociale or social enterprises. Autonomous decisions about objectives, output, strategies, marketing, sales, and management are their common guidelines. Social economy is not equivalent to slow economy. Économie sociale is used due to the French understanding and should not be confused with économie solidaire which aims exclusively at small, local and regional companies working with a social performance (Jeantet, 2010). Cooperatives are widely distributed enterprises of the social economy and are very successful entrepreneurs. Cooperatives may be suitable for landless and land poor households for residential, rural and agricultural community empowerment. They encourage independent groups, house construction and business communities, income generation and agricultural extension including processing and marketing. Cooperatives and associations can provide access to micro-credit institutions. The Grameen Bank in Bangladesh serves as a highly influential business model. There are numerous cases and best practices of smaller and less known credit cooperatives in other developing countries in Asia, e.g. in Thailand. Cooperatives could build up mortgage communities including long-term value chain business strategies or micro-insurance services. In particular, independent cooperatives which are strongly supported and advised by the Food and Agriculture Organization (FAO) and the International Labour Organization (ILO) rely on institutional arrangements and an environment of political commitment, including financial support.

Land use models using the concept of common property resources (CPR) or community-based natural resource management (CBNRM) with regulations, participation and decentralization strategies for avoiding a land-free-for-all-mentality are still underdeveloped in some Southeast Asian countries like Cambodia and Lao P.D.R. Fair and transparent land distribution and socio-ecological land policies also need a firm land use planning system which is incomplete in Cambodia and other Asian countries like the Philippines (Thiel, 2010). Agricultural associations and service/producer cooperatives or group rights under control of women's groups on common property resources are additional instruments for secure, gender-equal land rights. They can be combined with value chain business approaches. Agricultural extension services are the basis for food security and poverty reduction in many Asian countries like Cambodia, Vietnam or Thailand since about 80% of the population in these countries live in rural remote areas. Moreover, cooperatives and associations can provide access to fair trade systems and mutual public health insurance as the cornerstone of a social safety net. Preconditions for cooperatives, associations, and independent organizations in Asia are;

- Constitutional laws and related sub-laws (rule of law, consisting of land laws, business and commercial enterprise laws, competition laws, cooperative laws etc)
- The creation of property rights, consisting of land as a primary public, local commodity but not as an open resource affected by unlimited and unregulated use

Innovative constitutional and sub-constitutional regulations arrangements for the social economy need laws by the federal government to be finally implemented. The establishment of public communal and collective private property and/or public enterprises for the building industry and real estate as well as for energy like coal, water or geothermal energy, industries and banking or insurance companies could be appropriate social economy strategies.

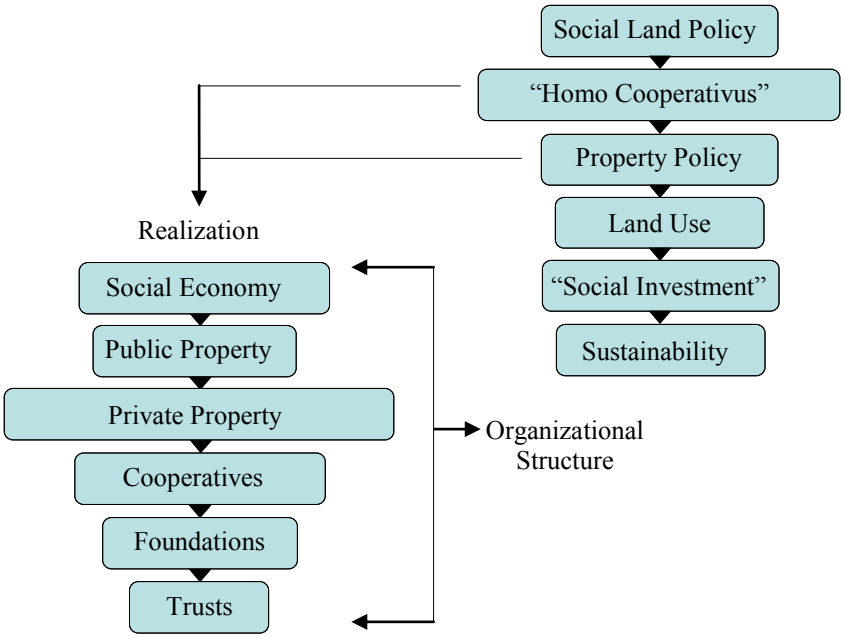


Fig. 1 Policy structure and the organizations of the social economy

Challenges and perspectives for the social economy in Asia: The example of Cambodia

A viable formula for a socially equal distribution of land as of paramount importance for a just and sustainable planning and property system (pro-poor property policy) – the property basis of the social economy – has yet to emerge in many Asian states. Property policy does not only consist of property rights and the attempts of the legislators to balance private and public interests. A system combining different forms of property and governance may be the means to bridge the gap between the private right to acquire which is easily exercised by those who understand the system and can

bear the transaction costs that legal private ownership entails. The needs and actions of real government efficiency in order to divide land up in a comprehensive and equal way per capita is an everlasting task for the social economy legislator (El-Ghonemy, 2010). Globalization induces structural problems and negative effects mainly in remote rural regions in Asia as it does worldwide. This development causes poverty in broad segments of the population and could lead to migration into cities or urban bias, and may result in problems particularly for farmers and small enterprises, especially due to insufficient resources and lack of access to financial services, working equipment, sales, new technologies, and updated knowledge.

The importance of amending sub-constitutional regulations can be illustrated with the example of Cambodia. An amendment of the existing legal framework – a Royal-Decree for agricultural cooperatives – is currently projected towards the implementation of a modern Cooperative Law. This law on cooperatives should form the basis to introduce successful models (e.g., purchase of farm inputs, bulk buying, marketing, credit and saving systems) to small-scale family farmers and other target groups like SME. Additionally, the law should help to increase the number of officially registered agricultural cooperatives slowly and sustainably. As of July 2010, there were 175 producer cooperatives registered in Cambodia to provide strategic and technical assistance towards the formation of cooperative federations and marketing systems like worker's unions (v. Walther, 2010). However, the recently drafted Cambodian Law on Associations and Non-Governmental Organizations ("NGO-Law") established procedures for mandatory registration, operation and termination of domestic associations as well as international NGOs. In particular, the law sets minimum numbers of founders or initiators (21 founders for associations and 3 initiators for NGOs). Foreign NGOs will have to collaborate with Cambodian governmental institutions which can examine the financial status reports and properties of associations and NGOs at any time. Registration and reporting requirements are comprehensive and a lack of clarity on applications and postponements or dissolution can be observed. In light of the registration procedures, the administrative "NGO-Law" could be seen as a contradiction to the existing Civil Code of Cambodia which also sets rules and procedures for associations and communities.

The Kampong Cham experience of founding and running a pepper farmer cooperative also shows that Cambodian farmers are strongly interested in organizing their own producer units. Since November 2009, different meetings with local farmers' groups were held to prepare the guidelines and discuss the future cooperative's role and its function. Pepper fields were extended from 450 hectare to around 550 hectare in 2010, equivalent to 1.1 million poles. The first assembly in March 2010 established the "Dar-Memot Pepper Development Agricultural Cooperative". The farmers were trained on organic plantation; a cooperative shop supplies organic fertilizer and pesticides. The cooperative was registered at the end of May 2010. Credits for poor pepper farmers were given by the cooperative (Glatzel, 2010).

CONCLUSION

Land property, land use planning mechanisms, and social property policy as basic elements for the social economy in Asia as well as around the globe should include;

- Just and equal distribution of property: different property forms and tenure securities for land beyond the private property rights solution for the use of non-renewable natural resources and any immovable properties
- Effective and efficient state land management with non-transferable public property
- Leasehold tenure contracts, combined with innovative property taxation collection models (redistribution of the ground rent for the benefit of the people as an 'add up')
- Property steering function of the spatial/land use planning policy (property policy)
- Reduced transaction costs for the access to fertile land, but avoiding the 'tragedy of the commons'

This review allows a number of final conclusions. How can better governance be achieved through the social economy in view of uncontrolled land consumption, urban migration and a

socially still unbalanced distribution of property rights, in particular of land use rights? Neutral land use planning – bare of private speculative interests – and property taxation can be achieved, as mentioned above. Due to globalization, the bilateral and multilateral donor organizations involved in the rule of law processes, those especially engaged in social economic reform activities in developing countries in Asia, are far more focused on the property rights reform than at any time in the last half century.

In the year 2000, neoliberal interpretations of property models dominated and were seen as a necessary foundation for development according to the Washington Consensus. The concept of the social economy was hardly discussed in scientific publications. However, times and property interpretations are changing rapidly nowadays because the private property rights orientation no longer holds everywhere in the world (Barrera-Hernández, 2010; Riddell, 2008). There is less agreement on how to resolve land and other natural resource allocation decisions and conflicts than it was at the end of the previous decade when that neoliberal model of private property rights had nearly universal acceptance (Riddell, 2008; Bromley, 2008). Today, social economy, pro-poor land policy, public/private land property management, and land use planning policy need framework arrangements guaranteed by the institutions responsible for rural and urban development.

REFERENCES

Barrera-Hernández, L. (2010) Got Title; will sell: indigenous rights to land in Chile and Argentina. In: McHarg, A., Barton, B., Bradbrook, A. and Godden, L. (eds.) (2010) Property and the Law in Energy and Natural Resources, Oxford.

Bromley, D. W. (2008) Land and economic development: new institutional arrangements. In: Cornia, G. C. and Riddell, J. (eds.) (2008) Toward a Vision of Land in 2015, International Perspectives, Lincoln Institute of Land Policy, Cambridge/Mass., 217-236.

Defourny, J. and Develtere, P. (2009) The social economy: the worldwide making of a third sector. In: Defourny, J., Develtere, P., Fonteneau, B. and Nyssens, M. (eds.) (2009) The Worldwide Making Of The Social Economy. Innovations and changes. Leuven/Den Haag, 15-40.

El-Ghonemy, M. R. (2010) Anti-poverty land reform issues never die. Collected essays on development economics in practice, London and New York.

Elsen, S. (2010) Social work and community-based social economies, reflections on the task of socio-political development. In: Sandu, D. (2010) European societies in transition: social development and social work, Berlin.

Glatzel, K. (2010) The Kampong Cham experience of establishing and running a farmer's cooperative. Presentation at the "Summer School" of the Faculty of Land Management and Land Administration at the Royal University of Agriculture, 30 September 2010, Phnom Penh.

Jeantet, T. (2010) Economie Sociale, Neu-Ulm.

Münkner, H.-H. (1982) Ten lectures on co-operative law, Bonn.

Olson, M. (1965) The logic of collective action: Public goods and the theory of groups, Harvard.

Ostrom, E. (1990) Governing the commons. The evolution of institutions for collective action, Cambridge Univ. Press, Cambridge.

Riddell, J. (2008) Toward a 2015 vision of land. In: Cornia, G. C. and Riddell, J. (eds.) (2008) Toward a vision of land in 2015. International Perspectives, Lincoln Institute of Land Policy, Cambridge/Mass., 307-323.

Thiel, F. (2010) Land Law and Planning Law in Cambodia: Problems and Perspectives. In: Cambodian Yearbook of Comparative Legal Studies, 1, 71-85.

Walther, H. v. (2010) Cooperatives and associations as innovative and successful mechanisms for rural development and economic growth. Presentation at the "Summer School" of the Faculty of Land Management and Land Administration at the Royal University of Agriculture, 30 September 2010, Phnom Penh.

Research article

Effect of Land Use Agglomeration on Nitrogen Concentrations in River Water in the Tokachi River

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

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

YUDAI KUDO
Docon Company Limited, Hokkaido, Japan

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

Received 10 December 2010 Accepted 9 January 2011

Abstract Since in the nineties, contamination of river water by nitrogen from cultivated land has been an issue in major agricultural region of Hokkaido. This study examines the effects of the ratios of cropland or forestland to the watershed area on the nitrogen concentration in the river water, taking as its survey area the Tokachi River basin in eastern Hokkaido, Japan. The study also investigates the impact of cropland and forestland agglomeration on the nitrogen concentration in river water. Survey samples were taken at 37 locations on the Tokachi River. Nitrogen concentrations in the river water were measured at all locations in June, August, and October of 2007, when water levels were normal. In addition, a GIS land use analysis was conducted using a land use map of the region with a grid resolution of 100 m. This analysis determined that cropland and forestland accounts 90% of the total area in the study watershed. Moreover, spatial continuity (*SC*) was calculated as an index of cropland and forestland agglomeration. *SC* represents the average area of a contiguous patch of cropland or forestland in this study. Based on the accumulated data, the followings were found; 1) nitrogen concentration in river water are positively correlated with the proportion of cropland, but are negatively correlated with the proportion of forestland. It is clear that the proportion of each land use is a factor affecting nitrogen concentrations in the river water. 2) The correlation between river nitrogen concentrations and *SC* values is positive for cropland, but negative for forestland. This indicates that nitrogen concentrations in river water likely decreases if the land use pattern is changed: scattering cropland to reduce its patch size, or connecting forestland together to make the forest patch size larger.

Keywords cropland, forestland, land use, agglomeration, nitrogen, river, watershed

INTRODUCTION

It is known that in agricultural watersheds where cropland is abundant, there is a high correlation between the proportion of cropland area and the nitrogen concentration in river water (Jordan et al., 1997; Ahearna et al., 2005; Zampella et al., 2007). This correlation is reported particularly in many agricultural watersheds in Hokkaido, the prefecture with the largest area of agricultural land in Japan (Tabuchi et al., 1995; Woli et al., 2002 and 2004; Okazawa et al., 2003 and 2010). As the results, this high correlation between the nitrogen concentration in river water and agricultural land use in watersheds in upland farming regions highlights the importance of managing land use to protect the quality of river water (Okazawa et al., 2010).

Table 1 Summary of data collected from different locations in the surveyed watershed

*Point	River name	Area (km^2)	Land use (%)				*SC*		T-N (mg/L)		NO_3-N (mg/L)		
			①Cropland	②Forest	①+②	Other	Cropland	Forest	③**Mean**	SD	④**Mean**	SD	④/③
1	Tokachi	632	1	88	89	11	33	3690	**0.32**	0.06	**0.12**	0.06	0.36
2	Tokachi	658	1	88	89	11	31	4125	**0.36**	0.15	**0.21**	0.07	0.59
3	Tokachi	801	2	88	90	10	41	2199	**0.68**	0.27	**0.35**	0.18	0.51
4	Tokachi	806	3	87	90	10	49	2136	**0.42**	0.14	**0.20**	0.04	0.47
5	Tokachi	840	5	85	90	10	75	1131	**0.44**	0.02	**0.21**	0.04	0.47
6	Tokachi	858	7	84	90	10	85	1009	**0.63**	0.17	**0.28**	0.02	0.44
7	Tokachi	1,289	15	77	91	8	151	352	**0.82**	0.12	**0.56**	0.12	0.68
8	Tokachi	1,531	19	72	92	8	195	242	**1.15**	0.18	**0.65**	0.15	0.56
9	Tokachi	1,777	21	70	91	9	225	223	**1.07**	0.14	**0.73**	0.13	0.69
10	Tokachi	1,798	21	70	91	9	225	214	**1.47**	0.32	**0.82**	0.16	0.56
11	Tokachi	2,669	31	60	91	9	393	123	**1.49**	0.14	**0.97**	0.25	0.65
12	Tokachi	2,683	32	59	91	9	386	122	**1.69**	0.25	**1.10**	0.10	0.65
13	Tokachi	2,686	32	59	91	9	377	122	**1.92**	0.37	**1.20**	0.00	0.63
14	Tokachi	4,479	32	58	90	10	367	117	**1.85**	0.51	**1.23**	0.25	0.67
15	Tokachi	5,098	36	54	90	10	418	99	**2.94**	0.52	**2.33**	0.21	0.79
16	Tokachi	8,224	30	61	92	8	219	142	**1.90**	0.24	**1.43**	0.23	0.76
17	Tokachi	8,982	30	62	92	8	207	148	**1.85**	0.21	**1.57**	0.21	0.85
A	Penkenai	23	0	98	98	2	1	2250	**0.37**	0.10	**0.20**	0.08	0.53
B	Penkenikorobetsu	48	1	98	99	1	9	2366	**0.30**	0.09	**0.15**	0.03	0.51
C	Penkenikorochin	72	1	98	99	1	10	7059	**0.34**	0.08	**0.17**	0.07	0.52
D	Sahoro	337	26	68	95	2	161	163	**1.36**	0.13	**0.98**	0.11	0.72
E	Memuro	210	38	56	94	6	248	80	**1.28**	0.08	**0.98**	0.11	0.77
F	Piuka	26	71	12	83	17	262	12	**6.54**	0.77	**5.63**	0.95	0.86
G	Bibaushi	35	79	19	97	3	301	31	**1.69**	0.79	**1.30**	0.82	0.77
H	Bisei	180	16	74	91	8	225	211	**1.17**	0.30	**0.89**	0.20	0.76
I	Shinobihiro	164	74	16	90	10	630	17	**3.97**	1.49	**3.27**	1.25	0.82
J	Shibusarabibaushi	33	53	43	96	3	1	56	**1.17**	0.28	**0.83**	0.18	0.71
K	Shikaribetsu	667	48	45	92	8	867	54	**2.44**	0.28	**2.23**	0.25	0.92
L	Otofuke	693	19	69	88	12	254	190	**1.94**	0.08	**1.53**	0.21	0.79
M	Satsunai	704	30	61	91	9	262	115	**1.85**	0.21	**1.53**	0.32	0.83
N	Obihiro	197	66	14	80	20	442	16	**5.64**	1.56	**4.07**	0.23	0.72
O	Shihoro	316	64	29	93	7	443	32	**5.14**	0.81	**3.43**	0.67	0.67
P	Tobetsu	127	79	13	92	8	494	13	**4.65**	1.27	**4.13**	0.85	0.89
Q	Sarubetsu	449	69	26	95	5	558	27	**7.00**	1.04	**5.57**	0.64	0.80
R	Toshibetsu	2,850	20	75	95	5	84	306	**0.77**	0.05	**0.32**	0.04	0.42
S	Ushisyubetsu	173	24	61	85	3	96	224	**0.36**	0.02	**0.16**	0.13	0.44
T	Rebunnai	66	43	51	93	6	97	82	**1.35**	0.41	**0.93**	0.15	0.69

*1 to 17 : Mainstream, A-T : Tributary

Since in the eighties, the water purification mechanism of vegetation found nearby rivers called riparian buffers zone which are composed of forests and marshes has been drawn in attention. Many studies have demonstrated that preserving forest areas near rivers helps keep the nitrogen concentration in river water to a low level. Excess nitrogen compounds discharged from agricultural land are captured and absorbed by riparian buffers, reducing the amount of nitrogen released into rivers (Johnston et al., 1984; Lowrence et al., 1984; Hill et al., 2000). However, there are only few studies with the same topic conducted in Asia which is distinguished by Asia monsoon climate area (Okazawa et al., 2010).

It is believed that nitrogen concentrations in river water vary even among watersheds with identical ratios of forestland and cropland, depending on whether the forests are concentrated near rivers or distributed across the watershed. Such spatial distributions of land use are called land use agglomeration. Not many studies have examined the relationship between land use agglomeration and nitrogen concentration in river water (Okazawa et al., 2009).

This study examines the relationship of nitrogen concentration in river water in agricultural areas. In particular, the study demonstrates the relationship between the proportions of cropland and forestland in agricultural watersheds and the concentration of nitrogen, and the effects of the agglomeration of cropland and forestland on the nitrogen concentration.

METHODOLOGY

Overview of watersheds

The Tokachi River basin located in eastern Hokkaido has a total area of 9,010 km^2 (Fig.1), the sixth largest river in the country and second in Hokkaido. More than 2,500 km^2 of this area is mainly consists of potatoes, beans, wheat, corn feedstuff, and sugar beets cropland.

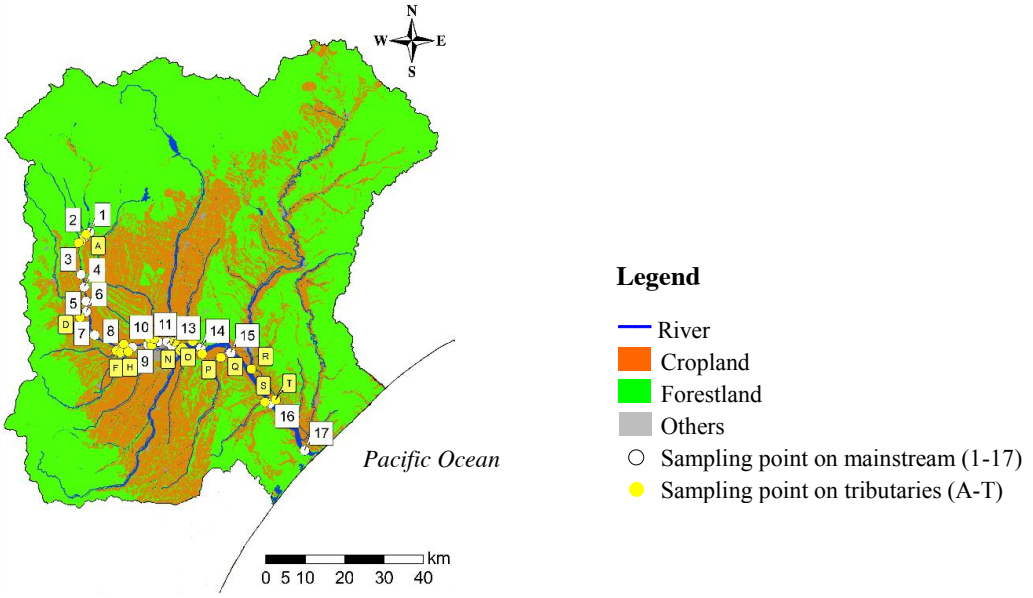


Fig. 1 Map of the Tokachi River basin

The summary of the surveyed watershed areas is given in Table 1. There were thirty-seven watersheds chosen for this study. The proportions of cropland and forestland in each watershed area varied significantly ranging from 0% to 79% and 12% to 98%, respectively. In all watersheds, however, cropland and forestland areas accounting at least 80% of the total land area. Meanwhile, the proportion of other land use patterns (such as residential or industrial) was small.

Water quality survey

Water quality was surveyed on sunny days to avoid the effects of flood. The field survey was conducted three times in June, August, and October of 2007. Samples were taken from river water at the downstream end of each watershed. Seventeen survey locations were chosen between the upstream end (Sampling Point 1) and the downstream end (Sampling point 17) of Tokachi River's main stream, and 20 locations (A–T) along its primary tributaries. The samples were taken back to the laboratory and their nitrogen concentration was analyzed using the Japanese Industrial Standards (JIS) method.

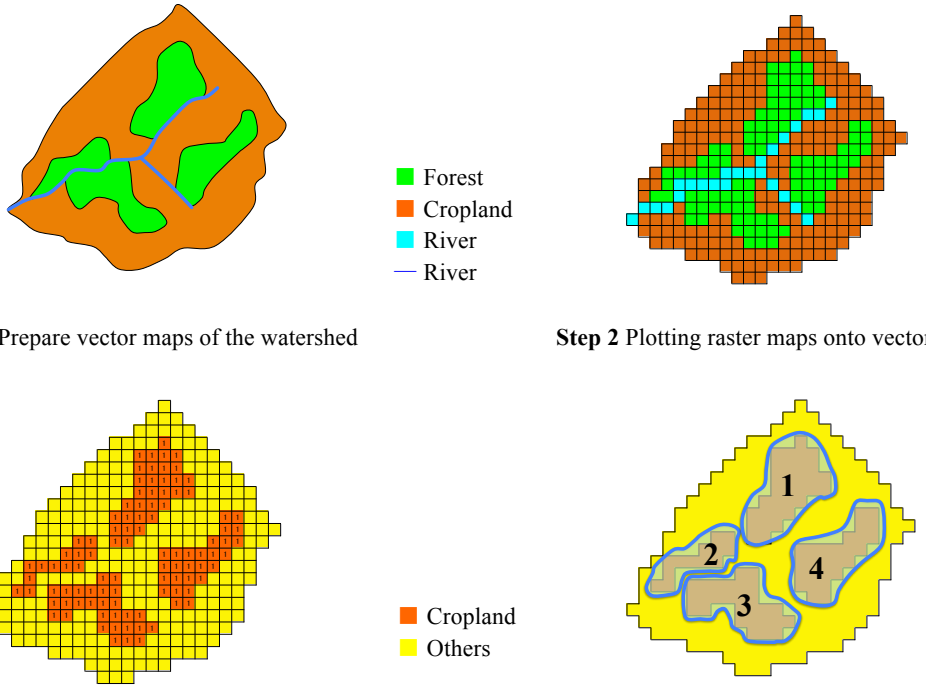
The nitrogen concentrations of river water in respective watersheds (mean values obtained from three survey results) are shown in Table 1. T-N ranges from 0.30 to 7.00 mg/L (mean: 1.81 mg/L), and NO_3-N from 0.12 to 5.63 mg/L (mean: 1.32 mg/L). The percentage of NO_3-N constituting T-N ranged from 33% to 92% (mean: 64%), showing that the majority of T-N is composed of NO_3-N.

Land use analysis

Rivers and their respective watershed boundaries were determined by using 1:25,000 topographic map. In addition, a land use map with a 100 m grid resolution, published by the Ministry of Land, Infrastructure, Transport and Tourism was used to determine the land use system such as cropland

and forestland. Land use ratios and agglomeration were analyzed using GIS software (ArcGIS 9.1, ESRI).

Two types of land use index were used in this study; the percentage of forestland or cropland in a watershed and the agglomeration of land use. Indices for the land use agglomeration include those that showed how 'joined' or 'clumped' land use areas are, as well as the 'spatial continuity' (*SC*) index of identical land use. In this study, *SC* which can be simply derived from GIS was employed as the index for land agglomeration. *SC* was proposed by Tsunekawa et al. (1991). A land use map with a grid resolution of 100 m was used to calculate *SC*.



Step 1 Prepare vector maps of the watershed

Step 2 Plotting raster maps onto vector maps

Step 3 Extracting cropland grid cells

Step 4 Adding up the number of patches (4 patches).

Fig. 2 Method of calculating spatial continuity or *SC*

Vector maps of the investigated watersheds were prepared (Step 1). Then raster data maps of each investigated watersheds were plotted onto the vector maps (Step 2), and only cropland grid cells were extracted from each watershed (Step 3). To obtain an *SC* index, grids representing cropland were grouped into 'patch' units (Step 4). Patch refers to a group of grid cells connected in a vertical, horizontal, or oblique direction. Referring to Fig.2, cropland of 100 grid cells evolve and are in four patches as in Step 4. The value of *SC* was obtained by using Eq. 1 as shown below.

$$SC = k / C_{patch} \quad (1)$$

Where k is the number of grid cells representing the cropland area in a watershed and C_{patch} is the number of patches represents the grouping of grid cells. In the example given in Fig.2, the number of grid cells representing cropland k is 100 (Step 3) and C_{patch} is 4 (Step 4), so *SC* is equal to 25. In other words, *SC* is equivalent to the average area of a patch in each watershed. The spatial continuity for forestland was also calculated using the same method.

RESULTS AND DISCUSSION

The relationship between the proportion of cropland in each watershed and the concentration of T-N in the river is shown in Fig.3. There was a significant positive correlation between the two

parameters. However, even in areas with a comparable cropland ratio, there were variations in the T-N concentration. For example, the watersheds G and P both had a cropland ratio of 79% but the nitrogen concentrations were 1.68 mg/L and 4.65 mg/L respectively.

Fig.4 shows the relationship between the proportion of forestland and the T-N concentration. In contrast to Fig.3, the larger the forest area, the lower the nitrogen concentration was. The correlation was stronger than that of cropland area ratio and nitrogen concentration.

The relationship between *SC* for cropland or the agglomeration of cropland use and the nitrogen concentration is shown in Fig.5. A rise in *SC* was often observed with a rise in T-N concentration and a significant correlation (r^2 = 0.48; significance level at 0.01) was found between the T-N concentration and *SC* of cropland. This demonstrates that the nitrogen concentration is higher in a watershed where croplands are contiguous but lower where croplands are scattered. In other words, since the *SC* index of cropland represents the average area of a patch of cropland in each watershed, therefore the larger the cropland's patch area in a watershed, the higher the nitrogen concentration of river water and vice versa.

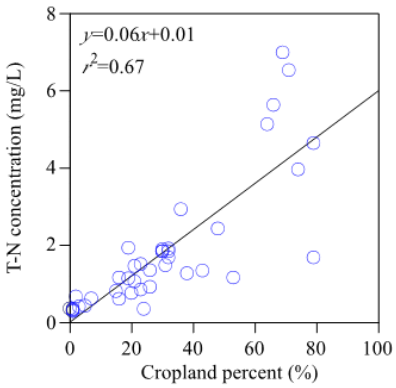


Fig. 3 Relationship between cropland and total nitrogen

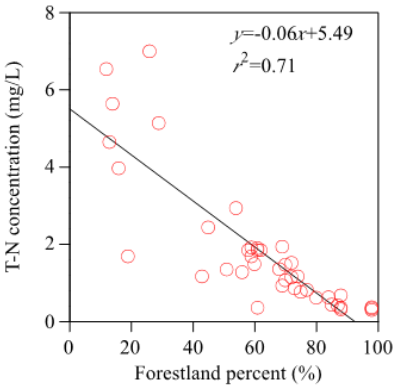


Fig. 4 Relationship between forestland and total nitrogen

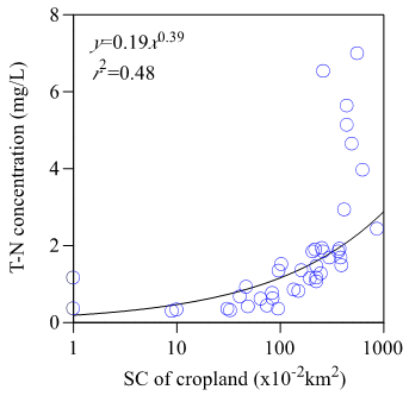


Fig. 5 Relationship between *SC* of cropland total nitrogen

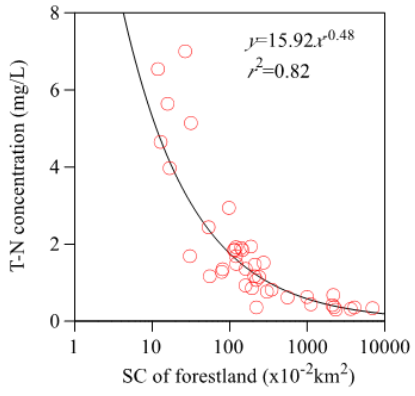


Fig. 6 Relationship between *SC* of forestland and total nitrogen

CONCLUSION

The effect of land use agglomeration on the concentration of nitrogen in river water in the Tokachi River basin in Hokkaido, Japan was examined. The results indicated that in addition to the proportion of cropland and forestland, their contiguity or *SC* had an impact on the quality of river water. This shows that decreasing the patch area of cropland or increasing the patch area of forestland could likely improve the quality of river water. However, the grid resolution of the land

use data in this study was set at 100 m; reassessment of the appropriateness of the grid size may be required in future studies.

ACKNOWLEDGEMENTS

This research was supported by Grant-in-Aid for Young Scientists (B) from The Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan (No.22780223). We would like to express our gratitude to Prof. Dr. Osamu Tsuji (Obihiro University of Agriculture and Veterinary Medicine). The authors are also grateful for the research assistance provided by the students of the Environmental and Rural Engineering unit, Obihiro University of Agriculture and Veterinary Medicine, and the laboratory of Hydro-structure engineering, Tokyo University of Agriculture.

REFERENCES

Ahearna, D.S., Sheibleya, R.W., Dahlgrena, R.A., Andersonb, M., Johnsonc, J. and Tated, K.W. (2005) Land use and land cover influence on water quality in the last free-flowing river draining the western Sierra Nevada, California. Journal of Hydrology, 313, 234-247.

Hill, A.R., Devito, K.J., Campagnolo, S. and Sanmugadas, K. (2000) Subsurface denitrofication in a forest riparian zone, interactions between hydrology and supplies of nitrate and organic carbon. Biogeo Chemistry, 51, 193-223.

Johnston, C.A., Bubenzer, G.D., Lee, G.B., Madison, F.W. and McHenry, J.R. (1984) Nutrient trapping by sediment deposition in a seasonally flooded lakeside wetland. J. Environ. Qual, 13, 283-290.

Jordan, T.E., Correll, D.L. and Weller, D.E. (1997) Relating nutrient discharges from watersheds to land use and streamflow variability. Water Resources Research, 33, 2579-2590.

Lowrence, R.R., Todd, R.L., Fail, J., Hendricson, J.O., Leonard, JR. and Asmussen, L. (1984) Riparian forests as nutrient filters in agricultural watersheds. BioScience, 34, 374-377.

Okazawa, H., Inoue, T., Yamamoto, T., Nagasawa, T. and Unoki, K. (2003) Characteristics of stream water quality during rainfall runoff on an upland field area of eastern Hokkaido, Japan. Transactions of the Japanese Society of Irrigation, Drainage and Rural Engineering, 227, 33-40 (in Japanese with English abstract).

Okazawa, H., Takeuchi, Y. and Samura, I. (2009) Relationship between land-use agglomeration and nitrate nitrogen concentration of river water in the Shari and Abashiri region of Hokkaido, Japan. Transactions of the Japanese Society of Irrigation, Drainage and Rural Engineering, 259, 53-59 (in Japanese with English abstract).

Okazawa, H., Yamamoto, D. and Takeuchi, Y. (2010) Influences of riparian land use on nitrogen concentration of river water in agricultural and forest watersheds of northeastern Hokkaido, Japan. International Journal of Environmental and Rural Development, 1-2, 1-6.

Tabuchi, T., Yoshino, K., Shimura, M., Kuroda, S., Ishikawa, M. and Yamaji, E. (1995) Relation between land use and nitrate concentration of outflow water from watersheds of agricultural and forest area. Trans. of JSIDRE, 178, 129-135 (in Japanese with English abstract).

Tunekawa, A., Lee, D.K., Yonemori, S. and Ide, H. (1991) Quantitative analysis methods of mixed land use, Journal of Environmental Information Science, 20-2, 115-120 (in Japanese with English abstract).

Woli, K.P., Nagumo, T. and Hatano, R. (2002) Evaluating impact of land use and N budgets on stream water quality in Hokkaido, Japan. Nutrient Cycle Agroecosystem, 63, 175-184.

Woli, K.P., Nagumo, T., Kuramochi, K. and Hatano, R. (2004) Evaluating river water quality through land use analysis and N budget approaches in livestock farming areas. Sci. Total Environ., 329, 61-74.

Zampella, R.A., Procopio, N.A., Lathrop, R.G. and Dow, C.L. (2007) Relationship of land-use/land-cover patterns and surface-water quality in the Mullica River basin. Journal of the American Water Resources Association, 43, 594-604.

Research article

Ecological Management in Salt-affected Area of Northeast Thailand: Monitoring Soil Quality

AUNG NAING OO
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
Email:ano1972@gmail.com;chulee_b@kku.ac.th

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

BUBPHA TOPARK-NGARM
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

Received 10 December 2010 Accepted 20 January 2011

Abstract Soil salinity has become one of the major determinants of crop productivity in Northeast Thailand, and has an adverse impact on the physical, chemical and biological properties of soil, as well as plant growth and yield. Ecological management of soil is essential to sustainable production. Soil microorganism may fulfill many important ecological roles including decomposition and nutrient cycling in salt-affected area. This study aimed to monitor the impact of salinity on soil properties under tree plantation at Amphur Borabue, Mahasarakam Province, Northeast Thailand. The study area was divided into 3 zones followed by the plant community found in each area which correlated with the flooding situation and soil salinity. Soil samples were collected from three different zones at the same depth (0-20cm) with three replications during the rainy seasons of 2008 and 2010 in order to analyze soil physical, chemical and biological properties. The results showed that biodiversity of soil biota and soil microbial activity in terms of soil microbial carbon, soil microbial nitrogen and soil respiration after tree plantation was higher than before. The EC, Na and K values were decreased, whereas pH, OM and N were increased after tree plantation. It could be concluded that soil physical, chemical and biological properties were improved after tree plantation. Therefore, this result would be valuable for sustainable land resources improvement and rehabilitation.

Keywords salinity, ecological management, soil quality

INTRODUCTION

Awareness of the ecological and environmental health of ecosystems around the world has been increasing in recent years. As a result, there has been a growing interest in sustainable agricultural alternative practices. In Thailand, the agricultural society has been criticized for problems with soil salinity, soil degradation, greenhouse gas release into the atmosphere, water pollution and a loss of wildlife habitat. Tree plantation has been associated with an increasing quantity of environmental and ecological benefits such as enhancement of microclimatic conditions, improved utilizing and cycling of soil nutrients, improved soil and water quality, creation of suitable habitats for insect and animal species, protection from erosion, and protection from wind (Jose et al., 2004). Ecological management such as tree plantation in salt-affected areas has the potential to alleviate salinity stress on farms for sustainable production.

Soils in Northeast Thailand are salt-affected due to salt bearing rocks (Department of Land Development, 1991), particularly in Nakhon Ratchasima, Khon Kean, Roi Et and Mahasarakham provinces (Department of Mineral Resources, 1982). Soil salinity has become one of the major determinants of crop productivity in those areas, and might have an adverse impact on soil physical properties (Boivin et al., 2004), chemical properties (Sumner, 2000) and soil microbial

communities and activities (Zahran, 1997; Sardinha et al., 2003) and also influence on plant growth and yield (Marschner, 1995). Among them, changes in mineralization of C and N with increasing salinity have been observed (Nelson et al., 1996; Pathak and Rao, 1998).

Salt-affected soils may be reclaimed by growing salt-tolerant tree species, which improve the physical and chemical properties as well as biological activity in the soil (Garg, 1998). Investigations carried out at various research locations in India have shown that salt-affected soil can be improved by trees plantation. For example, incorporation of trees in the land can help in maintaining the nutrient pool and enhance soil fertility (Young, 1997; Rao et al., 1998). Tejwani (1994) also reported that tree plantation is an excellent strategy for reclamation of salt-affected soils. Tree litter improves soil fertility not only through the release of nutrients in the soil by mineralization but by also adding soil organic matter. Thevathasan and Gordon (2004) also reported that tree intercropping under temperate significantly enhanced the diversity of birds, insects, and earthworms; increased soil organic carbon content and N cycling; and improved soil quality. The objective of this study was to monitor the impact of salinity on soil quality under tree plantation in salt-affected area of Northeast Thailand.

MATERIALS AND METHODS

Study area

This study was carried out at Ak-Kasatsuntorn water reservoir, Tumbon Borabue, Mahasarakam Province, Thailand at latitude of 16° 01' N and longitude of 103° 05' E, and at an elevation of 178 m from mean sea level. The study area was divided into 3 zones followed by the plant community found in each area where they are correlated with the flooding situation and soil salinity. The study site has been established for three years with tree plantation (2710 plants of 17 species). Woody plants such as common ironwood (*Casuarina equisetifalia* J.R. & C. Forst) and fruit plants such as manila tamarind (*Pithecolobium dulce*) in salt-affected area were grown covering with native grasses and weeds, i.e., torpedograss (*Panicum repens* L.).

Soil sampling and analysis

Soil was sampled from three random locations of each zone and unplanted soil near experimental site (control) at the depth of 0–20 cm during the rainy seasons of 2008 and 2010. The soils were analyzed to determine soil physical and chemical properties according to routine methods of the Land Resources and Environment section, Faculty of Agriculture, Khon Kaen University. Soil texture was determined by hydrometer method. Soil pH and electrical conductivity (EC) were determined in a 1:2.5 and 1:5 soil to water solution by pH meter and EC meter, respectively. Cation exchange capacity (CEC) was determined by 1 N ammonium acetate method. Total nitrogen (N) was measured by Kjeldahl method; available phosphorus (P) by the Olsen method, exchangeable potassium (K) by 1 N ammonium acetate and flame photometry; and total organic matter (OM) by using Walkley and Black method.

Microbial biomass C and N were determined in field moist subsamples immediately after sampling by the chloroform fumigation extraction method. For microbial biomass C (MBC), 20 g of fumigated and unfumigated soil were extracted with 100 ml of 0.5 M K_2SO_4. MBC in the extracts was determined after oxidation with $K_2Cr_2O_7$. For microbial biomass N (MBN), 20 g of soil was extracted with 100 ml of 1 M KCl. Besides, non-fumigated samples were extracted immediately after sampling. MBN was determined by the ninhydrin-reactive N method (Amato and Ladd, 1988). MBC and MBN were calculated as the difference between fumigated and unfumigated values and employing k_{EC} and k_{EN} factors of 0.33 (Sparling and West, 1988) and 3.1 (Amato and Ladd, 1988) to convert extracted organic C and N to microbial C and N, respectively. Microbial activity was studied by soil respiration using titrimetric method (Zuberer, 1991). This method was based on the determination of CO_2 evolved from the soils. Field moist soil (200g) was placed and incubated at 28°C in an airtight jar containing a vial with 15 ml of 1.0 M NaOH. After

incubation of a day, the NaOH solution was removed and the trapped CO_2 titrated with 0.5 M HCl after precipitating the carbonate with excess 0.5 M $BaCl_2$. Soil respiration, i.e., evolved CO_2-C, was computed according to the equation (1) described by Anderson (1982) as shown below:

$$CO_2\text{-C (mg)} = (B\text{-}V)\ NE \quad (1)$$

where B is the volume (ml) of acid (HCl) used to titrate the alkali (NaOH) of blank (no soil), V is the volume (ml) of acid used to titrate the soil sample, N is the normality of acid (HCl), and E is equivalent weight of CO_2-C. The metabolic quotient qCO_2 (Anderson and Domsch, 1986) of each sampling period was calculated by using equation (2).

$$qCO_2 = CO_2\text{-C} / MBC \quad (2)$$

where CO_2-C (mg kg^{-1} soil) is soil respiration and MBC (mg kg^{-1} soil) is microbial biomass C.

Statistical analysis: The data recorded was analyzed statistically using Statistix 8.0 software and Microsoft Excel software (2007) to compare each zone at 5% probability level.

RESULTS AND DISCUSSION

Soil physical and chemical properties

In this study, tree plantation covered with native grasses had a significant impact on soil physical properties of salt-affected soil. Soil texture of study area was sandy soil. Bulk density decreased from 1.72 g cm^{-1} to 1.55 g cm^{-1} under tree plantation, whereas soil moisture content increased from 9.3% to 13.5%.

Several soil chemical properties of salt-affected area were influenced by tree plantation and time (Fig. 1). Three years after planting (in 2010), decreases in the values of EC, Na, and K in the soil became apparent in growing trees when compared with the first year after planting (in 2008). Soil organic matter (OM) and total nitrogen (N) content in all zones by tree plantation increased with time since 2008, which were from 0.53 % and 0.057% in the first year after planting to 0.73% and 0.086 % in three years after planting, respectively. The increases in CEC, OM and N content could be attributed to the addition of leaf litter and root decay, which improved microbial activity in soil. The results confirm the findings of Mishra et al. (2004). Although there were no significant differences in pH and available P between tree plantation and unplanted soil, there were slight increases in all zones in year 2010.

Soil biological properties

The MBC and MBN values in 2008 and 2010 were significantly higher in tree plantation than in unplanted soil, with the highest value being with zone 3 (Fig. 2). It might be due to the accumulation of humus from decomposition of leaf litter and root decay, which increased soil organic C. Soil respiration, as a good index of the activity of microorganisms, was consistently lower in the unplanted soil when compared to tree plantation zones in both years 2008 and 2010. These results are in accordance to other findings, which showed decreased soil respiration (Sardinha et al., 2003; Tripathi et al., 2006) in natural saline soils. The metabolic quotient (qCO_2) was higher in 2008, probably as a result of stress by salinity on soil microflora (Anderson and Domsch, 1993; Rasul et al., 2006), whereas it tended to lower in 2010. A low metabolic quotient implies that the microbial populations were energetically efficient, i.e., allocating proportionally more carbon to growth (biosynthesis) than to maintenance (Zak et al., 1994).

There was a significant negative relationship between EC and microbial biomass C, microbial biomass N, basal soil respiration and metabolic quotient (Fig. 3). This relationship revealed the detrimental effect that soil salinity had on the soil microbial activity. These results are in line with the findings of Yuan et al. (2007). Increased soil microbial activity might be due to the ameliorative effects of trees and consequently organic matter inputs. According to Rao and Pathak (1996), carbon is an important factor influencing microbial activity in salt-affected soils.

Biodiversity index (H′) of soil biota in zone 1, zone 2 and zone 3 were 0.11, 0.63 and 0.71 in the first year after planting and 0.23, 0.95 and 0.75 in three years after planting, respectively. The results observed that biodiversity of soil biota after tree plantation was higher than before.

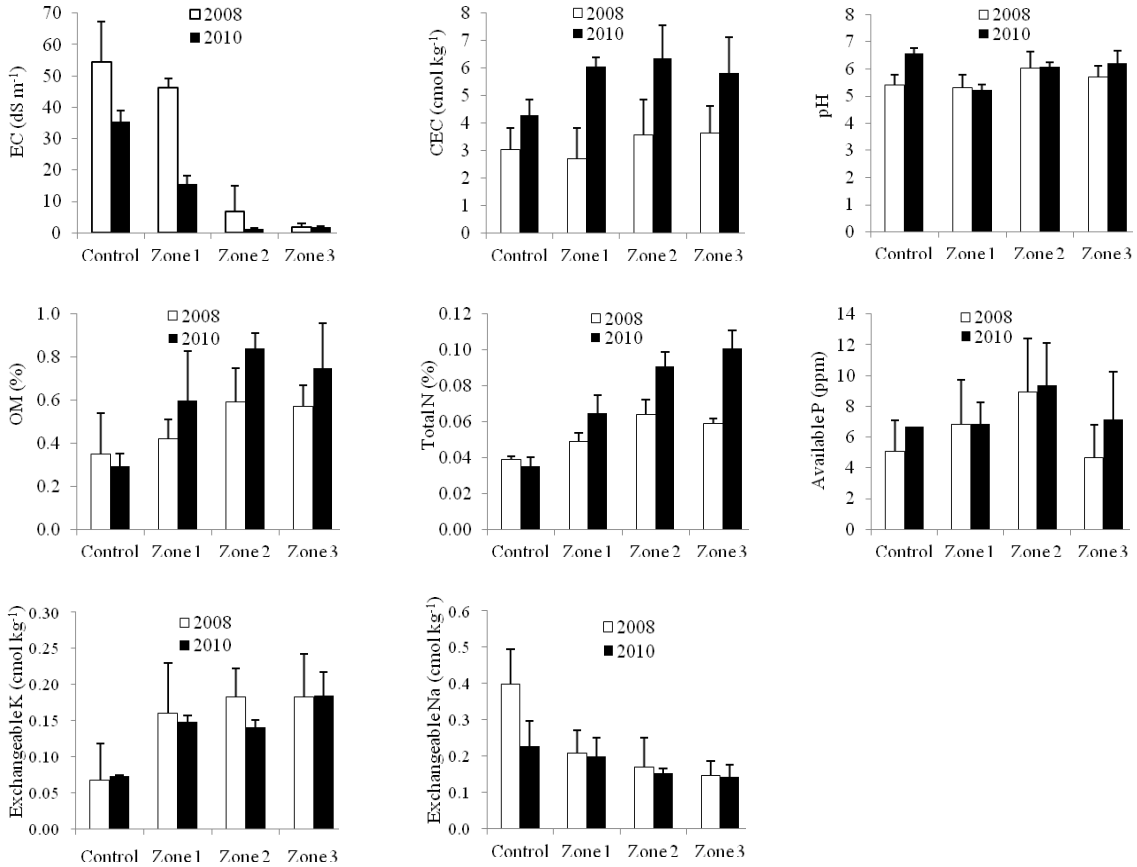


Fig. 1 Soil chemical properties of salt-affected soils after tree plantation
(2008 is the first year after plantation and 2010 is three years after plantation; Bars represent standard deviation)

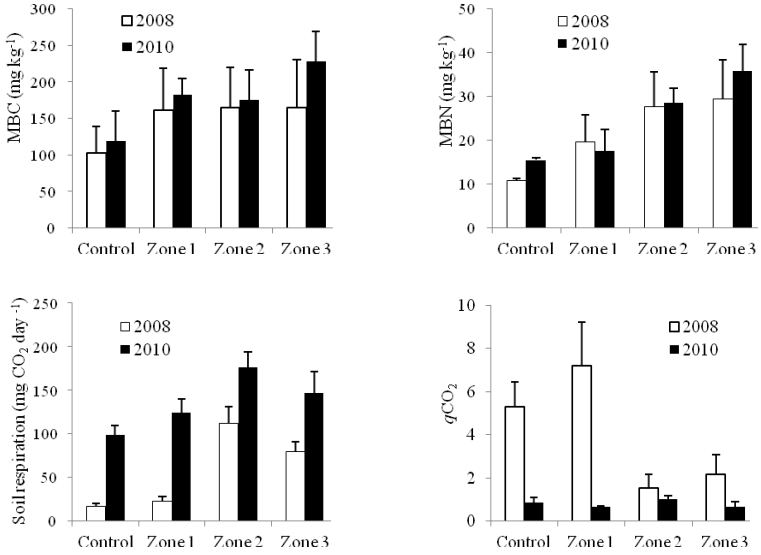


Fig. 2 Soil microbial parameters of salt-affected soils after tree plantation
(2008 is the first year after plantation and 2010 is three years after plantation; Bars represent standard deviation)

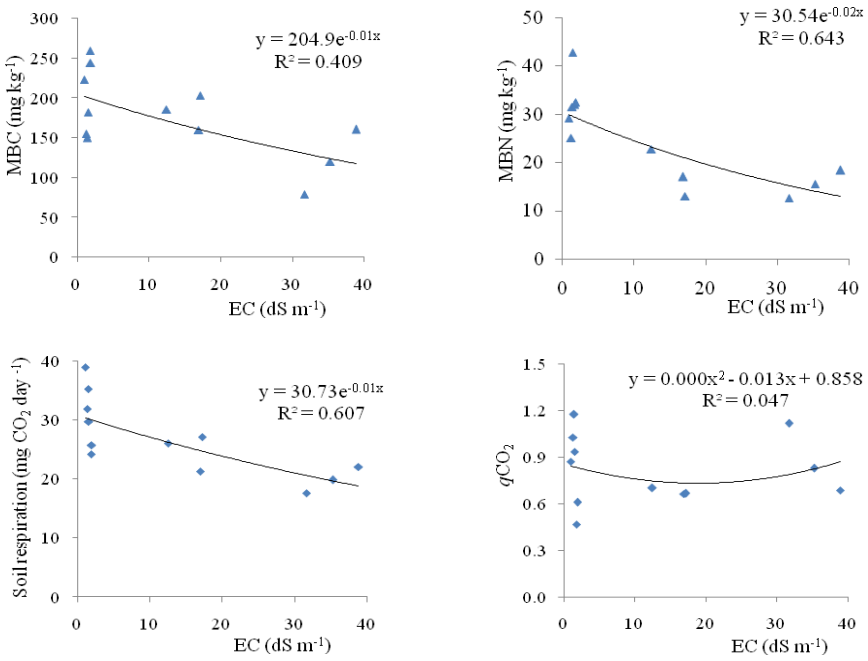


Fig. 3 Relationship of microbial parameters with electrical conductivity of salt-affected soils
(Regression equation, line of best fit and R^2 were shown)

CONCLUSION

Monitoring in salt-affected soil grown with tree species indicated more efficient changes in terms of dropping EC and decreasing Na^+ levels in the soil. In contrast, evidence of increased organic matter and total nitrogen showed after tree plantation. Likewise, there was greater microbial activity in salt-affected soil under tree plantation. It could be concluded that soil physical, chemical and biological properties were improved after tree plantation covered with native grasses in salt-affected soil. Therefore, it is pertinent that tree plantation has a great scope and potential in terms of ecologically sustainable land resources improvement and rehabilitation.

ACKNOWLEDGEMENT

This study was supported by the Research Project: "Problem Soils in Northeast Thailand", Khon Kaen University, Thailand and the KKU Research Project "Improvement of Soil Fertility and Biodiversity in the Salt-Affected Lowland Area by Various Species Trees Pantation".

REFERENCES

Amato, M. and Ladd, J.N. (1988) Assay for microbial biomass based on ninhydrin reactive nitrogen in extracts of fumigated soil. Soil Biology and Biochemistry, 20, 107-114.

Anderson, J.P.E. (1982) Soil respiration, Agronomy monograph number 9, part II. Chemical and biological properties, 2nd edition. American Society of Agronomy and Soil Science Society of America, USA, 831-871.

Anderson, T.H. and Domsch, K.H. (1986) Carbon link between microbial biomass and soil organic matter. Perspectives in microbial ecology, Proceedings of the 4th international symposium on microbial ecology, Slovenia, 467-471.

Anderson, T.H. and Domsch, K.H. (1993) The metabolic quotient for CO_2 (qCO_2) as a specific activity parameter to assess the effects of environmental conditions, such as pH, on the microbial biomass of forest soils. Soil Biology and Biochemistry, 25, 393-395.

Boivin, P., Saejiew, A., Grunberger, O. and Arunin, S. (2004) Formation of soils with contrasting textures by translocation of clays rather than ferrolysis in flooded rice fields in Northeast Thailand. European Journal of Soil Science, 55, 713-724.

Department of Land Development (1991) Distribution of salt affected soil in the northeast region 1:100,000 map. Department of land Development, Thailand.

Department of Mineral Resources (1982) Geologic map of Thailand. Department of Mineral Resources, Thailand.

Garg, V.K. (1998) Interaction of tree crops with a sodic soil environment: potential for rehabilitation of degraded environments. Land Degradation and Development, 9, 81-93.

Jose, S., Gillespie, A.R. and Pallardy, S.G. (2004) Interspecific interactions in temperate agroforestry. Agroforestry Systems, 61, 237-255.

Marschner, H. (1995) Mineral nutrition of higher plants. 2nd Edition. Academic Press, United Kingdom.

Mishra, A., Sharma, S.D., Pandey, R. and Mishra, L. (2004) Amelioration of a highly alkaline soil by trees in northern India. Soil Use and Management, 20, 325-332.

Nelson, P.N., Ladd, J.N. and Oades, J.M. (1996) Decomposition of ^{14}C labelled plant material in a salt affected soil. Soil Biology and Biochemistry, 28, 433-441.

Pathak, H. and Rao, D.L.N. (1998) Carbon and nitrogen mineralization from added organic matter in saline and alkali soils. Soil Biology and Biochemistry, 30, 695-702.

Rao, D.L.N. and Pathak, H. (1996) Ameliorative influence of organic matter on biological activity of salt affected soils. Arid Land Research and Management, 10, 311-319.

Rao, M.R., Nair, P.K.R. and Ong, C.K. (1998) Biophysical interactions in tropical agroforestry systems. Agroforestry Systems, 38, 3-50.

Rasul, G., Appuhn, A., Muller, T. and Joergensen, R.G. (2006) Salinity-induced changes in the microbial use of sugarcane filter cake added to soil. Applied Soil Ecology, 31, 1-10.

Sardinha, M., Muller, T., Schmeisky, H. and Joergensen, R.G. (2003) Microbial performance in soils along a salinity gradient under acidic conditions. Applied Soil Ecology, 23, 237-244.

Sparling, G.P. and West, A.W. (1988) A direct extraction method to estimate soil microbial C: Calibration in situ using microbial respiration and ^{14}C labeled cells. Soil Biology and Biochemistry, 20, 337-343.

Sumner, M.E. (2000) Handbook of soil science. CRC Press, USA.

Tejwani, K.G. (1994) Agroforestry in India. Oxford and IBH, India.

Thevathasan, N.V. and Gordon, A.M. (2004) Ecology of tree intercropping systems in the North temperate region: Experiences from southern Ontario, Canada. Agroforestry Systems, 61, 257-268.

Tripathi, S., Kumari, S., Chakraborty, A., Gupta, A., Chakrabarti, K. and Bandyapadhyay, B.K. (2006) Microbial biomass and its activities in salt-affected coastal soils. Biology and Fertility of Soils, 42, 273-277.

Young, A. (1997) Agroforestry for soil management. 2nd edition. Nairobi, Kenya: CAB International in association with the International Centre for Research in Agroforestry.

Yuan, B., Li, Z., Liu, H., Gao, M. and Zhang, Y. (2006). Microbial biomass and activity in salt affected soil under arid condition. Applied Soil Ecology, 35, 319-328.

Zahran, H.H. (1997) Diversity, adaptation and activity of the bacterial flora in saline environments. Biology and Fertility of Soils, 25, 211-223.

Zak, D.R., Tilman, D., Rarmenter, R.R., Rice, C.W., Fisher, F.M., Vose, J., Milchunas, G. and Martin, C.W. (1994) Plant production and soil microorganisms in late-successional ecosystems: A continental-scale study. Ecology, 75, 2333-2347.

Zuberer, D.A. (1991) Laboratory exercises in soil microbiology. Department of Soil and Crop sciences, Texas A&M University, USA.

Research article

Risk Assessment of Pesticide Residues in Organic Waste in Northeast Thailand

JARUPONG PRASOPSUK
Faculty of Agriculture, Khon Kaen University,Khon Kaen, Thailand.
Email: ja.prasopsuk@gmail.com; chulee_b@kku.ac.th

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

Received 10 December 2010 Accepted 25 January 2011

Abstract The objective of this study aims to monitor pesticide residues in organic waste in Northeast Thailand. Pesticides are widely used in agriculture and trade of agricultural products to increase agricultural yield and to protect plants from diseases, weeds and insect damage. The increasing use of pesticides has significantly increased crop contamination and human health hazard. On the Thai markets, fruit and vegetables have high risk for pesticide contamination. Uneatable and unusable parts of these goods transform to a fraction of organic waste. The quantity of waste in terms of solid waste from Northeast Thailand was 11,820 tons/day and over 50% was organic waste. Composting (such as compost, biological fermentation fertilizer) and animal feed are conventional methods to manage waste from vegetables and fruit in Northeast Thailand. However, the risk assessment of pesticide residue in organic waste should be studied and taken into consideration for environmental safety and human health. A total of 22 pesticides from different chemical groups (organochlorine, organophosphate and pyrethroid) in the different organic wastes collected from the markets in Khon Kaen provinces, in the Northeast of Thailand, were monitored in the rainy and winter season in the year 2010 by gas chromatography with electron capture detector (ECD) and flame photometric detector (FPD). Pesticide residues were found in organic waste. The most frequently found pesticides were cypermethrin followed by chlorpyrifos deltametrhrin and lambda-cyhalothrin, respectively ranging from 0.044 to 2.608 mg kg^{-1}. Pesticide residue in organic waste was found to be higher in the winter season than in the rainy season. Pesticide residue was found higher in cabbages followed by kale, lettuce and corn peel, respectively. Therefore, a monitoring program for pesticide residues and a risk assessment study in organic waste are needed for protection of human's health and the environment.

Keywords organic waste, biological waste, pesticide, pesticide residues, Northeast Thailand

INTRODUCTION

Thailand is an agricultural country where agriculture is a very important part of the economy. Thailand expanded exports of agricultural products and also imports fertilizers and pesticides intensively. Pesticides are used widely in agriculture and trade of agricultural products to increase agricultural yield and to protect plant from diseases, weeds and insect damage (Department of Agricultural, 2010). The result from increasing pesticides uses has resulted in significant increased crop contamination and human health hazard (Office of Epidemiological, 2009). The risk of pesticide contamination in fruits and vegetables in Thai market often occurs. Pesticide residues in agricultural products such as vegetables and fruit were studied in Northeast Thailand (Table 1) (Office of Agricultural Research and Development Region 3, 2010; Office of Agricultural Research and Development Region 4, 2010). Uneatable and unusable parts of agricultural products transform to a fraction of organic waste. The quantity of waste in term of solid waste from

Northeast Thailand was 11,820 tons/day and over 50% was organic waste. Solid waste in Khon Kaen province occurred about 800 tons/day (Pollution Control Department, 2010).

As agricultural production is vast worldwide, the increasing of waste and its adverse effects on the environment are of great concern. Waste management takes an important role for maintaining a sustainable environment. The organic waste management has been done in three main ways: 1) organic waste can be used for soil improvement, 2) animal feeding, and 3) alternative source of energy (biogas) (Lardinois and Klundert, 1993; Pollution Control Department, 2009). Composting (such as compost, biological fermentation fertilizer) and animal feed are the conventional methods to manage waste from organic waste in Northeast Thailand.

Composting is an important waste management strategy in Europe. The end product, compost, can be used as soil conditioner and fertilizer, thereby recycling nutrients back to agriculture and horticulture. However, compost may contain a wide range of organic pollutants (Kupper et al., 2008).

Therefore, using compost may be a case a hidden input of pesticides into the environment. Once incorporated into the soil the fate of pesticides is not fully clear (Taube, et al., 2002; Hart and Pluimers, 1996). The concern about the pollutants in the organic waste in Thailand has been increasing. However, most studies have dealt with the heavy metals contamination in the waste but less research has been done on pesticides. Therefore, the risk assessment of pesticide residues in organic waste were studied by monitoring pesticide residues in organic waste from the markets in Khon Kaen province in two seasons (rainy and winter season).

Table 1 Pesticide residues in vegetables and fruit in Northeast Thailand in 2009

Region	samples	Pesticide residues found		Pesticides found
		Number of Samples	Over MRL	
Upper Northeast Thailand	1,422	394(27.7%)	31(2.18%)	chlorpyrifos,cypermethrin, ethoprophos,deltamethrin, diazinon,cyfluthrin, lambda-cyhalothrin, methidathion
Lower Northeast Thailand	1,689	605(35.8%)	111(6.6%)	cypermethrin, chlorpyrifos, profenofos, lambda-cyhalothrin, fenvalerate

MRL = Maximum residue limit

Source: Office of Agricultural Research and Development Region 3, (2010)
Office of Agricultural Research and Development Region 4, (2010)

MATERIALS AND METHODS

Chemicals

Hexane, ethyl acetate and acetonitrile (PR grade), sodium chloride (analytical grade), magnesium sulfate anhydrous, primary secondary amine (PSA) and 1% acetic acid in acetonitrile were used for the pesticide extraction process.

Sample collection

The selection of the samples was based on the typical composition of organic waste. The samples chosen for analysis should match the fractions presenting a high percentage of the total organic waste. The samples were collected from three main markets in Khon Kaen province, Northeast Thailand in the rainy and winter season in 2010. Altogether, 3 samples of organic waste from each market and 4 samples of organic waste based on the typical composition of organic waste (cabbages, lettuce, kale and peel corn) were analyzed in three replicates by using the QuEChERS method (Anastassiades, et al., 2003).

Extraction and clean up

To prepare the samples, 15 g of a previously homogenized food material sample was transferred into a suitable vessel and filled with fifteen milliliters of acetonitrile. The vessels were capped before mixing on a Vortex mixer for 1 min at optimum speed. Once the initial sample mixing was completed, 1 g NaCl and 4 g anhydrous $MgSO_4$ were added and immediately mixed on a Vortex mixer for 1 min. To separate the phases, the samples were centrifuged for 5 min at 4000 rpm. Using an adjustable repeating pipette, 6.0 ml aliquot of upper acetonitrile layer was transferred into a 15 ml centrifuge tube containing 900 mg anhydrous $MgSO_4$ and 150 mg PSA sorbent. The centrifuge tube was tightly capped and shaken on a Vortex mixer for 1 min before the extracts (or the batch of extracts) were centrifuged for 5 min at 4000 rpm to separate the solids from the solution. The solution was then transferred into a vial for Gas Chromatograph (GC) analysis.

Pesticide residues analysis

The samples were analyzed for 22 pesticides from different chemical groups (organochlorine, organophosphate and pyrethroid) using GC multi-methods with ECD and FPD detection. Organophosphorus group were chlorpyrifos, diazinon, dicrotophos, dimethoate, ethoprophos, fenitrothion, malathion, methamidophos, methidathion, mevinphos, monocrotophos, parathion-methyl, pirimiphos-methyl, prothiophos, triazophos. For organochlorine group were ∝-endosulfan, β-endosulfan, endosulfan sulfate and pyrethroid group are lambda-cyhalothrin, cypermethrin, deltamethrin, fenvalerate, permethrin, cyfluthrin. GC-ECD used capillary column HP-5 5% Phenyl Methyl Siloxane (30m x 0.25mm ID, 0.25 μm flim thickness) with helium (2.0 ml min^{-1}) carrier gas, splitless injection and used electron capture detector (ECD) for organochlorine group and Pyrethroid group. GC-FPD used capillary column DB1701 (30m x 0.32mm ID, 0.25 μm flim thickness) helium (1.9 ml min^{-1}) carrier gas, splitless injection and used flame photometric detector (FPD) for organophosphorus group.

RESULTS

The analyses revealed that most of the samples contained pesticide. Residues were found in 100% of the samples from mixed organic waste (Table 2) in three markets. Pesticide residues (mg kg^{-1}) were found in the different kinds of organic waste collected in Khon Kaen province (Table 3). Pesticide residue in organic waste was found to be higher in the winter season than in the rainy season. The most frequently found pesticides were cypermethrin followed by chlorpyrifos, deltametrhrin and lambda-cyhalothrin, respectively ranging from 0.044 to 2.608 mg kg^{-1}. Most pesticides were recovered in the range of 70% – 110% with relative standard deviation (RSD) usually less than 10%.

Table 2 Pesticide residues (mg kg^{-1}) found in organic waste collected in Khon Kaen province

Markets	Rainy				Winter			
	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD
Banglumphu	cypermethrin	0.044	0.003	7.329	cypermethrin	0.086	0.003	3.076
	lambda - cyhalothrin	0.054	0.004	7.955	chlorpyrifos	0.077	0.003	4.193
					deltamethrin	0.281	0.020	7.183
O-Jira	cypermethrin	0.050	0.004	8.075	cypermethrin	2.608	0.018	0.678
					chlorpyrifos	1.066	0.069	6.507
					deltamethrin	0.736	0.028	3.832
Srimuangthong	cypermethrin	0.072	0.007	9.130	cypermethrin	1.667	0.045	2.716
					chlorpyrifos	0.742	0.042	5.629
					deltamethrin	0.761	0.060	7.898

$\bar{x}$ = Average, SD = Standard deviation, %RSD = Repeatability

Table 3 Pesticide residues (mg kg^{-1}) found in the different kinds of organic waste collected in Khon Kaen province

Organic waste	Rainy				Winter			
	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD	Pesticide (mg kg^{-1})	$\bar{x}$	SD	%RSD
cabbages	cypermethrin	0.059	0.005	7.685	cypermethrin	0.586	0.022	3.762
					chlorpyrifos	1.926	0.036	1.872
					deltamethrin	0.460	0.020	4.367
kale	cypermethrin	0.050	0.002	4.323	cypermethrin	1.415	0.035	2.498
	lambda - cyhalothrin	0.079	0.006	7.804	chlorpyrifos	0.129	0.002	1.187
					deltamethrin	1.297	0.082	6.329
lettuce	ND				cypermethrin	0.096	0.008	7.791
					deltamethrin	0.269	0.019	6.895
peel corn	ND				cypermethrin	0.075	0.004	4.807
					chlorpyrifos	0.102	0.004	3.922
					deltamethrin	0.148	0.006	3.833

ND = Less than limit of detection, $\bar{x}$ = Average, SD = Standard deviation, %RSD = Repeatability

Table 4 The maximum residue limits (MRL) of pyrethroids and organophosphorous pesticides in vegetables

Pesticides	Vegetables	MRL (mg kg^{-1})
cypermethrin	cabbages	1.00*
	corn	0.05*
	leafy vegetables	0.70*
lambda -cyhalothrin	cabbages	0.30**
deltamethrin	cabbages	0.10*
	corn	1.00*
	lettuce, kale	0.50*
	leafy vegetables	2.00**
chlorpyrifos	cabbages	1.00**
	sweet Corn	0.01**

**ACFS, Ministry of Agriculture and Cooperatives (2008)*
*** FAO/WHO (2010)*

CONCLUSION

The results from this study give information about the pesticide residues of the organic waste. Biological waste contains a variety of pesticides and some of them were higher than the MRL. In the composting process of organic waste, pesticides might be degraded or mineralized. However, they might also be persistent to biological degradation and still occur in the process. Although pesticide residues analyses in organic wastes are not legally required, a hidden and uncontrolled input of pesticides to the soil environment might take place. Generally, organic waste products are considered environmental friendly as they are one of the waste management solutions. However, persistent pesticides introduced into this agricultural system might appear in the product and affect human health. Therefore, a monitoring program for pesticide residues and a risk assessment study in organic waste are needed for protection of human's health and the environment.

ACKNOWLEDGEMENTS

The author would like to thank Khon Kaen University for the support, Department of Plant Sciences and Agricultural Resources, Land Resources and Environment Section, Faculty of Agriculture, Khon Kaen University, the Research Centre for Environmental and Hazardous Substance Management, Khon

Kaen University, Thailand and Office of Agricultural Research and Development Region3, Department of Agriculture, Ministry of Agriculture and Cooperative, Thailand.

REFERENCES

Anastassiades, M., Lehotay, S.J., Stajnbaher, D. and Schenck, F.J. (2003) Fast and easy multiresidue method employing acetonitile extraction/partitioning and "Dispersive Solid-Phase Extraction" for the determination of pesticide residues in produce, J. AOAC Int., 86, 412-431.

Department of Agricultural (2006) Analysis report on toxic substance contamination in the biological Fermentation, Thailand.

Dulac, N. and Scheinberg, A. (2001) The organic waste flow in integrated sustainable waste management. WASTE, Netherlands.

Hart, D. and J. Pluimers (1996) Waste agriculture, The use of compost in urban agriculture. UWEP Working Document 1.WASTE, Netherlands.

Lardinois, I. and Van de Klundert, A. (1993) Organic waste - options for small-scale resource recovery. Urban Solid Waste Series 1, WASTE/TOOL, Netherlands.

FAO/WHO (2010) Pesticide residues in food and feed, CODEX Pesticides. http://www.codexalimentarius.net/pestres/data/pesticides/.

Office of Agricultural Research and Development Region 3 (2010) Report monitoring pesticide residues in the field GAP in upper Northeast Thailand 2007-2009. Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand.

Office of Agricultural Research and Development Region 4 (2010) Report monitoring pesticide residues in the field GAP in lower Northeast Thailand 2007-2009. Department of Agriculture. Ministry of Agriculture and Cooperativs. Thailand.

Office of Epidemiological (2009) Annual epidemiological surveillance report 2009. http://www.epid.moph.go.th/.

Office of Control Plants and Agricultural Material, Department of Agriculture (2010) Report importing chemical agricultural 2002-2009. http://www.as.doa.go.th/ard/stat.php.

Office of Natural Resources and Environment (2009) Solid waste management. http://www.khonkhaenmnre.go.th/.

Ministry of Natural Resources and Environment (2010) Solid waste management, Pollution Control Department. http://www.pcd.go.th/.

Ministry of Natural Resources and Environment (2004) The manual inspect contamination underground in location of solid waste. Pollution Control Department, http://www.pcd.go.th/.

Ministry of Natural Resources and Environment (2009) Guideline and fundamental rules reduce reuse recycle solid waste. Pollution Control Department, http://www.pcd.go.th/.

Taube, J., Vorkamp, K., Forster, M. and Herrmann, R. (2002) Pesticide residues in biological waste. Chemosphere, 49, 1357-1365.

Ministry of Agriculture and Cooperatives (2008) Pesticide residues in Thai agricultural commodity and food standard TACFS 9002-2008. The National Bureau of Agricultural Commodity and Food Standards (ACFS), http://www.acfs.go.th/.

Research article

Fundamental Study on Nitrogen Removal from Paddy Drainage Using Clinker Ash

HITOSHI YAMAMOTO
Graduate School of Agriculture, Tokyo University of Agriculture, Japan
Email: h1okazaw@nodai.ac.jp

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

YUKO OHTAKA
Atsugi City Office, Kanagawa, Japan

YASUSHI TAKEUCHI
Faculty o Regional Environment Science, Tokyo University of Agriculture, Japan

YOSHITAKA MURAKAMI
Fukushima Prefecture, Fukushima, Japan

Received 10 December 2010 Accepted 27 January 2011

Abstract Clinker ash is a kind of coal ash produced by the burning of coal at thermal power plants. Recycling of clinker ash is highly desirable since most of it goes to landfills at present. Because of its porous solid, clinker ash has high potential as a means of purifying contaminated water. On the other hand, nitrogen outflow by paddy drainage has become a major problem in Japan. Therefore, this study examines the effectiveness of a filtering system using clinker ash for removing nitrogen from paddy drainage. A column experiment was conducted in the laboratory to examine the nitrogen removal function of clinker ash. Four types of filtering materials were prepared as the test samples. The Sample I consisted only of clinker ash; the Sample II and the Sample III were a mixture of clinker ash and paddy soil in the ratios of 3:1 and 1:3 respectively; and the Sample IV was comprised of paddy soil only. Each sample was poured into PVC columns (44 mm in diameter; 350 mm in length). A solution prepared with NH_4-N at a concentration of 10 mg/L and C/N of 12 was fed to the columns at a flow rate of 100 to 200 mL/d for 121 days. During the experiment, the columns were kept saturated at a room temperature of 24.4±1.3℃ and illuminated at 544±192 lux. The study showed that clinker ash has the effect of removing nitrogen. However, it also found that clinker ash's removal function is compromised when a large amount of paddy soil is mixed with clinker ash. In order to remove nitrogen from paddy drainage by using clinker ash, only a relatively small amount of paddy soil should be mixed with clinker ash.

Keywords nitrogen removal, clinker ash, paddy drainage, filtering system

INTRODUCTION

Water contamination due to agricultural activity is a global issue (Garnier et al., 2010). During Japan's rapid economic growth from the 1950s to 1970s, pollution issues relating to water contamination surfaced across the country. The Water Pollution Law was introduced in 1970 as a countermeasure, and other laws and regulations followed in subsequent years. These days, water contamination from point sources, such as factories and residential wastewater, has ameliorated thanks to regulatory efforts; however, nitrogen and phosphorous water contamination arising from farmland and other non-point sources is not yet sufficiently resolved (Mishima. 2007).

Many studies have reported nitrogen removal efforts on paddy fields, which account for 60% of farmland in Japan (Ichino et al., 1998; Feng et al., 2004). It has also been reported that nitrogen runoff from paddy fields is related to river water contamination, and paddy fields are thus identified as a source of water pollution. In particular, discharge of high-concentration nitrogen is noted to occur in paddy fields immediately after fertilizers are used (Yoshinaga et al., 2007).

Approximately 20% of Japan's total energy is provided by coal-fired thermal generation. In 2003, thermal generation produced a total of 7,470,000 tons of coal ash, which is roughly categorized into clinker ash and fly ash. Fly ash constitutes the majority of coal ash and is recycled as construction material. Although as much as 220,000 tons of clinker ash is generated each year, most of it ends up in landfills; thus recycling of clinker ash is an important issue to address (JETA et al., 2005). Since the surface of clinker ash has numerous pores of 1-20 μm in diameter (Fig. 1) and has a large specific surface area, it has good potential as a water purification material.

Nitrogen discharge from paddy drainage divided into seepage, surface runoff, denitrification and vaporization. Especially, it is easy to take measure regarding with decrease of nitrogen concentration in seepage and surface water using filtering system. In this study, a column experiment was conducted using clinker ash as a filtering material in order to illustrate the nitrogen removal performance of clinker ash when used against paddy field wastewater.

METHODOLOGY

A column experiment was conducted in the laboratory to examine the nitrogen removal function of clinker ash as shown in Fig. 2. Four types of filtering materials were prepared as test samples. Table 1 shows characteristics of each filtering material before the experiment. Sample I consisted only of clinker ash; Sample II and Sample III were a mixture of clinker ash and paddy soil in the ratios of 3:1 and 1:3 respectively; and Sample IV consisted of paddy soil only. Mixture samples were assumed to be degraded by paddy soil.

The coefficient of permeability was 6.23×10^{-2}cm/s in Sample I, and 1.20×10^{-4}cm/s in Sample IV. A rise in the ratio of paddy soil decreased the coefficient of permeability. While no amount of nitrogen was detected from Sample I, 181.4×10^{-5}kg/kg was found in Sample IV. The higher the ratio of paddy soil was, the greater the amount of nitrogen.

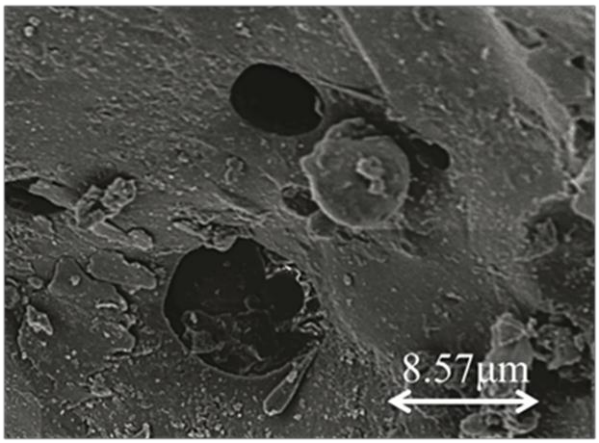


Fig. 1 Photomicrograph of clinker ash

Each sample was poured into a PVC column (44 mm in diameter; 350 mm in length). A test solution prepared with NH_4-N at a concentration of 10 mg/L and C/N of 12 was fed to the columns at a flow rate of 100 to 200 mL/d for 121 days. The drainage tube was lifted in the column upper part to make it a saturation state. During the experiment, the columns were kept saturated at the room temperature of 24.4±1.3 ℃ and illuminated at 544±192 lux. Water samples were taken every

day for the first 31 days. The sampling interval was then changed to once every 2 days until the 60th day, when it was again changed to once every 4 days until the 121st day.

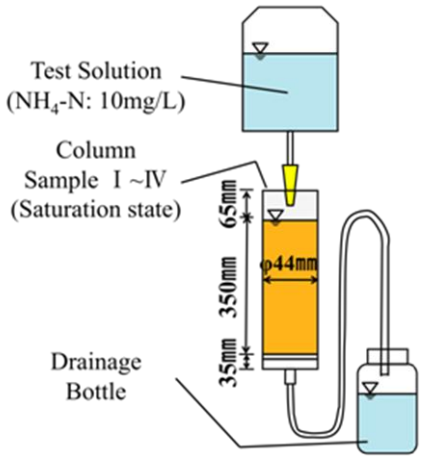


Fig. 2 Schematic diagram of column experiment

Parameters used to measure the water quality were total nitrogen (T-N), nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), and ammonium nitrogen (NH_4-N); these were analyzed using ultraviolet spectrophotometry in accordance with the Japanese Industrial Standards (JIS). The quantities of nitrogen and carbon were each measured using the CN coder (SUMIGRAPH NCH-22F : Sumika Chemical Analysis Service, Ltd.) before and after the column experiment.

RESULTS AND DISCUSSION

Fluctuation of outflow nitrogen concentration as a function of time and cumulative flow

Fig. 3 shows the relationship between the number of days elapsed and the T-N concentration (C_{out}) in the outflow. Fig. 4 plots the relationship between the cumulative flow of the solution and the C_{out} in the outflow. The volume of the solution passing through during the experiment period of 121 days varied from sample to sample, due to the differences in the coefficient of permeability.

Samples I and II recorded the lowest nitrogen concentrations at 2.21 mg/L (1st day: 0.42 L) and 3.24 mg/L (5th day: 1.27 L) respectively. From then on the concentration rose gradually, stabilizing at approximately 7 mg/L. Samples I and II both recorded lower concentrations of nitrogen than that in the incoming solution throughout the experiment period, consistently demonstrating the presence of a water purification mechanism.

Table 1 Physical and chemical properties of samples

Sample	Proportion CA: soil	Soil texture	Coefficient permeability (cm/s)	Dry density (g/cm^3)	Void ratio	T-C ($x10^{-5}$ kg/kg)	T-N ($x10^{-5}$ kg/kg)	C/N ratio
Sample I	1:0	S	$6.23X10^{-2}$	0.94	1.34	441.1	0.0	ND
Sample II	3:1	LS	$1.50X10^{-2}$	0.96	1.34	620.1	31.0	20.0
Sample III	1:3	CL	$3.17X10^{-4}$	0.99	1.50	1259.6	128.5	9.8
Sample IV	0:1	LiC	$1.20X10^{-4}$	1.03	1.55	1497.0	181.4	8.3

Samples III and IV, on the other hand, recorded the highest nitrogen concentrations, at 67.40 mg/L (3rd day: 0.25 L) and 98.72 mg/L (3rd day: 0.20 L), respectively. The concentrations gradually decreased, with Sample III stabilizing at 11 mg/L and Sample IV at 16 mg/L. These values were higher than those in the inflow, evidencing that Samples III and IV had no nitrogen cleansing effect. The above results demonstrate that the ratio of clinker ash and paddy soil is related to the performance of the mixture as filtering material.

Nitrogen balance in each column

The nitrogen balance in each column during the 121 days was calculated by using Eq. (1) and (2):

$$L_{out} = L_{in} + SD - SP \tag{1}$$

$$SP = P_{soil} + P_{vac} \tag{2}$$

Where L_{out} is nitrogen discharge (mg), L_{in} is nitrogen supply (mg), SD is nitrogen discharge from soil (mg), SP is nitrogen removed (mg), P_{soil} is nitrogen adsorbed (mg), and P_{vac} is microbial decomposition of nitrogen compounds (mg), obtained by a subtraction based on (2).

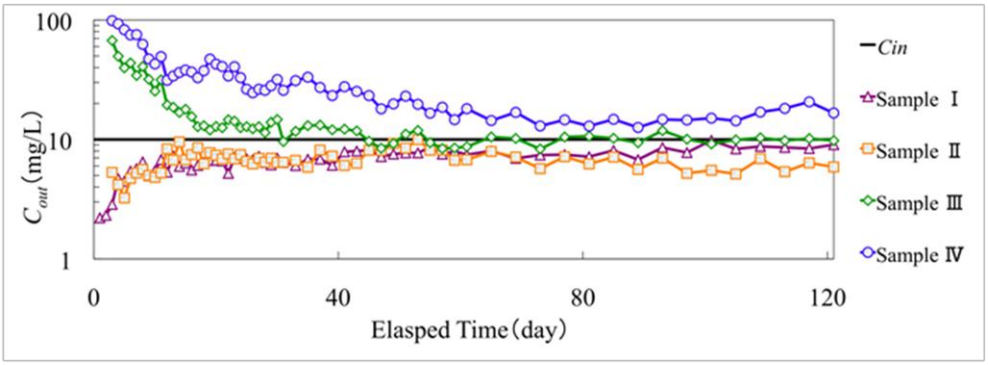


Fig. 3 Relationship between days lapsed and C_{out}

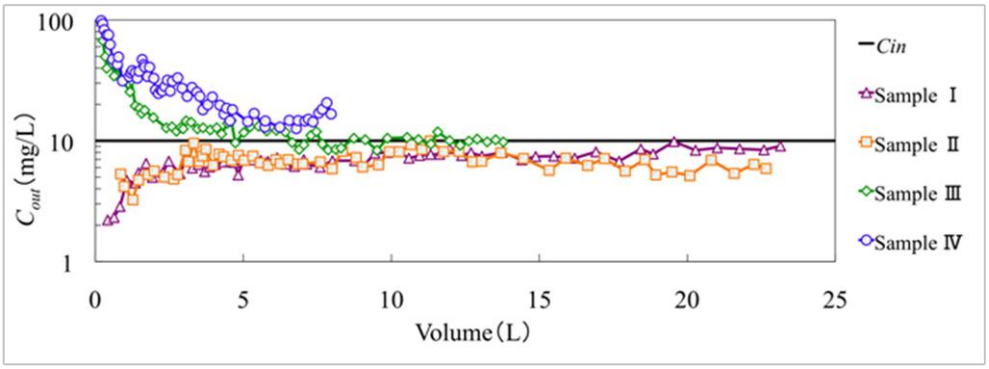


Fig. 4 Relationship between cumulative flow and C_{out}

Table 2 shows the nitrogen balance in each column. The ratios of effluence (L_{out} /L_{in}) of Samples I and II were respectively 0.74 and 0.64. This illustrates that when the nitrogen solution passes through a column containing a larger proportion of clinker ash, the concentration decreases by 26 to 36%. The values of P_{soil} and P_{vac} in Sample I were 43 mg and 17 mg, while those in Sample II were 69 mg and 10 mg. From these it is inferred that nitrogen adsorption and microbial decomposition occurred in Samples I and II.

Table 2 Nitrogen balance

Sample	L_{out} (mg)	L_{in} (mg)	SD (mg)	SP (mg)	P_{soil} (mg)	P_{vac} (mg)	Ratio of effluence L_{out}/L_{in} (-)
Sample I	169	229	0	60	43	17	0.74
Sample II	145	224	0	80	69	10	0.64
Sample III	183	135	83	35	0	35	1.36
Sample IV	195	77	165	47	0	47	2.52

Samples III and IV, on the other hand, recorded ratios of effluence of 1.36 and 2.52 respectively, demonstrating that nitrogen in the columns was released into the outflow. *SD* values of Samples III and IV were respectively 83 mg and 165 mg; it is assumed that nitrogen in the paddy soil in the column was discharged.

CONCLUSION

The column experiment confirmed that nitrogen is removed by nitrogen adsorption of clinker ash and microbial decomposition. It was further demonstrated that when the ratio of paddy soil to clinker ash rises in the mixture, the nitrogen removal mechanism fails to materialize, and the nitrogen contained in paddy soil is discharged. Thus, it is necessary to pay close attention to the mixture ratio between clinker ash and paddy soil when developing a water purification system using clinker ash.

ACKNOWLEDGEMENTS

This research was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan and Grant in Aid for young Scientists (B), 22780223, 2010. The authors are grateful for the columns experiment assistance provided by students of the Laboratory of Hydro-structure Engineering, Tokyo University of Agriculture, Japan.

REFERENCES

Feng, Y.W., Yoshinaga, I., Shiratani, E., Hitomi, T. and Hasebe, H. (2004) Characteristics and behavior of nutrients in a paddy field area equipped with a recycling irrigation system. Agricultural Water Management, 68, 47-60.

Garnier, M., Recanatesi, F., Ripa, M.N. and Leone A. (2010) Agricultural nitrate monitoring in a lake basin in Central Italy: a further step ahead towards an integrated nutrient management aimed at controlling water pollution. Environmental Monitoring and Assessment, 170, 273-286.

Japan Environmental Technology Association, Japan fly ash association (2005) Coal Ash Handbook, (in Japanese).

Ichino, M. and Kasuya, M. (1998) Nitrogen removal in paddy fields: An option for water quality improvement in rivers. Ecological Engineering, 10, 159-164.

Mishima, S., Taniguchi, S., Kohyama, K. and Komada, M. (2007) Relationship between nitrogen and phosphate surplus from agricultural production and river water quality in two types of production structure. Soil Science and Plant Nutrition, 53, 318-327.

Yoshinaga, I., Miura, A., Hamada, K. and Shiratani, E. (2007) Runoff nitrogen from a large size paddy field during a crop period. Agricultural Water Management, 87, 217-222.

Research article

Local Good Governance of Rural Infrastructure Development Planning: Case Studies of Commune Councils in Cambodia

YOUNG SOKPHEA
Regional and Rural Development Planning, Asian Institute of Technology, Thailand
Email: sophiabelieve@gmail.com

SOPARTH PONGQUAN
Regional and Rural Development Planning, Asian Institute of Technology, Thailand

SOPHAL EAR
Department of National Security Affairs, Naval Postgraduate School, United States of America

Received 10 December 2010 Accepted 30 January 2011

Abstract The research examines the application of local good governance (LGG) in the implementation of rural infrastructure development planning (RIDP) and analyzes its strengths and limitations. Two communes with longer and shorter working experience in the application of LGG in RIDP, viz. Khnach Romeas (KR) and Prey Khpos (PK) in Battambang province were selected. The study covered six elements of LGG: rule of law, participation, accountability, transparency, responsiveness and effectiveness and efficiency. The research revealed that the commune with relatively longer working experience (KR) had achieved better performance on several key elements of LGG than the one with shorter working experience (PK). Better performance in LGG by KR than PK commune was due to several factors, including better understanding and application of LGG in RIDP, wider learning by doing in RIDP, more effective fundraising for project implementation, stronger commitment among commune councils (CCs), better coaching and mentoring support from district planning facilitators and authorities and more active local participation. CCs and sampled households expressed relatively higher satisfaction levels on rural infrastructure projects as a result of the use of LGG. Therefore, the LGG performance in applying RIDP of the two study communes was significantly determined by several institutional, economic, and social factors.

Keywords decentralization, rural infrastructure, rural development planning process, local good governance, commune councils

INTRODUCTION

The Royal Government of Cambodia's strategic policy framework, outlined in the Rectangular Strategy Phase II, puts deconcentration and decentralization (D&D) policy to achieve good governance (RGC, 2008). D&D policy was formally put into action in February 2002 (Romeo and Spyckerelle, 2003), when commune elections were held, following extensive piloting since 1996 by the donor-funded Seila Program of the Royal Government of Cambodia which aimed to mobilize aid and coordinate D&D reforms and to alleviate poverty in selected northeastern provinces of Cambodia (RGC, 2000) through local governance reform and participatory planning. Five years of Commune Development Planning (CDP) and annual Commune Investment Plan (CIP) manuals were developed and endorsed for CCs in 2001, then revised in 2007 to improve the planning process (MoI and MoP, 2007). The investment grant through a fiscal transfer from the national budget to CCs for CDP implementation gives priority to rural infrastructure. The arguments for this are that rural infrastructure creates favorable opportunities for production, movement of goods, and market access and contributes to poverty reduction (NCSC, 2005).

The enabling environment for local good governance is still weak. An unclear legal framework and fragmented application of local governance contributed to a lack of decision-making at local levels; top officials have tended to exercise their power and control in local planning (ADB, 2000). There is limited participatory local governance, as democratic decision-making is poorly understood and internalized among the various committees of CCs (NCSC, 2005; Pellini and Ayres, 2007). To some extent, CCs still have limited capacity in the application of LGG through existing traditional and hierarchical decision-making structures (NCSC, 2005) that continue to affect the emergence of an effective local development process in developing countries (Hop, 2009). Specifically, there is poor participation in CDP and CIP, and limited engagement with the demands of local people (Vuthyand Craig, 2008). Moreover, local officials who facilitate planning processes lack experience in encouraging local participation in both planning and implementation (Charny, 1999). Accountability of CCs to local people through CDP is still weak and difficult to establish (Rohdewohld and Porter, 2006). The ongoing public administrative reform has not yet built effective systems for transparency and accountability (Sokha, 2005). Therefore, many aspects of LGG are weakly developed or nonexistent: there is low participation, lack of transparency, weak accountability, and low inclusiveness.

The research examines the application of local good governance (LGG) in the local planning and implementation process of rural infrastructure development planning (RIDP), and analyzes its strengths and limitations in order to identify the challenges and prospects for further strengthening LGG of RIDP.

METHODOLOGY

Rural Infrastructure Development Planning (RIDP), which is planned and implemented under the CDP and CIP, was conceptualized in seven key stages: 1) plan formulation; 2) identification/review of needs and problems; 3) selection of the priority project; 4) district integration workshop; 5) approval of the development plan; 6) project implementation; and 7) project monitoring and evaluation. Rural infrastructure projects studied in this research include rural laterite roads, box culverts, and earth roads. Six key elements of LGG assessed in this study are rule of law, participation, accountability, transparency, responsiveness, and effectiveness and efficiency.

The study was based in two purposely selected communes with relatively different working experience in RIDP, located in Battambang province. Khnach Romeas (KR) had longer experience in decentralization, since 1996, and Prey Khpos (KP) became involved in 2002. Primary data were collected by using two sets of standardized questionnaires designed for 60 CCs and committees, and 110 sampled households. Checklists were used for focus group discussion, key informant interviews, observation, and case studies on RIDP commune projects. Secondary data was scrutinized from literature, related laws, policies and development plans, sub-decrees, declarations, manuals, books, journal articles, and papers. Both quantitative and qualitative techniques were applied. A weight average index (WAI) based on Likert's five social-scale interval was applied to assess local perception of achievement and satisfaction of LGG applied in RIDP from CCs and committees, and sampled households.

RESULTS AND DISCUSSION

Analysis of application of LGG in RIDP

The application of LGG in RIDP was synthesized in both study communes and a comparison made against each element of LGG (Table 1).

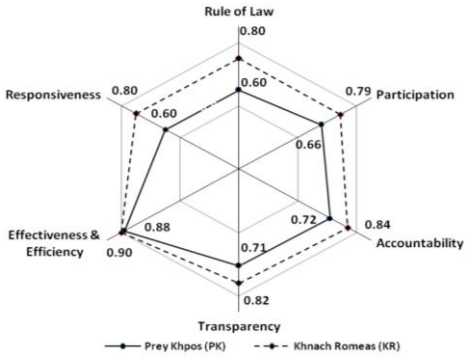
Table 1 Synthesis of LGG applied in RIDP of KR and PK communes

Khnach Romeas (KR)	Prey Khpos (PK)
Rule of Law	
• Rule of law in terms of guidelines and manual on RIDP and project implementation was well applied by both communes.	
Participation	
• Planning and Budgeting Committees (PBCs) participated in preparing budget and development framework during the initial stage of RIDP and reviewed local problems and needs. • Villagers, including women and vulnerable groups, actively participated in meetings to identify and prioritize their needs and identify locations for the project site. • NGOs and line departments participated in technical and financial support of proposed projects presented by PBCs, who were also active in exchanging ideas and explaining RIDP to supporters. • PBCs and CCs participated in decision-making to approve RIDP. • Local villagers were involved in the feasibility study. This led to harmonious solutions on the land contribution and impact assessment. Villagers were also involved in project implementation, in site clearance for the convenience of contractors and labor contribution, in addition to their cash contribution (10 percent of the project cost). • Villagers participated in project M&E as well as maintenance and gave comments on projects that were well received by village headmen and on which actions were taken.	• PBC members reviewed and prioritized problems and needs. • Villagers, including women and vulnerable groups, participated in meetings to identify and prioritize local problems, needs, and project sites. PBCs were unable to mobilize many of them to join in the activity. People did not speak out and mostly listened to PBCs, who led the decision-making. • NGOs and line departments provided technical and financial support to proposed projects by PBCs, but the PBCs were not so active in exchanging ideas and explaining RIDP to potential supporters. • PBCs and CCs participated in RIDP approval, but not all were present. • Villagers were involved in the feasibility study, yet proper action was not undertaken by CCs in order to solve key issues such as land acquisition for the infrastructure. Limited numbers of villagers participated in site clearance for project implementation, but villagers contributed cash (10 percent of project cost) for project implementation. • Villagers' participation in project M&E was weak, and comments from villagers were not acted upon by CCs and M&E committees. Local participation in project maintenance was not adequate.
Accountability	
• PBCs were involved in annual District Integration Workshop (DIW) to select infrastructure projects to be implemented, and to be endorsed by CCs. • The procurement committee took responsibility for preparing bidding documents and handled bidding properly. • The M&E committee mobilized public participation in project monitoring and evaluation, and reported on project progress to all participants at the monthly meetings. • Operation and maintenance groups functioned well.	• PBCs were involved in the DIW to finalize projects and get endorsement from CCs, but persons to be in charge of this activity were not designated clearly. • The procurement committee did not prepare and handle the bidding well, due to a lack of clarity and understanding of their roles and responsibilities. • The M&E committee did not adequately mobilize people to participate in project monitoring and evaluation, and did not make proper reports about project progress to the monthly meetings. • Operation and maintenance groups were not well established and lacked clear responsibility.
Transparency	
• Information on the RIDP was disseminated to local people, line agencies, and NGOs. • Bidding was conducted in a public place with participation from all interested stakeholders. The bidding documents were accessible and the contract was awarded based on the given criteria. Villagers were satisfied with the outcome. The result of bidding was announced publicly, and the contract was signed using a standard format. • Reports on RIDP implementation and finances were posted on public information boards. Project information was reported to the monthly meetings. Payment to contractors was based on consensus decision among CCs and the M&E committee. RIDP evaluation was conducted in a timely fashion. Financial auditing was conducted both internally and externally. Project signboards were not erected at the project site, and thus political parties gained	• Information on the RIDP was disseminated to local people, line agencies, and NGOs. • Bidding was conducted in a public place and with participation from all interested stakeholders. The bidding documents were accessible and the contract was awarded based on the given criteria. Villagers were not satisfied with the contractors due to their unfavorable reputation in the commune. The result of bidding was announced publicly, and the contract was signed using a standard format. • Reports on RIDP implementation and finances were not posted on the public information board. Project information was not disseminated properly at the monthly meetings. Payment to contractors was not based on consensus decision-making among CCs and the M&E committee. Moreover, RIDP evaluation was not

Khnach Romeas (KR)	Prey Khpos (PK)
credit by claiming that they had provided project support. • Allocation of the commune fund to each village was transparent, as it was given to prioritized projects in poor villages.	conducted on time and neither was the financial auditing. Project signboards were not erected at the project site, and thus political parties gained credit by claiming that they had provided project support. • Allocation of the commune fund was not transparent, as it was not given to prioritized projects in poor villages.
Responsiveness	
• Villagers were satisfied with the project outputs, and CCs were accountable through the establishment of a maintenance committee that ensures the long-term use of project outputs. The identified infrastructure projects solved the problems and needs of all groups of people in the commune.	• Villagers were not satisfied with the project outputs, and CCs were considered to be weakly accountable, as no maintenance committee had been established. The identified infrastructure needs were not met and the needs of all groups of people were not addressed.
Effectiveness and Efficiency	
• The project was implemented and finished per the given time line, and the objectives of RIDP have been achieved in general.	• Project implementation was delayed and therefore the objectives of RIDP were not achieved.

Perception and satisfaction with LGG achievement in RIDP of communes

Based on the WAI values shown in Fig. 1, the perception of CCs' achievement in applying LGG in RIDP in each commune was quite different. Overall, CCs in KR perceived a high level of performance in all six LGG elements: rule of law (0.80), participation (0.79), accountability (0.84), transparency (0.82), effectiveness and efficiency (0.90), and responsiveness (0.80). CCs from PK commune perceived varying degrees of LGG achievement: high levels of effectiveness and efficiency (0.88), participation (0.66), accountability (0.72), and transparency (0.71), and moderate levels of rule of law (0.60) and responsiveness (0.60).



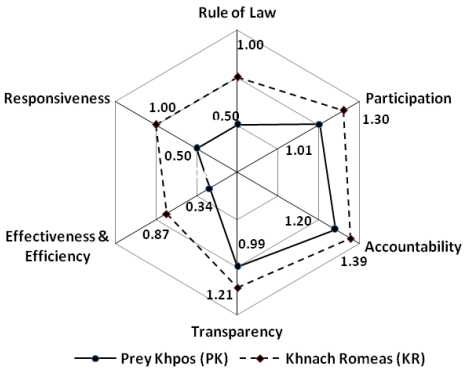
***Note**: 0.00-0.20: Lowest, 0.21-0.40: Low, 0.41-0.60: Moderate, 0.61-0.80: High, 0.81-1.00: Very High*

Fig. 1 Achievement of LGG in RIDP

Figs. 2 and 3 show the different degrees of satisfaction between the CCs and committees and sampled households in both communes. The CCs and committees and sampled households in KR commune are mostly strongly satisfied with the levels of participation, accountability and transparency; they also expressed satisfaction with the rule of law, effectiveness and efficiency, and responsiveness of RIDP implementation. In PK commune, however, CCs and committees are strongly satisfied with only two of the key elements of LGG, participation and accountability, while for the remaining elements they are only satisfied. Interestingly, the sampled households in both communes indicate they are satisfied with all LGG components.

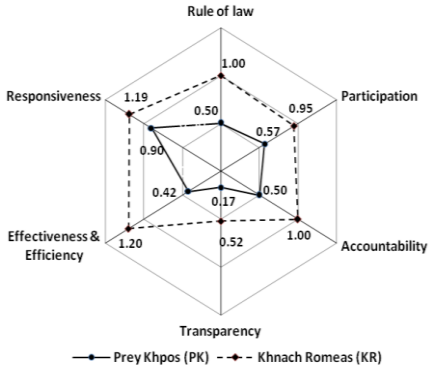
Strengths and limitations of the application of LGG in RIDP

Several key institutional, economic, and social factors contributed to the different perceptions of satisfaction with the implementation of RIDP. The key factors found in this study are contemplated as strengths and limitations in both study communes and can be categorized into institutional, economic, and social dimensions.



***Note**: -2: Strongly Dissatisfied, -1: Dissatisfied, 0: Neutral, 1: Satisfied, 2: Strongly Satisfied*

Fig. 2 Satisfaction of CCs and committees



***Note**: -2: Strongly Dissatisfied, -1: Dissatisfied, 0: Neutral, 1: Satisfied, 2: Strongly Satisfied*

Fig. 3 Satisfaction of sampled households

Some of the important institutional factors that contributed to LGG include the development of rules and regulations, active participation by local people, coaching, mentoring and on-the-job-training, local/international NGO funding support, training in LGG, and exchanging and sharing experience in LGG through exposure visits. Although these factors had a significant influence on both study communes, in KR commune they were more significant. This led to higher levels of achievement of the key elements of LGG in KR commune and they were perceived higher satisfaction from CCs and committees. Economic factors also played an important role in the perceptions of LGG of RIDP. These included clear rules and fair commune fund allocation criteria (allocated funds to all villages and prioritized needs of local people); financial auditing and RIDP evaluation, including but not limited to regular financial auditing from financial officers and external auditors, and evaluators; and ability to raise funds for additional infrastructure project implementation. These factors were better developed in KR than in PK commune. Social factors also affected the results in the two communes and include the degree of public awareness and its spread, particularly among poor and more vulnerable groups; the presence of local leadership able to generate and mobilize funds for RIDP implementation; and the regular monthly meeting of CCs where interested people were invited to participate actively.

Lower levels of achievement in the application of LGG in RIDP were the result of several institutional factors: the low levels of education, multiple responsibilities as a result of lack of human resources, lack of small-scale infrastructure technical knowledge, and incompatibility of roles and responsibilities among CCs who came from different political parties and had weak deliberative processes to enable good decision-making. Moreover, these economic factors in both communes were made worse by postponement of project implementation, inadequate amounts of commune funding, infrequent evaluation of RIDP and financial auditing, and low incentives and motivation to perform the assigned tasks. In addition, a range of other social factors led to low levels of LGG implementation, including dissatisfaction with land compensation, reluctance of local people to participate in planning processes, replacement of PBCs, inadequate levels of participatory decision-making, lack of public information disclosure, and limited participation in bidding processes of CCs. These factors had a significant influence on PK than KR commune.

These factors contributed to the different levels of performance in the application of LGG in RIDP of both study communes.

CONCLUSIONS

KR commune had higher achievement in six major elements of LGG of RIDP than PK commune. It appears that one of the main reasons for this is the longer time and higher levels of support this commune has had for decentralized planning.

The main areas of difference between the two communes are transparency (finance, information dissemination, reporting), accountability (committees in charge of various project activities), and effectiveness and efficiency (delivery of infrastructure projects), which need to be improved by PK commune. KR commune demonstrated a greater understanding of the principles and practice of LGG of RIDP. Its strength of LGG in RIDP came from higher levels of education as well as longer practical experience implementing RIDP and learning by doing, strong commitment of CCs and committees, more capable CCs that performed well in fundraising for project implementation, significantly higher levels of coaching and mentoring from district planning facilitators and authority, and higher levels of local participation. Despite these achievements, both communes face key policy challenges. These include weak incentives to actively encourage local participation and develop good deliberative processes. There is limited enforcement of proper compensation processes in land acquisition for infrastructure, and low continued support for capacity building of the key local government-citizen interface, the CCs. These factors all need to be addressed to help secure future progress of decentralization and local governance in Cambodia.

ACKNOWLEDGMENTS AND DISCLAIMER

The authors would like to extend their deepest gratitude to the CCs and villagers in the two study communes, who gave their warmest welcome and provided valuable information. We also appreciate the cooperation from the NCDD in Battambang province. Special gratitude is given to Mr. Young Pheak for his kind assistance in data collection and facilitating local communications and contacts during the field work for this research. The views expressed are solely those of the authors and do not necessarily reflect the views of sponsoring agencies, funders, or the authors' institutions of employment.

REFERENCES

ADB (2000) Enhancing governance for sustainable development in Cambodia. ADB, Philippines.

Charny, J.R. (1999) Issues for decentralized planning and financing of rural development. Regional Development Dialogue, 20-2, 176-192.

Hope Sr., K.R. (2009) Capacity development for good governance in developing societies: Lessons from the field. Development in Practice, 19-1, 79-86.

Ministries of Interior and Ministry of Planning (2007) Inter-ministerial declaration on commune development planning (CDP) and commune investment plan (CIP). Cambodia.

National Committee for Support Commune/Sangkat. (2005) Review of decentralization reform in Cambodia: Policy and practices. NCSC, Cambodia.

Pellini, A. and Ayres, D. (2007) Community participation in local governance in Cambodia: Learning from the village networks approach. Development in practice, 17-3, 404-409.

Rohdewohld, R.J. and Porter, D. (2006) Independent study of donor support for decentralization and deconcentration (D&D): Contributing to democratic development, Options for future donor support to decentralization and deconcentration. Cambodia.

Romeo, L.G. and Spyckerelle, L. (2003) Decentralization reforms and commune-level services delivery in Cambodia. Asian Development Bank, UNCDF, Philippines.

Royal Government of Cambodia. (2000) Seila program document 2001-2005. Selia task force, Cambodia.

Royal Government of Cambodia. (2008) The rectangular strategy (Phase II) for growth, employment, equity and efficiency, Cambodia.

Sokha, P. (2005) Decentralization and poverty reduction in Cambodia: experience and challenges. Regional Development Dialogue, 26-2, 114-120.

Vuthy, H. and Craig, D. (2008) Accountability and planning in decentralized Cambodia. Working paper 39, Cambodia Development Research Institute (CDRI), Cambodia.

Research article

Rural People's Livelihoods - A Case Study in a Commune at Mekong Delta, Vietnam

VO VAN VIET
University of Agriculture and Forestry, Ho Chi Minh, Vietnam
E-mail: vvviet@hcmuaf.edu.vn

Received 14 December 2010 Accepted 15 January 2011

Abstract Within the context of the Doi Moi period in Vietnam, rural people's livelihoods are more diversified and also vulnerable depending on the policy and other factors. This study seeks to understand the dynamic of rural people livelihoods in relationship with the changes in social and economic context. The general objective of this study is to describe the livelihoods system of rural people and identify the livelihoods strategies adapted by rural people and describe patterns/models of sustainable livelihoods options. This study is descriptive in nature. In order to draw a comprehensive range of information, the study make used of a variety of research methods. More particularly, the study used the participatory research method, combining both quantitative and qualitative techniques (i.e., secondary data collection, interviews, households' livelihood analysis and the like).

Keywords rural people`s livelihood, sustainable livelihood, participatory, Mekong Delta

INTRODUCTION

Vietnam is an agriculture-based country with about 80 percent of the total population living in the rural areas and 75 percent of the nation's labor force is in agriculture. Since 1986, the Vietnamese Government committed itself to a policy of renovation known as the Doi Moi. The core objective of this policy is to liberalize and stabilize the economy using strategic policies towards all economic sectors (i.e., state-owned business entities and nonstate-owned business entities). In order to implement this policy, Vietnam opened its doors to foreign investors and successfully achieved significant development. More attention is paid now to the expansion of all forms of business enterprises. With the renovation process, Vietnam has undergone a dramatic transformation and vast changes in both social and economic aspects. The economic transformation from a centralized-planned economy system to a market oriented economy led to profound changes in society. With the context of the Doi Moi period, people's livelihoods are more diversified and also vulnerable depends on the policy and other factors. This study seeks to understand the dynamic of rural people livelihoods in relationship with the changes in social and economic context. A community at Mekong Delta was selected as a case study.

METHODOLOGY

This study aims to understand how people in a commune change their livelihood strategies. Thus, a simple descriptive case study design was applied. Data for the study have been collected and analyzed simultaneously. More particularly, the study used the participatory research method. The data that have been collected come from secondary and primary sources. The following techniques were applied: 1. Semistructured interviews (SSI). This was conducted with 50 key informants. With the use of interview guides, the researcher collected data on the commune, such as socioeconomic characteristics, land use, socioeconomic infrastructure, development policies, natural resources and sociopolitical structure; 2. In-depth interviews (IDI). This was conducted with 30 households to generate understanding of household characteristics, particularly the difficulties and opportunities related to livelihood and strategies employed to overcome the

difficulties; 3. Focus-group discussion (FGD). This provided information on current household situations and helped in identifying the better off and worse off households. The FGD also helped gather data on the difficulties and advantages encountered by people in their livelihoods.

RESULTS AND DISCUSSION

About the study site

As shown in Fig. 1, Long Thuan commune is located at northern part of the isle of Cai Vung river in Hong Ngu district. Long Khanh A commune borders in the north, Phu Thuan A commune borders in the south, Phu Thuan B commune borders in the east and An Giang province borders in the west (Cai Vung River). The center of village is located about 5 km away from the center of the district and 17 km away from Vietnam-Cambodia border.

Surface land area of the commune covers about 2,010 ha (Statistical data in 2003) occupies about 6.05% area of the whole district. Of this, 78 percent is household-individual managed land, 22 percent is commune-managed land, and land devoted to economic and social institutions. Households and individuals manage most of the agricultural land.

The commune is composed of five hamlets which are named Long Thanh, Long Hoa, Long Hung, Long Thoi A and Long Thoi B. Long Thuan is strategically located in the isle. Therefore, the commune has many favorable conditions for agricultural development.

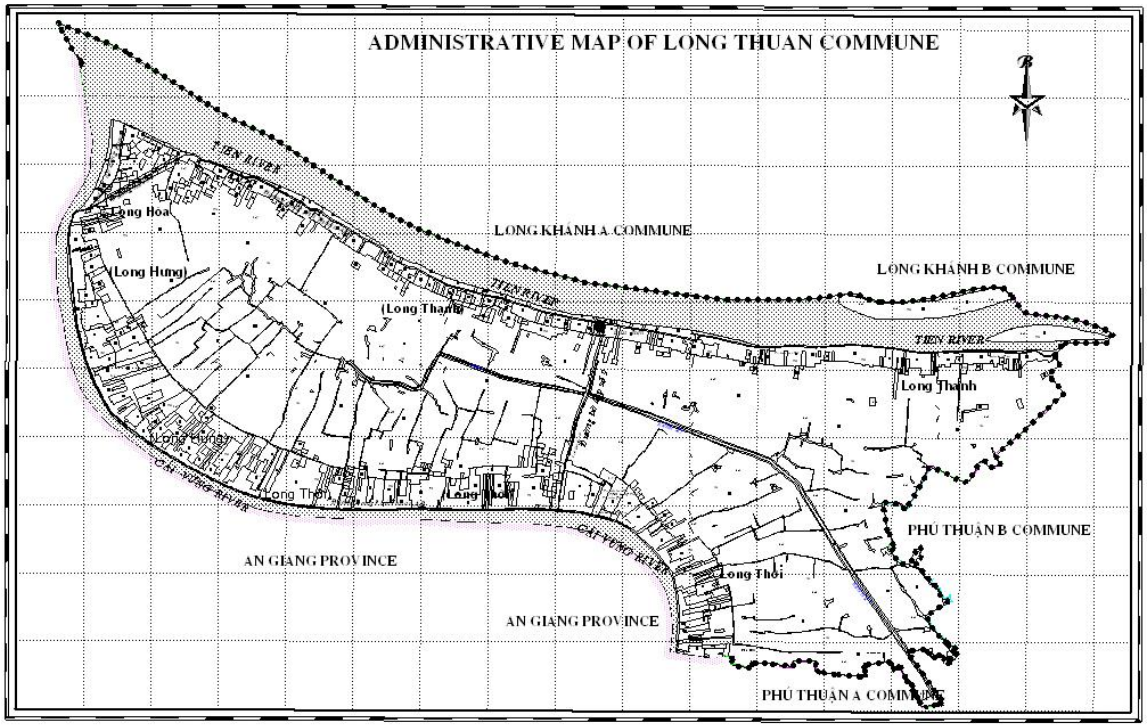


Fig. 1 Map of Long Thuan commune

Livelihood strategies

From the last years, the livelihoods of the peasant households of the community were linked to broader markets through an expanding group of rice-trading middlemen and rice-millers. Production was almost exclusively devoted to rice among Long Thuan households while some families engaged in both market oriented fruit growing as well as rice cultivation. Although relying increasingly on a money economy for their livelihood, these households were sustained by patterns of subsistence production, using local food resources as a basis for household sustenance. In the

recent years, however, there was a shifting in pattern of livelihoods, people follows diversified livelihood strategies that include both on and off farm activities. Productive assets such as agricultural tools and machinery differ from household to household depending on the types of land owned and used. On-farm activity diversification varies in terms of whether crops or livestock are raised, or have a mixed system. Off-farm strategy secures the income of many households. There are significant differences occur in the percentages of income derived from on-farm and off-farm activities. Those who have access to roads and market (physical capital), off-farm income plays an important role and vice versa.

Many households earn some income from the farms but also earn substantial income from other sources. Certain members of the households may have part-time or even full-time employment off the farm, or engage in cottage industries at home part of the time. The principal activity is small-scale farming while livestock serves to reduce risks. For some households, livestock raising, particularly dairy cow, has become a reliable income source.

The practice of diversifying the households' occupation into various nonagricultural sectors could be seen as a strategy of survival as much as status acquisition and maintenance. Nonetheless, the adaptation and the ability to diversify occupation and sources of livelihood of people in the commune are very different for particular groups. Those who have more assets can diversify their source of livelihood from among the three economic sectors such as industry, services, agriculture, or a combination of these sectors. Thus, It can be stated that the better the ability to access capital, the better the adaptation.

Research in the commune has brought to light cases of both successes and failures. In terms of livelihood opportunities, landed households have a wide range of choices. They can either continue to engage in farming with additional income from small services, or they can decide to sell land and totally become nonagricultural households. Otherwise, they can sell part of the land and invest the money in animal husbandry and intensively cultivate the land with new varieties and techniques. In contrast, land-less households or lack of natural capital, in general, are unable to take advantage of this opportunity. Clearly, their livelihood depends, for individual households, on the ability of its members to obtain other forms of livelihood.

New environment also provides new opportunities for households to move up. More jobs are being created in and around the commune. Nevertheless, new job opportunities are not being created at a sufficient rate to provide employment for the expanding labor force in the commune and the increasing income needed to support large households. Thus, migration to other areas in search for work, especially manual work, becomes an option taken by a growing number of households.

To obtain a secure livelihood, in the context of the commune, people are forced to choose a livelihood strategy that combines agriculture and services sectors. Most, if not all successful households or households with secure livelihood in this area, do not depend exclusively on agriculture for their livelihood. Services and trading provide additional sources of earnings for local residents. It should be noted that occupational diversification has a long history. The trend towards occupational diversification within lower-income households more recently is the result of an expansion of livelihood possibilities accompanying changes in the commune's economy. It is important to acknowledge that the process of occupational diversification is one in which households play an active part.

Non-farm and off-farm activities are becoming increasingly critical for people's livelihoods. Moreover, non-farm and off-farm occupations often offer individuals and households better income. It constitutes the key foundation for economic advancement, generates different effects on people's livelihoods, and determines to a large extent contemporary patterns of differentiation among households. The availability and the accessibility of assets, tangible or intangible, basically regulate the differentiation among households.

By analyzing the livelihood strategies of selected households, the study found that the success or failure of households in the commune depends on a composite of personal and nonpersonal or institutional situations. On the personal level, it means the ability of the individual or household to acquire the basic necessities of life such as food, shelter, and clothing. On the nonpersonal level, it means the ability of the State and other socioeconomic institutions in providing assistance to people

in terms of access to education, vocational training, health, information (including labor market information and urban planning information), job attainment and loans, among others. Good personal ability combined with a favorable institutional situation would likely provide people with better and more secure livelihoods and vice versa. The absence of one of these two components would cause difficulties for households in obtaining a secure, sustainable livelihood.

In the process of adaptation to the new environment, there is a general pattern easily observed in the commune; that most farmers have low level of education, are of old age, and have no technological skills so that they face more hardships. Occupational training for farmers in the process of transformation also has many difficulties. Interviews with KIs have shown that many young people lack the education and skills needed to benefit from new economic opportunities. Farmers are particularly ill-equipped for the new environment; the market economy.

CONCLUSION

Land is the principal economic asset of people, and the incomes of most agricultural households depend largely on access to land. While human capital and social capital are of some importance, the most significant capital is natural capital, more particularly, ownership and control of land.
Agriculture has, and continues to mainly contribute to the revenues of the commune, and this is likely to remain in the near future. However, at the household level in the study area, the role of agriculture in supporting livelihoods is slowly declining with the availability of other non-farm opportunities. Also, the significance of agriculture in terms of its role in supporting household livelihood is determined by the capacity of the households' landholdings, their access to labor and capital inputs, and the market. When access to land, labor, and market is restrained and new opportunities from urban employment are obtainable, the role of agriculture is likely to be weakened.

REFERENCES

Ashley, C. and Carney, D. (1999) Sustainable livelihoods: Lessons from early experience. Department for International Development, UK.

Barbichon, G. (1961) Adaptation and training of rural workers for industrial work. Organization for economic co-operation and development, France.

Brookfield, H. and Byron, Y. (1993) Southeast Asia's environmental future. Oxford University Press, Singapore.

Carney, D. (1998) Sustainable rural livelihoods: What contribution can we make? Department for International Development. Russell Press Ltd., England.

Coleman, J. (1990) Foundations of social theory. The Belknap Press of Harvard University Press, USA.

Dao T.T. (1996) The Peasant household economy and social change. In Viet Nam's Rural Transformation. Westview Press, USA, 139-164.

Dennis, A.F. (1956) Land reform and economic development. In land tenure. The University of Wisconsin Press, USA, 44-49.

DFID (2000) Sustainable livelihoods guidance sheets. Department for International Development, England.

Ferder, E. (1971) Latifundia and agricultural labour in Latin America. In peasants and peasant societes. Penguin Books Ltd., England, 83-97.

Franklin, H. (1971) The worker peasant in Europe. In peasants and peasant societies. Penguin Books Ltd., England, 98-102.

Hudson-Rodd, N. and Nyunt, M. (2001) Control of land and life in Burma. Land Tenure Center, University of Wisconsin-Madison, USA.

Hoang, Viet. Van De So Huu Ruong Dat Trong Nen Kinh Te Hang Hoa Nhieu Thanh Phan O Viet Nam. Nha Xuat Ban Chinh Tri Quoc Gia. (1999) Hoang, Viet. Issues on landownership in a multisector market economy of Viet Nam. National Politics Press, Vietnam.

Johnson, V.E. and Barlowe, R. (1954) Land problems and policies. McGraw-Hill Book Co., USA.

Lane, M. (2001) Indigenous land and community security: A (Radical) planning agenda. University of Wisconsin-Madison, USA.

Lastarria-Cornhiel, S. and Melmed-Sanjak, J. (1999) Land tenure in Asia, Africa, and Latin America: A look at the past and a view to the future. Land Tenure Center, University of Wisconsin-Madison, USA.

Lellis, F. (1998) Livelihoods diversification and sustainable rural livelihoods. In sustainable rural livelihoods: What contribution can we make? Department for international development. Russell Press Ltd., 53-65.
Maxwell, D. and Wiebe, K. (1998) Land tenure and food security: Review of concepts, evidence and methods. Land Tenure Center, University of Wisconsin-Madison, USA.
Nguyen T.C., et al. (2000) Social policy. In socioeconomic renovation in Vietnam. Institute of Southeast Asian Studies, Singapore, 139-172.
O'Callaghan, J.R. (1996) Land use: The interaction of economics, ecology and hydrology. England.
Parsons, K.H. (1956) Land reform and agricultural development. In land tenure. The University of Wisconsin Press, USA, 3-22.
Pal, A.P. and Polson, R.A. (1973) Rural people's responses to change. Dumaguete trade area, Philippines. New Day Publishers, Philippines.
Pham Xuan N., Be Viet B. and Hainsworth, G.B. (2000) Rural development in Vietnam: The search for sustainable livelihoods. In socioeconomic renovation in Vietnam. Institute of Southeast Asian Studies, Singapore, 1-48.
Popkin, S.L. (1979) The rational peasant. The political economy of rural society in Vietnam. University of California Press, USA.
Quan, J. (1998) Land tenure and sustainable rural livelihoods. In sustainable rural livelihoods: What contribution can we make? Edited by D. Carney. Department for international development. Russell Press Ltd., England, 167-180.
Ratcliffe, J. (1976) Land policy: An exploration of the nature of land in society, Great Britain.
Shearer, E.B., et al. (1999) The reform of rural land markets in Latin America and the Caribbean: Research, theory, and policy implications. Land Tenure Center, University of Wisconsin-Madison, USA.
Chambers, R. (1995) Poverty and livelihoods: Whose reality counts. Environment and urbanization, 7-1, 173-204.
Edgens, J.G. and Staley, S.R. (1999) The myth of farmland loss. Forum for applied research and public policy, 14-3, 29-34.
Fine, B. (1999) The development state is dead-long live social capital? Development and change, 30-1, 1-19.
Fulton, W. (1999) Covering the land use story. The Quill, 87-8, 27-30.
Mittal, A. (2000) Land loss, poverty and hunger. The Ecologist, 30-6, 44.
Rakodi, C. (1999) A capital assets framework for analysing household livelihoods strategies: Implication for policy. Development Policy Review, 17, 315-342.

Research article

Current State of Food and Agriculture Education (*SHOKUNOU KYOUIKU*) in Japan

HIROKI INAIZUMI
Faculty of International Food Studies, Tokyo University of Agriculture, Japan
Email:inaizumi@nodai.ac.jp

Received 14 December 2010 Accepted 31 January 2011

Abstract At the beginning of this century, the Japanese education system and associated curriculum dramatically changed, particularly concerning instruction related to acquiring a "Zest for Living" through food and agriculture education. Concomitant with these revisions, numerous studies and activities have been conducted predominantly at the elementary level, with only a few performed at the university level. In attempt to counter this trend, the Tokyo University of Agriculture (TUA) established the Food and Agriculture Education Theory Course (FAETC) in April 2007. In the present study, the effectiveness of the FAETC was investigated by examining the relationship among students' daily lifestyles, particularly nightly sleeping time and breakfast consumption custom, and their academic performance in this course. From the results of surveys conducted over a three-year period, it was revealed that students who had a regular lifestyle with respect to sleeping and eating trends exhibited superior academic performance. However, it appeared that students with an irregular lifestyle also improved their concentration levels. Therefore, these results suggest that a positive correlation exists between lifestyle and concentration level, and student conscientization can be promoted by continuous encouragement in regular class. In other words, it is concluded that a large possibility exists for the role of FAETC for conscientization by students in their daily lives.

Keywords food and agriculture education, food and nutrition education, zest for living, conscientization

INTRODUCTION

Since the Basic Law on *Shokuiku* (Food and Nutrition Education) was enforced on July 2005, numerous activities have emerged, including seminars, publications, and a certifying examination for *Shokuiku*/*Shokunou* (Food and Agriculture) Education, among others. The rapid expansion of this program has been termed the '*Shokuiku* bubble' in Japan.

Along with this trend, the Tokyo University of Agriculture (TUA) has begun '*Shokunou Kyouiku*' (Food and Agriculture Education Theory Course [FAETC]) in the Department of International Bio-Business Studies, Faculty of International Food Studies from April 2007.

Background of the FAETC

According to the preamble of the Basic Law on *Shokuiku*, the Japanese Government clearly stated the importance of *Shokuiku* as follows:

"Above all else 'SHOKU' (food/diet/eating) is important for children to cultivate rich humanity (i.e., develop into well-rounded and compassionate individuals), and to acquire the knowledge and means to live healthy lives. The Basic Law on Shokuiku formally makes Shokuiku the foundation for living, and positions it as the base of intellectual (Chiiku), moral (Tokuiku) and physical (Taiiku) education."

Three years before the Basic Law on Shokuiku enforcement, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) revised the National Curriculum

Standard (NCS) in 2002 by introducing the brand new subject 'Period for Integrated Study', which was aimed at the ability of students to acquire a 'Zest for Living'. Subsequently, many people thought *Shokuiku* and/or other food and agriculture studies were the key contents of the 'Period for Integrated Study' subject. Since foods are a prerequisite condition for every human being, this subject would be a strong learning assistant tool if it contained suitable educational content that was presented properly. In other words, it appeared that *Shokuiku* had significant potential to allow the acquisition of not only knowledge, but also mental and physical skills through individual learning activities.

Theoretical framework

After revising the NCS and enforcing the Basic Law, numerous studies focused on the importance of *Shokuiku* and/or food and agriculture education have been published in Japan. For example, Kageyama (2006) concluded that breakfast behavior and varietal food intake are closely related to academic performance in elementary school students, while Koshikawa et al. (2007) also described a close relationship between diet and learning attitude/motivation. Moreover, Suzuki et al. (2007) and Asaoka et al. (2010) pointed out that food and agriculture education has important functions for rebuilding human relations and revitalizing communication among local communities. However, most studies to date have focused on younger children or have presented complicated theoretical arguments without clear conclusions. For studies involving children, it make sense that eating habits are closely related to children's daily life, but those children cannot be considered independent, as their behaviors are strongly affected by their parents and/or surrounding adults.

Moreover, in addition to dietary habits, academic performance may also be influenced by household conditions (e.g. family structure, income levels, family norm, etc.). Therefore, it appears difficult to evaluate direct relationships between eating habits and academic scores in children. For those studies involving complex theoretical arguments, although the authors collected large amounts of historical and current evidences on food and agriculture education/activities and have put forth important efforts, a concrete theory has yet to be demonstrated.

Therefore, in the present study, an attempt has been made to establish another framework for food and agriculture education and student performance. Specifically, an empirical study involving university students was conducted for evaluating the educational effects of the FAETC in TUA. University students were selected as they are generally considered more independent than primary and secondary school students, which would allow the relations between their eating habits, autonomous behavior (derived from their own conscientization), and academic performance to be captured, and also fill the gaps of previous studies on food and agriculture education in Japan.

Research objectives

The main objective of this study was to evaluate the hypothesis that FAETC has a positive effect for achieving conscientization in students' daily lives and the integration of knowledge, which is typically presented incoherently during early stages of their education.

In general terms, the two main objectives of this survey were to: 1) Compare student behavior concerning breakfast consumption and hours of sleep with the guidelines of the Basic Program for *Shokuiku* Promotion (BPSP) set by the Office for Shokuiku Promotion in the Cabinet Office, Government of Japan in 2006, and 2) Evaluate the effects of FAETC on student lifestyle.

The three specific objectives were to: (1) Examine the current situation for breakfast consumption behavior among target students and compare these findings with the latest National average and/or National projection, (2) Identify factors affecting students' breakfast consumption behavior, and (3) Clarify the relation between students' customs and their performance in this course.

RESEARCH METHODOLOGIES

The FAETC

In response to these stated objectives for the Basic Act of *Shokuiku*, TUA established the FAETC for students who have an interest in food, agriculture, and environment. Table 1 shows a course outline of the FAETC in 2009. The purpose of this course was to allow student to discover the educational elements in agricultural activities.

To cover the areas of not only on food, but also more broad areas including agriculture and environment, TUA decided to adopt FAETC (*Shokunou Kyouiku*) and not Food and Nutrition Education (*Shokuiku*), even though the Basic Law is named *Shokuiku*. For achieving the outlined goals, several discussion sessions were offered as part of the course in addition to the normal lectures.

Table 1 Course content of the FAETC in 2009

Theme of lecture	Topics
1. Background of the birth of *Shokuiku*/ *Shokunoukyouiku*, and current situation	● Current situation of food and agriculture in Japan ● Background of *Shokuiku*/ *Shokunoukyouiku*
2. Education	● What is education? ● Examining educational history
3. History of education and agricultural education in Japan	● Pre-modern age ● Establishment and expansion of the school system ● Agricultural panic and the birth of farmer training centers ● Reformation after WWII ● Current situation
4. Food, agriculture and education	● Lessons learned from general educational theories ● Industrial education besides agriculture
Conclusion	Examining the educational factor in agriculture, introducing the theory of comparison

Source: Web-syllabus of TUA (2009)

Survey methods

To identify the factors affecting students' lifestyle habits, particularly the daily hours of sleep and breakfast consumption, data was collected from FAETC students over a three-year period.

Table 2 Background of participating students

		2007 (total=234)		2008 (total=215)		2009 (total=223)	
		Number	%	Number	%	Number	%
Participants (per total students)		111	47%	63	29%	70	31%
Gender	Male	55	50%	42	67%	46	66%
	Female	56	50%	21	33%	24	34%
Resident	Domestic	94	85%	52	83%	65	93%
	International	17	15%	11	17%	5	7%
Breakfast (total number)	Yes	649	68%	524	81%	543	73%
	No	308	32%	126	19%	198	27%
Course performance (max=10)	Average	7.32		7.29		7.14	
	SD	1.76		2.00		1.54	

To collect data, a survey was conducted by administering a small questionnaire at the end of each FAETC lecture between 2007 and 2009. The four-question questionnaire was distributed 15 minutes before the end of each lecture, filled out by students, and collected; typically, feedback would be given at the beginning of next lecture. Moreover, students were asked each time for their consent concerning the use of their personal information for research. If a student was not willing for their information to be utilized for research purposes, that data was eliminated from the analysis. The course performance was combined final examination and homework scores into 0 to 10 scales. The composition of students who participated in the survey is summarized in Table 2.

SURVEY RESULTS

Investigation of student background and their lifestyle with a focus on the daily hours of sleep and breakfast consumption

There are three majors (Management, Information, and Environment Sciences) in the Department of International Bio-Business Studies at TUA which offer specific lectures and seminars for each selected major. FAETC is one of the compulsory lecture courses in the Environment Major; therefore, the number of participating students varies each year. Table 2 indicates the number of participating students and their characteristics for each year during 2007-2009, as mentioned above.

As shown in the first column of Table 2, the total number of students in the department by academic year was: 234 in 2007, 215 in 2008, and 223 in 2009. Of these, the number and portion of participating students for FAETC was: 111 (47%) in 2007, 63 (29%) in 2008, and 70 (31%) in 2009, while the gender ratio (male: female) of participants was close to 7:3, with the exception of 2007, when the ratio was 5:5. The portion of domestic and international students was 85:15 in 2007, 83:17 in 2008, and 93:7 in 2009.

After compiling the collected student data related to lifestyle (Table 3), it was compared to the target figures of the BPSP.

Table 3 Average nightly sleeping hours and breakfast consumption

	2007		2008		2009		3-year average	
	Average	SD	Average	SD	Average	SD	Average	SD
Hours of sleep	5.92	1.492	5.98	1.569	5.91	1.552	5.93	1.532
Breakfast consumption (%)	67.80	0.467	80.60	0.396	73.30	0.443	73.10	0.444

Table 3 shows that in the initial year that FAETC was offered (2007), the average breakfast consumption rate was 67.8%, which was significantly below the national average of 73.5% reported by the BPSP in 2006. However, the three-year average consumption rate by students in this course (73.1%) was similar to national average reported by the BPSP and slightly higher than the value (71.9%) reported in the National Health and Nutrition Survey (NHNS) conducted by the Ministry of Health, Labour and Welfare in 2009. Although a peak breakfast consumption rate of 80.6% was observed in 2008, it appears that the BPSP target figure of 85% in 2011 may be difficult to achieve.

With respect to the reported hours of sleep, the three-year average of FAETC students was 5.93 hours per day, which was close to the national average reported in the NHNS of 6-7 hours per day.

Factors influencing breakfast consumption

Among the factors evaluated in this survey, several were selected to examine their correlation with breakfast consumption behavior (Table 4).

Table 4 Correlation of selected factors with breakfast consumption

		Correlation coefficient	Significance level	F value	Cases
Gender	(male=1)	-0.10	0.000	138.61	2348
Student	(international=1)	-0.06	0.000	33.86	2348
Sleeping time	(hours)	0.01	0.233	1.43	2348
Academic year	(2007-2009)	0.06	0.000	24.73	2348

According to Table 4, a positive correlation with breakfast consumption behavior was only shown for 'academic year', while negative correlations were detected for both 'gender' and 'student' background (Japanese-International [Intl.]). As the student breakfast consumption behavior gradually improved from 2007 to 2009, it suggests that breakfast consumption was affected by the series of educational activities promoted under the current '*Shokuiku* bubble' as *Shokuiku* and/or *Shokunou* became popularized in society, and might also be good evidence for the efficacy of the National Campaign for BPSP. The factor of 'male student' showed a negative correlation with breakfast consumption behavior, indicating that female students have a higher tendency to consumption breakfast than their male counterparts. Intl. students also had a negative correlation with breakfast consumption rate, suggesting that their behavior may have been affected by the additional cost of breakfast. The last examined factor, 'sleeping time', was positively, but not significantly, correlated with breakfast consumption behavior of the student participants.

Comparison of the hours of sleep between breakfast consumers and non-consumers

A comparison between breakfast consumers (hereafter 'bf-consumers') and non-breakfast consumers (hereafter 'bf-non-consumers') in connection with average sleeping hours by FAETC lecture number (Figures 1, 2) revealed a more stable trend in bf-consumers than bf-non-consumers. Although it is possible that bf-consumers had already established independent life routines and actions (autonomous behavior), no significant correlation existed between breakfast consumption behavior and hours of sleep against which the general public perceive.

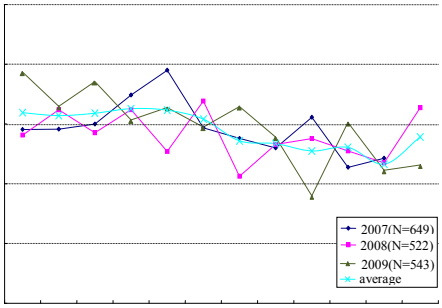


Fig. 1 Breakfast consumer's average sleeping hours by lecture number

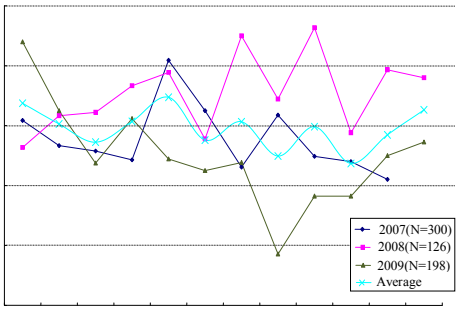


Fig. 2 Breakfast non-consumer's average sleeping hours by lecture number

Correlation between breakfast consumption behavior and academic course performance

As shown in Table 5, female students displayed good performance in the course, and course performance also had a positive correlation with breakfast consumption behavior. Even though the significance level was not high, a definite positive correlation between breakfast consumption behavior and FAETC performance was identified. This result displayed a similar trend with several studies that have also identified a close connection between these two factors in younger children.

Table 5 Correlation of gender and breakfast consumption with course performance

		Correlation coefficient	Significance level	F value	Cases
Gender	(male=1)	-0.16	0.204	7.711	2385
Breakfast	(consumption=1)	0.09	0.030	-4.616	2348

DISCUSSION

In this study, several factors affecting student lifestyle habits, particularly the hours of daily sleep and consume of breakfast, and the correlation of their lifestyles with FAETC performance were examined.

The present results confirmed that a positive correlation exists between breakfast behavior and course performance, which is similar to the findings of previous studies conducted at the elementary level. However, a clear difference among the two student groups was detected in terms of conscientization level. Although nearly all elementary students heavily rely on their parents for their life activities, many university students, particularly at the junior level, are more independent and in the process of establishing their own lifestyle. During this period, it could be quite useful to urge students to acquire awareness of their daily activities, not only those related to learning, but also more ordinal ones, such as part time working, reading a book and taking an exercise. For example, a clear difference in the trend of sleeping-hours was identified between bf-consumers who advanced establishment on an independent lifestyle and bf-non-consumers. Thus, it could be stated that the FAETC is an effective method to acquire a sense of conscientization.

Even before participating in FAETC, it was expected that the student participants would possess a good attitude towards breakfast consumption behavior. However, the results revealed that the difference between the student rates of breakfast consumption did not significantly differ from the National Average. This was also the case for the daily hours of sleep. From these results, it is apparent that even for the students who have an interest in food, a well-organized approach is required to improve their attitude towards healthy lifestyle choices.

It can be conclude that there is a need to offer FAETC for the early-twenties generation because this group faces the most negative nutritional condition in Japan. Although improvements to FAETC may be warranted, this course has the potential to positively change students' lifestyle choices, such as breakfast consumption behavior, and improves total performance, even with its current curriculum and methods are justified and numbered consecutively, with equation numbers in parentheses flush right, as in Eq. (1). First use the equation editor to create the equation. A sample equation is included here, formatted using the preceding instructions.

CONCLUSION

Students who have a regular lifestyle with respect to sleeping and eating habits tend to exhibit good academic performance. In addition, those students who improved their lifestyle also displayed increased concentration levels. From the results presented here, it was demonstrated that a correlation exists between lifestyle and concentration level, and that conscientization can be promoted by continuous encouragement in regular class. In other words, it is considered that a large possibility exists for the role of FAETC in conscientization by students in their daily lives.

Even though improvements to the current FAETC curriculum may be warranted, for example, evaluating the appropriateness of the stated objectives and addressing the confusion felt by some students between current *Shokunou Kyouiku* activities and the historical evidences from general education, the data presented here may help to establish more comprehensive and suitable *Shokunou Kyouiku* in the future through active discussions in academic societies and individuals who have an interest in this topic conclusion might elaborate on the importance of the work or suggest applications and extensions. Do not cite references in the conclusion as all points should have been made in the body of the paper. Note that the conclusion section is the last section of the paper to be numbered.

REFERENCES

Asaoka, Y. and Nomura, T. (2010) The Power of shokuiku. Kouseikan, Japan (in Japanese).

Basic Law on Shokuiku (2005) http://www8.cao.go.jp/syokuiku/about/law/law.html#zen.

Cabinet Office (2006) The basic program for shokuiku promotion (BPSP). http://www8.cao.go.jp/syokuiku/about/plan/pdf/kihonkeikaku.pdf (in Japanese).

Kageyama, H. (2006) Fostering children's academic performance by "sleep and wake up early and take breakfast". ShokuikuKatsudou (Activities on Food and Nutrition Education), Rural Culture Association (*NOBUNKYOU)*, 3, 36-39 (in Japanese).

Koshikawa, E., Okuda, T. and Murai, Y. (2007) The relation of dietary life with learning attitude and motivation in elementary school children. Bulletin of Osaka Kyouiku University, Section II, 55-2, 35-44 (in Japanese).

Ministry of Health, Labour and Welfare (2009) The national health and nutrition survey (NHNS). http://www.mhlw.go.jp/houdou/2009/11/dl/h1109-1b.pdf (in Japanese).

NOBUNKYOU (1998) Shokunou Kyouiku (Food and Agric. Education). 1, 152 (In Japanese).

Suzuki, Z., Asaoka, Y., Kikuchi, Y. and Nomura, T. (2007) Regeneration of education by Shokunou. NOBUNKYOU (in Japanese).

Web-syllabus of TUA (2010) http://sv1.all-campus.net/scl2/APM2P0201A.html?UPRM=tua (in Japanese).

Research article

Study on Evaluating the Hardness of the Sidewalk Pavement

MIE HIGUCHI
Graduate School of Agriculture, Tokyo University of Agriculture, Japan
Email: bamboo @nodai.ac.jp

YASUSHI TAKEUCHI
Faculty of RegionalEnvironmrnt Science, Tokyo University of Agriculture, Japan

HIROMU OKAZAWA
Faculty of RegionalEnvironmrnt Science, Tokyo University of Agriculture, Japan

KEN-ICHI SATO
Fukuoka University, Fukuoka, Japan

Received 15 December 2010 Accepted 27 January 2011

Abstract In Japan, some laws for the pavement, which took into consideration physically handicapped people and senior citizens, were established. In those relevant laws, it is recommended that safety and comfort for all users should be considered when the sidewalks are designed. But the evaluation method of safety and comfort is not established when the sidewalk pavement are constructed. Therefore, the objective of this study is to establish the simple evaluation method of the pavement's hardness that take into consideration safety and comfort of users, especially for handicapped people. Moreover, the SB/GB test and the Portable Falling Weight Deflectometer (PFWD) test were carried out in this study. In SB/GB test, 1 inch steel ball in diameter and a golf ball were used to measure *SB*/*GB coefficient*s that were calculated from the bounce height of each ball. The PFWD was used to measure *elastic moduli* of pavement. In the previous study, Takeuchi et al. pointed out that the range of an elastic modulus took into consideration safety and comfort of users that is 25-80MPa. However it is hard to obtain PFWD because of an expensive device. By contrast, SB/GB test can be conducted easily by using a golf ball and a steel ball, moreover, it is widely used in Japan. Hence, to simplify the hardness evaluation of sidewalk pavement, *SB*/*GB coefficient*s were compared with the *elastic modulus*. As the result, it was found that the range of *SB*/*GB coefficient*s corresponding to the range of 25-80 MPa in the *elastic modulus* were around 20-35% in *SB coefficient* and around 45-65% in *GB coefficient*. The range can be used to evaluate a road surface by cheap, easy and convenient equipment.

Keywords sidewalk pavement, universal design, hardness, *SB coefficient*, *GB coefficient*, *elastic modulus*

INTRODUCTION

Japan is seeing its population rapidly aging and the idea of barrier-free access has become widely accepted. It is also noted that paved roads in agricultural communities, which are primarily utilized by resident pedestrians, are a facility that is fundamental to the operation of a broad range of community activities as well as to the determination of location and active use of social and modernization infrastructure and service facilities in rural areas. The improvement of roads in agricultural communities allows a faster, smoother, and safer movement of goods and people, thereby expanding socio-economic activities in the community and contributing to higher income levels and a better living environment for residents.

In Japan, research efforts have been directed to produce pavement that is comfortable and easy to walk on. Nabeshima et al. (2005) employed the paved surface hardness test (JIS A 6519) in order

to identify a suitable hardness for resilient pedestrian pavement. And it was found that a comfort zone lies in the measured range of *impact acceleration* of roughly 80±10 G. Takeuchi et al. (2008) used this range to pursue structural engineering designs for pedestrian pavement with resilience performance based on the *elastic modulus* obtained in Portable FWD testing and the *impact acceleration* from hardness testing of paved surfaces. The *elastic modulus* corresponding to the *impact acceleration* within the hardness range that provides safe and comfortable for pedestrians, including the elderly and wheelchair users, was shown to be from 25 to 80 MPa (Fig.1). The tests used in the study (the Portable FWD test, which measures the elasticity as a parameter for the amount of physical strain caused by the pavement, and the hardness test of paved surfaces) are not easy to perform due to their high cost. For this reason the present study employed SB/GB testing, which is popular in Japan. This simple-to-perform test uses a steel ball and a golf ball. However, the sensitivity of this test is limited, and it can show only rough value ranges for different types of pavement (Fig.2).

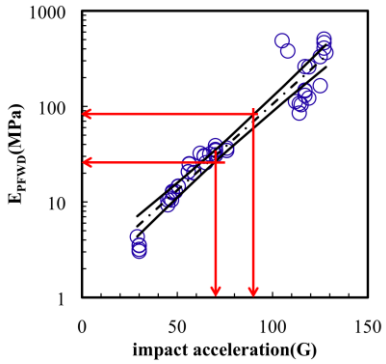


Fig. 1 Relationship between *impact acceleration* and *elastic modulus*

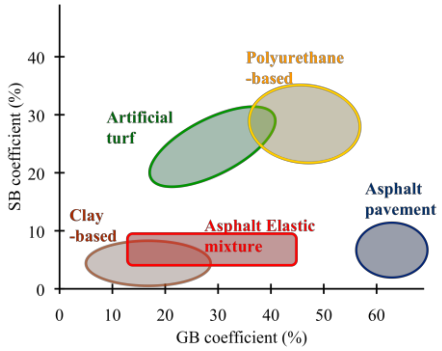


Fig. 2 Relationship between *SB* and *GB coefficient* of each pavement

In order to create a pedestrian environment that is safe and comfortable for senior citizens and the physically handicapped, there is a need to establish a simple testing protocol for pavement elasticity. This paper reports on our SB/GB testing of different paving materials for pedestrian traffic as well as Portable FWD testing for the purpose of developing a simple method to measure pavement resilience to evaluate the comfort level for pedestrians.

SAMPLE LOCATION

In this study, 57 types of pavement were randomly selected as samples. The sample locations are the Setagaya Campus of Tokyo University of Agriculture, the Nanakuma Campus of Fukuoka

University, Sakuragaoka Junior High School, Karasuyamagawa Ryokudo, Togasira Jutaku in Ibaragi, and pedestrian pavements in their surrounding areas, as well as specialty paving in a track field.

Table 1 Sample locations and pavement types

Type of pavement	Number of samples	Type of pavement	Number of samples
Resilient	27	Soil	2
Concrete slab	6	Synthetic resin mixed	2
Clay-based	5	Tile	2
ILB	3	Wood	2
Artificial turf	2	grass	1
Asphalt	2	Other	3

The types of pavement in those locations are shown in Table 1. For the discussion of test results, the measurement data produced by the Pedestrian Pavement Sub-Committee, Pavement Engineering Committee, Japan Society of Civil Engineers were also included.

TEST METHOD

SB/GB tests and Portable FWD tests were conducted for the purpose of measuring the resilience of the paved surface.

SB/GB test

A golf ball and a steel ball are dropped from a height of 100 cm (H) to the paved surface and their respective rebounding heights are measured. The free fall is repeated 5 times for each paving material, and the three most similar rebounds are used to calculate the mean value for rebounding heights (H_0). *SB* and *GB coefficients* are obtained using H_0 in Eq.1. It is believed that the *GB coefficient* reflects impact absorbance, while the *SB coefficient* represents rebound resilience. It is widely held that the smaller these factors are, the less bodily impact a pedestrian would receive. The tests were all performed in accordance with the instructions in the Handbook of Pavement Survey and Testing (Japan Road Association, 2007).

Fig.3 and Fig. 4 show the schematics of the SB/GB tester and how the test was done.

$$\textit{SB coefficient and GB coefficient}\ [\%] = \frac{H_0}{H} \times 100 \quad (1)$$

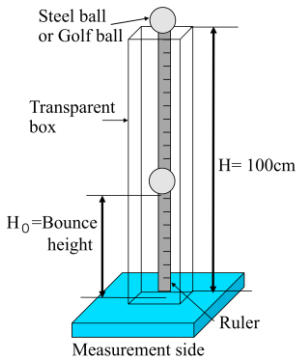


Fig. 3 SB/GB tester detail **Fig. 4 SB/GB testing *in situ***

Portable Falling Weight Deflectometer (PFWD) test

Portable FWD testing involves a load cell that is lifted up by hand and dropped to cause an impact on the paved surface; the impact load and deflection are to be measured. With the loading radius (r) at 0.05 m and the weight at 5 kg, the test was conducted by changing the dropping height to 5 levels from 10 to 50 cm. For each height, the cell was dropped 3 times or more until three similar peak deflection values were obtained. The *elastic modulus*, E_{PFWD} [MPa], was calculated using Eq.2 based on the maximum deflection, D[m], and the maximum load intensity, q [N/m^2], that was derived from the maximum load, P [N] divided by the loading area, A[m^2]. E_{PFWD} refers to the rate of stress-dependent change of displacement. In the case of pavements that incorporate rubber chips, measurements didn't stabilize before the load level reached 3000 N; their E_{PFWD} [MPa] were calculated from the measurements obtained with the maximum load at around 4000 N. E_{PFWD} [MPa], represents a value when the subsurface layers are deemed to be a single layer. In addition, the Poisson ratio, v, is assumed to be 0.4.

Fig.5 and Fig. 6 show the Portable FWD tester and actual testing.

$$E_{PFWD} = \frac{\pi(1-v^2)r \cdot q}{2 \cdot D} \times 10^{-6} = \frac{(1-v^2)P}{2 \cdot D \cdot r} \times 10^{-6} \quad (2)$$

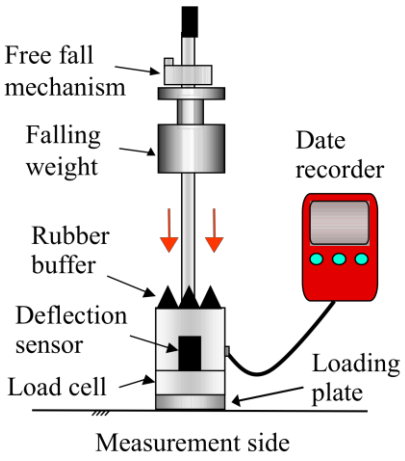


Fig. 5 PFWD tester detail

Fig. 6 PFWD testing *in situ*

RESULTS AND DISCUSSION

The test data were plotted to show the relationship between *SB* and *GB coefficients* (Fig. 7). Statistical analysis classified the data roughly into five groups. It was then decided to exclude the samples where the paved surface is not consolidated, such as artificial turf and soil-based paving, including those akin to clay-based paving and some tile pavements for which the data was rather isolated in the Figures. These samples had uneven top layer surfaces, and test results showed little stability and no correlation between the *SB* and *GB coefficients*. Data for the remaining pavement samples were used to calculate the relationships between *SB coefficient* and *elastic modulus* (Fig. 8), and *GB coefficient* and *elastic modulus* (Fig. 9). These Figures show that both *SB* and *GB coefficients* have a linear relationship with *elastic modulus* in single-logarithmic plotting. Although Takeuchi et al. (2008) did not find any correlations between *SB coefficient* and *elastic modulus*, this study involved more varied pavement samples, which likely produced the linear relationships of Figs. 8 and 9. The dotted line in each Figs. 8 and 9 represents an approximated curve, while the solid lines depict the upper and lower limits of the 99% confidence interval.

The upper limit, 80 MPa, and the lower limit, 25 MPa, of the elasticity range identified by Takeuchi et al. (2008) as appropriate for pedestrian comfort from their hardness testing were plotted on the horizontal axis and vertically extended in each chart to intersect the upper and lower limit lines of the confidence interval to obtain the values of *SB* and *GB coefficients* at the intersecting points. In Figs. 8 and 9 the horizontal arrowed solid lines show the range on the vertical axis that corresponds to the range of *elastic modulus* values and within the confidence interval. In SB and GB tests, results significantly vary depending on the surface condition of the paving material due to the small mass of the measuring apparatus (steel and golf balls). It is therefore assumed that the statistical distribution of data should be taken into account in assessing relationships between results of Portable FWD tests and SB/GB tests where load levels are not the same. Thus the ranges of *SB coefficient* and *GB coefficient* to fit the comfort range of *elastic modulus* were obtained at the confidence interval based on confidence levels of 90%, 95%, and 99%. The measurements obtained in this study are considered to indicate that SB/GB testing of pavements having resilience within the suitable range will produce measurements that fall within the range described in Fig. 8, which has 20% to 35% in *SB coefficient* and 45% to 65% in *GB coefficient* and overlaps partially with the range of polyurethane-based paving.

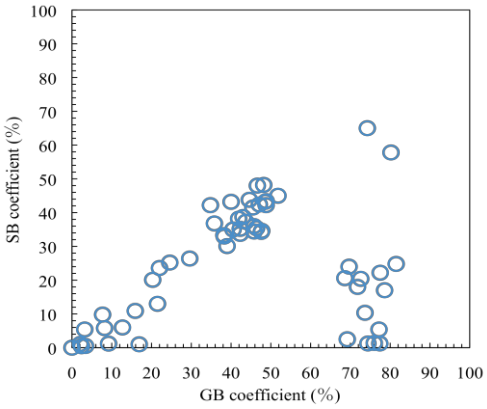


Fig. 7 Relationship between *SB* and *GB coefficients*

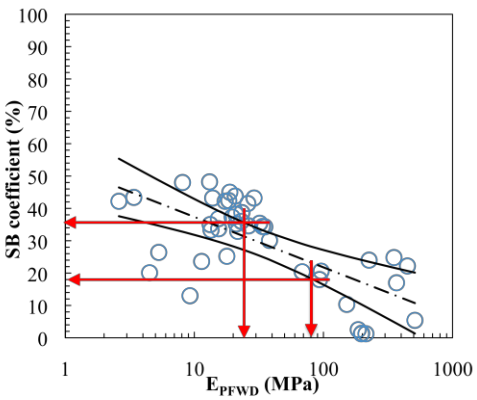


Fig. 8 Relationship between *elastic modulus* and *SB coefficient*

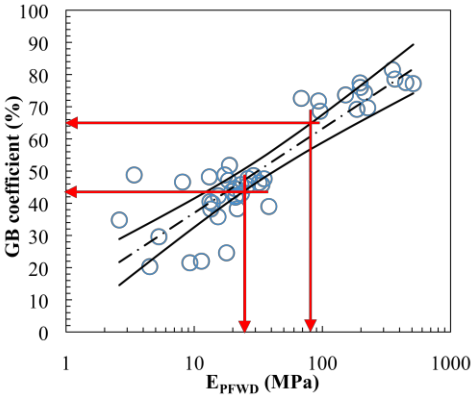


Fig. 9 Relationship between *elastic modulus* and *GB coefficient*

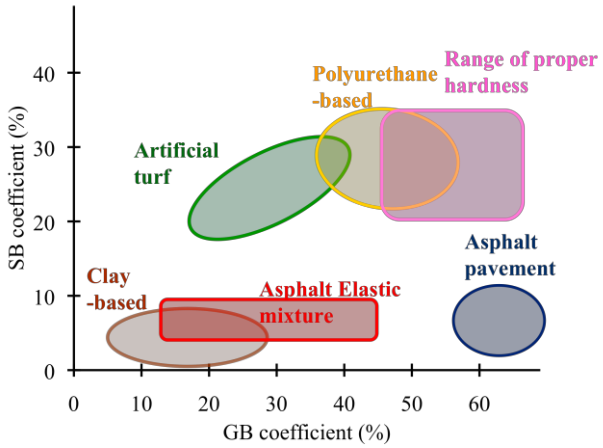


Fig. 10 Indexes commonly used and range of proper hardness

CONCLUSION

The test results suggest the following:

(1) Pavement resilience can be evaluated using only SB/GB tests because *SB coefficient* and *GB coefficient* show correlations with *elastic modulus*.

(2) The appropriate range of elasticity indicated by SB/GB tests is 20% to 35% in *SB coefficient* and 45% to 65% in *GB coefficient*.

These values are, however, applicable only to those pavements containing resin and the like, since the data exclude clay-based materials. We intend to collect more data in order to investigate the reliability of the SB/GB data further. We also plan to study the properties of clay-based pavements in order to revisit the definition of the appropriate hardness range.

ACKNOWLEDGEMENTS

We would like to express our gratitude to members of the Pedestrian Pavement Sub-Committee, Committee on Pavement Engineering, Japan Society of Civil Engineering. The authors are also grateful for the field assistance provided by students of the laboratory of Hydro-structure Engineering, Tokyo University of Agriculture and of the Road & Geotechnical Laboratory of Fukuoka University.

This research was supported by Grant-in Aid for challenging Exploratory Research (20658056) and Grant-in Aid for Scientific Research (B) (22360175) from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

REFERENCES

Japan Road Association (2000) Pavement performance rating system in separate volume, Rating system of the performance index to determine as needed, 218-222 (in Japanese).

Japan Road Association (2007) The handbook of pavement survey and testing, the first volume, 126-129 (in Japanese).

Nabeshima, M. and Yamada, M. (2005) Range of proper hardness for aged about walkway pavement, Official journals quarterly of the Japan Society of Civil Engineers, 788-67, 117-126.

Tanaka, K. and Uchida, K. (1989) Evaluation of comfortability and safety on pedestrian road pavement, Annual report of Inst. Civil Engineering of Tokyo Metropolitan Government, 15-26.

Takeuchi, Y., Sato, K., Aoki, M. and Yaginuma, H. (2008) Hardness evaluation of the sidewalk pavement using Portable FWD tester, the proceeding of the 64th JSCE Annual Meeting of the Japan Society of Civil Engineers, (CD-ROMS).

Research article

Sustainable Development in Indonesian Environmental Law; Lessons from Germany's Sustainable Forest Management Practices

SRI WAHYUNI
Islamic University of Riau, Riau, Indonesia
Email: sri_wahyuni6969@ymail.com

Received 16 December 2010 Accepted 15 January 2011

Abstract The work examines the impacts of rampant illegal logging practiced in Riau Province, which has placed the province ahead of other Indonesian provinces as having the highest rate of illegal timber exports. In addition to the problem of illegal logging, the Riau Province is also saddled with forest fires raging in Sumatra. These have been responsible for extensive environmental disaster experienced in this part of Indonesia – such as the destruction of biodiversity and their habitat and the release of atmospheric polluting gases. The illegal logging activities and the forest fires expose the affected region to soil erosion following heavy downpours experienced in the region. In Asia, for example, there are fundamental differences between the fire-related problems in India, China, Korea, Mongolia and Siberia on the one hand, and South-East Asia on the other. Indonesia, Malaysia, Myanmar, Laos, Cambodia, Vietnam and Papua New Guinea are experiencing ever greater problems with uncontrolled forest fire outbreaks. Key connected factors causing fires in land and forest use: First: The opening up and exploitation of forests to serve the wood industry is an important factor in that potentially. Second: The arrival of the wood industry is followed by new settlers who use fire to clear the land for cultivation; however, these settlers often lack a traditional relationship with the forests and thus have no interest in preserving it. Third: Apart from this exploitation of the forests, another important factor is the large-scale transformation from natural forest to woods for industry and oil palm plantations. This is highly profitable and was until recently even subsidized by the state. The instrument of choice for doing this, although officially forbidden, is fire.

Keywords sustainable development, environemntal law, illegal logging, fire forest

INTRODUCTION

Indonesia's current forest transformation programmed is unrealistic without clearing by fire. This leads to conflicts with the local population over land uses, which in turn are fought out with fire. Both large and small-scale land speculation and the use of fire for other purposes in the forest (e.g. illegal felling and hunting), together with carelessness and a lack of awareness of the problems complete the complex picture of a network of causes in each case.

The work examines the impacts of rampant illegal logging practiced in Riau Province, which has placed the province ahead of other Indonesian provinces as having the highest rate of illegal timber exports. In addition to the problem of illegal logging, the Riau Province is also saddled with forest fires raging in Sumatra. These have been responsible for extensive environmental disaster experienced in this part of Indonesia – such as the destruction of biodiversity and their habitat and the release of atmospheric polluting gases. The illegal logging activities and the forest fires expose the affected region to soil erosion following heavy downpours experienced in the region (Wahyuni, 2006).

All of these problems above happen in Indonesia as one of the developing countries, and Riau Province is one of from the 33 Provinces in Indonesia, that have a wide resources but it have the big problems to manage their environmental resources. For example, every year, Riau Province

meets the flood and the fire of forest. That's why, the people and the government of Riau Province ask about the sustainable development to solve the problem above.

The genesis of the concept of sustainable development is commonly reported to the 1987 Brundtland Report, which contains the well-known definition of "sustainable development" as: development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Report, 1987).

In an era of increasing economic globalization, the traditional environmental and social challenges seem to have gained a new dimension which must be taken into account. However, pursuant to the Johannesburg Declaration, "the rapid integration of markets, mobility of capital and significant increase in investment flows around the world has opened new challenges and opportunities for the pursuant of sustainable development (Massimiliano Montini, 2008)."

The basic and traditional definition of the principle of sustainable development was partially reviewed and updated at the Johannesburg Conference. In fact, the Johannesburg Political Declaration underlines that the principle of sustainable development is based on three: interdependent and mutually reinforcing pillars, namely 'economic development, social development and environmental protection', which must be collectively promoted and advanced at local, national, regional and global levels.

The Federal Republic of Germany is located in Central Europe, bordering Poland and the Czech Republic to the east, Switzerland and Austria to the south, the Netherlands, Belgium, Luxembourg and France to the west, Denmark, the North Sea and the Baltic Sea to the north. With its high population density and it's environmentally detrimental heavy industry.

With its high population density and its environmentally detrimental heavy industry, Germany is a country with a long tradition in air and water pollution control. Driven by a strong environmental movement, the country was among the international front-runners in a number of areas such as regulating emissions from large combustion plants (e.g. coal power stations) or introducing car emission standards, later on also in the fields of climate protection and waste management. At the beginning of the 1970s, Germany was already an early pioneer in strategic environmental planning. At that time, a number of innovative institutional arrangements and mechanisms for setting long-term environmental objectives as well as concrete action goals (1971 Environmental Program) and for integrating environmental considerations into the decision making of other sectors (notably a "Green Cabinet") were introduced. However, in spite of these early achievements and an altogether relatively successful environmental policy at present Germany seems to lag behind more pro-active European governments in its efforts to implement the more recent concept of sustainable development. The fact that Germany will be one of the last OECD countries to introduce a national strategy for sustainable development illustrates this point. Similarly, at the international level, Germany has been active in promoting concrete environmental initiatives, for example in the field of climate policy, rather than with regard to general issues of sustainable development (Jänicke & Jörgens (eds.) 2000).

In terms of sustainable development, Germany's high degree of industrialization and its central location in Europe are factors generating high traffic volumes, which have increased considerably due to the German reunification, the economic opening of Eastern Europe and the creation of an internal European market.

METHODOLOGY

This workpaper is the first of its kind to address the similarities and differences in the role of the concept of sustainable development and its central role in environmental regulation in the framework of forest fire management policies of Germany and Indonesia. It will help fill in the information gap of how Germany's experience can be adapted to developing country contexts. By doing this, it will contribute to improve developing countries' capacity to deal with the global issue of forest fires and forestry management. In addition, it concerned a correspondence with the people who live in the region that forest fire happened. These information and documents were very valuable things. Methodically this study was so put on the fact that the qualitative and quantitative

Information, which from official side over forest fire, with which particularly by interviews. In particular still the many thematic analyses could be mentioned, on the regional, national and local levels are accomplished and by Correspondent completed. The moreover one a number of institutions became visits in the context of this study, in which discussions and discussions with specialists took place.

RESULTS AND DISCUSSION

In the developing countries, most of the environmental problems are caused by under-development. Millions continue to live far below the minimum levels required for a decent human existence, deprived of adequate food and clothing, shelter and education, health and sanitation. Therefore, the developing countries must direct their efforts to development, bearing in mind their priorities and the need to safeguard and improve the environment. For the same purpose, the industrialized countries should make efforts to reduce the gap themselves and the developing countries. In the industrialized countries, environmental problems are generally related to industrialization and technological development.

The natural growth of population continuously presents problems for the preservation of the environment, and adequate policies and measures should be adopted, as appropriate, to face these problems. Of all things in the world, people are the most precious. It is the people that propel social progress, create social wealth, develop science and technology and, through their hard work, continuously transform the human environment. Along with social progress and the advance of production, science and technology, the capability of man to improve the environment increases with each passing day.

The United Nations Conference on the Human Environment, having met at Stockholm from 5 to 16 June 1972, having considered the need for a common outlook and for common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment.

In Germany, the rise of the concept of sustainable development challenges traditional policy making in a number of ways. Access to information and public participation are essential building blocks for sustainable development, preparing citizens to become informed decision makers, offering a basis for stimulating creative solutions to environmental, social and developmental problems, and providing a foundation for building consensus on critical priorities. Transparency and public participation are the basis for elaborating and working towards more sustainable. Transparency and public participation form the basis for an informed discussion as to how to address challenges relating to the intersection between economic developments on the one hand and social aspects and environmental protection on the other.

Both aspects of man's environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights the right to life itself. The protection and improvement of the human environment is a major issue which affects the well-being of peoples and economic development throughout the world; it is the urgent desire of the peoples of the whole world and the duty of all Governments.

Governments and institutions governed by transparency, openness, accountability and community participation are more capable of reconciling the needs of present and future generations, of balancing private and public interests, and harmonizing economic development with social and environmental needs. Thus, improved access to information and participation in decision-making will more likely lead to overall sustainable development.

Not only have access to information and participation been recognized as essential to achieving the goal of sustainable development, they have increasingly been recognized as human rights. All of these developments relate to a more general trend towards promoting “good governance”. All attempts to define the notion of good governance include the elements of transparency, participation, and accountability.

Changes in the political decision-making process and the institutional framework required by this concept relate to three main issues: the coherent integration of policies in the environmental,

social and economic spheres; the wide-ranging participation of civil society in decision making; and a long-term view of problems and resulting strategies.

Numerous international documents have affirmed the importance of transparency and public participation, and the need to institutionalize these elements in the move towards sustainable development. Much of the progress towards increased transparency and public participation so far has been mad at the domestic levels. However, in an increasingly inter-connected world, some decision-making is shifting from the national to the international level, and to institutions and processes that largely remain secretive and inaccessible to the public.

Environmental policy in general has also at a relatively early stage been connected to social and economic aspects such as employment, technology and competitiveness. Here, a link can be found between German environmental policy and the broader international debate on sustainable development. This could be the entry point to a broader definition of sustainable development. An important driving force of environmental policy integration can be seen in the Social Democrat/"Green" government coalition with its programm of ecological modernization, which is an innovation-oriented concept aimed at integrating environmental considerations into a wide range of different policies.

Important steps have been taken in the development and operationally of environmental indicators. Since 1989, the Federal Statistical Office has been developing an Environmental Economic Account, which integrates into the economic data environmental burdens such as emissions, utilization of materials and energy and pressures on soils. In 1990, the Federal Ministry for the Environment appointed a scientific advisory council to work on refining the Environmental Economic Account. In its 1998 draft program "Sustainable Development in Germany", the Ministry for the Environment proposed the introduction of an Environmental Barometer. Its aim is to create an environmental equivalent to the already-existing aggregate indicators in the economic and social sphere, such as gross national product, unemployment rate or rate of inflation. The environmental indicators included in the Environmental Barometer are intended to cover the most important issues of environmental protection and align them with key environmental medium- and long-term targets. Six indicators have been formulated for the fields of climate, air, soil, water, and use of energy and raw materials. Environmental developments can be described and the success or failure of environmental policy can be measured by means of a small set of widely known and easy-to-understand indicators.

Germany has a complex network of organized interest groups in the environment sector. Between 5 and 7 per cent of the population are organized in environmental NGOs. The number of environmental groups is estimated at a total of 400. Environmental organizations have been a strong driving force, both for environmental policy integration and a German strategy for sustainable development. The BUND, the German section of Friends of the Earth (230,000 members), together with the umbrella organization The German Nature Conservation Council (5.2 million members) supported the idea of a German Environmental Policy Plan in the 1998 election campaign.

In Germany, early Local Agenda 21 processes originated by and large from non-governmental players such as environmental and development organizations, church and youth groups, and to a lesser degree from local politics. Rather seldom were they initiated by business associations.

Among the main measures outlined in the coalition agreement are the elaborations of a national sustainable development strategy, as well as institutional innovations to promote and organize the drafting of this strategy. In July 2000, the National Council for Sustainable Development was created by Cabinet decision. It is designed as an independent and pluralistic advisory body on sustainability issues and will be composed of 17 individual members representing all major societal groups and actors (e.g. industry, trade unions, NGOs, science) which – after some delay –were appointed in February 2001. Among its tasks are the promotion of societal debate on sustainable development at the national and international levels (stakeholder dialogue) and the development of concrete projects for implementing a national sustainability strategy. The federal government may assign further tasks to the Council and ask for statements on specific issues.

CONCLUSION

The following lessons can be drawn from the German case study on governance for sustainable development:

1. Communicate the results to the general public as well as to relevant interest organizations to raise the necessary awareness.
2. The sustainable development strategy should be an extension and step-by-step enlargement of the environmental strategy, rather than replacing it, towards a broader understanding of sustainable development.
3. As shown above, the key elements of this climate-protection strategy are: high-level political commitment for the formulation and implementation of ambitious goals; integration of environmental policy objectives into other sectors; voluntary agreements; pioneer activities of local communities; and broad public participation.
4. Non-environmental policy sectors should be mandated to develop their own sectoral strategies. The leading role of Cabinet – or the "Green Cabinet" – should be clear and accepted by all ministries. This should include a critical evaluation of both the formulation of sectoral strategies and their implementation. The Federal Environment Agency and the Ministry for the Environment should play an important, mainly supportive; role in this process (so far these institutions have been rather cautious and have adopted a policy of "wait-and-see").
5. At the local level, general orientation for Agenda 21 processes, for example in the form of a competitive investment program for local sustainable development initiatives (as practiced in Sweden), should be provided.

REFERENCES

Brundtland Report (1987) Report of the world commission for environment and development, our common future. OUP, Oxford, 1-10, UK.

Weiss, B. (1999) Our rights and obligations to future generations for the environment. 84 AJIL 1990, 200-220.

Jänicke, M. & Helge, J. (2000) Umweltplanung im internationalen Vergleich Strategien. 55-60.

Massimiliano, M. (2008) Sustainable development within the climate change regime. in sustainable development in international and national law, edited by Hans Christian Bugge & Christiana Voigt. Europa Law Publishing, Netherlands, 20-30.

Sands P. (2003) Principles of international environmental law. Cambridge University Press, 120-130.

Wahyuni, S. (2006), Dissertation, Rechtsprobleme der Tropenwaldbewirtschaftung in Indonesien, Bundesverlag, 55, Germany.

Research article

Changes in Surviving *E.coli*, Coliform Bacteria and General Bacteria in Manure with Air Drying Treatment

YUTA ISHIKAWA
Graduate School of Agriculture, Tokyo University of Agriculture, Japan
Email: y.ishika@cronos.ocn.ne.jp

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

Received 16 December 2010 Accepted 20 January 2011

Abstract Approximately 87 million tons of dung is being produced annually from cattle farms all over Japan. Considering the proper treatment of this waste product, applying manure to farmlands has been focused from a viewpoint of popularizing organic agriculture. However, pathogenic bacteria known as *E.coli* may be released from the immature fermented manure that was applied in farmlands. So, the treatment for decreasing *E.coli* should be considered. Although air drying is known as an effective treatment for decreasing *E.coli*, it might affect beneficial bacteria as well as pathogenic bacteria. So, this study dealt with the observation of the change in several microorganisms such as *E.coli*, coliform bacteria and general bacteria under air drying treatment. In the experiment, 3 types of cow manure such as fresh, 2 weeks fermented and 12 weeks fermented were employed. Air drying treatment was carried out to observe the survival of *E.coli*, coliform bacteria and general bacteria during 28 days. The experimental results showed that the number of *E.coli* and coliform bacteria decreased with passing day of air drying process. Also, the number of general bacteria decreased with time of air drying process. However, it was considered that the decrease in general bacteria possibly affects the decomposing process of manure. Therefore, it was concluded that air drying treatment for fresh cow dung is not a proper way but is applicable to the manure fermented for 2 weeks or 12 weeks.

Keywords cow dung, air drying, *E.coli*, coliform bacteria, general bacteria

INTRODUCTION

In Japan, about 87 million tons of dung has been produced annually from cattle farms. From a viewpoint of promoting organic agriculture, a proper treatment of this product has been recently focused. However, in a bulk production of manure, the unintended inclusion of immature fermented manure is possibly happened. Thus, there might be pathogenic bacteria known as *E.coli* surviving and remaining in the produced manure (Chun-Ming et al., 2005). Once, these manures were broadcasted into farmlands, the release of *E.coli* may occur through surface runoff resulting in a broad contamination of the surrounding environment, particularly in the watersheds (Mishra et al., 2007).

Accordingly, treatment for decreasing *E.coli* should be considered. Many kinds of treatment as the supply of lime nitrogen and hot air were executed (Minato et al., 2001). Especially, air drying is known as effective and simple treatment for decreasing *E.coli* (Saito and Mihara, 2010). However, air drying treatment might affect beneficial bacteria as well as pathogenic bacteria.

So, the objective of this study is to observe the differences of survival rate of several microorganisms such as *E.coli*, coliform bacteria and general bacteria under air drying treatment.

METHODOLOGY

The materials used in the experiment were collected from Fuji Farm of Tokyo University of Agriculture. As shown in Figure 1, there were three types of materials collected; the fresh cow dung, the 2 weeks and 12 weeks fermented manure having water content at 82%, 76% and 74%, respectively. In addition, organic matters constituted 88% in the fresh cow dung, 87% in the 2 weeks fermented manure and 85% in the 12 weeks fermented manure. The colony-forming unit (cfu) of *E.coli* was 9×10^4 cfu/g for the fresh cow dung. However, *E.coli* was not observed in the manure fermented for 2 weeks or 12 weeks. The colonies of coliform bacteria were 36×10^6 cfu/g for the fresh cow dung, 6×10^4 cfu/g for the 2 weeks fermented manure and 32×10^4 cfu/g for the 12 weeks fermented manure. The colonies of general bacteria were 68×10^7 cfu/g for the fresh cow dung, 43×10^6 cfu/g for the 2 weeks fermented manure and 3×10^6 cfu/g for the 12 weeks fermented manure.

Fig.1 Cow dung and manure

Table 1 Properties of cow dung and manure

	Period fermented	*E.coli* (cfu/g)	Coliform bacteria (cfu/g)	General bacteria (cfu/g)	Water content (%)	Organic matter (%)
Cow dung	0 days	9×10^4	36×10^6	68×10^7	82	88
Manure fermented for 2 weeks	2 weeks	0	6×10^4	43×10^6	76	87
Manure fermented for 12 weeks	12 weeks	0	32×10^4	3×10^6	74	85

Air drying experiment was conducted for 28 days. At 4th, 7th, 11th, 18th and 28th day, sampling and mixing of manure was carried out (Fig. 2).

The colonies of *E.coli*, coliform bacteria and general bacteria were evaluated through the laboratory experiments. The analysis of *E.coli* and coliform bacteria was carried out with XM-G agar medium as shown in Fig. 3. The analysis of general bacteria was carried out with general agar medium (Fig.4).

Fig.2 Air drying process in experiment

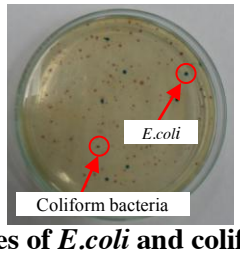


Fig. 3 Colonies of *E.coli* and coliform bacteria

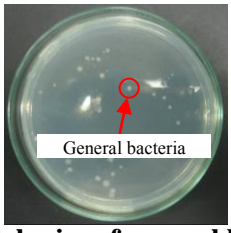


Fig. 4 Colonies of general bacteria

RESULTS AND DISCUSSION

Figs. 5-7 show the changes in the number of *E.coli* and water content in each sample. In cow dung, water content decreased with passing day, and further decreasing water content was not observed after 7 days passed. In addition, it was observed that the number of *E.coli* also decreased with passing day of air drying process. Based on the results of variance analysis, there was a significant difference between the number of *E.coli* of 0 day and that after 4 days passed. However, *E.coli* could not be sterilized perfectly. In 2 weeks or 12 weeks fermented manure, water content decreased with passing day, and there was no change in water content after 7 days passed as well as that of cow dung. In addition, *E.coli* was not detected from 2 weeks or 12 weeks fermented manure.

Figs. 8-10 show the changes in the number of coliform bacteria and water content in each sample. In cow dung, there was a tendency for the number of coliform bacteria to decrease with passing day of air drying process. And then, the number of coliform bacteria became stable at around 15×10^3 cfu/g. In 2 weeks or 12 weeks fermented manure, the number of coliform bacteria decreased with passing day of air drying process. Moreover, the number of coliform bacteria was not observed after 7 days passed.

Based on the results of variance analysis, there was a significant difference between the number of coliform bacteria of 0 day and that after 4 days passed. In 12 weeks fermented manure, the number of coliform bacteria also decreased with passing day of air drying process. Also, there was a tendency for the number of coliform bacteria to be stable after 11 days passed. Based on the results of variance analysis, a significant difference was observed between the number of coliform bacteria of 0 day and that after 4 days passed. Therefore, it was considered that air drying treatment is an effective way for decreasing pathogenic bacteria as *E.coli* or coliform bacteria.

Figs. 11-13 show the changes in the number of general bacteria and water content in each sample. In cow dung, there was a tendency that the number of general bacteria decreased with passing day of air drying process. Based on the result of variance analysis, there was a significant difference between the number of general bacteria before 7 days passed and that after 11 days passed. In 2 or 12 weeks fermented manure, the number of general bacteria decreased with passing day of air drying process as well. In addition, a significant difference was observed between the number of general bacteria of 0 day and that after 4 days or 11 days passed for 2 or 12 weeks fermented manure, respectively. Accordingly, it was considered that air drying process may diminish the number of general bacteria, which includes beneficial bacteria for decomposing cow dung.

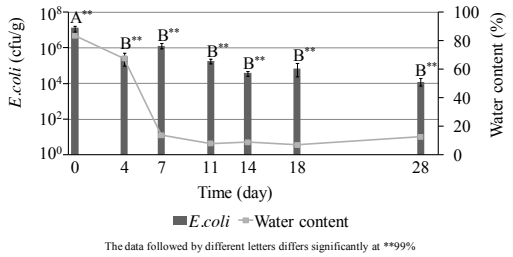


Fig. 5 Changes in *E.coli* and water content in cow dung

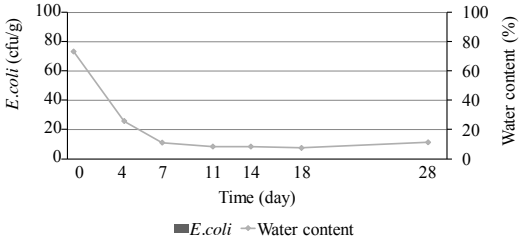


Fig. 6 Changes in *E.coli* and water content in 2 weeks fermented manure

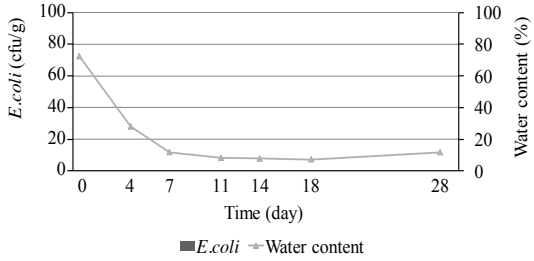


Fig. 7 Changes in *E.coli* and water content in 12 weeks fermented manure

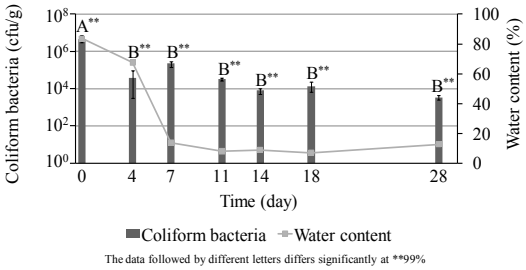


Fig. 8 Changes in coliform bacteria and water content in cow dung

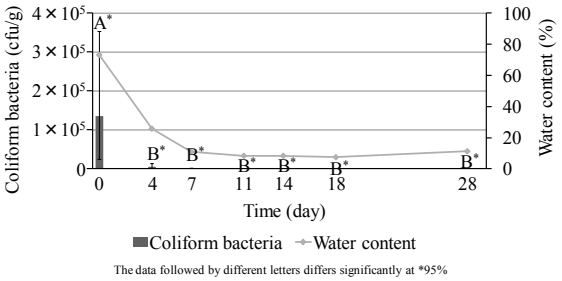


Fig. 9 Changes in coliform bacteria and water content in 2 weeks fermented manure

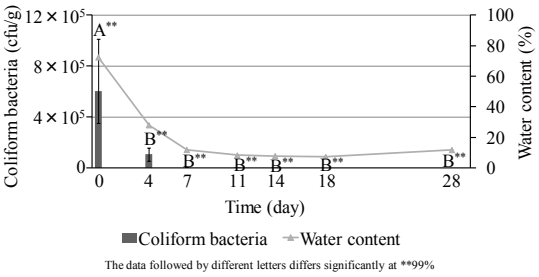


Fig. 10 Changes in coliform bacteria and water content in 12 weeks fermented manure

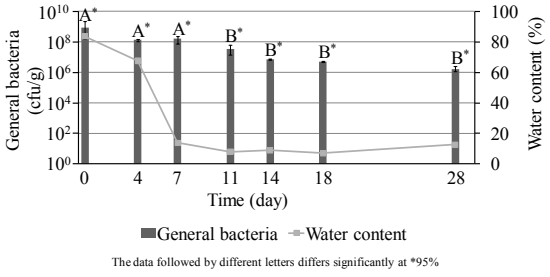


Fig. 11 Changes in general bacteria and water content in cow dung

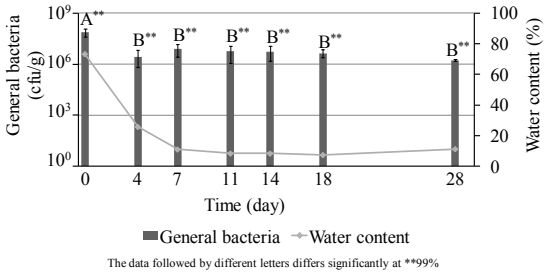


Fig. 12 Changes in general bacteria and water content in 2 weeks fermented manure

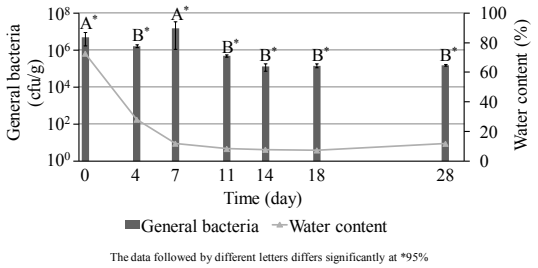


Fig. 13 Changes in general bacteria and water content in 12 weeks fermented manure

CONCLUSION

This study aimed to observe the difference in survival rate of *E.coli*, coliform bacteria and general bacteria under air drying treatment through air drying experiment for cow dung, 2 weeks and 12 weeks fermented manure.

Based on the experimental results, there was a tendency for the number of *E.coli* and coliform bacteria to decrease with passing day of air drying process. In addition, there was a significant difference between 0 day and after 4 days passed. It was considered that air drying treatment is effective way for decrease of pathogenic bacteria as *E.coli* or coliform bacteria.

However, the number of general bacteria also decreased with passing day of air drying process. It was considered that air drying process may diminish the number of general bacteria, which includes beneficial bacteria for decomposing cow dung.

Therefore, it was concluded that air drying treatment for cow dung is not proper treatment, but it is applicable to manure fermented for 2 weeks or 12 weeks from viewpoint of decreasing pathogenic bacteria as *E.coli* and coliform bacteria and of decomposing manure sufficiently. For manure fermented for 2 weeks or 12 weeks, it was proposed that air drying treatment for 10 days may be enough to decrease the number of *E.coli* and coliform bacteria extremely and to sustain certain population of general bacteria.

REFERENCES

Mishra, A., Benham, L. B. and Mostaghimi, S. (2007) Bacterial transport from agricultural lands fertilized with animal manure. Water Air Soil Pollut, 189-4, 127-134.

Gong, C., Koshida, J., Moriyama, N., Xiaodan Wang, Udou, T., Inoue, K., and Someya, T. (2005) Occurrence and survival of coliform bacteria, *Escherichia coli* and salmonella in various manure and compost. Journal of the Science of Soil and Manure, 76-6, 865-874.

Yagura, H., Tada, N., and Yasutomi, M. (2006) Nitrogen, phosphorus and coliform contamination of outflow in cattle grazing land. Research Bulletin of the Kyoto Prefectural Livestock Technological Research Center, 3, 71-73.

Minato, K., Tamura, T. and Maeta, Y. (2001) Effect of adding nitoroilime to composting of cattle manure and the impact on *Esherichia coli*. Bulletin of the Hokkaido Animal Research Center, 24, 11-16.

Minato, K., Tamura, T. and Maeta, Y. (2001) The effect of sterilized for *Eschrichia coli* in cattle manure by nitrolime adding. Bulletin of the Hokkaido Animal Research Center, 24, 21-24.

Saito, Y, and Mihara, M. (2010) Management of manure taking into account of *E.coli* loss from farmland. IJERD-International Journal of Environmental and Rural Development, 1-1, 175-180.

Research article

Growth and Yield of Organic Rice as Affected by Rice Straw and Organic Fertilizer

ANAN POLTHANEE
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
E-mail:panan@kku.ac.th

ARUNEE PROMKHAMBUT
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

SOMPOTH KAEWRAHAN
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

Received 16 December 2010 Accepted 25 January 2011

Abstract The objectives of this research were to investigate the effect of rice straw management and the application of different types of organic fertilizer on the growth and yield of transplanted rice grown under rainfed conditions. The experiment was conducted in a farmer's field in Khon Kaen province in 2009. A Randomized Complete Block Design was used with four replications. The treatments consisted of (1) rice straw incorporation into the soil, (2) rice straw combined with cattle manure, (3) rice straw combined with bio-extracted fertilizer and (4) rice straw combined with cattle manure and bio-extracted fertilizer. In the present experiment, the rice straw remaining in the paddy field was incorporated into soil after the rice harvest in April. Then the rice was transplanted in August. The amount of rice straw and cattle manure incorporated into the soil were about 5.1 and 9.4 tons/ha respectively, which provided N 129 kg/ha, P 41 kg/ha and K 382 kg/ha. A liquid bio-extracted fertilizer was applied into the soil during the incorporation of rice straw at a rate of 30 liters per hectare which provided N 28 g/ha, P 5 g/ha and K 135 g/ha and foliar application at 60 days after rice transplanting which provided N 1.11 g/ha, P 0.18 g/ha and K 5.4 g/ha. It was found that the application of different types of organic fertilizer combined with rice straw had a significant effect on plant height, but did not show any significant effect on leaf area and aboveground dry weight at 30 days after transplanting and at panicle initiation growth stage. At harvest, total aboveground dry weight and panicle number were significantly affected by the application of different types of organic fertilizer. The treatment of rice straw combined with cattle manure and bio-extract fertilizer gave the maximum panicle number. The treatment of rice straw combined with cattle manure gave maximum grain yield, but did not show any significant difference from the treatment of rice straw combined with cattle manure and bio-extracted fertilizer.

Keywords organic rice, organic fertilizer, cattle manure, bio-extracted fertilizer

INTRODUCTION

Northeast Thailand has 5.27 million hectares of rainfed lowland rice growing area, which is about 57% of the rice growing area in the whole country (Office of Agricultural Economic [OAE], 2006). The average grain yield in this region is low (2.07 t ha^{-1}) (OAE, 2009), due to unstable water availability (Bell and Seng, 2004). With the current renewed focus on sustainable agricultural efficient resources (rice straw) recycling may be an alternative method of soil fertility management for Northeastern lowland rice producers. Straw management by incorporation into the soils is an alternative method to avoid straw burning before land preparation. Cattle manure is commonly an organic fertilizer available in the farms of the smallholder farmers. The bio-extracted fertilizers are also can be produced by farmers themselves using organic material wastes available in the farm.

Present studies were, therefore, undertaken to evaluate the effect of rice straw alone and in combination with various organic sources of nutrients on the growth and yield of organic rice.

METHODOLOGY

The experiment was conducted in a farmer's field in Muang Yai village, Khon Kaen province in 2009. The soil physio-chemical characteristics before planting are shown in Table 1. Randomized Completed Block Design with four replications was used. The treatments consisted of (1) rice straw incorporation into the soil, (2) rice straw combined with cattle manure, (3) rice straw combined with bio-extracted fertilizer and (4) rice straw combined with cattle manure and bio-extracted fertilizer. Rice straw was incorporated after the rice harvest. The amount of nutrients returned to the soil by incorporating rice straw into the soil was calculated as in Eq. (1).

$$\frac{\text{Rice straw dry weight (kg ha}^{-1}\text{) x nutrient content (\%)}}{100} \quad (1)$$

The amount of nutrients in the cattle manure applied to the soil before transplanting two weeks at the rate of 9,375 kg ha^{-1} was calculated as in Eq. 2.

$$\frac{\text{Rate of application (kg ha}^{-1}\text{) x nutrient content (\%)}}{100} \quad (2)$$

The amount of nutrients in the bio-extracted fertilizer applied to the soil was calculated as in Eq. 3.

$$\frac{\text{Rate of application (kg ha}^{-1}\text{) x nutrient content (\%)}}{100} \quad (3)$$

The bio-extracted fertilizer (vegetable wastes and molasses; by-product of the processing of sugar cane into sugar, fermented for 7 days) applied into the soil at the rate of 3,125 liter ha^{-1} two weeks before transplanting, and foliar application at rate of 1,250 ml ha^{-1} at 60 days after transplanting.

Two to three seedlings per hill were transplanted in the first week of July in the pattern of 25 x 25 cm hills. Rice cv. KDML 105 was used in this study. Hand weeding was done one at 60 days after transplanting. No insecticide and fungicide were used in this experiment.

Five hills from each plot were measured to classify their height at 30 days after transplanting (DAT) and at panicle initiation (PI) growth stage. Five hills from each plot outside the harvesting area were randomly selected to determine leaf area at 30 DAT and PI. The leaf area was measured using leaf area meter. Again, five hills from each plot outside the harvesting area were randomly selected and oven dried at 80 ^{0}Celsius for 4 days to determine total aboveground dry weight at 30 DAT and PI. The numbers of panicles per hill in the harvesting areas were measured at harvest time. For the same samples, ten panicles from each plot were randomly selected to determine the number of filled and unfilled grains and calculated the percentage of filled grain per panicle. The grain yield was taken from the 2 x 3 m harvesting area of each plot and calculated as kg ha^{-1} at 14% moisture content. The filled grains were randomly selected from the grain yield sample to determine the weight of 1,000 grains. The data were analyzed using analysis of variance procedures and LSD was used to compare treatment methods when the F-test was significant.

Rainfall, maximum and minimum temperature were recorded at the Khon Kaen Meteorological Station 5 kilometers from the site. Weekly rainfall, as well as the maximum and minimum temperature during the growing season is shown in Fig. 1.

Table 1 Soil physio-chemical characteristics before planting of the experimental field

Soil characteristics	Values
Physical properties[1]	
-Sand (%)	83.09
-Silt (%)	7.60
-Clay (%)	9.25
Texture class	Loamy sand
Chemical properties	
-pH[2]	5.24
-EC (ms/cm at 25 ºC)[3]	0.070
-Organic Matter (%)[4]	0.352
-Total N (%)[5]	0.0213
-Available P (ppm) [6]	9.20
-Exchangeable K (ppm) [7]	54.65
-Exchangeable Ca (ppm) [7]	485.00

[1]Texture: Hydrometer method, [2]pH: pH meter (1:1 H_2O), [3] EC (1:5 H_2O),[4]O.M.: Walkley and Black method, [5]Total N: Kjeldahl method, [6]Extractable P: Bray II and Molybdenum-blue method, [7]Exchangeble K and Ca: 1N NH4OAc pH7 and Flame photometry method.

RESULTS

Plant height

The plant height is not a yield component in grain crops but it indicates the influence of various nutrients on plant metabolism. It was found that incorporation of rice straw into the soil combined with application of cattle manure gave the maximum plant height at 30 DAT and PI stage. The plant height, however, did not show any significant difference from the incorporation of rice straw into the soil combined with the application of cattle manure and bio-extracted fertilizer treatment (Table 2).

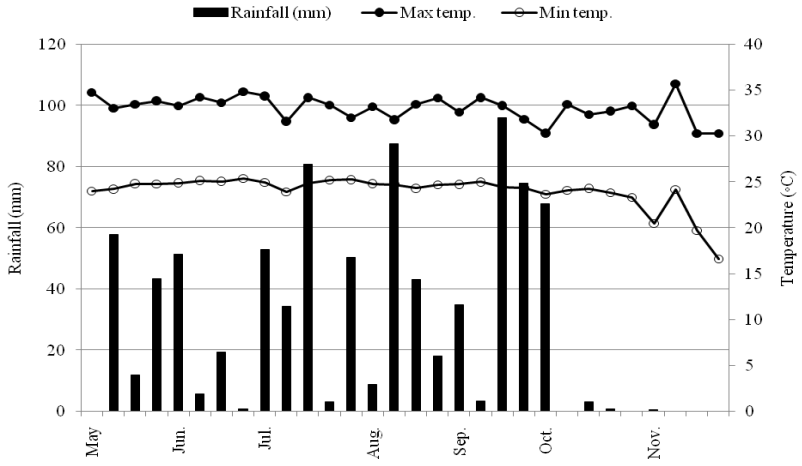


Fig. 1 Weekly rainfall (mm), maximum and minimum temperature (ºC) in the field during growing season in 2009

Leaf area per hill

The leaf area (cm^2 $hill^{-1}$) was taken at the 30 DAT and PI stage. It did not show any significant difference among the treatments. The leaf area per hill, however, obtained the highest in the treatment of the incorporation of rice straw into the soil combined with the application of cattle manure at 30 DAT and the treatment of incorporation of rice straw into the soil combined with cattle manure and bio-extracted fertilizer (Table 2).

Table 2 Plant height, leaf area and total aboveground dry weight of KDML 105 as affected by application of rice straw, cattle manure and bio-extracted fertilizer at 30 days after planting (DAP) and at panicle initiation (PI) in 2009

Treatments	Plant height (cm)		Leaf area (cm^2/hill)		Total aboveground dry weight (g/hill)	
	30 DAP	PI	30 DAP	PI	30 DAP	PI
Rice straw	59.00 b	100.75 ab	525.18	1358.70	3.63	19.35
Rice straw + cattle manure	65.75 a	110.35 a	869.25	1642.00	5.05	22.16
Rice straw + bio-extracted fertilizer	57.65 b	96.55 b	520.35	1367.80	2.87	15.68
Rice straw + cattle manure+ bio-extracted fertilizer	61.55 ab	105.95 ab	754.63	1767.00	4.41	20.27
F-test	*	**	NS	NS	NS	NS
CV (%)	5.05	4.17	40.00	4.17	29.68	19.64

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*

Total aboveground dry weight

The total aboveground dry weight (g $hill^{-1}$) was taken at the 30 DAT and PI stage. It did not show any significant difference among the treatments. The maximum total aboveground dry weight, however, was obtained in the treatment of incorporation of rice straw into the soil combined with the application of cattle manure at 30 DAT and PI stage (Table 2).

Number of panicle per hill

The number of panicle per hill or per unit area is the most important component of yield. The larger the number of panicles, the more the yield will be. In the present experiment, incorporation of rice straw into the soil combined with the application of cattle manure and bio-extracted fertilizer produced the maximum number of panicle per hill (9.00), but did not show a significant difference from the incorporation of rice straw into the soil combined with the application of cattle manure (Table 3).

Table 3 Grain yield and yield components of KDML 105 as affected by application of rice straw, cattle manure and bio-extracted fertilizer in 2009

Treatments	Panicle no./hill	Filled grains (%)	1000 grain weight (g)	Grain yield (kg/ha)
Rice straw	7.50 b	96.90	25.24	3103.13 b
Rice straw + cattle manure	8.50 a	96.65	26.42	3820.31 a
Rice straw + bio-extracted fertilizer	7.50 b	97.10	25.10	3239.38 b
Rice straw + cattle manure+ bio-extracted fertilizer	9.00 a	95.78	25.34	3796.88 a
F-test	*	NS	NS	*
CV (%)	6.60	1.58	4.12	11.78

Means followed by the same letter at the same column were not significantly different by LSD
** significant at P< 0.05 and NS not significant*

Fill grain percentage and 1000- grain weight

In the present experiment, rice straw incorporation into the soil alone and combined with various organic fertilizers did not show any significant difference in filled grain percentage and 1000-grain weight (Table 3).

Grain yield (kg ha^{-1})

The results showed that grain yield was significantly different among the incorporation of rice straw into the soil and rice straw combined with various organic fertilizers treatments. The rice straw incorporated into the soil combined with the application of cattle manure produced maximum grain yield (3820 kg ha^{-1}) which did not make a significant difference from the treatment of rice straw incorporated into the soil combined with cattle manure and bio-extracted fertilizer (3797 kg ha^{-1}) (Table 3).

Nutrient concentration in leaf

The incorporation of rice straw into the soil alone and incorporation with various organic fertilizers had no significant effect on N and K, but it did significantly affect the P concentration of the leaves. The incorporation of rice straw into the soil combined with cattle manure gave the maximum P (0.219%) concentration (Table 4).

Nutrient concentration in stem

The incorporation of rice straw into the soil alone and combined with various organic fertilizers had a significant effect on the N, P and K concentration of stem. The incorporation of rice straw into the soil combined with the application of cattle manure and bio-extracted fertilizer gave maximum N (0.535%) concentration of the stem. The incorporation of rice straw into the soil combined with application of cattle manure obtained the maximum P (0.267%) and K (2.938%) concentration of the stem (Table 4).

Table 4 Nitrogen, phosphorus and potassium content in leaves and stems of KDML 105 as affected by application of rice straw, cattle manure and bio-extracted fertilizer at panicle initiation in 2009

Treatments	Leaf			Stem		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Rice straw	1.614	0.165 b	2.381	0.430 b	0.193 b	2.510 b
Rice straw + cattle manure	1.580	0.219 a	2.514	0.484 a	0.267 a	2.938 a
Rice straw + bio-extracted fertilizer	1.603	0.176 b	2.389	0.500 a	0.208 b	2.756 ab
Rice straw + cattle manure+ bio-extracted fertilizer	1.645	0.212 a	2.548	0.535 a	0.259 a	2.859 a
F-test	NS	**	NS	**	**	**
CV (%)	2.92	2.92	3.56	3.72	9.41	4.73

Means followed by the same letter at the same column were not significantly different by LSD
*** significant at P< 0.01 and NS not significant*

DISCUSSION

The rice straw incorporated into the soil after the rice harvest combined with the application of cattle manure significantly increased the grain yield over the yields from incorporation of the rice straw alone. But it did not show any significant increase in the grain yield over the treatment of incorporation of rice straw into the soil combined with application of cattle manure and bio-extracted fertilizer. In general, rice straw provided a higher supply of K, but a lower supply of N and P than the other organic fertilizers (Javier et al., 2002). At crop maturity, the rice straw has about 40% of N, 30-35% of P and 80-85% of K (Dobermann and Fairhurst, 2002). In the present experiment, rice straw provided N, P and K in the soil at 25.7, 6.2 and 47.4 kg ha^{-1}, respectively. Rice straw improves the soil's physical, chemical and biological properties (Mandal et al., 2004).

In the treatment of incorporation of rice straw into the soil combined with the application of cattle manure, the rice crop received additional N, P and K from the cattle manure. In the present experiment, cattle manure provided N, P and K at 103.7, 35.1 and 335.6 kg ha^{-1}, respectively.

Cattle manure applied to the rice crop increased root density and enhanced root growth to deeper soil layers (Abe et al., 1995). Cattle manure-P is relatively more mobile than inorganic fertilizer-P and promotes microbiological activities and P cycling (Parham et al., 2002).

In the present experiment, however, bio-extracted fertilizer combined with cattle manure application did not show any significant effect on grain yield in comparison with cattle manure application. This is probably due to the small quantity of N, P and K that bio-extracted fertilizer provided to the rice crop. The concentration value of N, P and K was about 0.089, 0.014 and 0.433%, respectively. This means that the bio-extracted fertilizer provided an additional small quantity of the nutrients to the rice crop. Kaewtubtim (2008) reported that quantity of macro-nutrients in soluble bio-extracted fertilizer depends on the sources of materials fermented. He found an N concentration range of 0.24-0.64%, a P concentration range from 0.2 to 0.62% and a K range from 0.54 to 2.09% in soluble bio-extracted fertilizer fermented from 6 native fruits.

The sufficient N concentration in leaves at the PI stage was about 2.6-3.2% of dry weight (Mikkelsen and Hunziker, 1971). In this experiment, the N in leaves at PI stage was 1.580-1.645% of dry weight of all treatments. This indicates that the N in soil was not adequate for plant growth at PI. The N deficiency at PI stage caused a reduction of grain numbers per panicle and filled grain percentage (Dobermann and Fairhurst, 2000).

The sufficient P concentration value in leaves at the PI stage was about 0.17% of dry weight (Fageria et al., 1988). In the present experiment, P in leaves at PI stage was 0.165-0.219% of dry weight of all treatments. This indicates that P in soil provided an adequate amount for rice growth at PI. Similarly, in case of K, the sufficient K concentration value in leaves at the PI stage was about 1.0-2.2% of dry weight (Jones et al., 1991). In the present study, K in leaves at PI stage was 2.381-2.548% and 1.770-2.017% of dry weight of all treatments. This indicates that K in soil provided adequate amount for rice growth at PI.

In this study of the growth and yield of organic rice as affected by rice straw and organic fertilizer it was found that rice straw incorporated into the soil after rice harvest combined with application of cattle manure produced maximum grain yield (3820 kg ha^{-1}). It produced an 18.77% higher yield over the treatment of incorporation of rice straw into the soil alone. However, it did not show any significant difference from the treatment of incorporation of rice straw into the soil combined with application of cattle manure and bio-extracted fertilizer. In the present experiment, number of panicle per hill is the most important component of yield.

REFERENCES

Abe, J., Songmuang, P. and Harada, J. (1995) Root growth of paddy rice with application of organic materials as fertilizers in Thailand. JARO, 29, 77-82.

Bell, R.W. and Seng, V. (2004) Rainfed lowland rice-growing soils of Cambodia, Laos, and Northeast Thailand. ACIAR Proceedings, 116, 161-173.

Dobermann, A. and Fairhurst, T.H. (2002) Rice straw management. Better Crop International, 16, 7-11.

Dobermann, A. and Fairhurst, T.H. (2000) Rice: Nutrient disorders and nutrient management. International Rice Research Institute, Philippines.

Fageria, N.K., Wright, R.T. and Buligar, V.C. (1988) Rice cultivar evaluation for phosphorus use efficiency. Plant and Soil, 111, 105-109.

Javier, E.F., Marguez, J.M., Gnospe, F.S., Manucod, H.F. and Tabien, R.E. (2002) Three year effect of organic fertilizer use on paddy rice. Journal of Crop Sci., 27, 11-15.

Jones, J.B., Wolf, B. and Mills, H.A. (1991) Plant Analysis Handbook: A practical sampling, preparation, analysis and interpretation guide. Micro-Macro Inc., USA.

Kaewtubtim, M. (2008) Quantity of plant nutrients in soluble organic fertilizer from fermented native fruits. Agricultural Sci. J., 39, 31-34.

Mandal, K.G., Misra, A.K., Hati, K.M. and Kali, K. (2004) Rice residue management options and effects on soil properties and crop productivity. Food, Agriculture and Environment, 2, 224-231.

Mikkelsen, D.S. and Hunziker, R.G. (1971) A plant analysis survey of California rice. Agrichem., 14, 18-22.

OAE (Office of Agricultural Economics) (2009) The survey's report of major rice crop year 2007/08. Agricultural Statistics. Ministry of Agriculture and Cooperatives, Thailand.

OAE (2006) The survey's report of major rice crop year 2007/08. Agricultural Statistics. Ministry of Agriculture and Cooperatives, Thailand.

Parham, J.A., Deng, S.P., Roun, W.R and Johnson, G.V. (2002) Long-term cattle manure application in soil. I. Effect on soil phosphorus levels, microbial biomass C and dehydrogenase and phosphatase activities. Bio Fertile Soils, 35, 328-337.

Research article

Awareness of Organic Vegetable Production Practices in West Java and Bali, Indonesia

CHIFUMI TAKAGI
International Rice Research Institute, Makassar, Sulawesi Selatan, 90213, Indonesia
Email: c.takagi@irri.org, takagich@msu.edu

MURARI SUVEDI
Michigan State University, Michigan, USA

Received 16 December 2010 Accepted 21 February 2011

Abstract One of the challenges in developing organic agricultural production in Indonesia is increasing farmers' awareness of organic farming methods to grow high quality organic products. Recognizing the need for research and development of organic agriculture, the Development of New Bio-Agents for Alternative Farming (DNBAF) project established pilot farms in West Java and Bali in 2005 in order to field test the use of bio-pesticides and compost. Since lack of extension is a constraint in developing organic agriculture in Indonesia, it is important to understand what factors determine farmers' knowledge of organic farming methods. The goal of this study was to determine the factors associated with awareness of organic vegetable production practices including bio-pesticides and compost in West Java and Bali, Indonesia. The study tested the hypothesis that socio-economic variables affect the farmers' familiarity with bio-pesticides and compost. The socio-economic variables examined were: respondent's location, gender, age, education level, household size, number of family laborers, farming experience, farm size, distance to the pilot farm, irrigation sources, land tenure status, net revenue of cabbage, tomato, carrot production, exposure to the pilot farm and any information source groups (media, extension, farmer and commercial groups). Data were collected using a face-to-face survey. In the survey, a total of 627 households of vegetable farmers surrounding the pilot farms in West Java and Bali constituted the population, and 210 farmers selected by a systematic random sampling method were interviewed. The study hypothesis was tested by a binary logit analysis. The binary logit analysis showed that the factors associated with awareness of the practices included: location, gender, educational level, distance to the pilot farms, exposure to the pilot farms, and information sources.

Keywords organic agriculture, bio-pesticide, compost, socio-economic, binary logit analysis

INTRODUCTION

Vegetable production is an important agricultural sub-sector in Indonesia. In recent decades, due to a rapid increase and diversification in demand for fresh vegetables, production of temperate vegetables has drastically increased in the upland areas of the major islands including Java and Sumatera. For farmers, growing temperate vegetables has great potential for increasing their income (Fujimoto and Miyaura, 1997).

Historically, the golden era of agricultural extension in Indonesia was the Green Revolution program, and at this time agricultural extension played a pivotal role in increasing production of rice (Mundy, 1992). Although the agricultural extension system played an important role in the development of agriculture, lack of sufficient management and the huge institutional inertia of a large extension bureaucracy considerably weakened the system. Because of weakening financial and technical support, extension services virtually collapsed (Sulaiman and Hall, 2004). In the 1990s, the Ministry of Agriculture moved toward decentralization to ensure effectiveness, increase accountability to farmers, and reduce costs to the central government. Many districts dissolved their

old extension systems and set up new extension structures based on the needs of regional farming conditions (Zakaria, 2003). One result of this decentralization was the elimination of governmental subsidies for chemical fertilizers and pesticides, which increased their cost to farmers, and consequently decreased their use. This increased cost of chemical fertilizers and pesticides boosted interest in integrated pest management and non-chemical alternative technologies, such as organic agriculture[*] (Johnson, et al., 2008).

In 1997 the soaring cost of agricultural inputs precipitated by the monetary crisis induced many farmers to switch to organic methods (Prawoto and Suyono, 2005). Following this organic agriculture movement, the government issued the National Standard for Organic Food (SNI 01-6729-2002) adopted from the Codex CAC-GL 32/1999 in 2002. However, research and development activities related to organic agriculture in the country have been largely lacking (Prawoto and Suyono, 2005).

Recognizing the need for research and development of organic vegetable production, the Development of New Bio-Agents for Alternative Farming (DNBAF) project established pilot farms in West Java and Bali in 2005 in order to field test the application of biological insecticides (bio-pesticides) and the use of organic fertilizers (compost).

One of the challenges in developing organic farming in Indonesia is increasing farmers' knowledge of organic farming methods to grow high quality organic products (Surono, 2007). As a result of an agricultural extension process, farmers may adopt a new technology. The farmers will obtain enough knowledge of the technology through communication and education processes. Through these processes, farmers will form an attitude toward the technology, and can decide whether they will adopt the technology or not. If the farmers decide to adopt the technology, it will be implemented (Rogers, 1995). Since lack of extension is a constraint in organic agriculture in Indonesia, at the first step, it is very important to understand what factors determine farmers' knowledge of organic farming methods. However, until 2007, no systematic technology adoption study of the organic conversion process had been conducted in Indonesia.

Since the DNBAF project is an example of organic conversion, this study investigated farmers' knowledge of organic farming methods, including use of bio-pesticides and compost on three vegetable crops – cabbage, tomato, and carrot. The three crops were the major vegetables grown in the project sites. The study was conducted in two communities surrounding the pilot farms: Sukagalih village, sub-district of Megamedung, district of Bogor in West Java and Bangli village, sub-district of Baturiti, district of Tabanang in Bali.

METHODOLOGY

Data were collected using a face-to-face survey from July to October 2007. In the survey, a total of 627 households of vegetable farmers surrounding the pilot farms in West Java and Bali constituted the population, and 210 farmers selected by a systematic random sampling method were interviewed. This study tested the hypothesis that socio-economic variables affect the farmers' familiarity with bio-pesticides and compost. The socio-economic variables examined were: respondent's location, gender, age, education level, household size, number of family laborers, farming experience, farm size, distance to the pilot farm, irrigation sources, land tenure status, net revenue of cabbage, tomato, carrot production, exposure to the pilot farm and any information source groups (media, extension, farmer and commercial groups). These variables were identified based on Padel's (2001) organic conversion model and a literature review of organic vegetable production in Indonesia (Sudana, et al., 2003; Syaukat, 2003; Dadang, et al., 2005; Sumiartha, et al., 2005; Dadang, et al., 2006; Syaukat, 2006) . The study hypothesis was tested by a binary logit

[*] *Organic agriculture is defined by the Secretariat of the Joint FAO/WHO Food Standards Program (Codex CAC-GL 32/1999) as "holistic production management systems which promote and enhance agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system" (p.3).*

analysis, which is commonly used to analyze the factors influencing decision making in the field of agriculture, such as adoption of new technologies (Cavane, 2007; Banerjee, et al., 2008; Zhou, et al., 2008). The statistical software SPSS was used for the analysis. Definitions of variables used in the logit model are listed in Table 1. Two dichotomous dependent variables were:(1) familiarity with bio-pesticides is a dependent variable if respondent is familiar with bio-pesticides = 1 and if not familiar = 0 (F_BIO); (2) familiarity with compost is a dependent variable if respondent is familiar with compost = 1 and if not familiar = 0 (F_COMP).

Table 1 Variables definition in the binary logit model

Variables	Definition
Dependent Variables	
F_BIO	Familiarity with bio-pesticides (familiar = 1, not familiar = 0)
F_COMP	Familiarity with compost (familiar = 1, not familiar = 0)
Explanatory Variables	
LOCA	Location of respondent (West Java = 1, Bali = 0)
GEN	Gender of respondent (male = 1, female = 0)
AGE	Age of respondent (year)
EDU2	Education level of respondent (some primary school = 1, other = 0)
EDU3	Education level of respondent (completed primary school = 1, other = 0)
EDU4	Education level of respondent (completed junior high school = 1, other = 0)
EDU5	Education level of respondent (completed high school = 1, other = 0)
HS	Household size of respondent
FL	Number of farming labor force in a household
EXPERIENCE	Farming experience of respondent (year)
FARM	Area of the farm (unit: are; 1 ha = 100 a)
DIS	Distance from respondent's house to the pilot farm (km)
DIRR	Irrigation dummy (have irrigation = 1, no irrigation = 0)
DLAND	Land tenure dummy (secure land tenure = 1, unscure land tenure = 0)
CNETREV	Net revenue of cabbage production (thousand rupia / 0.5 ha)
TNETREV	Net revenue of tomato production (thousand rupia / 0.5 ha)
WNETREV	Net revenue of carrot production (thousand rupia / 0.5 ha)
EXPO	Total number of "exposure question" checks
IFG_MEDIA	Total number of "information source question" checks: TV, radio, magazine/journal, internet (media information group)
IFG_EXTEN	Total number of "information source question" checks: extension agent, NGO, university (extension information group)
IFG_FARMER	Total number of "information source question" checks: farmers' group, organic farmers, other farmers, family member, self-study (farmer information group)
IFG_COMMER	Total number of "information source" checks: market people, commercial company/agricultural retail store (commercial information group)

Note: EDU variables compare familiarity with bio-pesticides relative to vegetable farmers with educational level of no schooling (EDU1).

Explanatory variables include location of respondent (LOCA)**,** gender of respondent (GEN), age of respondent (AGE), five dummies for education level (EDU), household size of respondent (HS), number of farming family labor (FL), farming experience of respondent (EXPERIENCE), area of the farm (FARM), distance from respondent's house to the pilot farm (DIS), irrigation dummy variable if respondent has an irrigation = 1 and if no irrigation = 0 (DIRR), land tenure status dummy if respondent has secure land tenure = 1 and if unsecure land tenure = 0 (DLAND), net revenue of cabbage production in Indonesian rupiah per 0.5 hectare (CNETREV), net revenue of tomato production in Indonesian rupiah per 0.5 hectare (TNETREV), net revenue of carrot production in Indonesian rupiah per 0.5 hectare (WNETREV), total number of "information source question" checks for media information source group including TV, radio, magazine/journal and internet (IFG_MEDIA), total number of "information source question" checks for extension information group including extension agent, NGO, university (IFG_EXTEN), total number of

"information source question" checks for farmer information source group including farmers' group, organic farmers, other farmers, family member and self-study (IFG_FARMER) and total number of "information source" checks for commercial information source group including market people, commercial company/agricultural retail store (IFG_COMMER). In addition, variable of exposure to the pilot farm was identified as total number of "exposure question" checks (EXPO).

RESULTS

The coefficients, their standard errors, significance levels and odds ratio for bio-pesticides are listed in Table 2. The likelihood ratio test suggests the estimated model had a good fit with a statistically significant score of 192.15 at the 1 percent level. The McFadden R^2, a pseudo R-square, was 0.294, which falls in the range 0.2 to 0.4 that is considered an "extremely good fit" (Hensher and Johnson, 1981). Prediction success statistics indicated that the model correctly predicted about 76.6 percent of the responses.

The results of Table 2 identified no significant influences of any variables except exposure to the pilot farm (EXPO), educational level equaling completed primary school (EDU3), educational level equaling completed junior high school (EDU4) and distance from respondent's house to the pilot farm (DIS) for the probability of familiarity with bio-pesticides.

Tables 2 Estimated coefficients of the binary logit model for familiarity of bio-pesticide

Variables	B	S.E.	Wald	Sig.	Exp(B)
LOCA	1.204	0.733	2.697	0.101	3.332
GEN	20.194	11838.243	0.000	0.999	589042554.824
AGE	0.005	0.021	0.054	0.816	1.005
EDU2	1.239	0.759	2.666	0.103	3.453
EDU3**	1.729	0.872	3.930	0.047	5.637
EDU4**	2.392	1.087	4.846	0.028	10.938
EDU5	1.495	1.209	1.531	0.216	4.461
HS	0.167	0.146	1.301	0.254	1.182
FL	-0.111	0.310	0.128	0.720	0.895
EXPERIENCE	0.009	0.023	0.163	0.686	1.009
FARM	0.001	0.003	0.244	0.621	1.001
DIS*	-0.433	0.253	2.938	0.087	0.648
DIRR	-0.660	0.574	1.322	0.250	0.517
DLAND	-0.210	0.488	0.186	0.667	0.810
CNETREV	0.000	0.000	0.332	0.564	1.000
TNETREV	0.000	0.000	0.127	0.722	1.000
WNETREV	0.000	0.000	0.918	0.338	1.000
EXPO***	0.551	0.183	9.026	0.003	1.734
IFG_MEDIA	-0.029	0.267	0.011	0.915	0.972
IFG_EXTEN	0.003	0.403	0.000	0.993	1.003
IFG_FARMER	0.191	0.333	0.328	0.567	1.210
IFG_COMMER	0.244	0.386	0.400	0.527	1.277
Constant	-23.155	11838.243	0.000	0.998	0.000

*Note: Likelihood ratio test: $\chi^2 = 192.152$ (d.f. = 22); critical $\chi^2 = 33.92$; $p > \chi^2$: < 0.0001. McFadden $R^2 = 0.294$. The percent correct classification is 76.6 %. Number of observations = 210. ***, ** and * indicate statistical significant P<0.01, P<0.05, and P<0.10, respectively. EDU variables compare familiarity with bio-pesticides relative to vegetable farmers with an educational level of no school (EDU1). A positive sign on any of the educational dummies would mean that farmers in that particular educational category had a higher probability of being familiar with bio-pesticides than farmers with an educational level of no school.*

Exposure to the pilot farm (EXPO) had a significant positive effect at the 1 percent level in the model, indicating that vegetable farmers who knew about the pilot farm had higher probabilities of being familiar with bio-pesticides than farmers who did not know about the pilot farm. In addition,

the positive coefficients of the educational level of completed primary school (EDU3) and the educational level of completed junior high school (EDU4) were significantly different from zero at the 5 percent level. The odds ratio of DEU3 indicated that farmers who had completed primary school had about six times higher probability of being familiar with bio-pesticides, compared to the farmers who never went to school. Also, the odds ratio of DEU4 indicated that farmers who had completed junior high school had about eleven times higher probability of being familiar with bio-pesticides, compared to the farmers who never went to school. Moreover, the negative coefficient of distance from respondent's house to the pilot farm (DIS) was significantly different from zero at the 10 percent level. This was interpreted to indicate that farmers who lived closer to the pilot farm had a higher probability of being familiar with bio-pesticides rather than those who lived far from the pilot farm.

Table 3 shows the coefficients, their standard errors, significance levels and odds ratio for compost. The likelihood ratio test suggests the estimated model had a good fit with a statistically significant score of 209.116 at the 1 percent level. The McFadden R^2, a pseudo R-square, was 0.218, which falls in the range 0.2 to 0.4 that is considered an "extremely good fit" (Hensher and Johnson, 1981). Prediction success statistics indicated that the model correctly predicted 72.6 percent of the responses.

Table 3 Estimated coefficients of the binary logit model for familiarity of compost

Variables	B	S.E.	Wald	Sig.	Exp(B)
LOCA*	1.329	0.710	3.509	0.061	3.779
GEN*	1.730	0.898	3.716	0.054	5.643
AGE	0.013	0.020	0.399	0.527	1.013
EDU2	-0.317	0.664	0.228	0.633	0.728
EDU3	-0.263	0.731	0.129	0.719	0.769
EDU4	0.853	0.920	0.860	0.354	2.347
EDU5	1.598	1.197	1.782	0.182	4.944
HS	0.010	0.143	0.005	0.946	1.010
FL	0.090	0.284	0.100	0.752	1.094
EXPERIENCE	-0.016	0.021	0.552	0.457	0.984
FARM	0.001	0.003	0.043	0.836	1.001
DIS	-0.029	0.224	0.016	0.899	0.972
DIRR	-0.316	0.584	0.293	0.588	0.729
DLAND	0.213	0.482	0.195	0.659	1.237
CNETREV*	0.000	0.000	3.514	0.061	1.000
TNETREV	0.000	0.000	0.843	0.359	1.000
WNETREV	0.000	0.000	2.604	0.107	1.000
EXPO**	0.464	0.216	4.616	0.032	1.591
IFG_MEDIA	0.163	0.284	0.332	0.564	1.178
IFG_EXTEN	0.430	0.411	1.092	0.296	1.537
IFG_FARMER	0.143	0.340	0.178	0.673	1.154
IFG_COMMER*	0.644	0.359	3.206	0.073	1.903
Constant*	-3.113	1.640	3.603	0.058	0.044

Note: Likelihood ratio test: $\chi^2 = 209.116$ (d.f. = 22); critical $\chi^2 = 33.92$; $p > \chi^2$: < 0.0001.
McFadden $R^2 = 0.218$.
*The percent correct classification is 72.6 %. Number of observations = 210. ***, ** and * indicate statistical significant P<0.01, P<0.05, and P<0.10, respectively. EDU variables compare familiarity with bio-pesticides relative to vegetable farmers with an educational level of no school (EDU1). A positive sign on any of the educational dummies would mean that farmers in that particular educational category had a higher probability of being familiar with compost than farmers with an educational level of no school.*

The results of Table 3 identified no significant influences of any variables except exposure to the pilot farm (EXPO), location of respondent (LOCA), gender of respondent (GEN), net revenue of cabbage production (CNETREV), total number of "information source" checks for the commercial information source group (IFG_COMMER), and the constant on the probability of being familiar with compost.

Exposure to the pilot farm (EXPO) had a significant positive effect at the 5 percent level in the model, indicating that vegetable farmers who were exposed to the pilot farm had higher probabilities of being familiar with compost than farmers who were not exposed to the pilot farm. In addition, the positive coefficients of the location of respondent (LOCA) and gender of respondent (GEN) were significantly different from zero at the 10 percent level. According to the odds ratio of LOCA, farmers in West Java had about a four times higher probability of being familiar with compost than farmers in Bali. According to the odds ratio of GEN, male farmers had about a six times higher probability of being familiar with compost than female farmers. Moreover, the positive coefficient of net revenue of cabbage production (CNETREV) was significantly different from zero at the 10 percent level. However, the coefficients of CNETREV were zero because their frequencies were small; thus there was no influence on the familiarity with compost. The positive coefficient of total number of "information source" checks for commercial information source group (IFG_COMMER) was significantly different from zero at the 10 percent level. This was interpreted to indicate that farmers who obtained information for their vegetable production from market people and commercial company/agricultural retail stores (commercial information group) had higher probability of being familiar with compost than those who did not obtain information from the commercial information group. Finally, the negative coefficient of constant was significantly different from zero at the 10 percent level, but this interpretation of the intercept might not have any real meaning (Gujarati, 1995).

DISCUSSION

The analysis showed that an educational level of at least primary school (EDU3 and EDU4) and distance from respondent's house to the pilot farm (DIS) were associated with increasing farmers' awareness of bio-pesticide (Table 2) but there was no significant influence of educational level on the farmers' awareness of compost (Table 3). One of the possible reasons for this disparity is that use of compost might be recognized as a traditional technology and use of bio-pesticide might be recognized as a modern-new technology of organic farming by the vegetable farmers. For the farmers, they might be able to learn a new technology easily from their experiences despite the lack of a higher educational background if it was based on a traditional technology because they might have experience in using a similar form technology. However, if the new technology is a modern-new technology, it might be more difficult to learn because of lack of experience. To understand the modern-new technology, farmers may need guidance by agricultural specialists, observable concrete examples and basic knowledge of the technology.

Location of respondent (LOCA) and gender of respondent (GEN) were associated with increasing farmers' awareness of compost (Table 3) while there was no significant influence of the location on the farmers' awareness of bio-pesticide (Table 2). One of the possible reasons for this result is that the uneven gender balance in the respondents between West Java and Bali. All respondents in West Java were male. Most respondents in Bali (89.3 percent) were also male. One of the main reasons for the predominance of male respondents was that the study sites were in rural Indonesia, where the societies are male-centered, conservative, and have heavy religious influences from both Islam and Hindu faiths. When the researcher developed a list of respondents, all were male heads of households in West Java, and male heads of households also predominated in Bali. The researcher explored who was really involved in vegetable farming in a respondent's household during a short conversation before the actual interviews, and this was what the actual collected data showed.

CONCLUSION

The results indicated no significant influence of any of the variables, except exposure to the pilot farm (EXPO), educational level of completed primary school (EDU3), educational level of completed junior high school (EDU4) and distance from respondent's house to the pilot farm (DIS) on the probability of being familiar with bio-pesticides; no significant influences of any variables except exposure to the pilot farm (EXPO), location of respondent (LOCA), gender of respondent (GEN), and commercial information source groups (IFG_COMMER) on the probability of being familiar with compost.

These findings imply that an educational level of at least primary school, distance to the pilot farms, and exposure to the pilot farms would be the key factors in increasing farmers' awareness of bio-pesticides. Gender, exposure to the pilot farms, and commercial information source groups would be the key factors to increase farmers' awareness of compost. Especially, exposure to the pilot farms would be the most important factor to increase farmers' awareness of the target organic vegetable production practices.

ACKNOWLEDGEMENT

We would like to express our appreciation to Dr. Akimi Fujimoto, who was a leader of DNBAF project at Tokyo University of Agriculture in Japan. He provided the research opportunity for this study, and financial support for fieldwork in Indonesia.

REFERENCES

Banerjee, S., Martin, S.W., Roberts, R.K., Larkin, S.L., Larson, J.A., Paxton, K.W., English, B.C., Marra, M.C and Reeves, J.M. (2008) A binary logit estimation of factors affecting adoption of GPS guidance systems by cotton producers. Journal of Agricultural and Applied Economics, 40-1, 345-355.

Cavane, E.P.A. (2007) Farmers' attitudes and adoption of improved maize varieties and chemical fertilizers in the Manica district, Mozambique. Ph.D. dissertation. Department of Community, Agriculture, Recreation and Resource Studies, Michigan State University, USA.

Dadang, A. and Ohsawa, K. (2005) The effectiveness of plant extracts in reducing cabbage insect pest population and their effect on natural enemies. Journal of International Society for Southeast Asian Agricultural Sciences, 11-3, 142-149.

Dadang, G.S., Nawangsih, A.A., Syaukat, Y. and Tjahjono, B. (2006) Development of organic rice and vegetables in the district of Bogor, West Java, Indonesia: Development of new bio-agents for alternative farming systems: 2005 Report. Academic Frontier Research Center, Tokyo University of Agriculture, Japan.

Fujimoto, A. and Miyaura, R. (1997) Farm management appraisal of Tumpang Sari vegetable cultivation in highland West Java, A one year study of farmers' practices in Cipanas. Jour. Agri. Sci., Tokyo Nogyo Daigaku, 41-4, 211-228.

Gujarati, D.N. (1995) Basic econometrics, third edition. McGraw-Hill, USA.

Hensher, D.A. and Johnson, L.W. (1981) Applied discrete choice modeling. Croom Helm, UK.

Johnson, G.I., Weinberger, K. and Wu, M.H. (2008) The vegetable industry in tropical Asia: Indonesia. Tainan, Taiwan: The World Vegetable Center.

Mundy, P.G.W. (1992) Information sources of agricultural extension specialists in Indonesia. Ph.D. dissertation. Department of Mass Communications, The University of Wisconsin, Madison, USA.

Padel, S. (2001) Conversion to organic milk production, The change process and farmers' information needs. Ph.D. dissertation. Institute of Rural Studies, University of Wales, Dyfed, UK.

Prawoto, A. and Surono, I. (2005) Organic agriculture in Indonesia, A wannabe big player in the organic world. The Organic Standard, 49, 3-6.

Rogers, E.M. (1995) Diffusion of innovations. Free Press, USA.

Sudana, M., Temaja, I.G.R.M., Miyaura, R. and Fujimoto, A. (2003) Cultural practices and economic analysis of organic and conventional vegetable farming in Bali, Indonesia. Journal of International Society for Southeast Asian Agricultural Sciences, 9-3, 104-113.

Sulaiman, R. and Hall, A. (2004) Extension policy at the national level in Asia. Paper presented at the 4th International Crop Science Congress, Australia.

Sumiartha, K., Susila, W. and Sudiarta, P. (2005) Effect of "Selasih" (*Ocimum tenuiflorum*) plant oil on fruit flies (*Bactrocera dorsalis* complex) in Long Chili. Journal of International Society for Southeast Asian Agricultural Sciences, 11-3, 46-50.

Surono, J.I. (2007) Country case study of Indonesia. Power point document presented at the Regional Conference on Organic Agriculture in Asia, Thailand.

Syaukat, Y. (2003) Factors affecting farmers in adopting low-input rice farming system in Tempuran Sub-district, Karawang, Indonesia. Journal of International Society for Southeast Asian Agricultural Sciences, 9-3, 90-103.

Syaukat, Y. (2006) Potential development of organic vegetables in Sukagalih Village, Megamendung Subdistrict, Bogor, West Java. In Development of New Bio-agents for Alternative Farming Systems: 2005 Report, 194-205. Tokyo University of Agriculture, Japan.

Zakaria, A. (2003) Decentralizing extension to local government: Indonesia experience. Paper presented at the Regional Workshop on Operational Zing Reform in Agricultural Extension in South Asia, India.

Zhou, S., Herzfeld, T., Glauben, T., Zhang, Y. and Hu, B. (2008). Factors affecting Chinese farmers' decisions to adopt a water-saving technology. Canadian Journal of Agricultural Economics 56-1, 51-61.

Research article

Impacts of Micro-credit on Household Economics

SIVCHOU TENG
University of Battambang, Battambang, Cambodia
Email: sivchouteng@yahoo.com

SOKHAK PRIEN
University of Battambang, Battambang, Cambodia

NARA MAO
Royal University of Agriculture, Phnom Penh, Cambodia

BUNHOR LENG
Royal University of Agriculture, Phnom Penh, Cambodia

Received 17 December 2010 Accepted 25 January 2011

Abstract This research was conducted to investigate the impacts of micro-credit on local household economics in Prek Norin Commune by focusing on people who took a loan from microfinance institutions and continue to use it. This study mainly focuses on three objectives, socio-economic factors of households using credit, the status of using micro-credit and effects of micro-credit on household economics. Data were collected via survey, using face to face interviews with a hundred and forty two household heads. Simple random sampling method was used to select the samples from two villages (Prektachreng and Prek Krouch) in Prek Norin Commune, Ek Phnom district, Battambang province. Therefore, the accuracy of the analysis heavily relies on the data provided by interviewees. The result of this study revealed that those using micro-credit have better living standards than before because of income and asset growth. In addition, using micro-credit also creates more job opportunities and variety of economic activities, provides more jobs for women, and improves household education, women's status, and family welfare. It also reduces income inequality in the villages. However, micro-credit has negative impacts on people's feeling because most people are more concerned about paying back the loan.

Keywords impacts, micro-credit, economics

INTRODUCTION

Microfinance is a development program related to the provision of financial services to people with low incomes; these services are credit, saving and insurance (Khan and Rahaman, 2007; Wanchoo, 2007 and Bakhtiari, 2006). Microfinance is recognized as the most essential tool for poverty alleviation in many developing countries (Brandsma and Chaouli, 1998; ADB, 2000; Emilia, 2005; Posner, 2007 and Shastri, 2009), and microfinance is an effective instrument that can improve on most important things for poor people such as households' welfare, education, economics, people's living standards and empowerment of women (Felix, 2007 and Singh, 2004). Even though some of the studies showed that microfinance can reduce poverty, people who used credit did not know how microfinance could help to alleviate poverty (Khan and Rahaman, 2007).

Most of the research studies showed that microfinance could provide a lot of positive results on peoples household economy such as creating more job opportunities, increasing household incomes, building up women's abilities, improving household education and family welfare; however, microfinance could also be a heavy responsibility for people too. When people used financial service, they could increase household income more easily than before, buy more household's assets, and improve their living standards. Especially the group of poor households who have used microfinance to change their daily livelihood by preparing their future plans such,

as household investment and income, building and fixing their houses, improving family welfare and education (Bakhtiari, 2006 and Felix, 2007).

In Cambodia, the number of Microfinance institutions (MFIs) has increased significantly, especially in this last decade. A number of people borrowed funds from those MFIs to set up their economic activities, but up until now there has been no research study that shows how micro-credit affects people's lives. Therefore, this study was conducted to find out the impacts of micro-credit on people's living status. According to this research objective, a hypothesis was set that micro-credit provided positive results to the people's way of living.

METHODOLOGY

Quantitative research was applied, so that structured interviews were used to interview a hundred and forty two households heads by selecting them from two villages, Prek Tachreng and Prek Krouch, in Prek Norin Commune, Ek Phnom District, Battambang Province.

This study relied on two types of data; primary data and secondary data. Primary data which were collected from people through questionnaires was used as the most important data in this research. Therefore, the questionnaires were pre-tested in order to correct some difficult questions. A lot of documents such as the last research thesis, journal, and paper were used as secondary data to compare with the similar research all over the world.

The sample size was defined by using non-probability sampling method, selecting only the people who took a loan from institutions and continue to use it. Purposive sampling method was used to select the research location and the simple random sampling method was used to select household heads using credit from the list given by both village chiefs.

Data collected from interviewees was coded and entered into Ms Excel and SPSS for analysis. The data were analyzed in two ways, qualitative and quantitative data analysis. Descriptive and inferential statistics were used in data analysis, which were Time Series Regression, ANOVA, Chi-square Test, Gini Coefficient, Lorenz Curves, Graphic and Charts.

RESULTS AND DISCUSSION

Profiles of households using micro-credit

Interview status was focused on gender, age, marital status, education and time duration of living in this study area and the main annual income of every household using micro-credit. The results in Table 1 showed that 93 percent of families using credit were women, and only 7percent were men. The majority of credit borrowers were over thirty years old; besides this, they were in the age group of eighteen to thirty years old. Among all borrowers, most of them did not have high education, which 17 percent never having gone to school, 59 percent studied in primary school, 23 percent studied in secondary school, and only 1 percent studied in high school.

In addition, the result showed that 23.50 percent of seventy-one households were the families having a main job as doing business, 23.50 percent selling labor, 14.70 percent feeding animals, 10.30 percent rice farmers, and 11.80 percent having other jobs. The result of this study also illustrated that 41 percent of household using micro-credit could earn incomes between 15 to 10 million riels in a year, and only 7 percent could earn incomes over 20 million riels per year from households' main jobs.

Income distribution during 2008-2009

Fig. 1 indicated that household income distribution curve in 2008 moved away from the perfect equality; it means that income distribution of people in 2008 had inequality between group of people having high incomes and low incomes. Whereas, the Lorenz curve represented for income

distribution in 2009 had moved toward the perfect equality line than in 2008; it showed that income inequality of each household in 2009 was in low level. Moreover, Gini coefficient of incomes in 2009 (Gini=0.3484) fell down by comparing with 2008 (Gini=0.3847). This fall also illustrated that income inequality in 2009 was better than the last year, so micro-credit could help to reduce income inequality of people living in this study area.

Table 1 General status of interviews

Variables	Categories	Percentage
Gender (n=71)	Male	7.00
	Female	93.00
Age	18 to 30 years old	20.00
	31 to 40 years old	21.00
	Over 40 years old	59.00
Education	Illiteracy	17.00
	Primary school	59.00
	Secondary school	23.00
	High school	1.00
Main jobs in family	Doing Business	38.00
	Farmer	28.00
	Labor selling	11.00
	Animal feeding	10.00
	Other jobs	13.00
Annual Incomes (Main jobs)	1 to 5 million riels	38.00
	5,000,001 to 10,000,000 riels	41.00
	10,000,001 to 20,000,000 riels	14.00
	Over 20,000,000 riels	7.00

Income distribution during 2008-2009

The Fig. 1 represented that households income distribution curve in 2008 moved away from the perfect equality; it means that income distribution of people in 2008 had inequality between group of people having high incomes and low incomes. Whereas, the Lorenz curve represented for income distribution in 2009 had moved toward the perfect equality line than in 2008; it showed that income inequality of each household in 2009 was in low level. Moreover, Gini coefficient of incomes in 2009 (Gini=0.3484) fell down if comparing with 2008 (Gini=0.3847). This fall also illustrated that income inequality in 2009 was better than the last year, so micro-credit could help to reduce income inequality of people living in this study area.

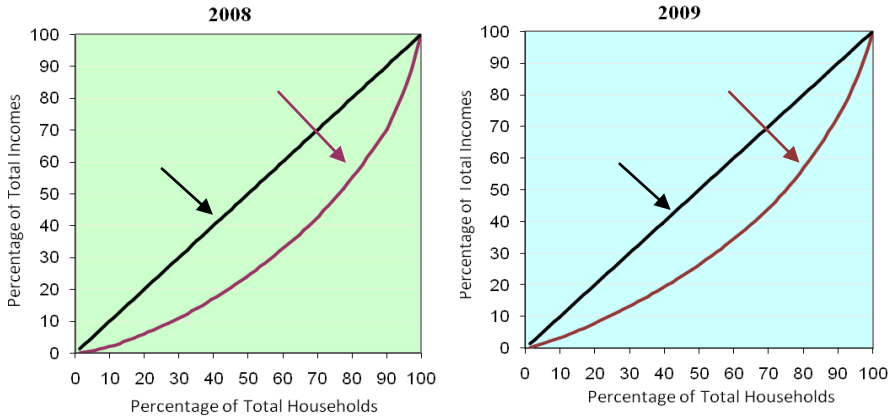


Fig. 1 Income inequality between 2008 and 2009

Status of using micro-credit

The Fig. 2 indicated that the total loan size of those borrowers in this area had increased from 2005 to 2009 according to the function of time series regression: y = 23,240,000 x -46,581,806,000, which x demoted the year, and y represented the total loan size in year x. The result displayed that the total loan size had grown up 23,240,000 riels per year, and this loan size had related to the year significantly (ANOVA: p = 0.0066**), which this model could be used to forecast the total loan size of sampling households to be 130,594,000 riels in 2010.

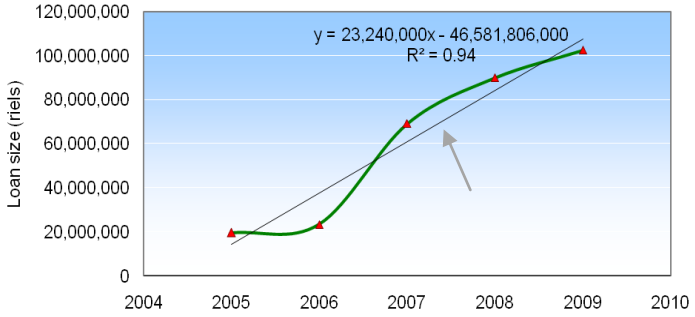


Fig. 2 Comparison of total loan size from 2005 to 2009

Impact on household's incomes

The study on impact of micro-credit on incomes was observed by the different important types of main jobs such as doing business, agriculture, labor selling and other jobs from 2006 to 2009. It indicated that the mean of households' incomes increased consequently during this period (Fig. 3).

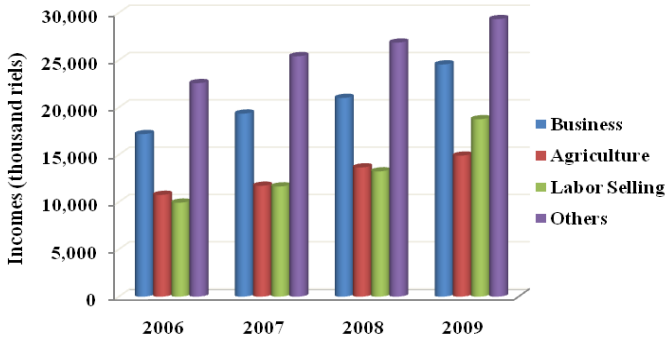


Fig. 3 Increase of income in different job sectors from 2006 to 2009

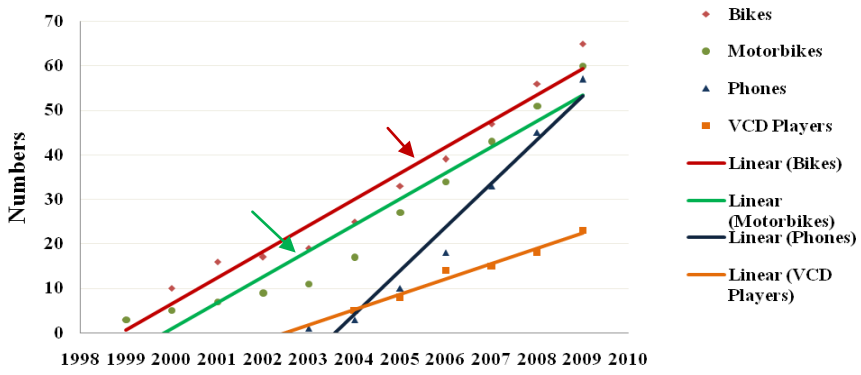


Fig. 4 Time series regression of increasing assets

Impact on household's assets

The study on households' asset status in this area was focused only on the important assets such as TV, motorbikes, bicycles and telephones and the other assets. According to the time series regression analysis of asset growth, it showed that the amount of households' assets in this study area had increased after using micro-finance until now. Through the function of time series regression analysis on households' asset, it could be estimated that the asset growth in 2010, which TV would increase to 53, motorbikes to 60, bicycles to 65 and telephones to 63 (Fig.4).

Impact on household's job opportunities

The result in Table 2 showed that the job opportunities had changed a lot, starting from having only one job to more jobs in each household after using micro-credit. In fact, during 2006 most of people had one job, and only a few people had two jobs in their families. However, in 2009 the majority of households had two jobs in the family, and the minority households had three jobs.

Table 2 Comparison of job opportunities of people from 2006 to 2009

Year	Percentage of households		
	One Job	Two Jobs	Three Jobs
2006	70	25	5
2007	56	36	8
2008	41	49	10
2009	21	62	17

Impact on women, education and welfare

This study had shown that most of people using micro-credit were women who had right to make decision on households' problems. In addition, all of those women had a lot of job opportunities, and had been involved in income generating activities for households' living.
The result also proved that using micro-credit could empower the level of education through borrowing loans to pay children's school fees and earning incomes for sending their children to school. Surely, 72 percent of households brought up children to school and left opportunities for them to get training. Furthermore, women also had more ability to supply food and nutrition for households' daily living. Therefore, using micro-credit could not only helped to increase households' income, assets and job opportunities, but it could help to empower women to be involved in society, provide household members' educational opportunities and make family's welfare better, too.

Impact on feeling

According to the results of interviews, the interviewees had observed that 34 percent of them were concerned about repayment the loan such as, paying late and having not enough money on the due date of the capital repayment. Some households were worried about confiscation of their lands, houses and assets by microfinance institutions they borrowed from. Some of other household were concerned about getting sue by institutions when they had no abilities to pay the loan in order to receive their mortgage-able things back. Moreover, most of those people did not want to be embarrassed or loss of reputation. All the above reasons revealed some negative impacts on people's feeling using micro-credit.

According to the result of hypothesis testing through ANOVA analysis on annual incomes, the means of those household's annual incomes had increased consequently from 2006 to 2009 in the level of significant testing at 10 percent, which p=0.086*. This result indicated that using micro-credit could help people to increase their incomes as the same as result of last researchers such as Dieckman, (2007); World Bank, (1998); Yunus, (2006); Yunus, (1999); Doocy *et al*., (2003);

Goldberg, (2005); Ottogenghi, (2008); Shetty, (2006); Rahman *et al*., (2009); Ghalib, (2007); Pathirange, (2005); Rajat, (2007); Hassan, (2006).

The testing on household's assets by using time series regression model focused on only the very important assets of people using micro-credits. The result of analysis showed that the amount of televisions, motorbikes, bicycles and telephones increased strongly in statistic at p=0.000***<0.001, which means that the increase of all above assets had strong correlation with the year when those assets were bought. This revealed that after using micro-credits, household's assets could increase, and it was the same as the findings of some last researchers such as ADB, (2007); Kaboki and Townsend, (2002); Zaman, (2000).

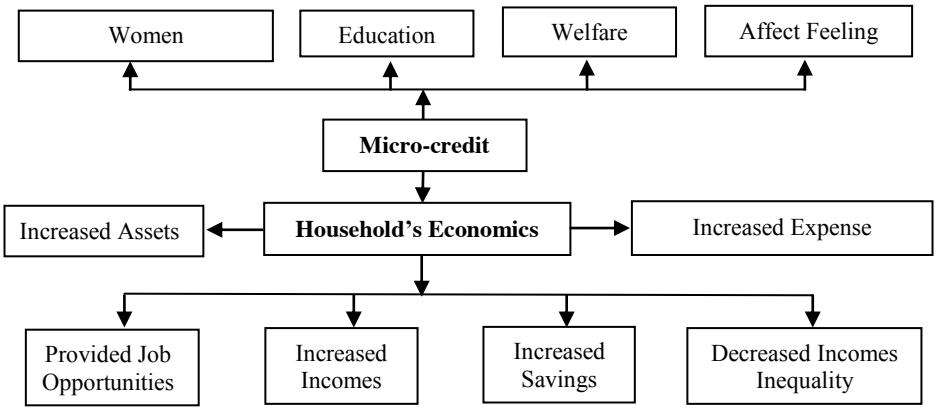


Fig. 5 Summary diagram of impact of micro-credit on household's economics

Furthermore, the study showed that using credit could improve households' living and other expenditure abilities such as spending on medical treatment to be helthier, and this study was the same as the result of Datar *et al*.,(2008), which indicated that microfinance had positive impacts on livelihoods and welfare when income increased. Additionally, micro-credit also helped to provide job opportunities for women, empowered women and provided educational opportunities for children, that was similar with the findings of Sayasene (2007); and Maldonado (2002).

CONCLUSION

According to the overall results of this study, it can be concluded that micro-credit was strongly related to the improvement of household's economics. In addition, micro-credit had improved household's living to be better, because it could increase household's incomes, assets, job opportunities, the empowerment of women, education and family welfare to those people using microcredit. However, data also showed that micro-credit created some negative impact such as the stress of borrowing. Despite this, we can say that microfinance is an effective tool for poverty alleviation in Cambodia.

ACKNOWLEDGEMENTS

We would like to give our regards to local authorities. The Prek Norin Commune leader, Prek Tachreng village leader and Prek Krouch chiefs, who gave a lot of information and documents related to people using micro-credit in this study area. Especially, we would like to say thanks to the people using micro-credit in both villages who had spent their value time to give interviews for our study.

REFERENCES

ADB (2000) Finance for the poor: Microfinance development strategy. www.adb.org/documents/policies/ microfinance/financepolicy.pdf.

ADB (2007) Effect of microfinance operations on poor rural households and the status of women. http:// www.adb.org/Documents/Evaluation/Management-Response/SES/MR-SES-Microfinance-perations.pdf
Bakhtiari, S. (2006) Microfinance and poverty reduction: Some international evidence. (IBER), 1-5.
Brandsma, J. and Chaouli, R. (1998) Making microfinance work in the Middle East and North Africa. http://Worldbank.org/document/research/library.
Datar, M.S., Epstein, M.J. and Yuthas, K. (2008) In microfinance, clients must come first. Stanford social innovation review. Leland Stanford Jr. University.
Dieckmann, R. (2007) Microfinance: An emerging investment to opportunity. Deutsche bank research. Uniting social investment and financial returns, Germany. http://www.dbresearch.com/PROD/DBR_ Internet_EN-PROD/PROD0000000000269174.pdf.
Doocy, S., Norell, D., Teffera, S. and Burnham, G. (2003) Outcomes of an Ethiopian microfinance program and management actions to improve services. Journal of Microfinance, 1-7, 84-87.
Emilia, L. (2005) Fighting poverty with microfinance: The democratisation of finance-future directions for microfinance: Utsikt motutveckling 25, Uppsala Universitet, 16.
Felix, O.O. (2007) Social and economic impact of Fondo Minga microcredit program. Master thesis, Universidad Austral de Chile, Chile.
Ghalib, A.K. (2007) Measuring the impact of microfinance intervention, A conceptual framework of social impactaAssessment. The Singapore economic review conference, 1-2.
Goldberg, N. (2005) Measuring the impact of microfinance, Taking stock of what we know. Grameen foundation USA publication series. http://www.gfusa.org.
Hassan, M. (2006) Institutional transformation of poverty-focused microfinance institutes in Bangladesh, Nepal and Malaysia. Universiti Sains Malaysia, 2-15, Malaysia.
Kaboski, J.P. and Townsend, R.M. (2005) Policies and impact, An analysis of village-level microfinance institutions. Journal of European Economic Association, 3-1, Thailand.
Khan, M.A. and Rahaman, M.A. (2007) Impact of microfinance on living standards, empowerment and poverty alleviation of poor, A case study on microfinance in the Chittagong district of Bangladesh. Umea School of Business, Department of Business Administration, Sweden.
Maldonado, J.H. (2002) The influence of microfinance on human capital formation: Evidence from Bolivia. The Ohio State University, USA.
Ottolenghi, D. (2008) The economic and impact of microfinance: Options for the mediterranean. 4th FEMIP conference. www.eib.org/attachments/general/.pdf.
Pathiranage, T.D. (2005) Role of micro-finance in improving living conditions - A case study of Samurdhi bank societies in SriLanka. Graduate school of regional development studies, Sri Lanka.
Posner, A.V. (2007) Green microfinance, A blueprint for advancing social equality and environmental sustainability in the United States. Master thesis, Brown University, USA.
Rahman, S., Rafiq, R.B. and Momen, M.A. (2009) Impact of micro-credit programs on higher income borrowers: Evidence from Bangladesh. Int'l. Business & Economics Research Journal (IBER), 119-123.
Rajat, W. (2007) Micro-finance in India: The changing face of microcredit schemes. MPRA paper, India.
Sayasene, C. (2007) Assessing credit needs of the rural poor in Lao PDR: A case study of two villages in Thakhek district. Master research, School of Environment. ARCMDG Publication.
Shastri, R.K. (2009) Micro finance and poverty reduction in India (a comparative study with Asian countries). African Journal of Business Management, 3-4. http://www.academicjournals.org/ajbm/abstracts/abs tracts/abstracts2009/April/Shastri.html.
Shetty, N.K. (2006) The microfinance promise in financial inclusion and welfare of the poor: Evidence from India. Research scholar centre for economic studies and policy institute for social and economic change, India, 1-10.
Singh, S.K. (2004) Microfinance and empowerment of scheduled caste women, An impact study of SHGs in Uttar Pradesh and Uttaranchal. BL centre for development research and action, India.
Wanchoo, R. (2007) Microfinance in India: The changing face of micro-credit schemes. UNSPE CIFIED, 2.
World Bank (1998) Using microcredit to advance women. PREM (poverty reduction and economic manage ment) notes. http://www.worldbank.org/documents/research.
Yunus, M. (1999) Banker to the poor, Micro-lending and the battle against world poverty. Public affairs, USA. http://nobelprize.org/nobel_prizes/peace/yunus-lecture-en.html.
Yunus, M. (2006) Nobel lecture. Norway. http://nobelprize.org/nobel_prizes/peace/yunus-lecture-en.html.
Zaman, H. (2000) Assessing the poverty and vulnerability impact of micro-credit in Bangladesh: A case study of BRAC.Office of the chief economist and senior vice-president (DECVP), World Bank. http:// www.worldbank.org/library/poverty.

Research article

Organic Rice Farming Systems in Cambodia: Socio-economic Impact of Smallholder Systems in Takeo Province

SA KENNVIDY
Royal University of Agriculture, Phnom Penh, Cambodia
Email: kennvidy@yahoo.com

Received 19 December 2010 Accepted 25 January 2011

Abstract Organic farming is recognized as an important system of agriculture and food production, that is environmentally sustainable and can generate several positive impacts to rural society. The development of organic farming in Cambodia is in its early stage. Thus, the objectives of this research were to identify the farmers' perception on organic rice farming and to analyze the economic effects of the system. Data collection was carried out through a pretested interview schedule, two types of questionnaires and a personal observation schedule while descriptive and inferential statistics were analyzed with the use of statistical package for the social sciences or SPSS software. The results showed that the majority of farmers converted their farms into organic farms because of premium prices on organic products and 15% increase from their farm incomes compared to conventional farms. Adapting organic rice farming is able to increase rice yields by 5% accounting from 2.46 to 2.59 tons per hectare. The increased amounts of rice production were equivalent to 21%. Furthermore, organic farming systems could be more stable since the analysis of its economic efficiency was higher than conventional farming system.

Keywords organic rice, farming system, potential, constraints, smallholder systems

INTRODUCTION

Rice production in Cambodia is considered as the dominant crop in the agricultural sector like the neighboring countries in Southeast Asia (Deichert and Yang, 2002) which provides food, income and employment. Most Cambodians consume rice as staple food and over 80% of farmers cultivate rice as the primary crop. Rice production accounts 9% of GDP (ACI, 2002) which directly connected to about 65% of Cambodians (Deichert and Yang, 2002).

Takeo province is one of the main rice farming areas in Cambodia. From 85% to 90% of population depend on agricultural sector. Rainfed rice cultivation is the main source of income of the farmers (Sath et al., 2008). In this region, farm sizes are classified into 3 extents; as small scale farming at an average of 0.8 ha, medium scale farming at an average of 2 ha and large scale farming at an average of 4.5 ha. Although farmland areas are limited in the region, agricultural cultivation method is still in a traditional way of farming (Saruth and Gee-Clough, 1998). Most farmers use synthetic fertilizer to increase crop production. In 2000, farmers in Takeo province initiated to use about 100% of inorganic fertilizers (Ieng et al., 2002, Pracilio et al., N/A).

According to the survey, using excessive amounts of fertilizer have only little effect on rice yields. In addition, poor practices in the application of agrochemicals can affect directly to human health, decline soil fertility and reduce aquatic resources (Mary et al., 2000).

An organic rice association (CEDAC) basing in Tramkok District, Takeo Province which produced organic rice, supports local farmers on technical knowledge in organic farming and facilitates marketing of organic rice products from the local farmers. However many farmers in the region could not adapt organic rice farming possibly due to the lack of education on the benefits of organic farming. Thus, the result in this study is expected that could contribute to the adaptation of the local farmers in organic farming.

The goal of this research is to analyze socio-economic impact of smallholder systems in Tramkok district. In this connection, the objectives of this study are to (1) identify the difference on production techniques and farmers' perception of organic rice farming in Tramkok district, Takeo province and (2) analyze the economic performance between organic and conventional farming.

METHODOLOGY

The results presented in this paper are based on qualitative and quantitative methods of primary data collection and inquiry. In order to study the differences of two rice farming systems, total of 60 farmers whom 30 farmers are dealing with organic farming and other 30 farmers from conventional farming were subjected for the interview in this study.

Furthermore, qualitative and quantitative methods such as semi-structured and in-depth interviews, identification of key-informants, and field visits were used to fulfill the necessary data needed in this study. Data was collected through a pretested interview schedule, two types of questionnaires and a personal observation schedule then descriptive and inferential statistics were analyzed with the use of SPSS software.

RESULTS AND DISCUSSION

Table 1 shows the differences between organic and conventional rice farming. It was observed that organic farming can save around 50% of seeds per hectare of rice field along with wider spacing on planting of rice seedlings in organic farming than that in conventional farming. Regarding with fertilizers, big amounts of organic fertilizers are necessary to be applied into the field than that of synthetic fertilizers. However the price of organic manures is much cheaper, that cost 10 riel per ton of cow manure than that of synthetic fertilizer that cost around 1600 riel per kg.

Table 1 Differences between organic and convention rice farming

	Production Stage	Organic farms	Conventional farm
Pre-cultivation	Farm location	Near from the village	Disperse
	Seed / ha	20 kg	More than 40 kg
Cultivation	Land preparation	2 or 3times	2 times or less
	Cultivation method	Transplantation	Direct seeding / transplantation
	Seedling age	12 - 15 days	More than 20 days
	Space between line and row	25 - 30 cm	< 20 cm
	Fertilizers	Organic fertilizers(1)	Chemical fertilizers
	Amount of fertilizers	3 - 4 tons	50-100 kg
	Weed control	Hoes and Hands	Hoes and Hands
	Pest control	No	No
	Irrigation	Rainfed	Rainfed
Post-harvest	Storage	12-13% of moisture separately with other products	No restriction

(1) *Organic fertilizers including compost, animal manure such as cattle dung …*
(2) *Farmers in the research area did not use pesticide or herbicides in their rice field.*

Motivations on transforming to organic farming

According to the data collected through individual interview, farmers have different motivations in transforming to organic farming. Farmers shifted to organic farming in order to reduce the expenses on synthetic fertilizers, to avoid the negative effects of synthetic fertilizers to health, to utilize the

available resources in the neighborhood, to conserve the environment as well as soil and water quality and to acquire the beneficial prices on organic products.

Fig. 1 shows that the low cost production and high price of organic rice products are the remarkable reasons for converting the conventional farming to organic farming accounting for 63% and 57% respectively. Meanwhile some of the farmers were encourage converting to organic farming due to its increasing effects on rice yields which accounts 40% of the interviewed farmers while 17% of them stated for health benefits.

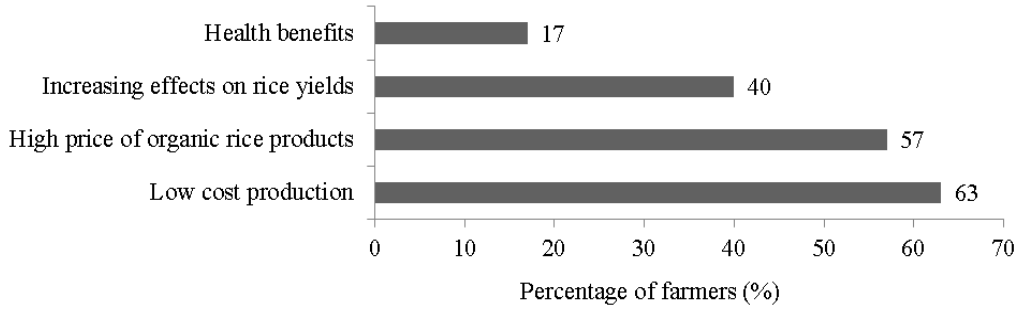


Fig. 1 Farmers' motivation on transforming to organic farming

Perception of organic farmers

Farmers slowly realized the advantages on cultivating rice through organic farming which results the increasing number of households along with the increasing area of paddy fields in rural villages in the region. In addition, most of the organic farmers pursue to continue on carrying out organic farming. As shown in Fig. 2, 80% of organic farmers were motivated to pursue organic farming due to the higher net income from organic products. Also, the high market demand and high quality of organic products was 57% and 30% respectively. Other farmers, constituting 15%, were favored to keep the products for their own consumption.

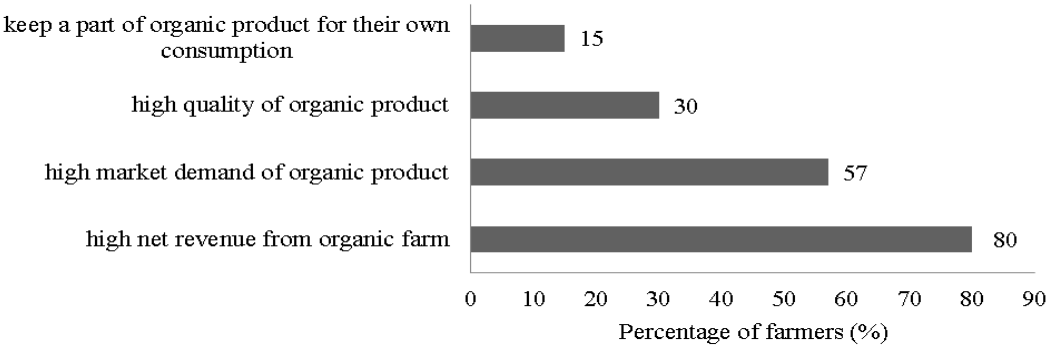


Fig. 2 Perception of organic farmers

Perception of conventional farmers

Fig. 3 shows that 60% of conventional farmers were convinced to convert their rice field into organic while the other 40% stated to remain the conventional method of rice farming.

Reasons from farmers who intend to shift into organic rice farming;

- Production cost is getting higher every year with the increasing prices of chemical fertilizers
- More amounts of synthetic fertilizers needed to be applied into conventional rice fields to maintain its production output

- Prevent the side effects of applying agrochemicals on human health
- Economically favorable for them since they can produce compost by themselves
- Promote social relationship among local farmers through ideas and knowledge sharing
- Farmers can have a benefit of acquiring technical support on organic farming from NGOs

Reasons from farmers who intend to continue the conventional methods on rice farming:

- High labor cost of transporting manures or organic fertilizers to the rice fields
- Excessive use of synthetic fertilizers results more rice yields
- Poor soil quality will be improved by using synthetic fertilizers.
- There is no enough labor to carry out organic rice farming.
- Rice cultivation is considered as the second source of income in their families
- Lack of understanding on the benefits of organic rice farming

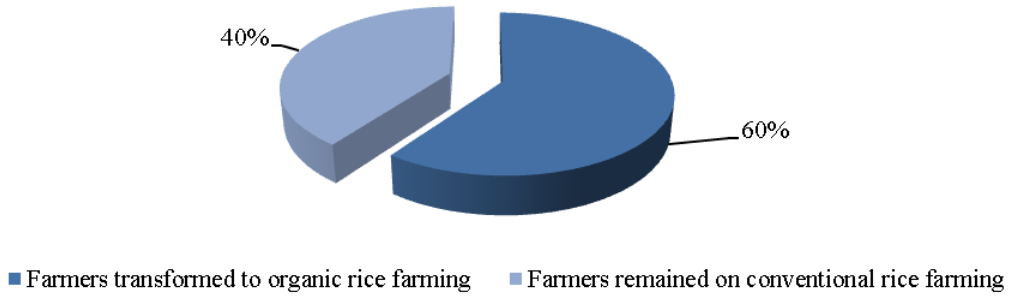


Fig. 3 Proportion of conventional farmers to convert into organic farming

Economic performance in organic and conventional rice farming

Based on the data collected at the research site, it was found out that the gross revenue at conventional rice farming was 2,460,059 riel while at organic rice farming was 2,081,110 riel. For clear comparisons of economic performances between organic and conventional farming, indicators were used as follows; net revenue, total cost, break-even yield, net revenue/cash expense ratio.

The net revenue was calculated per hectare of the field and as shown in Table 2, it is clearly indicated that organic rice farming was higher of net revenue at 21% than that in conventional rice farming. This could be attributed to the higher yields and higher prices of organic rice products. Total cost of production includes noncash and cash form. It was found out that conventional rice farming had higher cost production for 45% than that in organic rice farming. This was due to the higher cost of synthetic fertilizers accounting to 90% of cash cost. In this connection, to produce 1 ton of unmilled organic rice will cost 81,040 riel compared to conventional rice which will cost 147,061 riel. Break-even yield is the yield that will pay for the total cost variable cost. Since the total cost of production was mainly due to the higher cash cost of production, the break-even yield was the highest in the conventional farm followed by organic farm. Organic fields could produce 212 kg per ha at a price of 950 riel per kg of rice compensating for the total cost of 201,071 riel. Meanwhile, conventional fields could produce 343 kg per ha at a price of 848 riel per kg of rice compensating for the total cost of 290,946 riel. Net revenue/cash expenses are the ratio between the net return over the cost of production. Due to the high cash costs and the lower net revenue in the conventional farming, the net revenue/cash expenses values were lower than that in the organic farming. The economic efficiency of organic rice farming was at an average of 19 higher than that of conventional rice farming at an average of 9. Therefore, it was clearly indicated that the organic rice farming is economically more beneficial than conventional rice farming.

According to these results, organic rice farming has become the priority for the development

in agricultural sector in Cambodia, especially for small scale farmers. Although, organic rice yields increased only at 5%, its net revenue was higher than that in conventional rice farming. It was also observed that organic rice farming saves up to 50% of rice seeds compared to conventional rice farming by controlling the spaces between planting of rice seedlings.

Table 2 Economic performances between organic and conventional rice farming

Items	Organic farm	Conventional farm	OF-CF	Δ%	Significant level
Gross revenue (riel)	2,460,059	2,081,110	378,949	15%	**
Yield (t/ha)	2.59	2.46	0.13	5%	n.s
Price (riel/kg)	950	848	102	11%	
Total cost (riel)	201,071	290,946	-89,875	-45%	*
Noncash cost (riel)	82,494	53,959	28,535	35%	**
Cash cost (riel)	118,577	236,988	-118,411	-100%	*
Net revenue (riel)	2,258,987	1,790,164	468,823	21%	*
Net revenue/cash expenses	19	8	11	58%	**
Break-even yield (kg/ha)	212	343	-131	-62%	**
Total cost to produce 1 ton of rice	81,040	147,061	-66,021	-81%	**
Economic efficiency	19	9	10	53%	**

n.s : *no significant*, *: *significant at 0.05 level*, **: *significant at 0.01 level*
OF : *Organic farming*, CF : *Conventional farming*
Δ% : *Difference in percentage between organic and conventional farming*

CONCLUSION

The findings presented throughout this study indicated that organic rice farming is not only environment friendly but also gains more profit and economic efficiency than that of conventional farming with the use of high amounts of synthetic fertilizers. Farmers were also proposed to expand the area of organic rice fields to increase organic rice production. Moreover, farmers became aware of the risks and effects of chemical pesticides and synthetic fertilizers, thus, most of the conventional rice farmers in the study area proposed to stop using agricultural chemicals.

In conclusion, with the positive perception of farmers in Tramkok District, Takeo Province on organic rice farming, 60% of farmers adapted and converted their rice fields into organic farming. Organic rice farming also contributed to the improvement of economic situation to the farmers where its net revenue was higher than that on conventional rice farming.

REFERENCES

Agrifood Consulting International (2002) Rice value chain study: Cambodia, report prepared for the world bank, Phnom Penh, Cambodia, 13-27.

Deichert, G. and Yang, S.K. (2002) Experiences with system of rice intensification (SRI) in Cambodia, Cambodian Center for Study and Development in Agriculture (CEDAC), 01.

Mary, C., Vann, K. and Sun, V. (2000) Survey on environmental and health effects of agrochemical used in rice production in Takeo province, CAMBODIA, 9-17.

Pracilio, G., Bell, R.W., Cook, S., Ros, S. and Seng, V. (N/A) Mapping rice yield and its fertilizer response at provincial-scale in Takeo, Cambodia.

Saruth, C. and Gee-Clough, D. (1998) Agricultural mechanization in Cambodia: a case study of Takeo province, agricultural mechanization in Asia, Africa and Latin America, Tokyo, Japan, 51-56.

Sath, K., Borin, K. and Preston, T.R. (2008) Survey on feed utilization for cattle production in Takeo province. Livestock Research for Rural Development. Volume 20, supplement.

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.

President

Prof. Dr. Mario T. Tabucanon, United Nations University, Institute of Advanced Studies, Japan

Deputy President

Dr. Bunthan Ngo, Royal University of Agriculture, Cambodia

ISERD Secretariats:

Institute of Environment Rehabilitation and Conservation (ERECON)
2987-1 Onoji Machida-Shi, Tokyo 195-0064, Japan
Tel/Fax: +81-42736-8972
E-mail: iserd@int-erd.org
Webpage: www.int-erd.org

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@int-erd.org
Webpage: www.int-erd.org

UNITED NATIONS
UNIVERSITY

UNU-IAS

Institute of Advanced Studies

All articles and reports published in this journal were accepted through a peer-review process. However, most articles and reports published in this journal were presented at the 2nd International Conference on Environmental and Rural Development that was co-organized by United Nations University-IAS.