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Contents

Original Paper

Oral Presentation

Observation of Tsunami Damage to Coastal Forest Using Middle Spatial Resolution Satellite Data

(Observation of tsunami damage to coastal forest by satellite)

Shimpei INOUE[1] and Chinatsu YONEZAWA[1]

[1]Graduate School of Agricultural Science, Tohoku University, Sendai, JAPAN
1-1 Amamiya-machi, Tsutsumidori, Aoba-ku, Sendai, Miyagi 981-8555, JAPAN
Tel: 81-22-717-8661 Fax:81-22-717-9542

Corresponding Author: Shimpei Inoue
e-mail: shinpei.inoue@nrr.meitetsu.co.jp

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Abstract

The coastal forest of the northeast region of Japan's Honshu island was seriously damaged by the tsunami caused by the Great East Japan Earthquake on 11 March 2011. In this study, we examined the possibility of identifying the damage level of the coastal forest using middle spatial resolution satellite data ALOS/AVNIR-2 and TERRA/ASTER. Two types of damage, direct damage immediately after the tsunami and 'Akagare' (red withered) damage that progress after the tsunami, were investigated. Using unsupervised classification, we classified the damage to the coastal forest by the tsunami into four stages. The level of damage by 'Akagare' was estimated using the NDVI and its distributions are revealed in this paper.

Introduction

Coastal forest is an effective protection against tsunamis and other natural disasters, such as tidal waves and typhoons (Tanaka 2009). In the 2004 Indian Ocean Tsunami, mangroves greatly contributed to a decrease in tsunami power in some regions that were hit by the tsunami (Kathiresan et al. 2005, Olwing et al. 2007, Tanaka et al. 2007, Yanagisawa et al. 2009). However, coastal forests cannot completely protect against tsunamis. In the case of huge tsunamis, coastal forests can be uprooted and cause lethal damage to the hinterland and thus result in large amounts of rubble (Tanaka 2009).

A huge tsunami caused by the Great East Japan Earthquake on 11 March 2011, seriously damaged a large coastal area of the northeast region of Japan. Fallen trees, washing away, and inundation caused by direct impact of the tsunami were confirmed immediately after the earthquake. Furthermore, additional tsunami impacts on the trees have emerged, over time, such as 'Akagare', a phenomenon where plant leaves turn reddish brown and wither away. The main reasons for 'Akagare' are generally considered to be infectious diseases and increase in salt concentration in the soil.

The purpose of this study is to investigate the possibility of using middle spatial resolution satellite data to estimate tsunami damage to coastal forests. The coastal forest damage inflicted by tsunamis has been assessed using high spatial resolution data (Koshimura 2007). Further, the large-scale damage inflicted by tsunamis has been analyzed using middle spatial resolution satellite data (Belward et al. 2007, Kouchi et al. 2007, Sirikulchayanon et al. 2008). However, tsunami damage to coastal forests has not yet been analyzed using middle spatial resolution satellite data.

In this study, we examined two types of damage. One is the direct damage immediately after the tsunami, such as fallen and washed away trees. The other is the 'Akagare' progressive damage, which was confirmed over time. To determine direct tsunami damage, we analyzed ALOS/AVNIR-2 data, and extracted coastal forest using the unsupervised classification technique. To determine the 'Akagare'

damage, we analyzed TERRA/ASTER data obtained after the earthquake. The decreases in vegetable activation were estimated from Normalized Difference Vegetation Index (NDVI) computation.

Test site and data

A coastal area of Sendai seriously damaged by the tsunami was selected as the investigation area. Sendai is located in northeast Japan. A coastal forest approximately 650 m wide extended from the seashore before the disaster. The majority of the coastal forest trees were *Pinus*. Figure 1 shows the analysis area for this study (38.1926–38.2505N, 140.9140–141.0210E).

Two areas were set up. An aerial photograph (Figure 2) shows that Area 1 (38.2367–38.2376N, 140.9917–140.9925E) did not sustain 'Akagare' damage, whereas Area 2 (38.2357–38.2367N, 140.9938–140.9949E) was seriously damaged. A ground survey conducted on 9 November 2011 confirmed both direct tsunami damage and 'Akagare' damage.

Two series of Middle Spatial Resolution Satellite Data, ALOS/AVNIR-2 and TERRA/ASTER/VNIR were analyzed. AVNIR-2 data were obtained on 25 December 2006 and 19 March 2011, before and after the tsunami, respectively. ALOS completed its operation in May 2011. ASTER/VNIR data were obtained after the tsunami on 19 March 2011, 9 June 2011, and 23 November 2011. AVNIR-2 provides multi-spectral 10-m resolution images with 70-km swath width. ASTER/VNIR provides multi-spectral 15-m resolution images with 60-km swath width.

Aerial photographs were used as reference data. The aerial photos from the Geospatial information Authority of Japan (GSI) were taken on 12 March and 26 May 2011. A ground survey was conducted on 9 November 2011.

Methodology

1. Extraction of direct tsunami damage immediately after the tsunami

NDVI was calculated as follows:

$$NDVI = (NIR - RED) / (NIR + RED) \times Gn + Of \quad (1)$$

Here, Gn is gain and Of is the offset. One hundred was applied for both gain and offset. NIR corresponds to the near infrared band and RED corresponds to the red band.

Unsupervised classification was applied to the dataset including original data of the AVNIR-2 4 bands and that of the computed NDVI band. In this study, the ISODATA clustering method was used for unsupervised classification. The ISODATA clustering method is classification method that creates clusters automatically from the initial condition. Test area is classified into thirty classes with the unsupervised classification, and one of these classes is corresponded with vegetation. Coastal forest is identified from vegetation class.

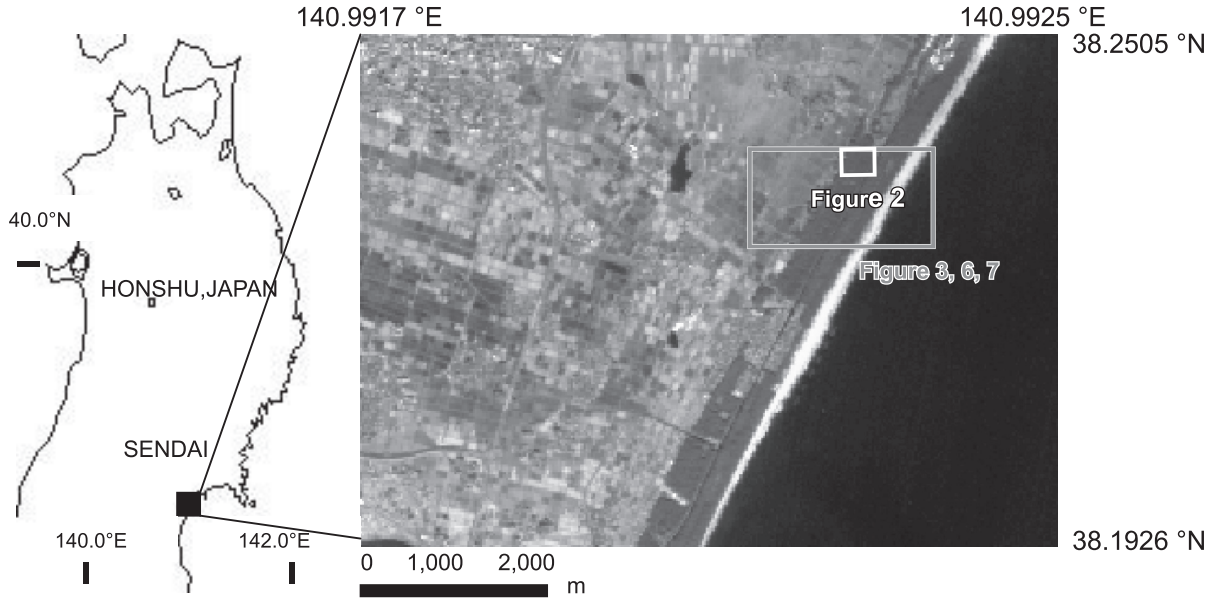

Figure 1. ALOS AVNIR-2 image of the Sendai area obtained on 25 December 2006. Color composite is false color. The white rectangle corresponds to the aerial photograph shown in Figure 2. The magenta rectangle corresponds to the area shown in Figures 3, 6, and 7.

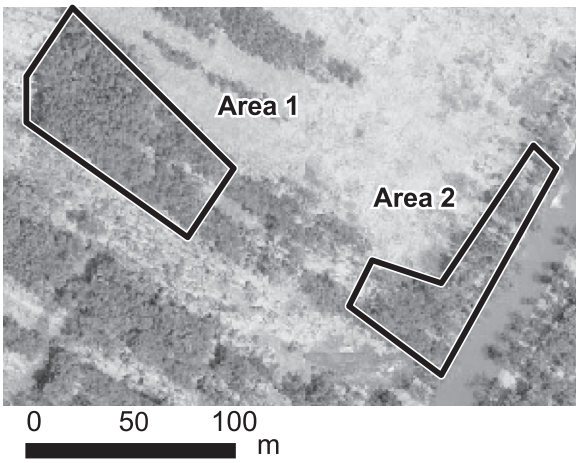

Figure 2. Aerial photograph acquired on 26 May 2011 by the Geospatial Information Authority of Japan. Area 1 corresponds to the area where 'Akagare' damage was not found. Area 2 is a seriously 'Akagare' damaged area.

The damage conditions of coastal forest after the tsunami were categorized with unsupervised classification. The coastal area in the AVNIR-2 data obtained on 19 March 2011 was classified into 30 classes. In order to classify vegetation coverage in the after-tsunami image, the non-vegetation area identified in the before-tsunami image was removed, because the removal of the non-target area decreases the errors in classification (Taguchi et al. 2003). We evaluated the classification results and compared them with the ground survey data.

2. Extraction of "Akagare" damage

NDVI of the three ASTER data were calculated using Equation (1). One hundred and twenty five was applied for both gain and offset. In this study, the NDVI were subtracted from each other to correct for reflectance between datasets easily. We call these data 'NDVI differences data'.

19 March – 9 June NDVI differences data : 19 March NDVI – 9 June NDVI (2)

9 June – 23 Nov NDVI differences data : 9 June NDV – 23 Nov NDVI (3)

19 March – 23 Nov NDVI differences data : 19 March NDVI – 23 Nov NDVI (4)

The relationship between 'Akagare' damage and decreases in NDVI was examined.

Results and Discussion

1. Extraction of direct tsunami damage

Figure 3(*a*) shows the identified vegetation area from unsupervised classification of the test site before the tsunami. One classification corresponds to vegetation area. The coastal forest is the dominant type of vegetation in the vegetation area.

In the after-tsunami image, visual interpretation with aerial photograph, four categories of damaged coastal forest were identified from unsupervised classification: remaining undamaged trees (No damage); remaining but fallen trees (Damage); removed trees and inundated land (Inundation); and removed trees with the land left bare (Bare land). These categories are shown in figure 3(*b*). Error matrices were used to assess the classification accuracy. An aerial photograph was used for reference. The overall accuracy, random 200 points corresponding, was 79.50 %, with Kappa statistics of 0.6387.

The spectral reflectance of the four identified damage categories is shown in Figure 4. The digital number of each category is the average of all pixel data in the analysis area shown in Figure 1. The digital numbers of the 'No damage' and the 'Damage' classes are high in band 4 (NIR) and low in band 3 (RED). These characteristics correspond to vegetation. The 'No damage' class shows a larger difference in the digital number between band 3 and band 4 than the 'Damage' class. A larger difference between the digital number of band 3 and band 4 indicates a larger NDVI. The digital numbers of the 'Inundation' class are low in band 3 and band 4. The 'Inundation' class corresponds to an area where coastal forest was removed and the land was inundated, so the spectral reflectance in this area is similar to that of water. The digital numbers of the 'Bare land' class are high in all bands, which can be explained by the influence of soil.

Some misclassifications are confirmed by visual interpretation. One reason for misclassifications is that the 'No damage' and 'Damage' classes show similar spectral reflectance characteristics. We defined the 'Damage' class as the area of fallen trees that remain in site, so this area contains trees in different conditions. It includes fallen trees with and without leaves. The fallen trees with leaves show similar characteristics to trees in the 'No damage' class, and fallen trees with no leaves show similar characteristics to the 'Bare land' class and the 'Inundation' class, which could lead to misclassification.

The classification results were compared with ground survey data. In figure 3(*c*), three purple

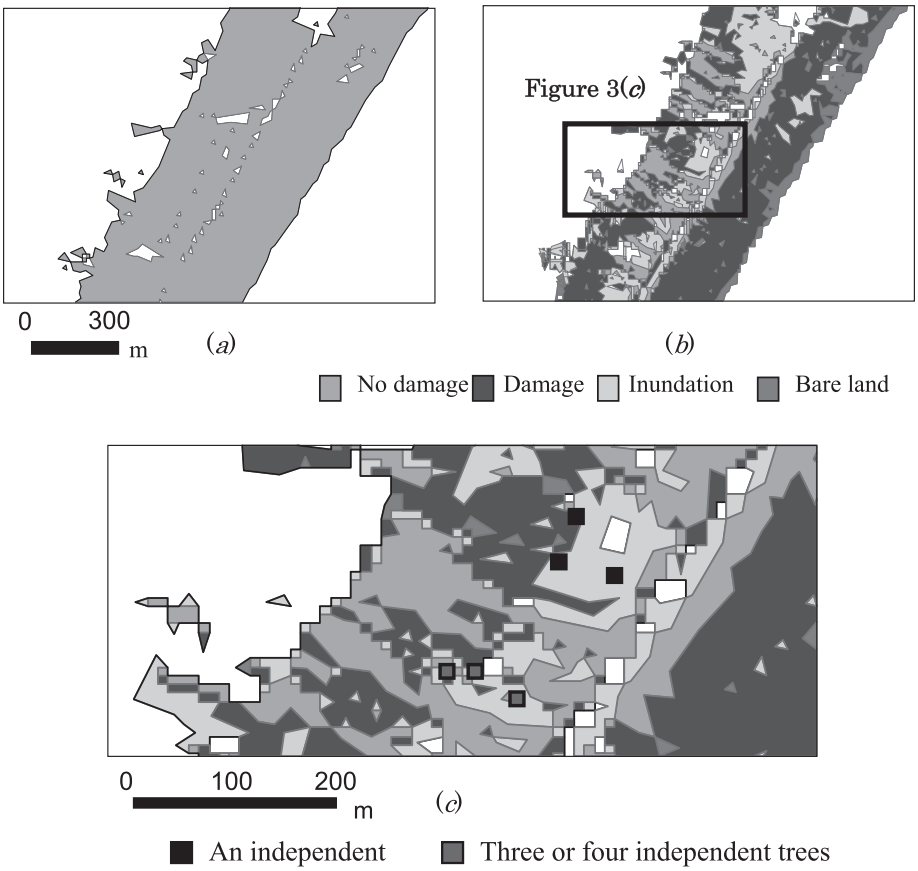

Figure 3. Classification image of the coastal forest area (*a*) before the tsunami, (*b*) after the tsunami, and (*c*) expanded image of the rectangular area denoted (*b*). The rectangular area in (*b*) corresponds to the area shown in (*c*)

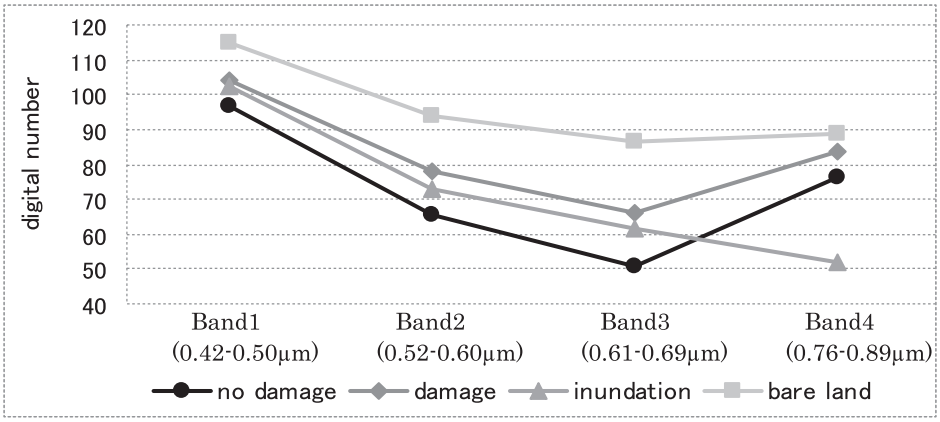

Figure 4. Spectral reflectance characteristics of the four damage categories.

squares show points where an undamaged tree stood independently. Three blue squares show points where a group of three or four undamaged trees stood independently. Two of three independent undamaged trees were classified to the 'Inundation' class rather than, the 'No damage' class. On the other hand, all of the groups of trees were correctly classified in the 'No damage' class. The mixel problem may cause misclassification of independent trees. Grouping of trees may help to avoid this problem. A mixel is a pixel that contains more than one category. The mixel problem is prominent in low spatial resolution satellites. ALOS/AVNIR-2 is a middle spatial resolution satellite with 10-m spatial resolution, which is considered insufficient for precise classification of the condition of an independent tree.

2. Extraction of 'Akagare' damage

The relation between 'Akagare' damage and decrease in NDVI was examined. The 19 March-9 June NDVI differences data for the area with no 'Akagare' damage (Area 1) and the area with extensive 'Akagare' damage (Area 2) are shown in Figure 5. A paired F-test with a 95% confidence interval showed no difference in dispersion between Area 1 and Area 2. Next, a single t-test with a 95% confidence interval that assumed same dispersion showed the average of Area 2 is larger than that of Area 1. Therefore, the decrease in NDVI in Area 2 is larger than that in Area 1. Three factors are considered as the reason decreasing NDVI. The first possible factor is seasonal change in vegetation activation. Vegetation activation is generally high in summer and low in winter, so NDVI usually increases in summer and decreases in winter. However, the predominant tree species in the target area is *Pinus*. Since *Pinus* is an evergreen tree, it would not exhibit such a seasonal change in vegetation activation. If the vegetation activation changed, the NDVI in the period from 19 March to 9 June would increase. The second possible factor for NDVI decrease is the occurrence of a large-scale natural disaster. However, such a disaster did not happen during the observation period (19 March to 23 November) at the test site. Visual interpretation of ASTER data indicates neither large-scale reduction in coastal forest nor changes in land use. The third possible reason is 'Akagare' damage. Because of the low probabilities of other factors, we infer that the decreases in NDVI were caused by 'Akagare' overwhelmingly. There is a relationship between NDVI decrease and 'Akagare' damage.

A composite image of 19 March-9 June NDVI differences data and 9 June-23 Nov NDVI differences data is shown in Figure 6. The transition of area showing an NDVI decrease from 19 March to 23 November is also shown. The area showing a NDVI decrease in trees corresponds to the area classified as the 'No damage' area in the after tsunami classification.

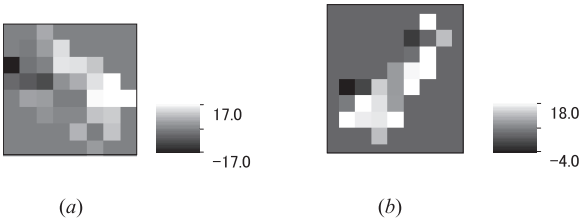

Figure 5. 19 March-9 June NDVI differences data for (*a*) Area 1 and (*b*) Area 2 shown in Figure 2.

The area that is not black in Figure 6 corresponds to the area of coastal forest identified from the ALOS/AVNIR-2 image classification before the tsunami. In Figure 6, the green area shows that the 19 March-9 June NDVI differences data are greater than 0 and the 9 June-23 Nov NDVI differences data are equal to or lower than 0, indicating a remarkable decrease from 19 March to 9 June. The magenta area shows that the 19 March-9 June NDVI differences data are equal to or lower than 0 and the 9 June-23 Nov NDVI differences data are greater than 0, indicating a remarkable decrease from 9 June to 23 November. The white area indicates that the 19 March-9 June NDVI differences data and the 9 June-23 Nov NDVI differences data are higher than 0, indicating a decrease from 19 March to 23 November, via 9 June. An area showing NDVI decrease from 19 March to 9 June was identified. This indicates the occurrence of 'Akagare' damage on 9 June. From 9 June to 23 November, the NDVI decreasing area spread. This could be interpreted as expanding of 'Akagare' damage during this term. 'Akagare' damage in Area 2 is confirmed by aerial photographs. Most of Area 2 is occupied by white pixels, which indicates that the decrease in NDVI had begun before 9 June. White pixels are also found in Area 1, where 'Akagare' damage was not found on 26 May. The mixel problem could possibly explain the presence of white pixels in Area 1. There is a possibility that 'Akagare' damage in Area 1 was not identifiable from the aerial photograph. The ASTER data was acquired 14 days later than the aerial photograph observation, and 'Akagare' damage could have occurred during this term.

Levels of NDVI decrease were estimated by setting up a threshold for the 19 March-23 Nov NDVI differences data (Figure 7). The average of 19 March-23 Nov NDVI differences data in the investigation area is -2.59418. In NDVI differences data, a value close to the average indicates a slight change in NDVI. A value larger than the average indicates a decrease in NDVI, a value smaller than the average indicates an increase in NDVI. The area classified as 'No damage' immediately after the tsunami shows values that exceed the average by far. This means that the area with decreasing NDVI spread wide. A decrease in NDVI is found in Area 1 and Area 2. However, the decrease in Area 2 is larger than that in Area 1.

The area closest to the sea was severely damaged. There are pixels that indicate a different class from

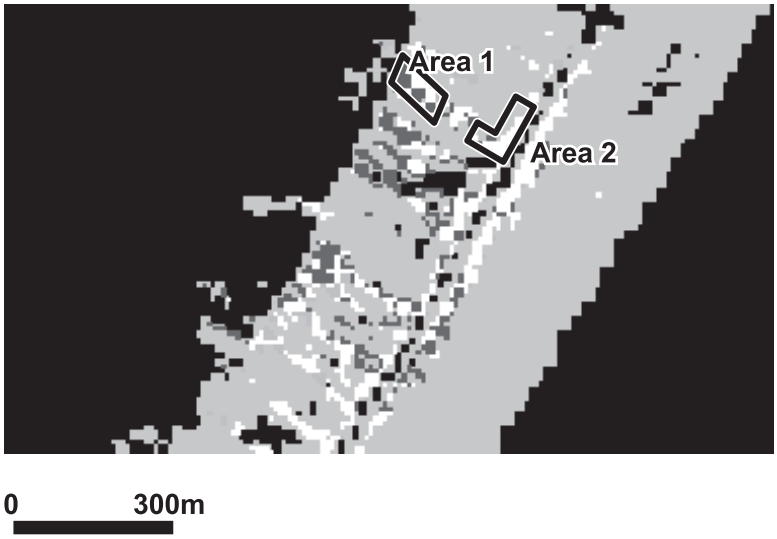

Figure 6. Composite image of 19 March-9 June NDVI differences data and 9 June-23 Nov NDVI differences data. R:G:B = 9 June-23 Nov NDVI differences data : 19 March-9 June NDVI differences data : 9 June-23 Nov NDVI differences data. Green area shows 19 March-9 June NDVI differences data > 0 and 9 June-23 Nov NDVI differences data : 0. Magenta area shows 19 March-9 June NDVI differences data : 0 and 9 June-23 Nov NDVI differences data > 0. White area shows 19 March-9 June NDVI differences data > 0 and 9 June-23 Nov NDVI differences data > 0.

Figure 7. Level of the 19 March-23 Nov NDVI differences on the 'No damage' coastal forest area after the tsunami.

the predominant class around them. This may arise from the mixel problem. In this case, a pixel contains a large other area than a pixel that is not influenced by the mixel problem, and hence, the pixel does not indicate the characteristics of the vegetation when there is a small decrease of NDVI. The influence of mixel is most likely to arise in areas at the boundary between coastal forest and other areas.

Conclusion

We analyzed middle spatial resolution satellite ALOS/AVNIR-2 and TERRA/ASTER data from the Tohoku coastal forest area, collected before and after the 11 March 2011 earthquake off the Pacific coast of Tohoku, and obtained the following results:

1. The damage to coastal forest immediately after the tsunami is assessed and classified into four classes

by unsupervised classification.

2. A relationship between the decrease in NDVI and the damage by 'Akagare' is revealed. 'Akagare' damage was found on 9 June and it has since expanded. The 'Akagare' damage was serious in the areas near the sea.

It is difficult to detect the distribution of damage in detail at an independent tree scale because of the mixel problem. However, in the case of a large-scale disaster like the 2011 Tohoku Earthquake, it is necessary to estimate the damage of a wide area quickly. The middle spatial resolution satellite with 10-15 m resolution can observe a 60-70 km swath width. It is valuable to detect the damage distribution of coastal forest immediately after the disaster and the progressive damage after the disaster.

Acknowledgments

We used ALOS/AVNIR-2 data provided by the Japan Aerospace Exploration Agency (JAXA), TERRA/ASTER data provided by the Geo GRID project team of the National Institute of Advanced Industrial Science and Technology. We would like to thank for them.

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Potential Evaluation of a Locally-Designed Wind-Pump System for Water Pumping to Irrigate Rice Crop Based on a Ten-Year Weather Data in the Philippines

Elmer G. BAUTISTA[1], Nguyen Thanh NGHI[2], Masanori SAITO[3] and Manuel Jose C. REGALADO[1]

[1]Rice Engineering and Mechanization Division, Philippine Rice Research Institute, Maligaya, Science City of Munoz, Nueva Ecija, Philippines
[2]Center for Agricultural Energy and Machinery (CAEM), Nong Lam University, Ho Chi Minh City, Vietnam
[3]Field Science Center, Graduate School of Agricultural Science, Tohoku University

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Abstract

Windmills for water pumping and electricity generation have been an important point of interest in the world today. This study was aimed to examine the actual performance of a locally designed wind-pump system installed in Tarlac, central Luzon, Philippines, and to evaluate its potential using a 10-year (2004-2013) weather data, and to assess the input-output energy of the wind-pump system. Field tests showed that the daily discharge of the wind-pump system fluctuated from 0.7 m^3 day^{-1} to 22.1 m^3 day^{-1} with an average of 9.2 m^3 day^{-1}. Based upon the relationship between wind speed and discharge of the wind-pump system, annual average daily wind speed of 1.78 m s-1 in Nueva Ecija, central Luzon, Philippines will make it possible to discharge 8.38 m^3 day^{-1} of water with the wind pump. The potential of the wind-pump estimated from an average of 10-year weather data showed that the highest daily water output was in December with daily average of 7.34 mm d^{-1}, and that the lowest was in August with an average daily output of 1.27 mm d^{-1}. An average pumping output during dry season (December to March) was estimated to be 14.13 m^3 day^{-1} which was far below for irrigating 1 hectare of rice field. The energy output was computed from the water output of the wind-pump system which was assumed to be used for 20 years. The energy input and output of the wind-pump system was 25.0 GJ and 37.5 GJ, respectively. The raw materials for manufacturing the system contributed to the highest proportion of the energy input. The input-output energy ratio was found to be 1.5 within its 20 years life.Thus, the wind pump system in this study has only a limited potential for irrigation to rice field under the weather conditions in central Luzon. It may be needed to explore more suitable use of the present system such as drip irrigation to vegetables.

Introduction

The interest in renewable energy (RE) sources especially wind energy for electricity generation gained interest towards the end of 20th and beginning of the 21st century. Wind is abundant and free natural resources especially in the tropics like the Philippines. Wind energy is socially, industrially and politically accepted as practically clean and naturally unlimited source. Wind power was used as a source of mechanical energy especially for irrigation as early as 1000 AD by the Europeans.

In 1854, the first windmill with four wooden blades was patented by Daniel Halliday in America (Rao 2011) and more than 6.5 million windmills of this kind were sold in 1880- 1935. In 2008, the 12 bladed Kijito wind-pump also became popular in the US and other parts of the world (Harries 2002). Many windmills are still used today for pumping livestock water and domestic water supplies. These units normally produced maximum power of 1 kW and pump less than 3 m^3 h^{-1} (Clark 1979). However, the discovery of the internal combustion engine and the development of electrical grids caused many windmills to disappear.

In the last decade of 20th century, however, a million windmills were used mainly for water pumping, despite the spread of electric pumps (Fraenkel 1999). In 1996, a small wind pump for manufacture in de-

veloping countries was developed (Fraenkel 1996). Some studies were conducted to optimize pumps and windmill design for a given situation (Bragg 2009), for possibility of lifting irrigation water in India (Parikh 1984), Central Nigeria (Clouter 2011) and Turkey (Kedare 1990). Mathematical equation of the electrical and mechanical behavior of the windmill was also derived including equation for optimization of the low technical wind pump (Valdes 2001). A rope wind-pump was also designed in Nicaragua to ultimately reduce cost of fabrication (Ikilic 2010).

In the early 21st century, installed wind power capacity of top ten countries such as Germany, Spain, the U.S., Denmark, India, Netherland, Italy, Japan, England and China made up 86% of the world (Chinh 2007). In 2007, there were 93,850 MW generated through wind energy in the whole world. In recent years, there has been a revival of interest to introduce cost-effective wind energy conversion systems for this renewable and environmentally benign energy source.

Currently, most windmills for water pumping applications have horizontal axis variety, and have multi-bladed rotors to supply high torque required to operate a mechanical pump. In Philippines, only few windmills are found in the country side to pump water for household purposes. Since most windpumps does not start below 3 m s^{-1} wind and will furl at 12–15 m s^{-1}, water output is critically dependent on prevailing wind (Berry 2005) and design of the rotor (Purohit 2007). A wind-powered irrigation system developed in the Central Philippine University through a project sponsored by the DOST-PCARRD (Department of Science and Technology-Philippine Council for Agriculture, Forestry and Natural Resources Research and Development) and MoWEC (Mobile Wind Energy Plant) in 1997 for surface and pressurized irrigation (Omara 2004) have shown the technical feasibility and commercial viability. The wind-pump system, shown in the Figure 1, consisted of 24 blades, horizontal axis rotor windmill with a 10-m tower, a cylinder pump and water tank. Several windmills of this type was installed, one unit at the PhilRice's model farm, two units in Pampanga, four in Quezon and four in Tarlac which served as a demonstration units. The unit installed in Tarlac province was the one considered in this study because it is situated in a rice farm with insufficient irrigation source. The study site has an average wind speed of 4.4 m s^{-1} at 30-meter height and 3.6 m s^{-1} at 10 m height (Elliott et al., 2001). It is located in a rain-fed area where rice crops could be planted only in the wet season.

This study was carried out to evaluate the performance of a locally designed wind-pump system, and

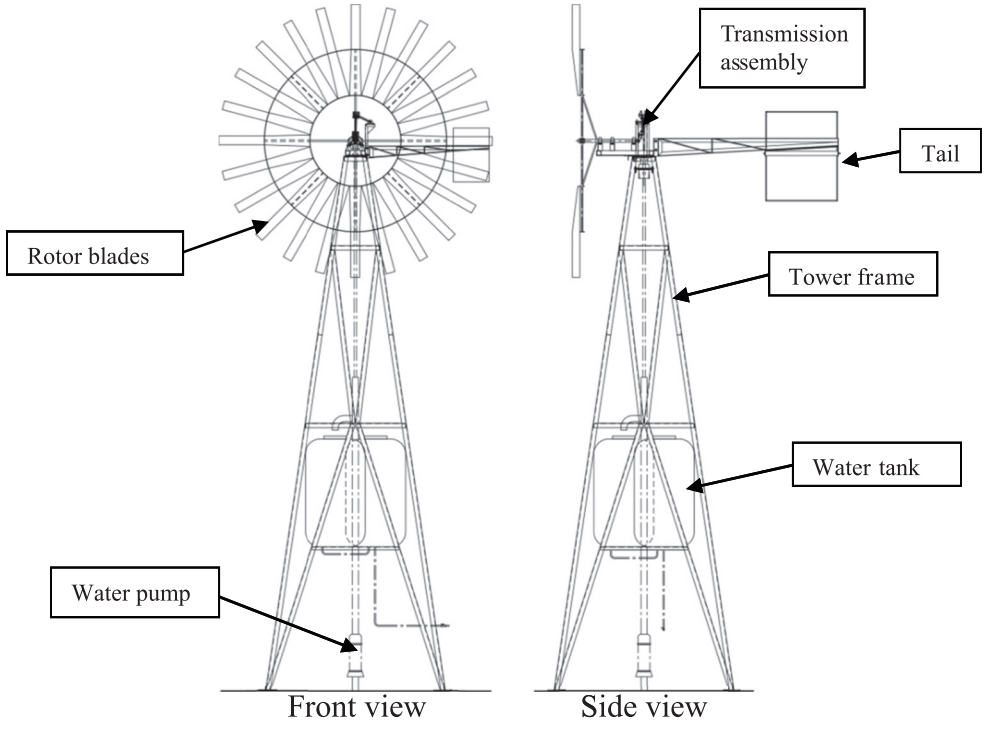

Figure 1. The schematic diagram of the locally-designed wind-pump system for water pumping

especially to assess the potential water output of the wind-pump system using a 10-year (2004-2013) weather data and to determine its capacity to irrigate rice field. Furthermore, the energy input for manufacturing the wind-pump system and the energy output of the pumping were evaluated.

Materials and methods

(1) Performance of the wind-pump

Site Description

The wind pump system was located in Barangay Magaspac, Gerona, Tarlac, central Luzon (15º 3N 130º 35 E). Specification of the wind pump is shown in Table 1 and is schematically show in Figure 1. Water table in the area has an average depth of 3 meters from ground surface. There were many shallow tube-wells serving around about 1 hectare per unit as the main source of irrigation water for rice and sugar cane crops in Barangay Magaspac.

Pumping rate

Pumping rate was measured to evaluate capability of the wind-pump system for water pumping in April-July 2010. It was directly recorded by water meter installed at the discharge of the wind-pump with respect to the given wind speed. These parameters were used to calculate water pumping capacity of the wind-pump system based upon an analyzed wind speed data. The relationship of the wind speed data and pumping rate was analyzed and came up with regression analysis equation which was used to derive the estimated wind-pump discharges. Several level of pumping rate corresponding to wind speed was then determined.

(2) Potential of the wind-pump: Estimation with a 10-year weather data

A 10-year daily rainfall and wind speed data from 2004-2013 was acquired from PhilRice weather station. The PhilRice monitoring station is located in Maligaya, Science City of Munoz, Nueva Ecija, Philippines with coordinates 15º 40’ 17”N 120º 53’ 27”E approximately 33 km from the wind-pump system in Gerona, Tarlac. This was the nearest weather station from the windmill installation during the conduct of the study.

Table 1. General specification of the locally designed wind-pump system

Model	CPU WP – 24450
Rotor diameter	4.5 m diameter with 24 blades
Speed control mechanism	Main hinge vane and side vane
Tower height	10 m steel lattice tower type
Installed pump	Cylinder water pump 44 cm diameter bore
Start-up wind speed (windmill will start)	2.2 m s^{-1}
Cut-out wind speed (windmill slow down by side vane)	Indeterminate

Water output of the wind-pump system based on normalized 10-year wind speed data was predicted using the relationship between the monitored daily wind speed and daily discharge of the wind-pump system. Total potential water supply was calculated by including water pumped from the wind-pump system and rainfall as well. The 10-year data from PhilRice weather monitoring station was analyzed.

(3) Evaluation of energy input and output in the wind-pump system

Energy input for manufacturing the wind-pump system was evaluated. Energy output created by the operation of the wind-pump was also estimated by estimating the total water output pumped by the wind-pump system in 20 years (Wang 2012, Varun 2009). The total water output was calculated using the daily average output found in previous study multiplied to 365 day-year and energy coefficient of irrigation water 0.615 MJ m^{-3} (Pimentel 1992, Ozkan et al 2008, Esengun 2006).

Data for manufacturing such as duration of operations and electricity consumption were monitored during actual cutting, bending, welding, drilling and machining of wind pump specific parts. Shop operations were individually measured using a stopwatch in three replications each. Dimensions of materials were measured from raw materials before shop works had been done. Length of welding of each part was measured from the wind-pump system previously constructed in the study site.

Several shop equipment for manufacturing were used during fabrication of wind-pump system. An

arc welding with 22kW, 500A was ordinarily used to weld parts of the wind-pump system. Actual welding of materials was done to gather information for specific material and correspondingly measuring the length and time of welding. Shear cutter machine with 5.7 kW power rating was used to cut sheet metal for the wind-pump blades. Cutting of sheet metal was done by two technicians who simultaneously holding and controlling the shear cutter. The 4.2 KW lathe machine was used for machining main shaft of rotor. The total time consumed by one technician to fabricate specific part was manually measured.

The energy input for human labor, electricity and steel material was computed using the energy coefficient of 0.8 MJ h^{-1} (Pimentel D. 1992, Umar 2003,) 12.36 MJ kWh^{-1} (Pimentel 1992, Esengun 2006) and 20 MJ kg^{-1} (Hammond G. and Craig J., 2008), respectively

System boundary

Figure 2 shows the system boundary of this study. The system boundary included the raw materials, fabrication, and utilization of the wind-pump system. The energy of scrap materials after 20 years was not included in the study due to unavailable energy factor for scrap metal in the Philippines.

Results and Discussions

(1) Performance of the wind-pump

Figure 3 shows wind speed and water discharge with the wind-pump system. Wind speed form April to July 2010 was monitored at the study site in daily and hourly measurement with varying value from 0.1 m s^{-1} to 2.7 m s^{-1}. The computed average daily wind speed was 1.6 m s^{-1}. The daily discharge of the wind-pump system varied from 0.7 m^3 d^{-1} to 22.1 m^3 d^{-1} with average discharge of 9.2 m^3 d^{-1}. Highest wind speed of 2.7 m s^{-1} resulted to highest discharge which was observed somewhere in April while the lowest was in May with wind speed of 0.5 m s^{-1}. The functional relationship between the wind speed and the discharge of the wind-pump system was found as follows.

$$\mathbf{q_s = 6.6433*V - 3.4436} \quad (R^2 = 0.9069)$$

where: q_s = discharge of suction pump, m^3 day^{-1}

V = wind speed, m s^{-1}

This indicates that, with annual average daily wind speed of 1.78 m s^{-1} in Nueva Ecija, the discharge of the pump will be 8.38 m^3 day^{-1}.

(2) Potential of the wind-pump: Estimation with a 10-year weather data

Figure 4 shows the 10-year (2004-2013) average daily rainfall from weather station at PhilRice, Nueva Ecija. Highest average daily rainfall were observed in the month of August with average 13.92 mm d-1 and lowest was in the month of January with average 0.15 mm d^{-1} only. The rainfall in 2005 and 2006 had the

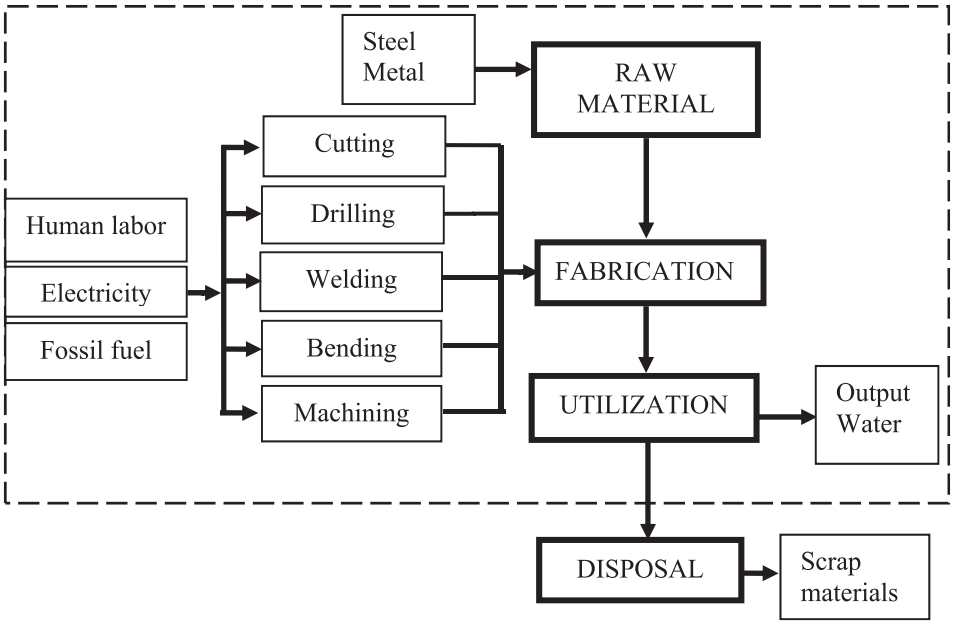

Figure 2. System boundary for evaluation of manufacturing the wind pump system,

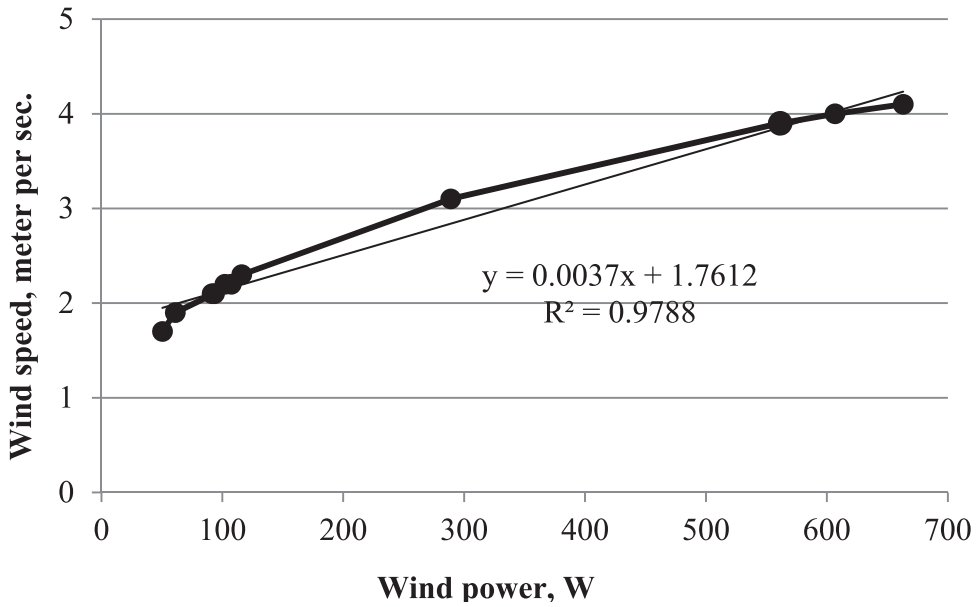

Figure 3. Relationship between wind speed and wind power. Field data was collected at Tarlac, central Luzon, Philippines

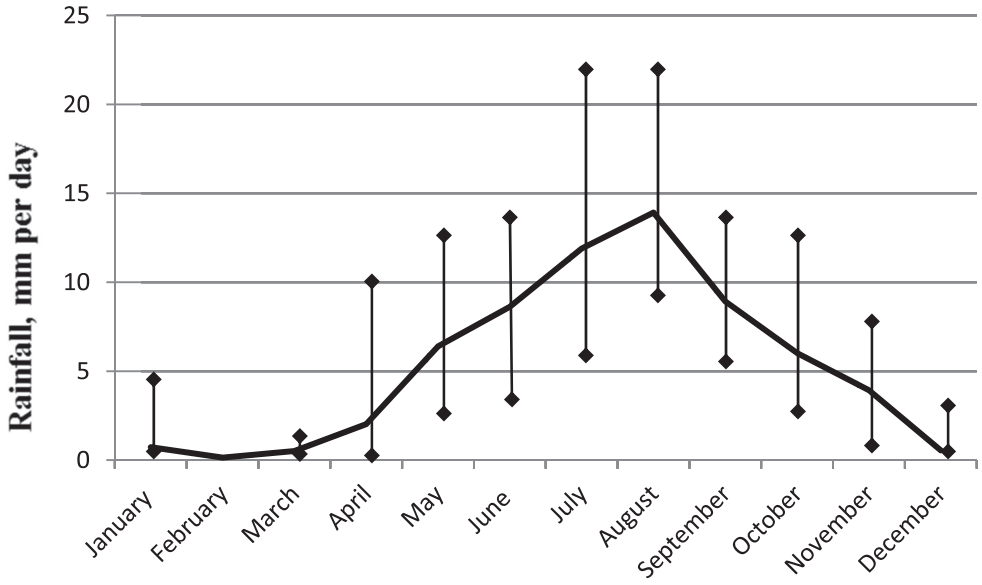

Figure 4. The 10-year rainfall data at PhilRice, Nueva Ecija, Philippines.

highest amount of daily average rainfall to almost 22 mm d^{-1} which were also observed in August and July, respectively. Rainfall usually started in the month on May until October then became very low to almost zero rainfall in December until March.

Figure 5 shows the 10-year (2004-2013) annual average wind speed data at PhilRice weather station. Strongest average wind speeds were monitored during December with 3.28 m s^{-1} and January with 2.88 m s^{-1}. This became weaker during the months of April until September of every year to only about 1 m s^{-1}. The year 2007 and 2008 had apparently strong winds in this period. The average prevailing wind speed that was favorable to wind-pump system was observed in the months from November to February, hence, remaining months' average fell below for starting up wind speed. It was also noticeable that wind during the low rainfall months was favorable to wind-pumping operation.

Figure 6 shows the monthly change in rainfall, water pump output, and estimated water availability in comparison with water requirement for 1/4 ha of rice

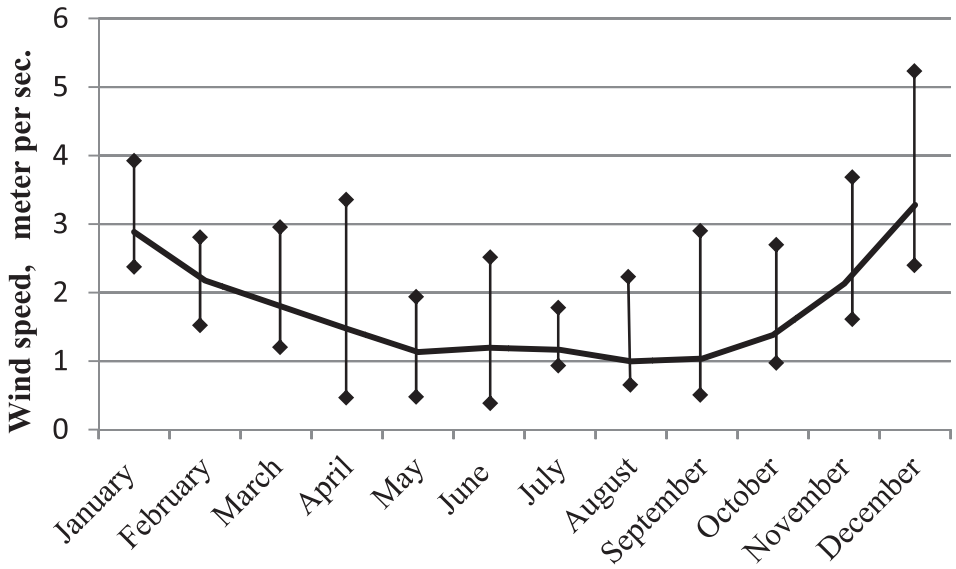

Figure 5. Ten-year wind speed at PhilRice, Nueva ecija, , Philippines.

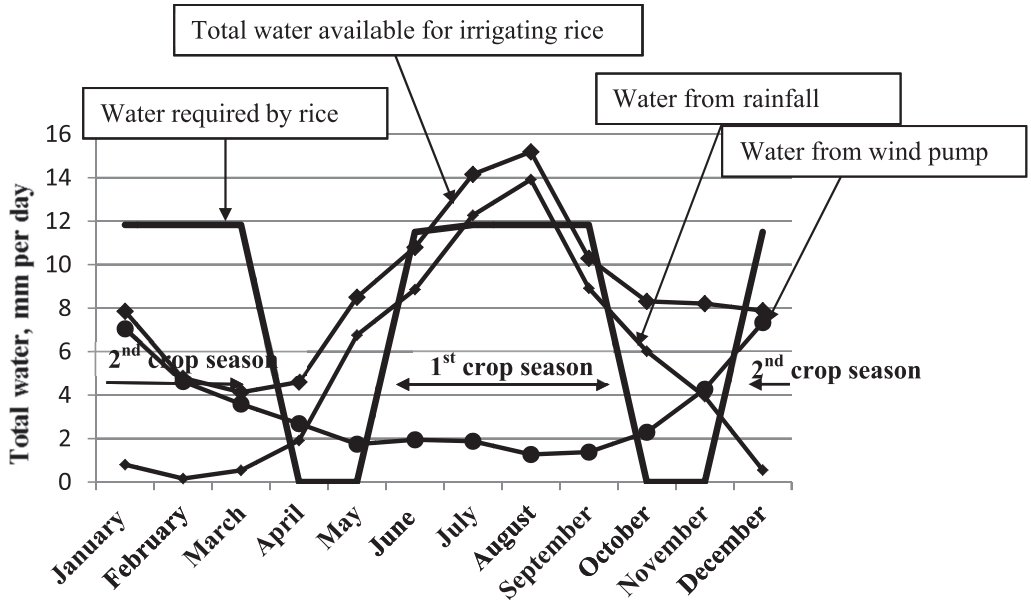

Figure 6. Monthly change of rain fall, wind pump output and their sum in comparison with water requirement in 1/4 ha rice field.

field. Water availability is the sum of rainfall and water output by the wind pump system, which was estimated based upon the weather data and the empirical equation in the section (1).

Rice cropping season in the Philippines commonly started on every December and June, and will be harvested every March and October for dry season and wet season crop season, respectively. Water requirement of rice crop will be at the least 11.8 mm d^{-1} (Yoshida 1981). In dry season, therefore, supplying irrigation water for rice crop from wind-pumping alone will make it insufficient even for 1/4 ha (Figure 6). However, the wind-pump may contribute to a supplemental role for irrigation. Assuming that 1 ha of rice field needs 11.8 mm d^{-1} in average for a growing period, 120 days, in a dry season, it is equivalent to 13,200 m^3ha^{-1} $season^{-1}$. If the water is irrigated by the sum of rain fall and pumped up water by engine, it may require 389 L/ha/season of diesel oil for water pump because the common diesel water pump has an ability to discharge 32.4 m^3h^{-1} with one liter of diesel oil. During dry season, total 1,717 m^3 of water can be discharged by the wind-pump system, so the diesel oil needed for pumping up 1,717 m^3 could be reduced. This corresponds to 53 L diesel oil per ha a dry season. In terms of greenhouse gas (GHG) emis-

sion due to combustion of diesel oil, 140 kg CO_2eq could be reduced per ha.

Thus, the wind pump system in this study has only a limited potential for irrigation to rice field under the weather conditions in central Luzon. It may be needed to explore more suitable use of the present system such as drip irrigation to vegetables.

(3) Evaluation of energy input - output and GHG emission of the wind-pump system

Table 2 shows energy input-output estimates for 20 years of wind pumping operations. The energy input of the wind-pump system was 25.0 GJ with raw materials being the biggest energy contributor at 23.2 GJ followed by welding at 1.8 GJ. Other fabrication activities contributed a very small amount of input to the system. Energy output was found at 37.5 GJ composed of pumped irrigation water by wind-pump system within a 20 years period. This showed that using the wind-pump system could give more benefit compared to the cost of fabricating the unit. The energy input-output ratio was 1.5 which indicated that the system is economically acceptable. It showed that wind-pump system could be used for smaller area of rice crop. It could also be suggested to use wind-pump system for irrigation of high value crops and other crops which requires lesser water and which does not require total flooding.

The raw materials of wind-pump system were the major source of input energy. The weight of fabricat-

Table 2. Energy input-output of wind-pump system

Energy input, MJ	Raw materials		
	Rotor		3,780
	Transmission		1,900
	Tail		1,340
	Tower frame		16,140
	Fabrication	Drilling	3.9
		Cutting	16.9
		Bending	17.0
		Machining	23.1
		Welding	1,826.0
	Total		25,045.9
Energy output, MJ	Irrigation water (20 years)		37,487.3
Input-output ratio			1.5

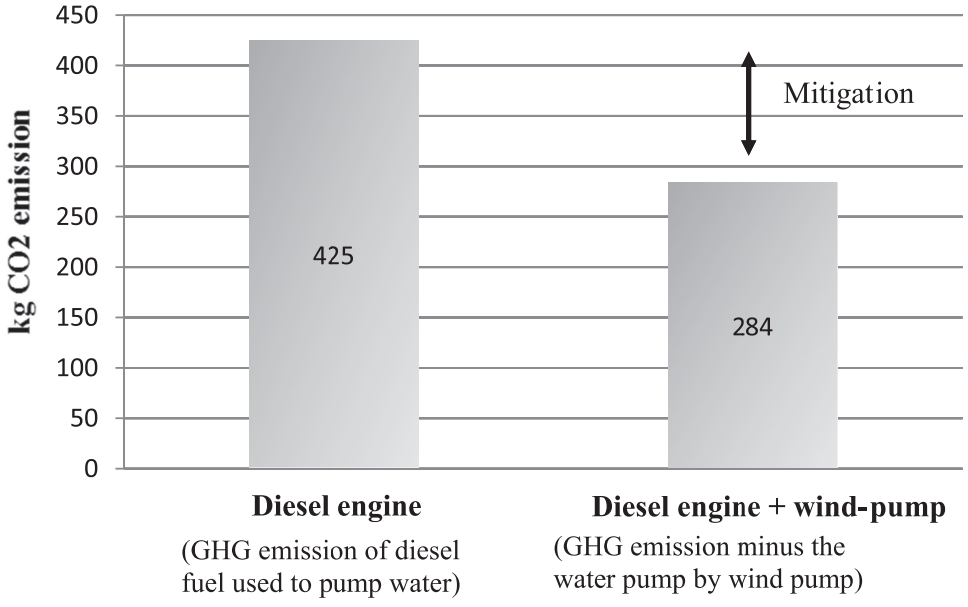

Figure 7. GHG emissions during water pumping for irrigation using full diesel engine and diesel engine + wind-pump system.

ed parts was the basis of energy input computation. The whole wind-pump system has had a total weight of 1158 kg consisted of base plate 75kg, lower frame 428 kg, upper frame 254, rotor 119 and others . It indicates that improving the design of the present wind-pump system will further improve the input-output ratio.

The GHG emission of irrigating rice crop by using engine-pump system minus the rainfall available during the dry season was 425 kg CO_2 eq ha^{-1}. It was computed from the diesel fuel consumed by the engine-pump system to pump the water required to irrigate rice crops. When the wind-pump system was used together with the engine-pump system to pump water, the GHG emission was about 284 kg CO_2 eq ha^{-1}. This means that using wind-pump system during irrigation of rice crop could mitigate around 141 kg CO_2 eq. ha^{-1}.

Conclusion

Performance and potential of the locally designed wind-pump system was evaluated in central Luzon by using the 10-year weather data. The 10-year weather data is very useful in predicting the potential of wind-pump system by estimation of water output in specific area. The wind pump alone could irrigate only an area of 0.25 hectare rice crop from November to April in dry season. However, the wind-pump system in this study has only a limited potential for irrigation of rice fields under the weather conditions in central Luzon. It may be needed to explore more suitable use of the present system, such as drip irrigation of vegetables.

Energy input-output analysis for manufacturing the wind-pump system was proven to be feasible in 20 years of life. The energy output was computed from the water output of the wind-pump system pumped within 20 years of utilization. The input-output energy ratio was found to be 1.5 within its 20 years life. The wind-pump system was proven to be feasible considering energy input-output ratio.

The GHG mitigated during its operation in the dry season pumping also had significant amount. The wind-pump system mitigated the GHG emission during water pumping by replacing the fossil fuel with naturally available source of energy.

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Basidiomycetous Ectomycorrhizal Fungal Communities of Current-Year *Pinus Densiflora* Seedlings That Regenerated on Decayed Logs and on the Forest Floor Soil

Yu FUKASAWA

Laboratory of Forest Ecology, Graduate School of Agricultural Science, Tohoku University, Naruko-onsen, Osaki, Miyagi 989-6711, Japan.
Tel: +81 229 84 7397, Fax: +81 229 84 6490
e-mail: fukasawayuu@gmail.com

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Abstract

Decayed pine logs killed by pine wilt disease (PWD) could be important seedbeds for many tree species in post-PWD forests in Japan. Although mycorrhizal symbionts are essential for seedling establishment on logs, ECM communities on decayed pine logs have not been studied yet. In this study, I measured the number and the properties of *Pinus densiflora* seedlings on pine logs and their associations with basidiomycetous ectomycorrhizal communities using rDNA sequence, and compared them with seedlings on the soil in a post-PWD *P. densiflora* stand in Japan. Pine seedling density, shoot dry mass, and specific root length (SRL) were significantly higher, but shoot/root ratio was lower in decayed logs than in soil. High water and nutrient contents of the white-rotted logs may partially contribute this. The ECM colonization rate was higher but the diversity of operational taxonomic units (OTUs) of basidiomycetous ECM was lower in decayed logs than in soil. In total, 21 basidiomycetes OTUs were detected, and *Amanita citrina* (Amanitaceae) was the most frequent species in decayed logs. Russulaceae and Thelephoraceae were the dominant ECM fungal families in the soil. Electrical conductivity negatively affected the OTU richness, and canonical correspondence analysis showed that the substrate water content, pH, and light conditions significantly affected the ECM fungal communities. *Tomentella* sp.2, Boletaceae sp.1, and *Rhizopogon luteolus* were associated with high pH and dry soil conditions, whereas *A. citrina* and *Lactarius* species were associated with low pH and wet log conditions. There results indicate that decayed logs of *P. densiflora* provide potential seedbeds for their juveniles, and *A. citrina* is the dominant basidiomycetous ECM fungi in the logs at this site.

Introduction

Tree seedling establishment on decayed fallen logs called “nurse logs” is an important mean of tree regeneration in various forest ecosystems (Harmon et al. 1986; Doi et al. 2008; Sanchez et al. 2009; Iijima and Shibuya 2010; Fukasawa 2012). Several advantages of seedling establishment on fallen logs have been reported, e.g., greater light availability (Harmon and Franklin 1989), reduced litter accumulation (Duchesneau and Morin 1999), reduced densities of soil pathogenic fungi (O’Hanlon-Manners and Kotanen 2004), lower root and shoot competition (Coomes and Grubb 2000), a relatively stable water content (Greene et al. 1999), and the high colonization capacity of mycorrhizal fungi (Tedersoo et al. 2008). Mycorrhizal symbiosis is an important nutritional strategy, particularly in nutrient-poor substrates (Read et al. 2004). In general, fallen logs contain less nutrients to support seedling growth compared with soil (Goodman and Trofymow 1998; Baier et al. 2006); thus, the mycorrhizal fungal communities that inhabit logs and their colonization of seedlings may be essential for seedling establishment, particularly during the colonization of highly decayed logs where mycorrhizal fungi dominate the fungal communities (Rajala et al. 2012). Although reports about mycorrhizal fungal communities within decayed logs have been increasing (Tedersoo et al. 2003, 2008, 2009a; Walker and Jones 2013; Walker et al. 2014), diver-

sity of mycorrhizal fungal in decayed logs has been poorly understood.

Japanese red pine (*Pinus densiflora* Sieb. et Zucc.) is a dominant canopy tree species in temperate secondary forests of Japan, while pine wilt disease (PWD) has killed many adult pine trees over recent decades (Takemoto and Futai, 2008). The post-PWD forest vegetation varies from *Pinus* to evergreen or deciduous *Quercus* stands, or plantations of *Cryptomeria japonica* and *Chamaecyparis obtusa*, depending on the climate and forest management regimes (Fujihara et al. 2002; Kato and Hayashi 2006, 2007), while a common feature is the deeply accumulated litter layer, due to the abandonment of coppice management including litter removal from forest floor for use as soil conditioner or fuel (Fujihara et al. 2002). Thick litter layer prevents regeneration of small-seeded tree species such as *P. densiflora*, and in such circumstances, decayed pine logs which massively accumulated on forest floor (Kato and Hayashi 2006) provide important microsites for small-seeded species (Fukasawa 2012). Thus, it is necessary to evaluate the pine logs as regeneration sites for pine seedlings and their ectomycorrhizal (ECM) associations within the logs, in order to find proper deadwood management for successful regeneration of pine trees. ECM community of *P. densiflora* forest is a well-researched area (Yamada and Katsuya 1996, 2001; Iwański and Rudawska 2007; Ma et al. 2010, 2012; Lee and Eom 2013), while ECM communities on decayed pine logs have not been studied yet.

The aims of the present study are (1) to compare pine seedling density and properties between logs and soil, and (2) to compare ECM communities on pine seedlings between logs and soil. Physicochemical properties of pine logs and soil were also compared and their relationships with seedling regeneration and ECM communities were discussed. In the present study, I focused on basidiomycetous ECM fungi because though they are only a part of the ECM communities, they include many functionally important species with ECM-forming capacities and the ability to decay organic compounds (Tanesaka et al. 1993). This dual functionality may be particularly important for colonizing and supporting seedling growth on logs. I expected that basidiomycetous ECM species with saprotrophic abilities such as Thelephorales, Atheliales, and Sebacinales are dominant on pine seedlings as suggested by Tedersoo et al. (2003, 2008, 2009a).

Materials and methods

Study site and sampling

The present study was conducted in a forest park called "Ikoi-no-mori" in Kurihara city (38°43.1′N, 141°00.2′E; 71 m a.s.l.), Miyagi Prefecture, Northern Honshu, Japan. The mean annual temperature for the period 2001-2010 at the nearest meteorological station in Tsukidate (38°44.1′N, 141°00.3′E; 25 m a.s.l.) was 11.3°C. The mean monthly temperature ranged from −0.6°C in January to 23.5°C in August. The mean annual precipitation was 1210.6 mm (Japan Meteorological Agency 2013). The study area was a plantation of *P. densiflora* with an approximate area of 2 km × 1 km, and it was surrounded by a mixture of paddy rice fields and residential districts. *P. densiflora* was the only canopy tree in the study area. The averages and standard errors for the tree density, basal area (BA), and diameter at breast height (DBH) were 7.3 ± 0.8 ha^{-1}, 33.8 ± 3.5 m^2 ha^{-1}, and 23.6 ± 0.8 cm, respectively (average ± SE of six 10 × 10 m plots for tree density and BA and of 44 pine trees within the plots for DBH). The forest floor was covered with a variety of vegetation, including dwarf bamboo (*Pleioblastus chino*), shrubs (*Ilex crenata, Rhododendron obtusum*, and *Viburnum dilatatum*), tree saplings and seedlings (*P. densiflora*, *Quercus serrata*, *Clethra barbinervis*, and *Eleutherococcus sciadophylloides*), herbs (*Thalictrum minus* var. *hypoleucum*, and *Sanguisorba officinalis*), and liana (*Akebia trifoliata*). The forest floor vegetation was annually cleared by cutting and the height was maintained at approximately 10–20 cm. PWD had severely affected the study area for a decade and dead pine trees were felled and cut to lengths of approximately 2 m, before piling up in mounds in the study area. Many of these mounds were observed to be in various stages of decay in the study area.

In October 2012, three mounds were selected and a 1 m × 1 m plot was established on each mound, which included the projecting areas of several logs. All of the logs in the selected mounds exhibited white rot and they were assigned to decay classes IV or V according to the classification of Fukasawa (2012), as follows: class IV wood was considerably decayed, it was penetrable with a knife to approximately 5–10 cm, bark was lost in most places, and the original log circumference had begun to disintegrate; class V

wood had disintegrated either to a very soft crumbly texture or was flaky and fragile, it was penetrable with a knife to >10 cm, and the original log circumference was barely recognizable or indiscernible. Three additional 1 m × 1 m plots were located on the ground adjacent to each of the three mound plots. Thus, three pairs of mound plots and ground plots were established. The numbers of *P. densiflora* seedlings were recorded in each plot. Photon densities were measured 15 cm above the substrates in each plot using a portable spectroradiometer (MS-720, EKO Instruments Co., Ltd., Tokyo, Japan). Because photon densities vary within a short-time scale, three measurements were obtained at intervals of several minutes within a cloudy day, which were averaged and used as the data for each plot.

In each plot, 10–12 current-year *P. densiflora* seedlings (66 seedlings in total) were sampled carefully to collect all of the roots, as far as possible. If sufficient seedlings were not collected within the ground plots, additional seedlings were taken from ground near the plots. The seedlings were taken to the laboratory and divided into aboveground shoots and underground roots. The shoots were oven dried to constant weight at 70°C and weighed. The intact root fresh weight and the overall root length were measured, and individual root samples were cut into two subsamples. The root lengths were measured using ImageJ with a scanned copy of the roots (Tajima and Kato 2013). One subsample was used to calculate a conversion coefficient for the fresh root weight to the dry mass at 70°C. Next, the dried weight of the intact whole root length was calculated based on the fresh weight of the intact root using the conversion coefficient. The shoot/root ratio (S/R) and the specific root length (SRL) were calculated using the following equations.

S/R = shoot dry mass/root dry mass

SRL (m g^{-1}) = root length/root dry mass

Another subsample was used to obtain mycorrhizal fungal colonization measurements and identification.

The substrate for seedling establishment (i.e., decayed log or soil) was sampled from each plot. Each substrate was sampled from three points in each plot, which were combined to form a composite sample. A sample from each plot was mixed well and divided into two subsamples; one was used to determine the water content after drying at 70°C, as the percentage of water weight relative to the dried substrate and the other was used for chemical analysis, after drying at 40°C and grinding using a laboratory mill, followed by sieving through a 2.0-mm mesh.

Mycorrhizal colonization rate and identification

For individual root subsamples, the ECM colonization rate (%) was measured as the percentage of ECM root tips relative to the total root tips (tip ratio). After obtaining the measurements, eight ECM root tips were sampled randomly from each subsample (528 root tips in total) and DNA was extracted from each root tip using a DNeasy 96 plant kit (Qiagen Sciences, Valencia, USA). The internal transcribed spacer (ITS) region of the basidiomycetous fungal rDNA was PCR-amplified using the primer pair ITS1F and ITS4B (Gardes and Bruns 1993). The PCR products were purified using Exo-Sap enzymes (Sigma, St Louis, MO, USA). Sequencing was performed using the same primer pair. An ITS region with a shared identity of 97% was used as the criterion for the molecular identification of species. The taxonomic interpretation depended on the percentage sequence identity at the genus (94%–96% similarity) or family (90%–93% similarity) level. Therefore, the units were identified at a mixture of species, genus, and family levels, which were represented uniformly as operational taxonomic units (OTUs) to simplify the analysis. BLAST searches were performed against the public sequence database at the National Centre of Biotechnology Information (NCBI) and UNITE to identify the ECM fungi. The occurrence of a fungal OTU in a seedling was scored as a binary variable, regardless of the number of root tips colonized by the OTU. The frequency (%) of each OTU in each substrate was calculated as the number of records for an OTU/total number of seedlings (N = 33) ? 100. The OTUs with frequencies >10 % in either of the two substrates were referred to as frequent OTUs.

Chemical analysis of substrates

The pH, electrical conductivity (EC), and the concentrations of cations (Na^+, NH_4^+, K^+, Mg^+, and Ca^+) and anions (F^-, Cl^-, NO_2^-, Br^-, NO_3^-, SO_4^{2-}, and PO_4^{3-}) were measured in the substrate samples (decayed log or soil) from each plot. Dried samples (10–50 g) were extracted using 25 mL of distilled water in a 50-mL polyethylene bottle with manual shaking for approximately 10 s. After leaving for 1 h, the pH of the supernatant was measured using a portable

pH meter (HORIBA, Kyoto, Japan). After obtaining the pH measurement, another 25 mL of distilled water was added to the bottle and the bottle was gently shaken using an automatic shaker for 1 h at 25°C. After shaking, EC was measured using a portable EC meter (HORIBA, Kyoto, Japan). The water extract was then filtered to remove any woody residues or soil particles, before the concentrations of cations and anions were measured using an ion chromatography system (ICS-1000/2000, DIONEX, CA, USA). The EC and ion concentrations were expressed as values per 1 g of dried sample.

Statistical analysis

The light conditions (photon density), water content, pH, and EC of the substrates, as well as the seedling density (no. m^{-2}), shoot dry mass, S/R, SRL, and the numbers and frequencies of ECM fungal OTUs were compared between the decayed log and soil samples using a generalized linear model with R version 2.14.2 (R development core team 2012).

To compare the accumulation and richness estimates for the OTUs in the decayed log and soil samples, rarefaction curves with 95% confidence intervals were calculated using EstimateS version 9 (Colwell 2013). The root systems of individual seedlings were used as the sampling units and they were sampled randomly without replacement.

A canonical ordination method was used to determine the relationships between the basidiomycetous ECM fungal community compositions and the substrate and seedling properties. A detrended correspondence analysis was performed as a preliminary analysis to check the length of the ordination axis, which showed that the length was > 4 SD, suggesting that the response curve could be unimodal. Thus, canonical correspondence analysis (CCA) was appropriate (Jongman et al. 1995). The occurrence data for fungal OTUs with > 10% frequency were binary transformed for each seedling and used as species data. One nominal variable (type of substrate: log or soil) and seven quantitative variables (light, water content, pH, and EC of substrates and shoot dry mass, S/R, and SRL of seedlings) were used as environmental variables. All of the quantitative variables were transformed into Z-scores using the following equation to eliminate the effects of different units:

$$Z = (x_0 - x_\times) / \mathrm{SD},$$

where x_0 is the value of variable x in a particular log and x' is the arithmetic mean of variable x in the sample.

All of the ordination analyses were performed using Canoco 4.5 (ter Braak and Šmilauer 2002), where the relationships between sets of environmental variables and ordination scores were plotted in ordination diagrams. In the diagrams, the arrows for the environmental variables depicted the direction and magnitude of the relationships among the environmental variables and the ECM fungal community. The biplots focused on the inter-species distance. We tested the explanatory variables using the automatic forward selection procedure provided by Canoco 4.5 (Monte Carlo permutation test with 9999 randomizations).

Results

Substrate properties

Table 1 shows the physicochemical properties of decayed logs and soil. The photon densities did not differ significantly between substrates. The water content was over 10 times higher in the decayed logs than the soil. The pH was lower in the decayed logs than the soil. EC was almost 50 times higher in the decayed logs than the soil. The concentrations of Na^+, NH_4^+, K^+, F^-, and Cl^- were greater in the decayed logs than the soil, whereas the concentrations of Mg^+, $Ca^{+,}$ Br^-, SO_4^{2-}, and PO_4^{3-} did not differ significantly between the substrates. The concentrations of NO_2^- and NO_3^- were too low to be detected.

Properties of *P. densiflora* seedlings and mycorrhizal colonization

The seedling density and shoot biomass of *P. densiflora* were significantly higher on decayed logs compared with the soil (Table 2). Very few individuals were observed in soil. S/R was significantly higher in soil than on decayed logs, whereas SRL was higher on decayed logs than in soil. The ECM fungal colonization rate was higher on decayed logs than soil, in terms of the tip ratio. Almost all of the root tips of the seedlings were colonized by ECM fungi on decayed logs.

In total, 21 OTUs of basidiomycetous ECM fungi were recorded from 528 randomly selected root tips (Table 3). Only six OTUs were detected on the decayed logs, which were dominated by Amanitaceae and Russulaceae, whereas all 21 OTUs were detected in soil, which were dominated by Russulaceae, Thelephoraceae, and Boletaceae (Table 4). In addition,

Table 1. Comparison of the qualities of the decayed log and soil substrates

	Log	Soil	P [a]
Photon density (μmol m^{-2} s^{-1})	35.3±2.9	41.5±2.9	n.s.
Water content (%)	439±68	32±11	**
pH	3.99±0.03	4.91±0.05	***
EC (μs cm^{-1})	50.7±9.1	0.9±0.2	**
Nutrients (mg L^{-1})			
Na^+	0.61±0.08	0.17±0.06	**
NH_4^+	1.37±0.27	0.40±0.10	*
NO_2^-	n.d.	n.d.	n.a.
NO_3^-	n.d.	n.d.	n.a.
K^+	6.13±1.85	0.21±0.01	*
Mg^+	0.39±0.21	0.07±0.01	n.s.
Ca^+	1.90±0.96	0.19±0.03	n.s.
F^-	1.25±0.08	0.37±0.06	***
Cl^-	2.04±0.18	0.40±0.06	**
Br^-	0.36±0.14	0.21±0.07	n.s.
SO_4^{2-}	0.39±0.07	0.46±0.07	n.s.
PO_4^{3-}	1.18±0.72	0.01±0.01	n.s.

Data represent average ± standard error (N = 3)
n.d. not detected
[a] GLM results *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, n.s. not significant, n.a. not applied

Table 2. Comparison of the properties of *Pinus densiflora* seedlings established on decayed logs and in soil

	Log	Soil	P [a]
Density (no. m^{-2})	75.0±17.4	0.3±0.3	***
Shoot biomass (mg)	47.7±3.5	30.7±2.7	***
S/R [b]	1.81±0.11	3.96±0.48	***
SRL (m g^{-1}) [c]	33.0±1.1	27.0±1.4	**
ECM tip ratio (%)	96.9±0.6	88.9±1.7	***

Data represent average ± standard error (N = 3 for density and 33 for other properties, except for S/R, see below)
[a] GLM results *** $P < 0.001$, ** $P < 0.01$
[b] Shoot to root ratio. Only data of seedlings without any root loss were used for analysis (N = 29 for decayed log and N = 11 for soil)
[c] Specific root length

38% and 28% of the total root tips of seedlings from decayed logs and soil, respectively failed to amplify (Table 4). Furthermore, 26% and 9% of the total root tips of seedlings on decayed logs and in soil, respectively, were not identified as known ITS sequences in the NCBI and UNITE databases. Among the identified fungi, *Amanita citrina*, Boletaceae sp.1, *Hygrophorus* sp., *Lactarius* sp., *Rhizopogon luteolus*, *Sebacina* sp., *Tomentella* sp.1, and *Tomentella* sp.2 were detected in > 10% of the seedlings on one or both of the substrates (Table 3). The differences in the substrates affected the ECM fungal diversity and composition. The number of OTUs per seedling was significantly lower on seedlings established on decayed logs compared with those in soil (Table 3). Based on the separation of the confidence intervals, the cumulative number of ECM fungi OTUs was significantly lower on seedlings established on decayed logs compared with those in soil (Fig. 1). The estimated total OTUs on logs and in soil were 6.5 and 23.9, respectively, according to Jacknife2, and 8.9 and 28.8, respectively, according to Chao2 (Table 3). Most of the OTUs showed no significant preferences for either of the two substrates, but Boletaceae sp.1,

Table 3. Frequencies (%) of basidiomycetous ectomycorrhizal (ECM) operational taxonomic units (OTUs) detected from *P. densiflora* seedlings established on decayed logs and in soil, and their sequence similarities and accession numbers

OTUs	Accession NO.	Frequcney (%)		*P* [a]	Most similar sequence in database			
		Log	Soil		Taxa	Accession NO.	% ID	Database
Frequent								
Amanita citrina	AB972821	39.4±26.9	23.0±12.2	n.s.	*Amanita citrina*	KF245908	99	NCBI
Boletaceae sp.1	AB972823	–	20.7±13.3	n.s.	Boletaceae sp.	HE814137	99	NCBI
Hygrophorus sp.	AB972829	–	16.7±16.7	n.s.	*Hygrophorus hypothejus*	UDB001579	95	UNITE
Lactarius sp.	AB972830	15.2±15.2	12.8±8.9	n.s.	*Lactarius zonarius*	UDB011468	95	UNITE
Rhizopogon luteolus	AB972831	6.1±3.0	18.5±5.5	n.s.	*Rhizopogon luteolus*	UDB015830	99	UNITE
Sebacina sp.	AB972836	–	17.2±9.6	n.s.	*Sebacina* sp.	HQ154376	97	NCBI
Tomentella sp.1	AB972838	3.0±3.0	20.0±15.3	+	*Tomentella* sp.	AY940642	97	NCBI
Tomentella sp.2	AB972839	–	21.8±13.2	n.s.	*Tomentella* sp.	EF655702	96	NCBI
Infrequent								
Atheliaceae sp.	AB972822	9.1	6.7	n.a.	Atheliaceae	UDB008299	98	UNITE
Boletaceae sp.2	AB972824	–	5.6	n.a.	Boletaceae	JQ991657	93	NCBI
Ceratobasidium sp.	AB972825	–	10.0	n.a.	*Ceratobasidium*	JQ991678	98	NCBI
Entoloma crassipes	AB972826	–	2.8	n.a.	E*ntoloma crassipes*	AB301603	99	NCBI
Entolomataceae sp.	AB972827	–	8.3	n.a.	*Entoloma*	UDB008232	89	UNITE
Gomphidius roseus	AB972828	–	3.3	n.a.	*Gomphidius roseus*	UDB011692	99	UNITE
Russula sp.1	AB972832	–	10.0	n.a.	*Russula* sp.	AB629047	100	NCBI
Russula sp.2	AB972833	–	3.3	n.a.	*Russula* sp.	JN129410	99	NCBI
Russula sp.3	AB972834	–	3.0	n.a.	*Russula* cf. *vesca*	EU567074	94	NCBI
Russulaceae sp.	AB972835	–	6.4	n.a.	Russulaceae sp.	AB636107	99	NCBI
Suillus bovinus	AB972837	3.0	3.3	n.a.	*Suillus bovinus*	UDB011438	99	UNITE
Tomentella sp.3	AB972840	–	3.0	n.a.	*Tomentella* sp.	GQ900537	99	NCBI
Tomentella sp.4	AB972841	–	6.4	n.a.	*Tomentella subclavigera*	UDB003303	96	UNITE
Number of OTUs per seedling		0.8±0.1	2.2±0.2	***				
Observed OTUs richness		6	21					
Eestimated OTUs richness [b]								
Jacknife 2		6.5	23.9					
Chao 2		8.9	28.8					

Data represent average ± standard error for frequent taxa (N = 3)

[a] GLM results *** $P < 0.001$, + $P < 0.1$, n.s. not significant, n.a. not applied

[b] EstimateS (Colwell 2013)

Table 4. Percentage occurrences of families of basidiomycetous ectomycorrhizal (ECM) fungi in randomly sampled root tips of current-year *Pinus densiflora* seedlings established on decayed logs and in soil

Family	Log	Soil
Amanitaceae	19.7	5.7
Atheliaceae	4.2	1.1
Boletaceae	–	7.6
Ceratobasidiaceae	–	2.7
Entolomataceae	–	6.8
Gomphidiaceae	–	0.4
Hygrophoraceae	–	3.8
Rhizopogonaceae	0.8	7.6
Russulaceae	10.2	11.0
Sebacinaceae	–	4.2
Suillaceae	0.4	0.8
Thelephoraceae	0.4	11.4
Unamplified	38.3	28.0
Unknown sequences	26.1	9.1

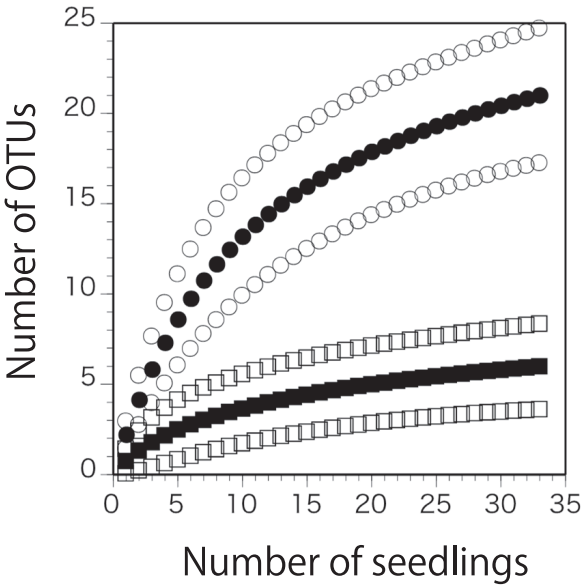

Figure 1. OTU accumulation curves of basidiomycetous ectomycorrhizal (ECM) fungi (filled symbols) and their 95% confidence intervals (open symbols). Square: decayed logs, circle: soil.

Hygrophorus sp., *Sebacina* sp., and *Tomentella* sp.2 were detected only in soil. Among the photon density, water content, pH, and EC, only EC significantly affected the observed OTU richness (estimated parameter = −0.61, $p = 0.047$).

Based on the CCA, the water content ($F = 4.89$, $p < 0.001$), light conditions ($F = 3.30$, $p = 0.002$), and pH ($F = 4.54$, $p < 0.001$) of the substrates affected the mycorrhizal communities significantly, in addition to the specific substrate ($F = 6.32$, $p < 0.001$) (Fig. 2). In particular, *Tomentella* sp.2, Boletaceae sp.1, and *R. luteolus* were associated with high pH and dry soil conditions, whereas *A. citrina* and *Lactarius* sp. were associated with low pH and wet log conditions. The shoot biomass, S/R, and SRL of seedlings were not significantly related to the ECM fungal communities.

Discussion

The numbers and shoot growth of current-year seedlings were greater on decayed logs than in soil at the study site. This may have been due partly to the high water and nutrient contents of logs compared with the soil at the study site. Previous studies have reported that decayed logs generally have poor nutrient levels compared with soil (Goodman and Trofymow 1998; Baier et al. 2006). However, Walker and Jones (2013) reported that the extractable ammonium content was higher in decayed logs than mineral soil in a clear-cut disturbed forest. Takahashi et al. (2000) reported that white-rotted logs contained a large amount of nutrients, with an EC value approximately 12 times greater than that of soil. White-rotted logs contain large amounts of delignified readily utilizable carbohydrate and high water content, stimulating the growth of bacterial communities, including nitrogen-fixers; thus, the white-rotted logs would contain large amounts of nitrogen (Jurgensen et al. 1989). This may be one reason why the white-rotted pine logs observed in this study had high nutrient levels. The low S/R and high SRL values of the pine seedlings growing on logs in the present study indicated the increased allocation to roots and the effective extension of the root lengths, respectively, demonstrating the effective absorption of nutrients in logs. This may appear to be inconsistent with the higher amounts of nutrients found in logs compared with the soil at this site, because it has been generally believed that C allocation to roots increases under nutrient poor conditions (Tilman 1988). A possible reason for this inconsistency may be the low pH of the logs, that stimulate C allocation to root and lateral root extension (Schindelbeck and Riha 1988; Narukawa and Yamamoto 2003; Doi et al. 2008; Six and Halpern 2008). Belowground competition with grass roots in soil also must be considered. However, it may not be the main factor determining root biomass allocation

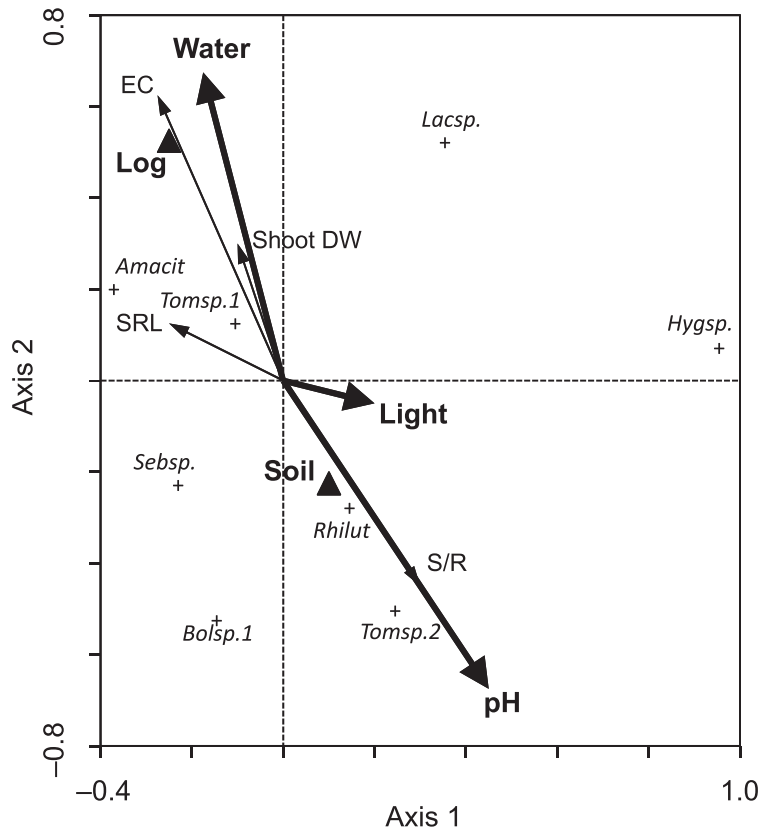

Figure 2. Diagram showing the canonical correspondence analysis ordination for the corresponding positions of frequent fungal OTUs (frequency > 10%) based on occurrence data from decayed logs and soil. The environmental variables are indicated by arrows (quantitative variables) and closed triangles (nominal variables). Quantitative variables with a significant effect are shown in bold (Monte Carlo permutation test, $p < 0.05$). Abbreviations for fungi: *Amacit*, *Amanita citrina*; *Hygsp*., *Hygrophorus* sp.; *Lacsp*., *Lactarius* sp.; *Rhilut*, *Rhizopogon luteolus*; *Sebsp*., *Sebacina* sp.; *Tomsp*.1, *Tomentella* sp.1; and *Tomsp*.2, *Tomentella* sp.2. Two axes explained 59.9% of the total variation in the species–environment relationship.

in the present study because previous experimental studies reported that the presence of root competition generally promote carbon allocation to root (Kolb and Steiner 1990), in contrast to the present study.

Increased biomass allocation to roots and effective extension of the root length inevitably affect the mycorrhizal colonization and vise versa. The basidiomycetous ECM colonization rate was high in seedlings on logs compared with those in soil, which is consistent with the previous studies (Vogt et al. 1995; Baier et al. 2006). The high demand for nutrients in poor nutritional conditions facilitates mycorrhization (Kazantseva et al. 2009), but this may not have been the case in the present study because the nutrient contents of the logs were higher than those of the soil. Alternative explanation seems to be the relatively good growth of seedlings on logs than soil supported by convenient water and nutrient content of logs promoted ECM colonization. Druebert et al. (2009) reported that seedlings with suppressed growth were less colonized by ECM fungi than well-growing individual even if the ECM propagule densities were set to a same level.

Substrate difference also affected species richness of ECM fungi. The observed low ECM diversity in logs was consistent with previous studies, but the causal mechanisms may differ slightly between this and previous studies. Previous studies suggest that the low nutritional status of decayed wood limits the colonization to the fungal taxa such as Thelephorales, Atheliales, and Sebacinales (Tedersoo et al. 2003, 2008, 2009a). Alternatively, in the present study, a possible explanation is that the high nutrient status limited the ECM diversity in decayed logs by stimulating some nutrient-demanding species (Rao et al. 1997; van der Heijden et al. 1999; Parrent et al. 2006;

Toljander et al. 2006; Kalliokoski et al. 2010) such as *Amanita* which dominated in logs in the present study. Among the nutrient ions measured, potassium concentration had the largest difference between logs and soil in the present study, and thus was supposed to be a main component of the difference in nutrient condition between logs and soil. Tedersoo et al. (2009b) reported that soil potassium concentration, rather than other elemental nutrients (nitrogen, phosphorus, calcium and magnesium), determine species diversity of ECM fungi associated with alders (Betulaceae) roots, but the reason was unclear.

Variables other than nutrient availability are also undoubtedly important determinants of fungal communities. I found that the substrate pH strongly affected the ECM fungal community, which is in agreement with other studies of soil ECM communities (van der Heijden et al. 1999; Toljander et al. 2006; Cox et al. 2010). Laboratory-based pure culture studies using *Amanita* and *Lactarius* species (which exhibited a preference for low pH in the present study) showed that their optimum hyphal growth occurred at relatively low pH values (pH 3–5; Jongbloed and Borst-Pauwels 1990). Theodorou and Bowen (1969) reported the hyphal growth of *R. luteolus* and its colonization of pine roots in soil at pH 5.0, supporting the ordination analysis of the present study that the occurrence of mycorrhiza of *R. luteolus* was closely associated with the soil pH gradient (i.e. pH = 4.9). The water content is another important factor that affecting fungal communities. A very low water content prevents hyphal growth by reducing the osmotic potential of hyphae (Griffin 1972), as well as reduces ECM fungal colonization of plant roots (Kennedy and Peay 2007), but a very high humidity level can prevent hyphal growth by decreasing the oxygen content (Hintikka and Korhonen 1970). In the present study, the water content of the decayed logs was over 10 times higher than that of the soil. However, it is not clear whether this high water content affected the oxygen demands of ECM fungi because the seedling roots were distributed only in the superficial regions of decayed logs where the oxygen content was not reduced greatly (Hintikka and Korhonen 1970). The root depths of the pine seedlings were not recorded in the present study, but Doi et al. (2008) reported that the seedling root depth of Pinaceae species was approximately 3 cm on logs in decay class IV. The light conditions also affect the ECM community structure by modifying plant carbon productivity (Druebert et al. 2009). The effect of light on the ECM community composition was significant in the present study, but it may not be an important determinant of the difference between substrates because the light conditions of the logs and soil were not significantly different.

Against my prediction, *A. citrina*, probably a species with little wood decay ability, was a dominant ECM symbionts on decayed logs. The relatively high nutrient content of the white-rotted logs may explain their dominance because species in the genus *Amanita* have been reported to prefer high nitrogen and phosphorus in soils (Cox et al. 2010; Reverchon et al. 2012). There have been a few reports of *Amanita* from decayed logs, but this genus has been detected frequently in the soil of mature pine stands in the Northern hemisphere (Yamada and Katsuya 1996; Rao et al. 1997; Gehring et al. 1998; Taylor and Bruns 1999; Parrent et al. 2006; Cox et al. 2010; Ma et al. 2012; Reverchon et al. 2012), as well as recently in the Southern hemisphere due to biological invasion (Pringle and Vellinga 2006). In contrast, the ECM fungi reported from boreal forests dominated by *Picea*, *Abies*, *Tsuga*, and *Pseudotsuga*, where the majority of the ECM fungal communities on decayed logs have been analyzed, rarely include *Amanita* (Tedersoo et al. 2003, 2008, 2009a; Toljander et al. 2006; Elliott et al. 2007; Kalliokoski et al. 2010; Walker and Jones 2013). Thus, it is possible that future studies on the ECM inventory in pine stands may detect *Amanita* on decayed logs with a high frequency.

In conclusion, this study showed that current-year *P. densiflora* seedlings colonized well on decayed logs and formed a seedling banks in a post-PWD pine stand in Japan. Seedling roots were highly colonized by ECM fungi, and their basidiomycetous ECM fungal communities were affected significantly by the physicochemical properties of the substrates. The dominance of *A. citrina* in the decayed logs may be attributable to the high nutrient contents of the white-rotted logs at this study site.

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Effect of Winter-Flooding and Organic Farming on Density of Aquatic Oligochaetes in Ricefields: Case Study in Miyagi Prefecture, Northeastern Japan

Toyoaki ITO[1], Kota HARA[1,2], Tihomi KON[1,3] and Akifumi OHTAKA[4]

[1]Graduate School of Agricultural Science, Tohoku University, Field Science Center, Graduate School of Agricultural Science, Tohoku Univ., 232-3 Yomogita, Naruko-onsen, Oosaki, Miyagi 989-6711, Japan
[2]ROCK FIELD Co. LTD., 15-2 Uosakihamamachi, Higashinada, Kobe, Hyogo 658-0024, Japan
[3]Aomori Prefectural Industrial Technology Research Center, 183-1 Aisaka, Aisaka, Towada, Aomori 034-0041
[4]Department of Natural Science, Faculty of Education, Hirosaki University, 1 Bunkyocho, Hirosaki 036-8560, Japan

Correspondence: toyoaki@bios.tohoku.ac.jp

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Abstract

Although aquatic earthworms (oligochaetes) in paddy fields have various functions for rice cultication such as enhancement of nitrogen mineralization and imbedding of weed seeds through bioturbation, factors influencing their density have not been sufficiently understood. We investigated the effect of winter-flooding and organic farming on density of aquatic oligochaetes in ricefields of Miyagi prefecture, northeastern Japan. Aquatic oligochaete community in the winter-flooded organic fields was composed of four naidid species, ie, *Limnodrilus hoffmeisteri*, *Branchiura sowerbyi*, *Bothrioneurum vejdovskyanum* and *Ilyodrilus templetoni*, of which *L. hoffmeisteri* was the most abundant. It became clear that winter-flooding treatment and organic fertilizer application were effective in increasing aquatic oligochaetes in organic ricefields.

Introduction

Aquatic earthworms (Oligochaete) occur in various kinds of freshwaters. They are abundantly found in paddy fields, and have important function for rice cultivation as a conveyor belt type feeder (Rhoads, 1974). The worms burrow into paddy soil and feed on and excrete them into the soil surface. Such soil disturbance (bioturbation) brought about by oligochaetes caused a vertical redistribution of the soil particles and buried weed seeds 3-5 cm under the soil surface (Kikuchi and Kurihara 1977), resulting in suppressing the development and growth of weeds. The weeding effect of aquatic oligochaetes was suggested by the results of field study that weed densities were lower in the plots with higher density of oligochaetes than the plots with fewer oligochaetes (Kikuchi et al., 1975).

Aquatic oligochaetes enhance nitrogen mineralization and phosphorus transformation into labile form in paddy soils through stimulation of organic matter decomposition, and also increase the release of ammonium nitrogen and soluble phosphorus into the floodwater from the paddy soil (Kikuchi and Kurihara, 1977; Kikuchi and Kurihara,1982; Ito and Hara, 2010). Aquatic oligochaetes burrow, and feed on and excrete soils onto soil surface. In flooded paddy fields, oxidized layer is formed on the soil surface and suppresses the diffusion of soluble nitrogen and phosphorus into floodwater from soils. Such a soil disturbance breaks the oxidized soil layer and enhances soil-water interface area, resulting in accelerating the nutrient diffusion from soil into overlying water. The enhanced release rates of inorganic nitrogen and phosphorus cause increases of phytoplankton and zooplankton in the overlying water. It became clear

that the presence of aquatic oligochaetes increased populations of microalgae, macrophytic algae, floating macrophyte and also zooplankton (Cladocera and Ostracoda) in the floodwater (Kikuchi and Kurihara, 1982). Consequently, aquatic oligochaetes influence nutrient dynamics in the soil-floodwater interface and impact the ecosystem in paddy floodwater.

Bioavailable nutrients (N and P) in submerged paddy soils and floodwater increased in proportion to the densities of aquatic oligochaetes (Ito and Hara, 2010). These functions will benefit organic rice farming with no chemical fertilizers and pesticides. Aquatic oligochaetes are projected to contribute to the increase of rice production and biological enrichment in organic ricefields. Thereafter, estimation of oligochaete density is very important for evaluating the functions in organic ricefields.

It has been clarified that aquatic oligochaetes showed higher density in the ricefields with greater contents of soil organic matter and soil moisture (Simpson et al.,1993a; Kikuchi et al., 1975), and application of organic matter increased oligochaetes in the ricefields (Simpson et al., 1993b; Kikuchi et al., 1975). It is considered that organic matters are substrate for soil bacteria and represent potential food source for the aquatic oligochaetes (Simpson et al., 1993a). Information about pesticide impacts on aquatic oligochaetes in ricefields is still scare and the impacts varied with dependence on kinds of pesticides. No pesticide impacts (Simpson et al., 1993a; Rossaro et al., 2012) or positive impacts (Mesléard et al., 2005) on oligochaete density in ricefilds have been reported. On the other hand, an insecticide, imidacloprid significantly decreased oligochaete density in the paddy mesocosm experiments (Hayasaka et al., 2012). Taking the results into consideration, organic rice farming is presumed to increase the oligochaete density due to application of organic matters and no use of pesticides that are essential to organic farming systems. However, densities of aquatic oligochaetes have been measured only in organically managed ricefields by several researchers (Simpson et al., 1993a; Suhling et al., 2000; Mesléard et al., 2005; Wilson et al., 2008).

Most of the rice paddies had been converted from natural wetlands. The ricefields are often located in areas that historically provided important waterfowl habitat, such as the Ebro Delta in Spain and the Sacramento Valley in California (Fasola and Ru´ız,1996 ; Elphick, 2000). It has been clarified that winter-flooded fields potentially serve as an important substitute habitat for many species of waterbirds in California (Elphick and Oring, 1998; Elphick, 2000) and in Japan (Kurechi, 2007). Furthermore, it is known that winter-flooding provides benefit for rice production through decreasing weed density and increasing rice straw decomposition (Bird et al., 2000; Groenigen et al, 2003). Takada et al. (2014) verified that both the density and species richness of spiders, ubiquitous predators in rice paddies, were significantly higher in the winter-flooded ricefields than in the conventional ricefields. However, little information is available for aquatic oligochaetes in the winter-flooded organic ricefields except for the result reported by Yachi et al. (2012).

The objective of the present study was to investigate the effect of winter-flooding and organic farming on abundance of aquatic oligochaetes in ricefields as case study in Miyagi prefecture, northeastern Japan.

Materials and methods

Surveyed fields

We surveyed three sets of adjoining ricefields located in Osaki City and Ishinomaki City of Miyagi Prefecture, northeastern Japan (Table 1). Tajiri A and B soils belonged to Fine-textured Gley soil, and Kanan soil belonged to Muck soil according to the classification of cultivated soils in Japan (Nat. Inst. Agric. Sci., 1983). Each set of ricefield has been managed by the same farmer. For Tajiri A fields, all three fields have been conventionally managed with conventional use of chemical fertilizers and pesticides till 2003 and have been organically managed with winter-flooding since 2004. For Tajiri B fields, the conventional and winter-flooding ricefields have been continuously cultivated by each farming method since 2004. In Japanese organic rice farming, organic fertilizer and rice bran are usually used for supply of nutrients to rice plants and weed control (Nozoe et al., 2012), respectively. However, in Kanan fields, neither organic fertilizer nor rice bran were applied to the organically managed ricefilds. For Kanan fields, low pesticide treatment without fungicide and insecticide was surveyed as the reference treatment.

According to the weather data of Furukawa and Ishinomaki observing stations (Japan Meteorological Agency), the average of mean annual air temperature in 2005 and 2006 were 11.0 and 11.5 ℃ for Tajiri and

Table 1. Agricultural management conducted at the surveyed ricefields in 2005-2006.

Field name	Tajiri A (Oosaki City, Miyagi)			Tajiri B (Oosaki City, Miyagi)		Kanan (Ishinomaki City, Miyagi)		
Treatments	Winter-flooding + organic	Organic*1	Conventional	Winter-flooding + organic	Conventional	Winter-flooding + organic	Organic*1	Low pesticide
The first year converting from conventional management to organic management with winter-flooding	2004	2004	2004	2004	- *2	2004	2005	-
The year converting from organic management with winter-flooding to each treatment	-	2005	2005	-	-	-	-	-
Surveyed year	2005, 2006	2005	2005, 2006	2006	2006	2005, 2006	2005, 2006	2005, 2006
Period of winter flooding	January to mid March	-	-	January to mid March	-	December to spring flooding	-	-
Starting time of spring flooding	Beginning of May	Mid March	Mid March	Mid March	Mid March	Late April	Late April	Late April
Mid season drainage	-	-	7 days in late July	-	7 days in late July	-	-	unknown
Fertilizer	Organic fertilizer (4.2, 5.2 g m^{-2} as N) in one month before transplanting*3	Organic fertilizer (4.2 g m^{-2} as N) at transplanting	Compound fertilizer (5 g m^{-2} as N)	Organic fertilizer (3.7 g m^{-2} as N) in one month before transplanting	Compound fertilizer (5.2 g m^{-2} as N)	-	-	Compound fertilizer (6 g m^{-2} as N)
Organic materials for weed control	30, 20 g m^{-2} for rice bran and 30, 30 g m^{-2} for waste soybean*3	30 g m^{-2} for rice bran and 30 g m^{-2} for waste soybean	-	60 g m^{-2} for rice bran and 45 g m^{-2} for waste soybean	-	-	-	-
Pesticides	-	-	Fungicide, insecticide, herbicide *4	-	Fungicide, insecticide, herbicide *4	-	-	Herbicide *5
Rice variety	Hitomebore	Hitomebore	Hitomebore	Hitomebore	Hitomebore	Sasanishiki	Sasanishiki	Sasanishiki
Transplanting time	5/22, 5/21	5/22	5/22, 5/21	5/23	5/23	6/7, 6/10	6/7, 6/10	5/1, 5/3

*1 : Organic management without winter-flooding.

*2 : Hyphen indicates no operation or no application.

*3 : The first and second figures indicate the values for 2005 and 2006.

*4 : Fungicide (probenazole), insecticide (fipronil, dinotefuran) and herbicide (bensulfuron-methyl,clomeprop, oxaziclomefone) were applied with standard quantity.

*5 : Herbicides (pretilachlor, simetryne, molinate, MCPB) were applied with half of standard quantity.

Kanan sites, respectively.

Measurement of aquatic oligochaete density

In order to estimate the density of aquatic oligochaetes in the ricefields studied, we randomly collected plow layer soil of 10 cm depth with 4 replications from each ricefield using core sampler with a diameter of 7 cm. We sieved the soil sample with a net of 0.5 mm mesh and moved the residues retained on sieve into sorting trays with tap water. We picked up oligochaete worms by hand-sorting and counted the individual number visually, according to Yachi (2012). Species composition was examined for the specimens from the winter-flooded organic fields collected on Jun 29 in 2006. Brinkhurst and Jamieson (1971) was used for oligochaete identification.

Soil characteristics

Three soils researched in this study were alluvial soils derived from river deposit. Total carbon and nitrogen contents of soils were measured by dry combustion method using NC-analyzer (Sumigraph model NC-80). Texture was measured by the pipette method (Wada, 1986), after pretreatment with H2O2 and ultrasonic dispersion.

Statistical analysis

We tested for significant differences in the oligochaete densities between three or two treatments using Tukey's HSD or student's t-test, respectively with significance at $P < 0.05$. All analyses were conducted using JMP v4.0.5.J (SAS Institute, 2001).

Results

Four species of aquatic oligochaetes, ie., *Limnodrilus hoffmeisteri*, *Branchiura sowerbyi*, *Bothrioneurum vejdovskyanum* and *Ilyodrilus templetoni*. all of which belonging to the family Naididae sensu (Erséus et al., 2008) were recognized in the specimens from winter-flooded organic fields. Among them, *L. hoffmeisteri* was the most abundant, accounting for more than 60 % of the total oligochaetes in all three sites studied.

Winter-flooded ricefields had higher oligochaete densities compared to organic ricefields without winter-flooding or conventional ricefields. The densities of aquatic oligochaetes increased from spring to summer, especially in the conventional ricefields and the ricefields with low application of pesticide (low pesticide ricefields) (Figures 1 and 2). In Tajiri A site, averaged values of the oligochaete densities during study period were 22,275, 9,427 and 3,702 m^{-2} for winter-flooded organic field, organic field and conventional field, respectively. They were 5,785, 3,066 and 657 for winter-flooded organic field, organic field and conventional field with low application of pesticide in Kanan site in 2005, respectively. Winter-flooded organic field and conventional field in Tajiri A site had averaged densities of 49,289 and 10,025 m^{-2}, respectively in 2006. The average densities in winter-flooded organic field and conventional field were 16,435 and 3,316 m^{-2} in Tajiri B site in 2006. Those of winter-flooded organic field, organic field and low pesticide field were 25,471, 7,866 and 9,092 m^{-2} in Kanan site in 2006, respectively.

The oligochaete densities were higher in the ricefields with winter-flooded organic farming than those of the conventional or low pesticide ricefields for Tajiri A in 2005, Tajiri B in 2006 and Kanan in both years (Figures 1 and 2). Organically managed ricefields without winter-flooding had significantly higher density than the conventional ricefield and had lower density than the winter-flooded organic ricefield with significant difference in Tajiri A (Figure 1A). On the other hand, densities of aquatic oligochaetes showed no significant difference between the organic ricefield and the low pesticide ricefield in Kanan site in both years (Figures 1B and 2C). The oligochaete densities in the winter-flooded organic ricefield showed higher in Tajiri A site than Kanan site in both years, and showed higher in Tajiri A site than in Tajiri B site in 2006 (Figures 1 and 2).

Discussion

Density of aquatic oligochaetes in winter-flooded organically managed paddy

Average of oligochaete densities during summer three months ranged from 16,435 to 49,289 m^{-2} for winter-flooded organically managed ricefields in Tajiri and Kanan sites, except Kanan in 2005 with fewer number of observations. These values were greater than the highest abundance of 5,836 m^{-2} obtained in the winter-flooded organically managed ricefields of Kamakura City, Kanagawa Prefecture, Japan (Yachi et al., 2012) and also higher than mean densities in conventional ricefields of the Laguna Province, Philippines (4,700-10,400 m^{-2}) (Simpson et al., 1993a). The oligochaete densities in winter-flooded organical-

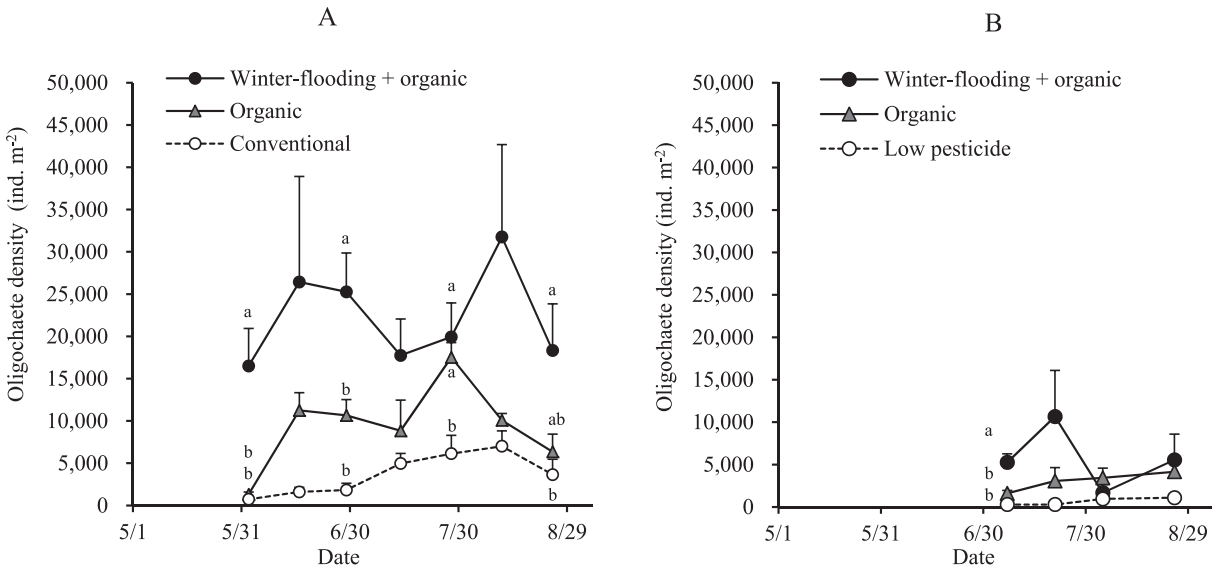

Figure 1. Aquatic oligochaete densities in the paddy fields of Tajiri A (A) and Kanan (B) in 2005.
Vertical lines show upper standard errors (n = 4). Different alphabet shows significant difference with P value < 0.05 between oligochaete densities obtained at the same research date.

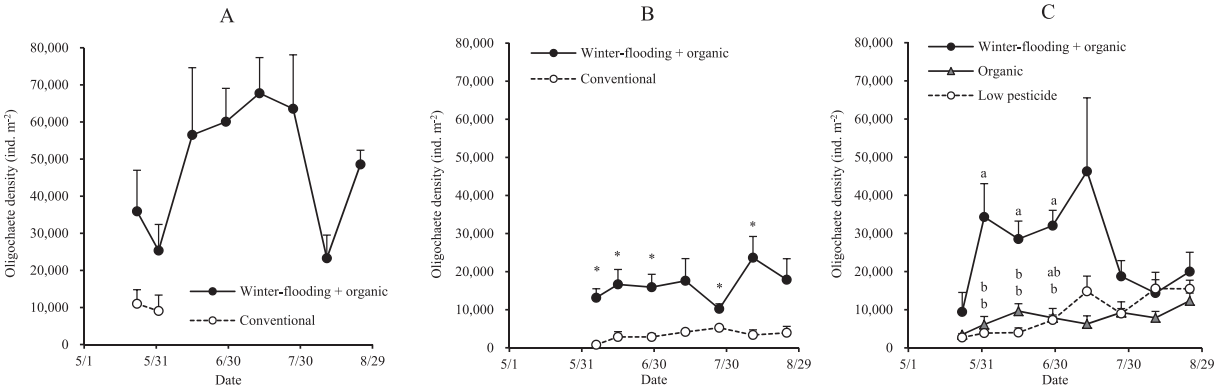

Figure 2. Aquatic oligochaete densities in the paddy fields of Tajiri A (A), Tajiri B (B) and Kanan (C) in 2006.
Vertical lines show upper standard errors (n = 4). Different alphabet shows significant difference with P value < 0.05 between oligochaete densities obtained at the same research date.

ly managed ricefields can be affected by the duration period of flooding, application of organic fertilizer and organic matter content of paddy soil.

Oligochaete densities of winter-flooded organically managed ricefields were compared between Tajiri A and Tajiri B sites for the purpose of analyzing the effect of soil organic matter on aquatic oligochaetes. The two places were close each other and had same duration of winter-flooding and organic management. The oligochaete density in winter-flooded organic ricefields was about 3 times higher in Tajiri A than those in Tajiri B (Figures 2A and 2B). Plow layer soils had higher contents of organic matter for Tajiri A than Tajiri B, as shown by total C and N contents (Table 2). The result suggests that high content of soil organic matter contributes to growth of aquatic oligochaetes. Soil organic matter could be substrate for soil bacteria and represent potential food source for the aquatic oligochaetes, as shown by former researchers (Simpson et al.,1993a). It is possible that larger application rate of organic fertilizer also contributed to higher density of aquatic oligochaetes in Tajiri A field as shown in Table 1.

We compared the oligochaete densities of winter-flooded organically managed ricefields between Tajiri A and Kanan fields for estimating the influence of organic fertilizer application on oligochaete growth. In spite of lower soil organic matter in Tajiri A than

Table 2. Some properties of the surveyed ricefields.

Field name	Tajiri A (Oosaki City, Miyagi)			Tajiri B (Oosaki City, Miyagi)		Kanan (Ishinomaki City, Miyagi)		
Treatments	Winter-flooding + organic	Organic	Conventional	Winter-flooding + organic	Conventional	Winter-flooding + organic	Organic	Low pesticide
Total C g kg-1	19	-[*1]	19	14	15	27	26	28
Total N g kg-1	1.7	-	1.8	1.3	1.4	2.4	2.3	2.5
Texture	CL[*2]	CL	CL	-	-	-	-	-

*1 : Not determined

*2 : Clay loam

Kanan (Table 2), the oligochaete densities were higher in Tajiri A than in Kanan in both of 2005 and 2006 (Figures 1 and 2). The difference suggests that application of organic fertilizer and organic materials (rice bran, waste soybean) stimulated aquatic oligochaete reproduction. Previous researchers also reported the application of organic matter increased oligochaete density in ricefields (Simpson et al., 1993b; Kikuchi et al., 1975).

Effect of winter-flooding on aquatic oligochaete density

Combination of winter-flooding and organic farming practice significantly increased oligochaete densities compared to the organic management without winter-flooding for Tajiri A in 2005 and Kanan in 2005 and 2006. In order to estimate winter-flooding effect on oligochaete densities, we compared the increasing ratio of oligochaete density from 2005 to 2006 between winter-flooded organic ricefield and organic ricefield. The ratios of oligochaete densities averaged over July and August (averages of four sampling times) in 2006 to those in 2005 were greater in the winter-flooded organic ricefield (4.3) than in the organic ricefield (2.9). It can be concluded that winter-flooding is effective in increasing aquatic oligochaetes in organically managed ricefields.

Conclusions

From the foregoing results, it is concluded that the winter-flooding is effective in enhancing aquatic oligochaete density in organically managed ricefields, and greater amount of soil organic matter and larger application of organic fertilizer also contribute to increasing aquatic oligochaetes.

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The Effect of Grazing on Fecal Shedding of Pathogenic *Escherichia coli* in Beef Cattle

Hiraku SASAKI[1], Raheela AWAIS[2], Junko TAKAHASHI[3], Yasunori TANJI[2], Chika TADA[3], Shin-ichiro OGURA[4], Shusuke SATO[4] and Yutaka NAKAI[3]

[1]Department of Health Science, School of Health and Sports Science, Juntendo University, Chiba, Japan 270-1695
[2]Department of Bioengineering, Tokyo Institute of Technology, Yokohama, Japan 226-8501
[3]Laboratory of Sustainable Environmental Biology and
[4]Laboratory of Land Ecology, Graduate School of Agricultural Science, Tohoku University, Miyagi, Japan 989-6711

Corresponding authors: Yutaka Nakai (nakai@bios.tohoku.ac.jp)
Hiraku Sasaki (hirakus@juntendo.ac.jp)

Keywords: Coliform, Enterohemorrhagic *E. coli*, *eaeA*, *slt-I*, *slt-II*

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Abstract

The virulent types of *Escherichia coli* including enterohemorrhagic *E. coli* are life-threatening foodborne pathogens. Asymptomatic cattle can be a natural reservoir of these pathogens. Although various dietary and breeding regimens influence colonization of these *E. coli*, there is insufficient knowledge about the carriage of the pathogens. In this study, the effect of grazing on fecal shedding of *E. coli* and the virulence-associated with *E. coli* in cattle were investigated. The fecal shedding of *E. coli* and total coliforms enumerated on the Chromocult agar did not vary before and after grazing. The number of sorbitol-fermenting cells on sorbitol MacConkey agar containing cefixime and tellurite significantly decreased ($P < 0.05$) in cattle samples after grazing. Using PCR targeting the *eaeA*, *slt-I* or *slt-II* gene, four cattle tested positive for non-O157 enterohemorrhagic *E. coli* in pre-grazing fecal samples, three of which did not test positive after grazing. Our data from 12 beef cattle before and after grazing indicate that cattle grazing decreases fecal shedding of sorbitol-fermenting *E. coli*.

Introduction

Enterohemorrhagic *Escherichia coli* (EHEC) are foodborne pathogens that threaten public health worldwide. EHEC are the major causative agents of hemorrhagic diarrhea and post-diarrheal hemolytic uremic syndrome (HUS). In EHEC strains, the serotype O157:H7 is particularly virulent and is a major etiological strain associated with hemorrhagic diarrhea and HUS cases. Severe O157:H7 infections occur at a higher frequency than infections caused by the other known EHEC serotypes (Gyles, 2007). Further, the incidence of non-O157 EHEC infections have reportedly increased, unlike that of O157:H7 infections, according to a recent survey (Gould et al., 2013). Therefore, continuous monitoring will help us to prevent the incidence of EHEC infections and to understand the prevalence of both O157 and non-O157 EHEC strains.

EHEC asymptomatically propagate on the surface of the bovine terminal rectum and are shed in feces (Naylor et al., 2003). Although the correlation between diet and EHEC survival varies among experimental conditions, feeding regimen is thought to affect fecal shedding of EHEC (Kudva et al., 1995; Diez-Gonzalez et al., 1998; Looper et al., 2006; Fraser et al., 2013). Moreover, although EHEC shedding is assumed to be affected by management systems including grazing on pasturage, little is known about the effects of grazing on the fecal shedding of EHEC or on the frequency of virulence-associated *E. coli* genes. In this study, we examined the effect of grazing on fecal shedding of *E. coli* and on the fate and

occurrence of virulence-associated EHEC genes in cattle.

Materials and Methods

Fecal samples

To monitor fecal shedding of *E. coli* and virulence-associated EHEC serotypes before and after grazing in Rokkaku paddock of Kawatabi Field Center (Osaki, Miyagi, Japan), rectal feces were obtained from healthy 12 beef cattle. In brief, rectal feces were sampled from the cattle fed in a free-stall barn before grazing, and they were defined as the pre-grazing sample. After 60 days of summer to autumn grazing, rectal feces were obtained from the same cattle and defined as the after-grazing sample. The feeding regimens were shifted from high-grain based diets to high grass-based diets before and after grazing.

Isolation and enumeration of *E. coli* cells in fecal samples

Fecal samples were diluted with sterilized water in a 1:20 ratio, and 10 serial dilutions were spread on Chromocult agar (CCA; Merck, NJ, USA) and sorbitol MacConkey agar (Merck) containing cefixime and tellurite (CT-SMAC). For the CCA, violet and red colonies were identified and enumerated as *E. coli* and all coliform bacteria, respectively. For the CT-SMAC, pinkish and whitish colonies were identified and enumerated as sorbitol-fermenting (SF) and non-sorbitol-fermenting (NSF) *E. coli*, respectively. Subsequently, multiplex PCR was performed as described below for further detection of virulence-associated genes. The cell counts were assessed by performing Student's *t* test.

Detection of virulence genes in E. coli isolates

To determine the presence of *E. coli* O157:H7 and the virulence-associated genes, 10 each of SF and NSF colonies grown on CT-SMAC plates were isolated and further analyzed with a multiplex PCR assay (Table 1 lists the oligonucleotide primers used in this study). In brief, *rfbE*, encoding perosamine synthetase, and *fliC*, encoding flagellar (H) antigen, were targeted to determine the presence of the O157 and H7 antigens in the isolates. The virulence genes *slt-I*, *slt-II*, and *eaeA* encoding shiga-like toxin type I (SLT-I) and II (SLT-II) and intimin, respectively, were targeted. The *E. coli* O157:H7 strain EDL933 was used as a positive control for all experiments. PCR conditions and protocols were described in previous studies (Hu et al., 1998; Awais et al., 2007). In brief, PCR was performed in a volume of 100 µl containing 200 µM each of dNTPs, 2.5 mM of Mg^{2+}, 2.5 units of KOD DNA polymerase (Toyobo, Osaka, Japan). The ideal concentration of each primer pair that yielded five distinct bands were 60, 75, 100 and 200 nM for $FLIC_{h7}$-F/$FLIC_{h7}$-R, IntF/IntR, RfbF/RfbR and SLT-IF/SLT-IR and SLT-IIF/SLT-IIR, respectively. Each bacterial colony was picked up with a sterilized toothpick and directly transferred to the PCR tube as DNA templates. Each PCR cycle consisted of 30 s at 94°C, followed by 60 s at 59°C and 60 s at 72°C in a PCR thermal cycler (Takara Bio, Shiga, Japan). In total 35 cycles were performed for each reaction. Amplified DNA fragments were resolved by gel electrophoresis using 2% agarose and stained with ethidium bromide.

Table 1. Primer sequences used in the multiplex PCR and the expected sizes of the products

Target	Gene	Size (bp)	Primer	Sequence
O157	*rfbE*	292	RfbF	5′-GTGTCCATTTATACGGACATCCATG-3′
			RfbR	5′-CCTATAACGTCATGCCAATATTGCC-3′
H7	*fliC*	625	$FLIC_{h7}$-F	5′-GCGCTGTCGAGTTCTATCGAGC-3′
			$FLIC_{h7}$-R	5′-CAACGGTGACTTATCGCCATTCC-3′
Intimin	*eaeA*	368	Int F	5′-GACTGTCGATGCATCAGGCAAAG-3′
			Int R	5′-TTGGAGTATTAACATTAACCCCAGG-3′
SLT-I	*slt-I*	210	SLT- IF	5′-TGTAACTGGAAAGGTGGAGTATAC-3′
			SLT- IR	5′-GCTATTCTGAGTCAACGAAAAATAAC-3′
SLT-II	*slt-II*	484	SLT-IIF	5′-GTTTTTCTTCGGTATCCTATTCCG-3′
			SLT-IIR	5′-GATGCATCTCTGGTCATTGTATTAC-3′

Results and Discussion

Table 2 summarizes the comparison of *E. coli* cell numbers grown on each media. Using CCA plates, 5 of 11 cattle demonstrated decreased fecal shedding of *E. coli* after grazing. In two cattle, the total number of coliform bacteria was in the range of 10^5 to 10^7 colony-forming units (CFU)/g, and this number did not change after grazing ($P = 0.115$). We detected SF colonies using CT-SMAC; fecal shedding of bacteria decreased after grazing for all the cattle ($P = 0.036$), excluding two unmeasurable samples. Unlike the changes in number of SF colonies, NSF colonies insignificantly remained unchanged between pre-grazing and after grazing sample ($P = 0.128$).

To determine existence of pathogenic *E. coli* in isolates, multiplex PCR assay was performed. As demonstrated in a previous study (Awais et al., 2007), 5 genes were distinctly detected when the multiplex PCR was performed with *E. coli* O157:H7 strain EDL933. Then, multiplex PCR was performed with the *E. coli* isolates grown on CT-SMAC plates. Table 3 summarizes the multiplex PCR results of the *E. coli* isolates from pre-grazing and after grazing cattle fecal samples. We did not detect *rfbE* and *fliC* in any of the *E. coli* isolates, indicating that the beef cattle using in this study do not carry serotype O157:H7. In pre-grazing samples, each SF and NSF isolate had the gene encoding SLT-I and SLT-II, respectively, and four cattle shed non-O157 EHEC. In the after-grazing samples, three isolates had either the gene encoding intimin or SLT-I, and of these, one individual shed an equal number of SLT-I-positive *E. coli* before and after grazing. Although there was no statistically significant difference in distribution of virulent-gene associated *E. coli*, the shedding of non-O157 EHEC might be affected by the grazing in three of the four EHEC-shedding cattle. It may result from dietary changes, from high grain feeding to high roughage feeding. High grain feeding is known to increase ruminal volatile fatty acid (VFA) production and decrease colon pH following an increase in the number of acid-resistant *E. coli* colonies in ruminants (Diez-Gonzalez et al., 1998). Diets with low nutrient composition and high fiber content are thought to inhibit ruminal VFA production and lead to increased colon pH, with eliminating bacterial colonization (Kudva et al., 1995; Diez-Gonzalez et al., 1998). These results may also reflect the fact that populations of breeding cattle in free stall housing systems are more concentrated than cattle grazing on pastures, and a decreased occurrence of contagions may prevent bacterial dissemination from cattle to cattle. Although types of grasses, endophyte infections, and grazing periods are thought to influence shedding of *E. coli* during grazing, the experimental infection of O157:H7 revealed no correlation between these conditions and bacterial shedding (Looper et al., 2006). Thus, dietary changes and breeding systems may each be important predic-

Table 2. Comparison of *E. coli* cell counts by the Chromocult agar and Sorbitol MacConkey agar containing cefixime and tellurite.

Selective media	Pre-grazing*	After-grazing*	*P* value
CCA	$1.3 \times 10^8 \pm 1.2 \times 10^8$	$2.3 \times 10^8 \pm 2.2 \times 10^8$	0.115
CT-SMAC			
SF	$1.2 \times 10^7 \pm 1.8 \times 10^7$	$8.6 \times 10^5 \pm 1.0 \times 10^6$	0.036
NSF	$2.4 \times 10^7 \pm 3.4 \times 10^7$	$1.3 \times 10^6 \pm 1.6 \times 10^6$	0.128

*Results are shown as mean ± SD.

[a] CCA: Chromocult agar.

[b] CT-SMAC: Sorbitol MacConkey agar containing cefixime and tellurite.

[c] SF: Sorbitol fermenting *E. coli* cells grown on CT-SMAC. SF was counted by total 11 cattle before and after grazing. Each of one unmeasurable sample in both before and after grazing cattle sample was excluded.

[d] NSF: Non-sorbitol fermenting *E. coli* cells grown on CT-SMAC. NSF was counted by limited number of cattle before and after grazing.

Table 3. Prevalence of virulence-associated genes in *E. coli* isolates from pre-grazing and after grazing cattle fecal samples.

Target	Gene	Pre-grazing*	After-grazing*
O157	*rfbE*	0/12	0/12
H7	*fliC*	0/12	0/12
Intimin	*eaeA*	0/12	1/12
SLT-I	*slt-I*	3/12	2/12
SLT-II	*slt-II*	1/12	0/12

*Results are represented as positive number of cattle / total number of cattle.

tors for the fecal shedding of *E. coli*. Further, almost pathogenic *E. coli* excluding serotype O157 is known to be grown on SMAC agar as SF colonies (March & Ratnam, 1986). After grazing, the decrease numbers of SF colonies reveal that cattle grazing might inhibit colonization of sorbitol-fermentative *E. coli* such as non-O157 EHEC in bovine intestinal tracts. In this study, we observed the occurrence of culture-based *E. coli* and PCR-based virulence-associated EHEC genes in 12 beef cattle before and after grazing, and determined that fecal shedding of SF and the frequency of virulence genes were affected by the grazing.

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The 12th International Symposium on Integrated Field Science
The 7th Symposium on Innovative Research Center for Agricultural Science

New Phase of Field Science in Agriculture

Date: September 29-30, 2014

Venue: Graduate School of Agricultural Science (Amamiya Campus), Tohoku University, Sendai, Japan

Organizer:
Field Science Center, Graduate School of Agricultural Science, Tohoku University
Innovative Research Center for Agricultural Science, Tohoku University

Co-Organizer:
Tohoku Agricultural Science Center for Reconstruction, Graduate School of Agricultural Science, Tohoku University

Secretary General
Kiyohide Morita
Professor
Laboratory of Field Science and Technology for Society, Graduate School of Agricultural Science, Tohoku University

Objective

Field science in agriculture has played an increasingly significant role in the reconstruction process since the Great East Japan Earthquake on 11 March 2011. Field science rerated to agricultural science includes numerous topics, e.g., scientific fields directly linked to agriculture, forestry and fisheries, environmental science, social science and application of information technology and science.

The aim of this symposium is to find new phases of field science in agriculture from various subjects proposed from presenters.

Program

29 September (Mon)

12:00-13:00 Registration

13:00-13:20 **Opening Ceremony** (Welcome Address)
Michio Komai
(Dean, Graduate School of Agricultural Science and Faculty of Agriculture, Tohoku University
Director, Tohoku Agricultural Science Center for Reconstruction, Graduate School of Agricultural Science, Tohoku University)
Yutaka Nakai
(Director, Field Science Center, Graduate School of Agricultural Science, Tohoku University
Vice Director, Tohoku Agricultural Science Center for Reconstruction, Graduate School of Agricultural Science, Tohoku University)

13:20-14:50 **Keynote Presentation-1**
Chair Person: Kiyohide Morita (Tohoku University, Japan)

13:20-13:50 Kamaruddin Abdullah (Darma Persada University, Indonesia)
Case stories of Field science and Agriculture in Indonesia

13:50-14:20 Chen Tinggui (Shanghai Ocean University, China)
Impact of Food Safety Incident on Consumers' Willingness to Pay:the Case of China

14:20-14:50 Yutaka Nakai (Tohoku University, Japan)
The Rapeseed Project for Restoring Tsunami-Salt-Damaged Farmland after the GEJE

14:50-15:20 ------ Tea Break -------

15:20-15:40 **Young Scientist Presentation**
Chair Person: Michiaki Omura (Tohoku University, Japan)

15:20-15:40 Jia Lei (Tohoku University, Japan)
A Brief Summary of Development of Farmer Cooperatives in China

15:40-16:40 **Keynote Presentation-2**
Chair Person: Michiaki Omura (Tohoku University, Japan)

15:40-16:10 Daisuke Kunii
(Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan)
Multi-Dimensional Assessment of Resource, Environment and economy of Biomass Use - A Case Study of Firewood Use in Households in Nishiwaga-

16:10-16:40 Magaly Koch (Boston University, Boston, USA)
Spectral and Thermal Mapping of Desert Surface Sediments for Agricultural Development

17:20- Reception

30 September (Tue)

9:30- Registration

10:00-11:15 **Poster Presentation**

Chair Person: Chinatsu Yonezawa (Tohoku University, Japan)

P1 Naoto Kuroiwa[1], Mizuki Akamatsu[1] , Yui Sato[1] and Michiaki Omura[1]
([1]Tohoku University, Japan)
Study on Use of Small Multi-Copter (UAV) in Agriculture

P2 Teruhiko Hoshino[1], Toru Uno[1], Ryosuke Tajima[1], Toyoaki Ito[1] and Masanori Saito[1]
([1]Tohoku University, Japan)
Vertical Distribution of Radiocesium in Pasture Soils after Pasture Renovation

P3 Elmer G. Bautista[1] and Masanori Saito[2]
([1]Philippine Rice Research Institute (PhilRice), Philippines, [2]Tohoku University, Japan)
Greenhouse Gas Emission of Rice Production System in the Philippines based on Life Cycle Inventory Analysis

P4 Kenji Takisawa[1], Gen Yoshida[2], Chika Tada[1], Yutaka Nakai[1] and Yasuhiro Fukuda[1]
([1]Tohoku University, Japan, [2]Research Institute of Environment, Agriculture and Fisheries, Japan)
Energy Production from Fish Waste in Large-scale Anaerobic Digestion

P5 Moe Takada[1], Chika Tada[1], Yu Yoshihara[1], Yasuhiro Fukuda[1], Tuner Baldan[2] and Yutaka Nakai[1]
([1]Tohoku University, Japan, [2]Mongolian State University of Agriculture, Mongolia)
Escherichia Coli in Tuul River, Mongolia

P6 Yumi Mori[1], Fuyumi Tojo[1, 2], Yasuhiro Fukuda[1], Chika Tada[1] and Yutaka Nakai[1]
([1]Tohoku University, Japan, [2]Akita Prefectural University, Japan)
Enrichment and Characterization of an Ammonia-Oxidizing Archaeon of Moderate Thermophilic Taumarchaeotal Group I.1a From Cattle Manure Compost

P7 Yasunori Baba [1, 2], Chika Tada[1], Yasuhiro Fukuda[1], Masanori Saito[1] and Yutaka Nakai[1]
([1]Tohoku University, Japan, [2]Japanese Society for the Promotion of Science)
Methane Production Using Cattle Rumen Fluids and Its Application to Reduce Volume of Radiation-Polluted Biomass

P8 Masami Nanzyo[1]
([1]Tohoku University, Japan)
Fundamentals for Improving Phosphorus Cycle in Soil-Plant Systems

11:15-11:30 Closing Ceremony
Masami Nanzyo
(Director, Innovative Research Center for Agricultural Science, Tohoku University)
Closing Remarks
Kiyohide Morita
(Professor, Laboratory of Field Science and Technology for Society)
Closing Remarks

13:00- Excursion to Tsunami Damaged Area by the Tohoku Earthquake
(For invited speakers)

Case stories of Field Science and Agriculture in Indonesia

Kamaruddin ABDULLAR

The Graduate School, Renewable Energy, Darma Persada University

Abstract

With the improvement in irrigation facilities and the growing of foreign and domestic investment for agricultural development, the growth of food crops (which comprise of rice, maize and soybeans) in Indonesia in terms of Gross Domestic Product between 2010 to 2013 has increased from 1.6% to 1.8% (7.5% to the national GDP). This is indicated with the increase in productivity from Rp. 6.7 million/worker in 2010 to Rp. 7.9 million/worker in 2013. The harvested area of paddy has increased from 13.3 million Ha in 2010 to 13.8 million Ha in 2013, which has produced 36.6 million tons of rice in 2010 to 38.2 million tons of rice in 2013. The rice consumption has been between 33 million tons and 34.1million tons. However, during that period Indonesia has imported rice from 687,582 tons in 2010 to 472,000 tons in 2013. From 2004 to 2013 the price of premium grade rice has increased from Rp. 4,900/kg to Rp.11,000/kg. The harvested area for corn has decreased from 4.13 million ha in 2010 to 3.89 million ha in 2013. However, the productivity has increased from 4.4 tons/ha in 2010 to 4.8 tons/ha in 2013. For soybeans the harvested area has been decreased from 660,823 ha in 2010 to 571,564 ha in 2013, and the production was decreased from 907, 031 tons to 847,157 tons during the same period. The productivity, however, has increased from 1.4 tons/ha to 1.5 tons/ha during the same period.

Introduction

With the improvement of irrigation facilities and the growing of foreign and domestic investment for agricultural development, the development of food crops in Indonesia in terms of Gross Domestic Products has increased between 2010 and 2013 with a rate of 1.6%/annum to 1.8%/annum (or an average of 7.5% share in the national GDP). The investment from foreign capital for agriculture, namely for food crops, has decreased from US$ 751 million in 2010 to US$ 372.6 million in 2013, while the number of project decreased from 159 projects in 2010 to 146 projects in 2013 In the case of domestic investment the decrease was from Rp. 8,727 billion to Rp. 1664,6 billion in 2013. (, BAPPENAS 2014)

Rice production (BAPPENAS, 2013)

Rice production has increased from 36.6 million tons in 2010 to 38.2 million ton in 2013 as shown in Table 1. except for 2011 when there was a decrease in harvested area to 13,203,643 Ha, During that period rice consumption has been from about 33 million ton to 34 million tons. Despite the increase in rice productivity and national stock, rice import has been increasing from 687,582 ton in 2010 to 1,927,563 ton 2012 but decreased to 472,000 ton in 2013.

Table 1. Rice production

Indicator	Unit	Year			
		2010	2011	2012	2013
Harvested area	Ha	13,253,450	13,203,643	13,445,524	13,835,252
Rough rice (milled dry)	Ton	66,469,394	65,756,904	69,056,126	69,271,053.
Productivity (Rice)	Ton	36,558,167	36,166,297	37,980,869	38,190,869
Yield (rough rice-milled dry)	Ton/Ha	5.015	4.98	5.136	5.152
Rice consumption	Ton	33,067,791	33,563,807	34,067,264	32,980,000*)
Rice import	Ton	687,582	2,750,620	1,927,563	472,000
National stock	Ton	4,177,958	5,948,490	5,841,168	n.a.

Source: National Bureau of Statistic, Ministry of Agriculture, 2013.*)
Total population 248.334 million, consumption/capita, 97.4 Kg/Cap. /Year

Corn production (BAPPENAS,)

As shown in Table 2. corn production was also increased despite decreasing harvested area, except for the year 2011 when there was a decline in production. Corn yield was also increased from 4.436 tons/ha to 4.842 tons/ha in 2013. Our import during the period has increased from about 1.5 million tons to about 3 million tons in 2013.

Soybean production (BAPPENAS, 2013)

Soybean has been known as the main material to produce tempe and tohu, but also as animal feed. The harvested area of soybean has been decreasing from 2010 to 2013, which had made import to increase from about 19 million tons in 2010 to about 2.1 million tons in 2012.

Table 2. Production of corn

Commodity	Indicator	Year			
		2010	2011	2012	2013
Corn	Harvested area (Ha)	4,4.131.676.	3,864,692	3,957,595	3,890,974
	Production (tons)	18,327,636	17,643,250	19,387,022	18,838,529
	Import (tons)	1,527,476	2,889, 173	1,889,431	3,000,000
	Yield (ton/Ha)	4.436	4.565	4.899	4.842

Source: National Bureau of Statistics and Ministry of Agriculture, 2013.

Table 3. Harvested area, production and import

Commodity	Indicator	Year			
		2010	2011	2012	2013
Soybean	Harvested area (ha)	660,823	622,254	567,624	571,564
	Production (ton)	907,031	851,286	843,153	847,157
	Yield (Ton/ha)	1.373	1.368	1.485	1.482
	Import (ton)	1,876,855	1,911,987	2,128,763	584,000

Source:National Bureau of Statistics and Ministry of Agriculture, 2013

Except for 2011, soybean yield continues to increase from 1.373 tons/ha in 2010 to 1.482 tons/ha in 2013.

Sugar production

Sugar cane is the main source of sugar in Indonesia. Sugar canes are grown in paddy field. Sugar production has been very low in Indonesia and therefore the amount of import has been increasing each year except for 2012, as shown in Table 4. The low production of sugar was due to lack of availability of land, no investment in new milling factory, lack of input such as fertilizer and lack of irrigation facility, especially lack of infrastructure in the outer island of Java.

Number of population under less access to food

Fig.1. shows the proportion of people which have less access to food. The number has been decreasing but the number could change when there are natural disasters that would lead to failure in crop production. There are several factors as the cause of food crisis. Among them are the large number of poor people and underweight babies, lack of access to electricity, no access road for four wheeled vehicle, and no access to clean water.

Table 4. Import, target and production of sugar

Commodity	Indicator	Year			
		2010	2011	2012	2013
Sugar	Production target (ton)	2,900,000	3,900,000	3,900,000	2,530,000.-
	Realization (ton)	1,380,000	1,361,000	2,600,000	2,554,800.-
	Import	1,913,271	2,655,650	494,131	2,750,000.-

Source: National Bureau of Statistics, and Ministry of Agriculture, 2013

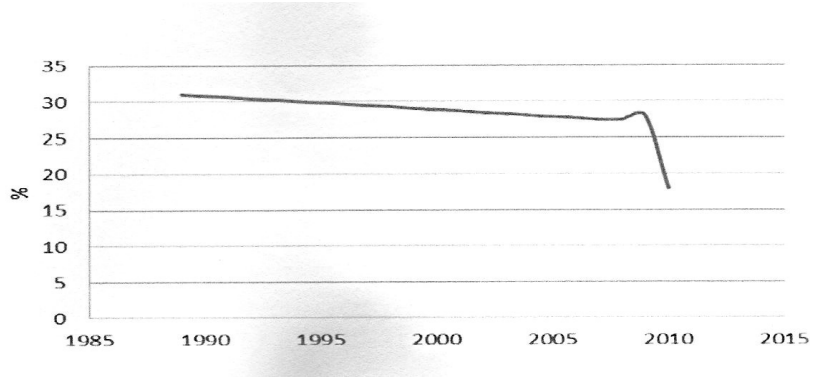

Figure 1. Proportion of population which has less access to food
(Source: National Bureau of Statistics).

There are some provinces which encounter food crisis. The most critical can be found in Papua province and the next is in East Nusatenggara.

Price of rice

The price of rice varies according to its quality. Based on the Presidential instruction No.3, 2012, the harvest dry rough rice at farm level has a price of Rp. 3300/kg with maximum moisture content of 25% wb and foreign material and empty grains less than 10%. This price is increased to Rp. 3,350/kg at rice millers. For milled dry with maximum moisture content of 14% wb with 3% empty grains and foreign material, the price will be Rp. 4,150/kg. The price of rice is Rp. 6,600/kg, with 14% wb moisture content containing 20% broken rice and 2% brewer's rice, and with polishing quality of 95% .

Exchange value of farmer

Exchange value of farmer is defined as the ratio between the price index to be received by the farmer as compared to the production cost or to the household consumption. This indicator can be used as an indicator of farmer's welfare. Based on the National Bureau of Statistics in 2010-2012 the Exchange Value of Farmer (EVF) was increased from 103.1 to 105.75 to 105.87, respectively. Between 2011 and 2012 this indicator has surpassing the national standard of 105. As shown in Fig.2., the highest value was obtained in 2008 where the indicator has reached 108.

Income per capita of farmer

Another indicator to measure the welfare of the farmer is by comparing the income per capita with that of the industrial workers. As shown in Fig. 3., the income percapita of farm worker are far behind that of industrial workers. During the period of 2004 to 2012, the number of population engaged in agricultural sector has decreased from 41.2 million to 38.8 million.

The challenges

a.Rice price

One important issue for agricultural development in Indonesia is the fluctuating and increasing price of commodity, particularly rice. The average price of

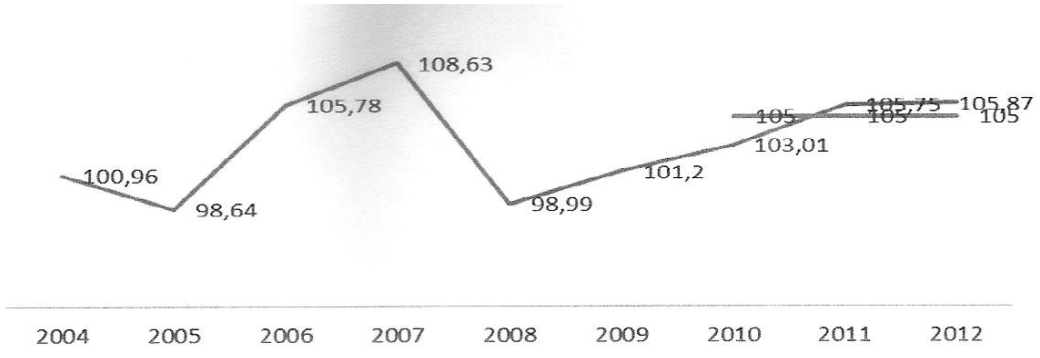

Figure 2. Change in the Exchange Value of Farmer.

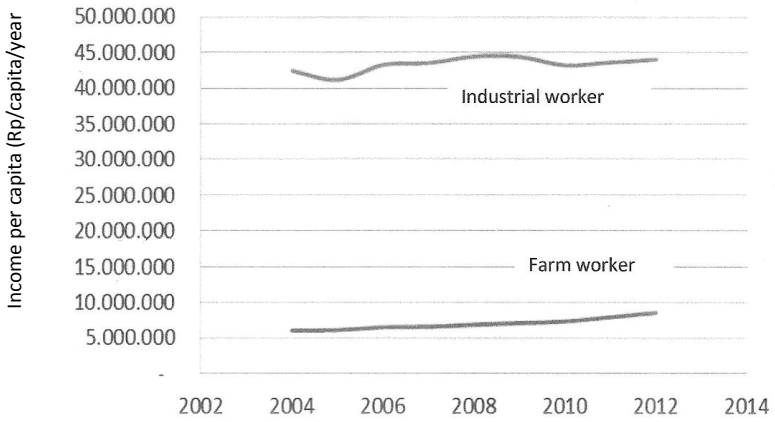

Figure 3. Income per capita of farm workers (blue line) as compared to industrial workers (red line).
(Source: National Bureau of Statistics).

medium grade of rice at the retailer increased about 14.39%/year during 2004-2012, while the international price has increased to 13.9%/year during the same period. During the economic crisis in 2007-2008 the price of domestic rice has increased between 5.29% to 7.38% whereas the international (Thai grade, 5% broken) has increased to 85.37% (Ministry of Agriculture, 2012).

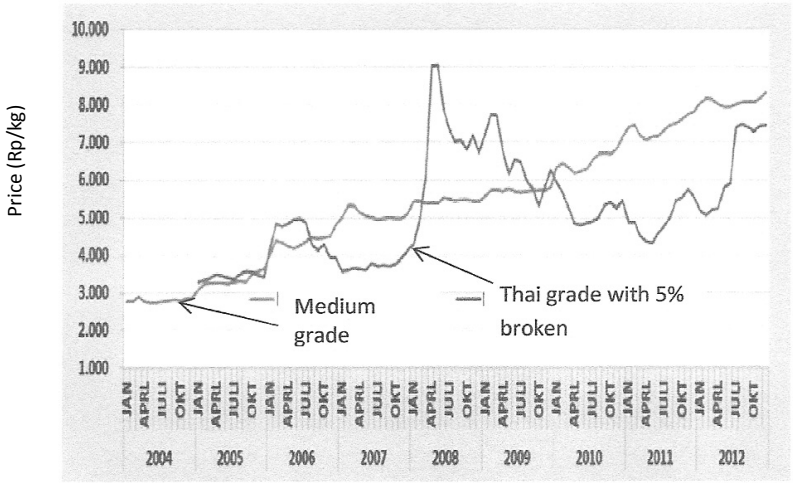

Figure 4. Fluctuation in rice price.

b.Price of corn

The increase in international price of agricultural commodity has caused the increase in price of corn. The corn price from 2005 to 2011 at farm, big supplier and consumer level has increased by 10.13%, 11.56% and 11.72% on annual basis, resepctively. This is shown in Table 5. below.

Due to climate anomaly the production of corn has decreased and the corn price has increased from US$ 98.41/MT (FOB) in 2005 to US$ 271.78/MT in 2011, or an increase of 14.23%. Due to the increase in FOB price, the price of imported yellow corn has increased to 12.14%/year. The price of imported corn in 2005 was Rp. 1,260/kg and increased to Rp. 3,213/kg in 2008.

c.Price of soybeans

The price of soybeans has been fluctuatiing due to unstable supply.The international price has inceased siginficantly from 2007 to 2008. During this period the price of the American yellow soybeans has increased dramatically from 46% and 43%. The increase in American soybean occured on January 11,

Table 5. Price of corn at different location

Year	Price at Producer (Rp. /kg)	Price at Big supplier (Rp. /kg)	Price at Consumer (Rp/kg)	Margin	
				Consumer and produces	Big supplier and producer
2005	1,668	2,150	2,002	334	482
2006	1,802	2,333	2,221	419	531
2007	1,894	3,617	2,605	711	1,723
2008	1,986	4,000	3,123	1,137	2,014
2009	2,672	4,000	3,591	919	1,328
2010	2,153	4,000	3,732	1,579	1,847
2011	3,400	4,271	3,800	400	871
Trend (%/year)	10.13	11.56	11.72	12.32	14.31

Source:National Bureau of Statistics (2005-2011).

2008 when the price reached 461.7 US$/MT, which has caused the domestic price to increase significantly to 60%.

The main reason for this increase in soybean price was firstly the decline in world soybean production of about 14 million tons in 2007, secondly the increase in soybean consumption especially by China and India and thirdly, the use of corn as alternative fuel (bioethanol) in the US, which has changed their production to corn which was more attractive in their price.

Table 6. Price of soybeans

Year	Price on farm (Rp/kg)	Price at consumer (Rp/kg)	International price (US$/MT)[1)]
2005	3,894	4,228	223
2006	4,036	4,472	217
2007	4,588	4,847	317
2008	6,212	7,788	453
2009	6,288	8,411	379
2010	6,664	8,683	385
2011	7,236	8,641	484
2012	7,262	8,631	478
Trend (%/year)	10.07	12.04	11.61

Source:PSE-KP (2012)

Note: 1) Soybean variety: US soybeans, soybeans, Chicago soybeans future contract (first contract forward), No.2 yellow and par, US dollars per metric ton

Urban agriculture (www.hydroponic.cm, 2014)

Jakarta, the capital city of Indonesia now has the population of about 10 million. As also experienced by many big cities, Jakarta now is facing a problem on how to shorten the transportation distance of food supply to feed its population wih fresh food. Up to now most of fresh produces are hauled as far as Lembang area which is about 221 km away from Jakarta or from Puncak farms which may take 3 to 4 hrs by car. The transportation from these areas, where fruits and vegetables are grown, may take longer time due to traffic jam along the road. Now Jakarta governor has the initiative to built greenhouses where people can grow vegetables as sources of income. It covers an area of 840 m^2 in Marunda, north of city Jakarta where people can grow vegetables such as chili, eggplant, and Pok Choi. Generally, vegetables are grown on a regular sterilised medium like paddy husks, charcoal, sand, small rock, carbon, or zeolite Beside vegetables the people may grow medicinal plants, or ornamental plants.

To address the problem of limited spaces in urban areas, the horizontal footprint of greenhouses can be replaced by stacking the spaces on top of each other,

creating vertical farms that will be suitable for urban spaces. Other area in the city where greenhouse farming is being practiced is Rajawali, and area south of Jakarta where the people grow hunderds of variety of plants from medicinal plants, productive to ornamental plants. Here the people are also practicing recycling of wastes into fertilizers. This area is now well known as agro-tourism village.

Other alternative is to supply fresh produce from Parung farm, about 40 km south of Jakarta city, where they grow leafy vegetables, mostly red and green spinach and kangkoong [water spinach] in the lowland Parung; and we grow mostly many kinds of lettuce such as Batavia lettuce, curly lettuce, green oakleaf, red oakleaf, butterhead, endive and romaine in the highland. Most of these plants are grown in simple greenhouses using hydroponic technology or organic farming method. The green house size varies from 136 m^2 to 240 m^2 in the low land and from 70 m^2 to 100 m^2 with total size of about 4,900 m^2.

Conclusions

The paper has presented state-of-the-art Indonesian agriculture, in which the target of selfsufficient in food has not being achieved yet as import of food is still necessary. As Indonesia is facing food crisis there is a need to increase harvested area for food crops, especially rice which is the staple food of the people. Big cities are now turning toward urban agriculture using green/screen house so that the application of IT as developed by Tohoku university may help in reducing the scarcity of food for the people and also can help to increase their income. We are now testing the application of the T-SAL technology in Darma Persada University to study the application of IT for agricultural production as a collaborative research activity.

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Impact of Food Safety Incident on Consumers' Willingness to Pay: the Case of China

Chen TINGGUI[1], Chen MIAOMIAO[1] and Kiyohide MORITA[2]

[1]College of Economics and Management, Shanghai Ocean University
[2]Graduate School of Agricultural Science, Tohoku University

Abstract

After the food safety incident of Bright Dairy's baby cheese which occurred in September 2012, we surveyed the consumers' willingness to pay (WTP) for safer baby cheese in Shanghai, China and received 318 valid questionnaires. This study uses ordered logistic regression model to analyze the impact of the food safety incident on consumers' WTP. The results show that the food safety incident negatively impacts consumers' WTP. More than one third of the respondents chose foreign products as substitutes after the food safety incident and has a higher WTP. In addition, the consumers have a higher WTP who either have the relevant knowledge about food safety or trust Bright Dairy's baby cheese to be safe. However, both the consumers over 40 and working either in the government or in the private sector show negative WTP.

Introduction

With the improvement of living standards, dairy products are playing an increasing important role in people's life. Dairy products have almost become a necessity of people's lives in the developed cities and consumption is rising year by year. However, there have been several serious dairy safety incidents in China in recent years. In 2004, the "Fuyang inferior powdered milk incident" happened in Fuyang city in China. And in July 2008, several infants were diagnosed with kidney stones after consuming powdered milk produced by Sanlu Dairy & Food Co., Ltd. Melamine pollution has been detected in Sanlu Dairy's powdered milk. If it's not one thing, it's another. Bright Dairy & Food Co., Ltd, a joint-stock company headquartered in Shanghai and one of the biggest dairy manufacturers and sellers in China, was involved in six food quality and safety incidents in only five months from June to October 2012. It exposed the food safety management problems of the dairy industry in China again.

According to the statistics of the Customs, the imported dairy products continue to increase, from 0.35 million tons in 2008 to 1.15 million in 2012, more than triple the amount. The amount of imported dairy products passing through Shanghai Customs has been 506,000 tons during the first 11 months in 2013 — up 43.6 percent from a year-ago. On one hand, more and more people can pay higher prices for imported dairy products which reflect the growth of residents' income in China. On the other hand, the occurrence of dairy product safety incidents also drives an increasing number of families to choose the imported dairy product. Some consumers no longer trust the safety of domestic dairy products, and that is not conductive to the development of dairy industry in China.

As people's standard of living rises, so does their demand for quality and safe food. However, the higher quality and safer food lead to higher cost. The extra cost will eventually be passed on to consumers in the form of higher prices. The premium is the consumers' willingness to pay (WTP) and that is determined by many factors.

There have been a number of empirical studies which focus on the WTP for several types of food with special labels such as low pesticide residue, certified food (including organic food, green food, contaminant-free agricultural products, HACCP certification, etc.) and the traceable food. Most existing literature studies firstly consumers' awareness and attitude on certified food and traceable food, then they get consumers' WTP by the contingent valuation method (bidding games, open-ended, payment card and dichotomous choice), in the end, they analyze the factors determining consumers' WTP with Logistic model or Probit model (Alias 2010, Angulo 2007, Dai 2006, Han 2008, Wang 2003, Wang 2009, Zhou 2006).

Some other literature used the laboratory auction method to get the more reliable WTP (Colson 2011 and Colson 2010), but it is complicated and costly.

Regarding other models, Luo (2010) used double-hurdle model to estimate the factors affecting consumers' WTP and the premium and analyzed the differences between the two. Wu (2010) applied CVM to survey the consumers in 13 cities of Jiangsu province, and got the determinants of the consumers' payment level to traceable vegetables with the interval censored model.

Wang (2007) found that information, knowledge, occupation, family income of the shoppers had important effects on the consumer WTP for HACCP dairy products in Beijing using the stepwise regression method. Wang (2012) concluded that the factors influencing the consumers WTP in Beijing, Tianjin and Shi Jiazhuang city for safer liquid milk were knowledge, children and the health of the consumers. Based on the data surveyed in Beijing, Chen (2009) analyzed the impact of "San Lu powdered milk contamination incident" on WTP for certified vegetables, and the result showed the influence was negative.

As reviewed above, compared to studies of fresh vegetables and meat, there are relatively few empirical studies of dairy products, and even fewer that are specific to the baby cheese and studying the impact of the food safety incidents (as a kind of information) on WTP.

This article focuses on how the food safety incident impacts consumers' WTP and choice of dairy products (imported products versus domestic products).

In the sections that follow, the second part is the data sources and a sample characteristic, the third part is an analysis of the factors impacting consumers' WTP. The last part is conclusions and recommendations.

Data

Data sources

The data was collected by a survey in Shanghai, China from January to February, 2013. The main consumers of the baby cheese are 0 to 6 year-old children, so it is their parents who decide which to buy. The parents of three kindergartens located in Pudong and Songjiang district of Shanghai were randomly selected to survey. 400 questionnaires were issued and 308 were valid. Following are the reasons why we chose Shanghai as the research area and the baby cheese as research object. First of all, Shanghai is the center of China's economy and finance and the residents in Shanghai have the highest average income in China. Compared to the general dairy products, the price of cheese is higher. The residents in Shanghai are more able to purchase the baby cheese than anywhere else in China. Secondly, the dairy products of Bright Dairy occupy a large market share in Shanghai, so consumers spend more on them and are more familiar with that brand. Thirdly, on September 18, 2012, Bright Dairy's baby cheese was found contaminated by forbidden mineral salts. Just ten days prior, on September 8, 2012, Bright Dairy received the complaints from 952 consumers for the rancid taste of its bottled milk. There were six food quality and safety incidents in only five months from June to October 2012 in Bright Dairy products.

Sample characteristics

This questionnaire was mainly divided into three parts, including consumers' view on food safety, the consumption of dairy products and baby cheese of Bright Dairy, and demographic characteristics. The respondents' demographic characteristics are shown in table 1.

As we can see from Table 1, the majority of the respondents is female, under 40 years old, has attended college and is working for the government or in the private sector. The monthly income (RMB) in almost half of the households is from 5,000 yuan to 10,000 yuan (1$=6.17yuan, August 6, 2014).

In addition, nearly half of the respondents often buy the dairy products of Bright Dairy and more than 70% have bought baby cheese. Most of the respondents buy the dairy products and baby cheese at the supermarket, and less than 2% buy them at the speciality stores. The survey results also show that almost all respondents are concerned about food safety; half of the respondents think that the food they have recently purchased is safe; after the food safety incidents, 35% of the respondents chose the foreign products as substitutes. We know that consumers have high concern about food safety, but they still don't carefully evaluate the food they purchase. Due to the food safety incidents, some consumers lose confidence in domestic products, and prefer the imported products.

Method

Contingent valuation method (CVM) is adopted to reveal consumers' preferences, through an empirical model to explore consumers' WTP for safer baby cheese. Y represents the consumers' choice. If consumers prefer to consume safer baby cheese, Y = 1;

Table 1. Respondents' Demographic Characteristics

Characteristics	Options	Frequency	Percentage(%)
Gender	Male	102	32.08
	Female	216	67.92
Age	≤29 years	43	13.52
	≥30 years ≤39 years	236	74.21
	≥40 years ≤49 years	22	6.92
	≥50 years ≤59 years	7	2.20
	≥60 years	10	3.14
Education level	Under middle school	8	2.52
	High school	56	17.61
	College	229	72.01
	Graduate	25	7.86
Occupation	Working in government	98	30.82
	Working in private sector	169	53.14
	Freelancers	19	5.97
	Unemployment	14	4.40
	Others	18	5.66
Household monthly income (RMB)	≤5000yuan	51	16.04
	>5000yuan ≤10000yuan	155	48.74
	>10000yuan ≤20000yuan	76	23.90
	>20000yuan	36	11.32

Conversely, Y = 0. The BID represents the additional price that consumers are willing to pay for safer baby cheese. P represents the price of regular baby cheese. X represents factors other than price affecting consumer choice. This would include gender, income, consumers' awareness and evaluation of food safety etc. The symbol ε is a random error term, and α, β, and λ are parameters to be estimated. The utility of safer baby cheese and regular baby cheese are $U_{Y=1}$ (X, BID, ε_1) and $U_{Y=0}$ (X, P, ε_0), respectively. If and only if $U_{Y=1} \geq U_{Y=0}$, the consumers will choose to consume safer baby cheese. Let $U^* = U_{Y=1} - U_{Y=0}$, we can get the probability equation that consumers choose to consume safer baby cheese (Y = 1):

$$P(Y=1) = P(U^* \geq 0) = P(U_{Y=1} \geq U_{Y=0}) \quad (1)$$

Due to ε_1 and ε_0 obeying the Weibull distribution, the equation can be set to linear logistic model through the transformation.

$$\ln\left[\frac{P(Y_1)}{P(Y_0)}\right] = \alpha + \beta X + \lambda BID \quad (2)$$

The price of regular baby cheese was 11yuan/92g at the supermarket in January 2013. We want to know how much the respondents are willing to pay for safer baby cheese. Six price options on safer baby cheese were given to the respondents to choose: no purchase or 11yuan/92g, 11-12yuan/92g, 12-13yuan/92g, 13-14yuan/92g, 14-15yuan/92g and 15-16yuan/92g. The variable definition and summary statistics are showed in Table 2.

Results

Survey results show that only 15.1% of the respondents are willing to pay more for safer baby cheese. The price of the regular baby cheese is 11 yuan/92g, and the respondents are willing to pay 22.9% more of that for safer cheese.We define the WTP as 0, 1, 2, 3, 4, 5 for 0, 0-1, 1-2, 2-3, 3-4, 4-5 which is ordered explained variable and reflects the increasing trend of consumers' WTP. Table 3 shows the results of the ordered logistic model by Stata11.0.

The WTP of the consumers who are aware of the Bright cheese incident (Kno2) is lower, which means that the impact of the food safety incident on WTP is negative. After the food safety incidents, some consumers lost confidence in the products and no longer believe them to be safe, so they don't want to buy the products or pay additional price for them. Knowledge

Table 2. Variable Definition and Summary Statistics

Variable	Variable Definition	Mean	Std.
WTP	Consumers' willingness to pay more for safer cheese (0, 0-1, 1-2, 2-3, 3-4, 4-5 (Unit: yuan/92g))	0.38	1.07
Kno1	Food safety certificates (known = 1, unknown = 0)	0.77	0.42
Kno2	Bright Dairy baby cheese incident (known = 1, unknown = 0)	0.14	0.34
Kno3	Mineral salt (known = 1, unknown = 0)	0.48	0.50
Kno4	Knowledge of agriculture, food or medical (known = 1, unknown = 0)	0.14	0.34
PD&SL	Production date and shelf life (as the most primary factor = 1, others = 0)	0.48	0.50
BA	Brand awareness (as the most primary factor = 1, others = 0)	0.31	0.46
Freq	Purchasing frequency of baby cheese (one time or more a week = 1, other = 0)	0.26	0.44
Atti	Attitude for "banning mineral salt in infant food " (agree = 2, agree a little = 1, disagree = 0)	1.17	0.68
SE	Evaluation for Bright Dairy baby cheese (safe = 1, others = 0)	0.30	0.46
Subs	Substitutes for domestic baby cheese (foreign = 1, others = 0)	0.35	0.48
Gender	Male = 1, female = 0	0.32	0.47
Age	Over 40 years old = 1, others = 0	0.12	0.33
Edu	College or above = 1, others = 0	0.80	0.40
Work	Working for the government or in the private sector = 1, others = 0	0.84	0.37
Income	>10000yuan = 1, others = 0	0.35	0.48

Table 3. The Regression Results of Ordered Logistic Model (N = 318)

Variable	Coefficient	Standard Error	P>|z|
Kno1	0.486	0.475	0.307
Kno2	-0.957*	0.565	0.091
Kno3	1.045***	0.370	0.005
Kno4	1.097***	0.420	0.009
PD&SL	0.883*	0.497	0.076
BA	0.477	0.561	0.396
Freq	0.326	0.362	0.367
Atti	0.189	0.283	0.504
SE	1.047***	0.358	0.003
Subs	0.707**	0.355	0.046
Gender	0.538	0.372	0.148
Age	-2.259***	0.866	0.009
Edu	0.216	0.532	0.684
Work	-0.904*	0.491	0.066
Income	0.320	0.357	0.371
Log		-185.33	
Wald χ^2		43.14	
Pseudo R^2		0.1043	

Note: *, **, *** denote 10%, 5%, and 1% significance, respectively.

of mineral salt (Kno3) and Knowledge of agriculture or food or medical (Kno4) have significant positive impacts on their willingness to pay for safer baby cheese. The consumers who know about the mineral salts are willing to pay more for safer baby cheese to avoid risks. Besides, the consumers who have knowledge about agriculture, food or medicine have a higher WTP for safer baby cheese because of their higher knowledge of safe food.

Consumers who consider the production date and shelf life to be important have a higher WTP. Although the effect of "BA" is not significant, the coef-

ficient is positive. It means that consumers who care about the brand are willing to pay more. "SE" positively affects the consumers' WTP. In other words, the safer consumers believe the Bright Dairy baby cheese to be, the higher their WTP for safer baby cheese. High safety evaluation means high trust so that consumers are willing to buy the products and pay more.

"Subs" indicates that after the food safety incident, consumers who chose a foreign brand of baby cheese as a substitute have higher WTP than others. These consumers think the imported food is safer and their income is higher so that they are able to buy the foreign products. Therefore, these consumers are willing to pay more for even Chinese food as long as the safety is ensured.

In addition, the impact of age (Age) and work (Work) on WTP is significant. WTP of consumers over 40 of age (or "over 40"...) is lower than that of the consumers under 40 (or just "under 40"). Table 1 shows that about 12% of respondents are over the age of 40. Those people may be the children's grandparents. Their WTP for food safety is lower because of their consciousness and consumption habits. Besides, the age of the children of consumers over 40 may be older so their demand for baby cheese is lower. Table 1 also shows that the consumers besides those who work for the government or in the private sector are "freelance", "unemployment" and "other". Some of these consumers may be housewives who usually buy food and have more time to consider food characteristics so they have a higher recognition of safer food, and consequently a higher willingness to pay.

Conclusions and Recommendations

Based on the "mineral salt incident of Bright Dairy baby cheese", we surveyed consumers' WTP in Shanghai for safer baby cheese and analyzed the factors impacting WTP with ordered Logistic model. We came to the following conclusions: Firstly, the food safety incident negatively affects consumers' WTP for safer baby cheese. The WTP of the consumers who know about mineral salts or have knowledge about agriculture, food or medicine have higher WTP for safer baby cheese. Secondly, the WTP of the consumers who consider the production date and shelf life to be important is higher. Thirdly, the consumers who believe the Bright Dairy baby cheese is safe are willing to pay more for safer baby cheese. Fourthly, the consumers choosing foreign brands of cheese as substitutes have a higher WTP than others. Finally, the consumers who are over 40 and work in either the government or in the private sector show negative WTP.

According to the above conclusions, we make the following recommendations: Firstly, after the food safety incidents, the government and relevant supervisory departments should quickly begin the emergency plan to control the situation and remove the defective products from their shelves, recall and seal the products. Also the vendors should tell the consumers the truth and offer remedial measures which will be implemented to eliminate consumers' panic and enhance their confidence. Secondly, the organizations issuing information (especially the media) should disseminate real and reliable information to guide consumers in their search of relevant information to increase their knowledge of food safety, which will result in their heightened awareness. Thirdly, in order to improve consumer confidence in the domestic products and take advantage of brand preference in the consumers' minds, the manufacturers should produce the products in strict accordance with the provisions of the state and eliminate food safety issues. This is the most fundamental way to solve the problem of food safety, but it requires effective supervision of the government and consumers. Finally, the target consumer groups of the safer baby cheese should be the young mothers below the age of 40 and the housewives.

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The Rapeseed Project for Restoring Tsunami-Salt-Damaged Farmland after the GEJE

Yutaka NAKAI, Takeshi NISHIO, Hiroyasu KITASHIBA, Masami NANZYO, Masanori SAITO, Toyoaki ITO, Michiaki OMURA, Miyuki ABE and Yukie OGUSHI

Graduate School of Agricultural Science, Tohoku University

Abstract

The Graduate School of Agricultural Science, Tohoku University, launched an Agri-Reconstruction Project in 2011 immediately after the March 11 Great East Japan Earthquake disaster, and this continues to date. We started the Rapeseed Project for Restoring Tsunami-Salt-Damaged Farmland immediately after the disaster. Damaged farmlands were surveyed and salt-tolerant rapeseed varieties from Brassicaceae and related species were used to restore the soil. The plants came from the gene bank developed at the Graduate School of Agricultural Science, and were planted on damaged farmland in Sendai and Iwanuma. As part of the project, the production and sale of edible as well as fuel oil obtained from rapeseed plants was organized in coordination with the Miyagi Prefecture, Sendai City government, a number of private companies and other partners. This enterprise and the genetic selection of the salt-tolerant varieties of Brassicaceae plants continue to date.

Introduction

Many lives were lost and horrendous damage was caused by the Great East Japan Earthquake and tsunami disaster of March 11, 2011. Farmers and farmlands were also severely damaged by tsunami. We considered that we should support the agricultural, forestry and fisheries reconstruction process in the tsunami disaster area. Then the Graduate School of Agricultural Science launched the Agri-Reconstruction Project in March 23, soon after the disaster. The project is based at our Graduate School in a consortium-like group of independent researchers.

Along the Tohoku region, 37 research projects were done. These activities have been carried out in close cooperation with local residents. Among these, one of outstanding projects was the Rapeseed Project for Restoring Tsunami-Salt-Damaged Farmland.

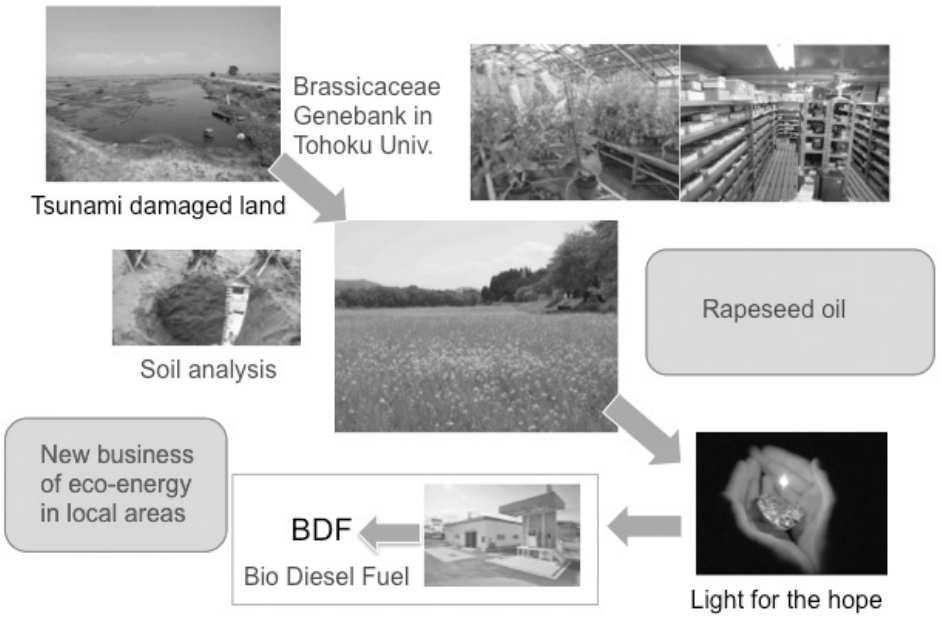

Figure 1. Concepts of Rapeseed (Nanohana) Project for restoring tsunami-salt damaged farmland

The rapeseed project objectives included soil surveys of the affected farmlands and selection of Brassicaceae plants such as rapeseeds suitable for the level of salt damage. Moreover, it included sowing these seeds on the damaged land, planting yellow rapeseed flowers to improve the landscape and to symbolize the agricultural revival and eco-energy development. Oil is obtained from the harvested rapeseed to produce biodiesel fuel, BDF. This fuel is used to operate machinery for the restoration of the affected areas, and will be a new business of eco-energy in disaster-stricken areas.

The members of the project were professors who worked in the leading edge of each specific research field in plant breeding, soil science, agronomy, microbiology and agricultural economics. Our Graduate School of Agricultural Science is a leading research institution in Japan in the field of genome sequencing of Brassicaceae plants and holds a renowned gene bank of phyletic lines specializing in Brassicaceae-related plants. Brassicaceae related species include *Raphanus* (radish), *Capsella* (shepherd's purse), *Eutrema* (Japanese horseradish) and others. The genus *Brassica* alone includes B. juncea (mustard, mustard greens, Sichuan vegetable (zha cai), B. *oleracea* (cabbage, cauliflower, Brussels sprouts and others), B. *napus* (rapeseed) and B. *rapa* (Chinese cabbage, turnips, Japanese mustard spinach (komatsuna), potherb mustard (mizuna) and others. Over the last 50 years the gene bank has sampled and managed roughly 800 phyletic lines from 177 species in 58 genera, gathered from research institutions overseas. Ancestors of rapeseeds were considered to be Mediterranean seashore origin. Some of the lines had been clarified as salt tolerance lines through cultivation trials in our school.

We decided to launch the project with objectives of soil surveys on the affected farmlands as well as selection of Brassicaceae plants suitable for the level of salt damage. Moreover, it included sowing these seeds on the damaged land, planting yellow rapeseed flowers to improve the landscape and to symbolize the agricultural revival and eco-energy development. Oil is obtained from the harvested rapeseed to produce biodiesel fuel. This fuel is used to operate machinery for the restoration of the affected areas, and run school buses for children living in disaster-stricken communities.

It was considered that the construction of a regional autonomous energy supply system making use of rapeseed would play a useful role in the restoration of the disaster-affected areas.

As a complementary objective, it was hoped that through the cultivation of rapeseed local farmers would be encouraged to resume farming at the earliest possible time, as this would lead on to the revival of the farming economy.

Detailed and wide-ranging soil survey covering the entire (14,300 ha of) tsunami-affected farmland in Miyagi Prefecture was carried out in coordination with prefectural research institutes and other partners. The survey at 344 locations in the area showed that there were significant differences in the damage from region to region. In some places, the soil surface had been covered by a tsunami deposit consisting of mud, while in others the plow layer was covered in a thick deposit of sand. In other places, the topsoil had been washed away, while the other land had simply been immersed in seawater. It was clear that the farmland restoration method would differ according to the type of damage found in each area.

We sampled soil in the east area of Sendai to investigate the growth of rapeseed. Rapeseed could not grow in the Tsunami sludge, but could well in plow layer well. It was decided that the salt damaged fields could be restored by removal of surface Tsunami sludge. We announced the results through our web site and newspaper. This approach was welcomed by the local community and farmers. This in turn encouraged the local people to keep looking forward despite the difficulties.

We planted out salt tolerant lines and conventional lines 'Kizakinonatane' in Sendai Nogyo Engei Center and paddy fields in Sendai, and conventional lines at four private farms' farmland in Iwanuma.

We removed weed and Tsunami sludge on the paddy field in Sendai with 120 volunteers, and seeded it with 30 volunteers. We planted seedlings of salt-tolerant lines with 70 volunteers. At the end of January, migratory wild swans completely devoured the leaves. The birds fed on the plants, because they could not find any grains and other type of feed on the Tsunami damaged farmland. It was a new finding that few leaves of *B. juncea*, a kind of mustard were eaten. The reason may be the spicy taste of the plant.

Conventional rapeseeds eaten by the swans bolted in the spring, and the field was filled with yellow

flowers. In front of the flowers, one of the neighboring farmers commented,
"Although almost were totally eaten, I was greatly encouraged by the rapeseed flowers that sprang up strongly. I should follow them." We thought that it must be one of the greatest achievements of our project.

We sold harvested plant in April as edible vegetable rapeseed in markets and a department store. In July, we harvested it to produce rapeseed oil. In the year 2011-12, culturing area was 2.7 ha, and we obtained 4,500 kg of seed. We pressed 63 L edible oil from 450 kg seed, and purified BDF. In the year 2012-13, culturing area was 2.55 ha. We obtained 1,200 kg of seed from 30 a of the Sendai Nougyou Engei Center. We pressed 34 L edible oil from 250 kg seed, and purified BDF. We are still continuing the cultivation, harvest and production. We have tried to produce various products such as the lamplight, candle and preserved flower.

We perform pot experiments for salt tolerance with the plant crops to produce strongly salt-tolerant lines. This led us to believe that a certain degree of salt-removal effect could be expected from the strongly salt-tolerant lines. We also perform the research for the elucidation of the salt tolerance mechanism and the development of strongly salt-tolerant *B. napus* lines. Besides using the salt-tolerant varieties of the plants in tsunami-damaged fields, they are also used overseas in the rehabilitation of salt-damaged farmlands.

We have been collaborating with the rapeseed project in Minamisoma city. The city was damaged by tsunami and polluted by radioactive substances. We are providing seeds, performing trial cultivation on farmland, and field experiments with the objective of assessing the migration of radioactive substances to the plant body and seeds.

In the project, we worked with prefectural and city governments and many private companies. The aim of our project is the implementation of scientific knowledge and research resources in our university on the damaged farmlands and farm operations. However, people have paid attention our activities as one of social movements. We think that the reason is the nonprofit attitude of our university. Our professors worked voluntarily in fields as well as laboratories to act as the main sector of the activities. After the earthquake, several professors around us have changed their mind to jump out to the fields and farmlands.

We hope to continue the enterprise. Rapeseeds are suitable to plant in the salt or radioactive polluted areas, and we can construct a recycle system as an eco-energy production as shown in Figure 2. We would like to construct a local-production-for-local-

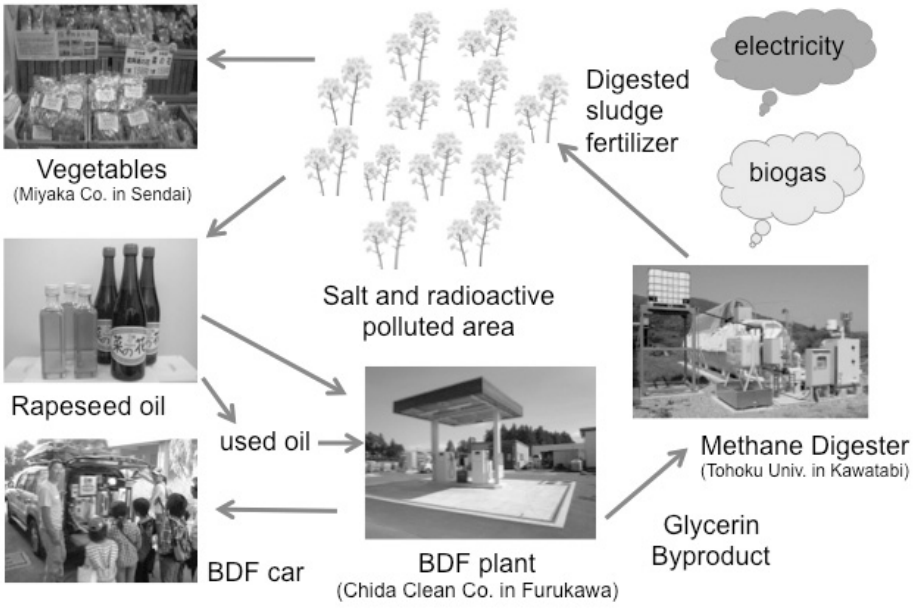

Figure 2. Restoration of agriculture and production of eco-energy by rapeseed

consumption energy system for from rapeseed oil.

Full bloom of rapeseeds on the spring farmland is the landscape that depicts the minds of Japanese people. We would like to carry out the project with the heart-warming yellow flower.

Acknowledgment

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A Brief Summary of the Development of Farmer Cooperatives in China

Jia LEI

Graduate School of Agricultural Science, Tohoku University

Introduction

China's agricultural production has been conducted in a fragmented small-manner and the production of agricultural products has remained highly dispersed for a very long time. Farmer cooperatives are regarded as one way to resolve the contradiction of "small-scale production" and the "big market" under the current food marketing system whilst improving economic welfare benefits to farmers. After the implementation of "Law of the people's Republic of China on Specialized Farmer Cooperatives" in 2007, the number of cooperatives has increased dramatically. However, the development of cooperatives in China has been strongly influenced by political approaches. This paper begins by briefly laying out an overview of the development of cooperatives after the foundation of People's Republic of China in 1949; it then gives an introduction to the current situation of cooperative's development by conducting a case study of Zhejiang Province. The author tries to contribute to the understanding of the development and the driving forces of the great emergence of cooperatives in China in order to provide references for the development of cooperatives and future research.

The Development of Farmer Cooperatives after 1949

The promulgation of "Land Reform Law" in June 1950 marked the beginning of nationwide agricultural reforms in China. The so-called "Land Reform Period" lasted from 1950 until 1952, abolishing landownership by the landlord class and introducing private landownership. As a result, Chinese farmers owned their own farmland for the first time in history (Figure 1).

2.1 Agricultural Collectivization Period (1952-1958)

Under a state monopoly economy, by establishing the agricultural collectives, farmers were proposed to form "mutual aid teams" of 5-15 households, which was regarded as the first stage of the agricultural collectivization movement in 1953. From 1956 "elementary agricultural cooperatives" of 20-40 households and "high level cooperatives", consisting of 100-300 families, were initiated (Feng 2003). Through this movement, the land that had been handed out to the farmers was slowly returned to the state. By 1958 private ownership was entirely abolished and households all over China were forced into state-operated communes.

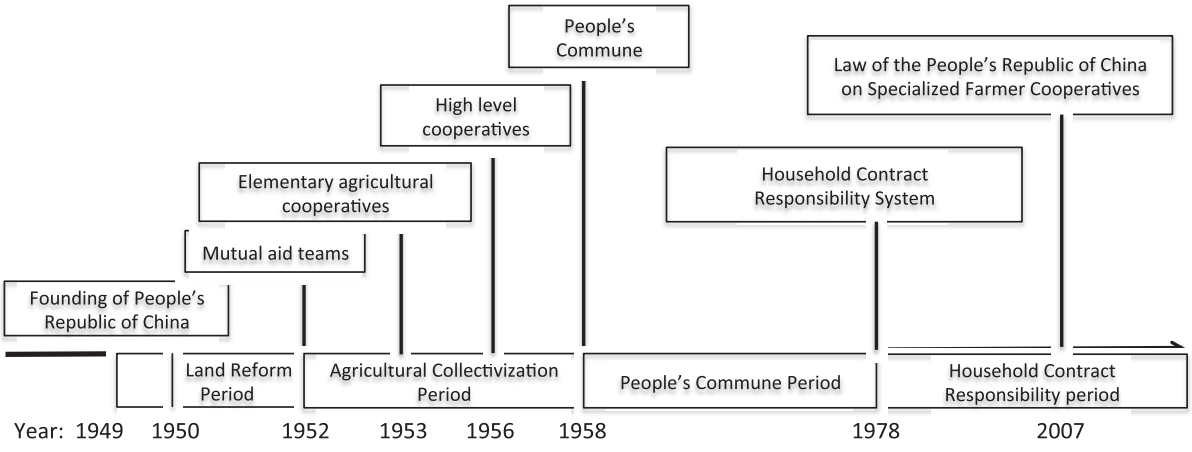

Figure 1. Evolution of Agricultural Cooperation Movement in China

2.2 People's Commune Period (1958-1978)

After 1958, rural life was collectivized completely after various forms of rural cooperatives were merged into very large people's communes. People's communes had become the new form of economic and political organization throughout rural China that marked the entire abolishment of private landownerships. Farmers in the communes received points instead of wages. In terms of grain production, the figures were fixed much higher than their true value due to the excessive zeal of local officials, who were whipped up in the general atmosphere of enthusiasm while at the same time afraid to be seen as moving too slowly. Approximately 25,000 communes had been set up by the end of the year, with an average of 5,000 households each. The collectivization movement achieved some early success, with grain output increasing by 21.8% from 1952 to 1958 (Table 1). However, in the following three years China experienced its worst economic crisis, which caused the Great Famine due to the decline of food production from 1959 to 1961 (Great Leap Forward Period). The existing empirical findings mainly support the 'exit right' hypothesis to explain the dramatic productivity fluctuations in the Chinese agriculture, and support grain availability and the urban-biased food distribution system as important causes of this disaster (Lin 1998).

Table 1. Average Grain Output Per Mu 1951-1958

Year	1952	1953	1954	1955	1956	1957	1958
Total Output (10 thousand ton)	16392	16683	16952	19394	19275	19595	20000
Average Yield Per Mu (kilo)	88.14	87.83	87.61	94.44	94.25	97.31	104.48

Source: China Agriculture Year Book 1980

2.3 Household Contract Responsibility System (1978-2007)

The period from 1978 to 2007 was characterized by the implementation of a "Household Contract Responsibility System" which had become the main policy tool for the reform in rural areas. Through signing long-term contracts with the collective, farmers were able to manage agricultural production on their own initiative while the ownership of farmland still remained in the hands of the rural collective. The start of this system is also viewed as a milestone for the economic opening-up of China.

The people's commune system was abolished under the reform and a system of township government was restored. Farmers' ambitions were stimulated, resulting in a substantial increase in agricultural production. Between 1978 and 1990, rural farmers' incomes increased by 6.7% (Lin 1992). However, farmer cooperatives were growing slowly during the early and middle reform years (1980s and 1990s); farmers in some places found it especially difficult to purchase inputs after the abolishment of the commune system (Stone, 1988). Part of the problem was that the Supply and Marketing Cooperatives failed to provide marketing services for millions of individual small farmers. In order to facilitate better access to inputs, the central government issued a policy encouraging Supply and Marketing Cooperatives to work with farmers and jointly establish early versions of farmer cooperatives in 1987, which might have triggered an early surge in the emergence of farmer cooperatives (Deng, 2010).

By the late 1990s, the ground rules for the agricultural economy began to fundamentally change, as emerging national markets in agricultural produce shifted from a supply to a demand orientation (Zhang 1999), which increased opportunities to specialize in producing higher-value cash crops and specialty commodities. Farmer cooperatives had begun to emerge, especially in the fruit and vegetable sectors. The Ministry of Agriculture began to slowly promote farmer cooperatives and launch pilot programs in the late 1990s and early 2000s. The research conducted by Deng (2010), argued that the determinants of the development of agricultural cooperatives show that the role of the government is of primary importance. It was clear that the lack of legislation affected the development of farmer cooperatives before 2007.

The Development of Farmer Cooperatives in Zhejiang Province

With the implementation of the "Law of the people's Republic of China on Specialized Farmer Cooperatives" in 2007, the number of farmer cooperatives increased dramatically. This gave formal legal status to farmer cooperatives, which also enabled them to sign contracts and act as business entities. There were 828,000 registered farmer cooperatives (32 times more than in 2007) with 65,400,000 members, accounting for 25.2% of the total number of farmers in China in August 2013 (Ministry of Agriculture).

3.1 Introduction to Zhejiang Province

Zhejiang is located on the southeast coast of China and is traditionally known as the "Land of Fish and Rice, Home of Silk". The province has a very high level of economic development and has made itself one of the richest provinces in China. The total population of Zhejiang Province in 2012 was 54,728,000, of which 34,599,000, or 63.2% of the total population, were farmers. Of this number only 1,002,800 farmers had joined farmer cooperatives, accounting for 2.9% of the total. The number of farmer cooperatives in Zhejiang Province increased from 5,141 in 2007 to 37,428 in 2013 while the number of members increased from 385,000 to 1,149,000 - a growth rate of 628% and 198% respectively.

3.2 Farmer Cooperatives' Formation Pattern

The formation pattern of farmer cooperatives reflects the identities of their founders, as these farmer cooperatives usually revolve around the industries or professions most familiar to the founders. There are mainly five types of foundation patterns in Zhejiang Province as figures 3 shows.

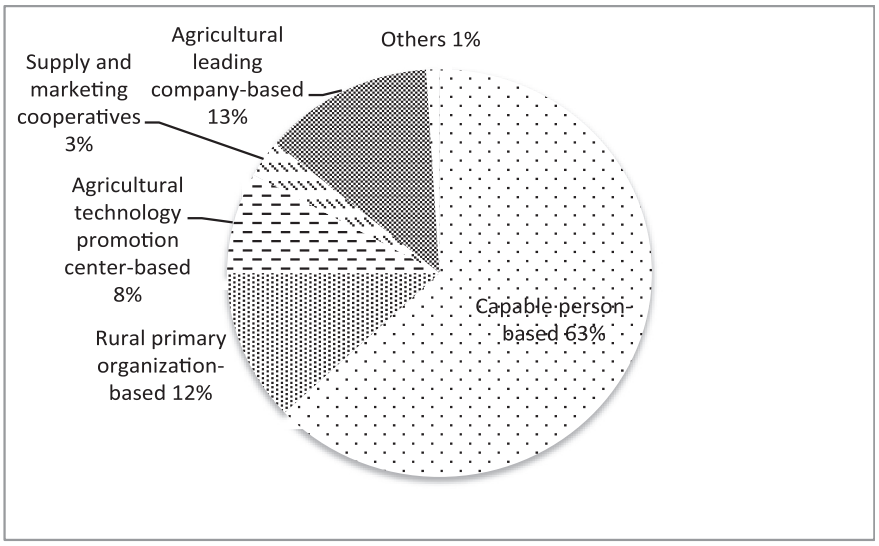

Figure 2. Formation Pattern of Farmer Cooperatives of Zhejiang Province
Source: Zhejiang Province Department of Agriculture, 2013

3.3 Farmer Cooperatives' Categories

Table 2 shows that in 2013 crop farming cooperatives accounted for 58.4% of the total, of which 20.5% were fruit cooperatives and 14.9% were vegetable cooperatives. The livestock husbandry cooperatives and fishery cooperatives accounted for 21.8% of the total. Product from crop farming and breeding industry has a very high commodity rate and also shows that farmers are more familiar with the traditional industry, such as farming and livestock husbandry that do not require high investment.

Table 2. Farmer Cooperatives' Categories in Zhejiang Province

Category	Crop farming	Livestock husbandry	Fishery	Forestry
Others				
Proportion 12.7%	58.4%	13.9%	7.9%	7.1%

Source: Zhejiang Province Department of Agriculture, 2013

Farmer Cooperatives and Nongchaoduijie

4.1 Supermarkets and Farmer Cooperatives in the Nongchaoduijie Program

The *Nongchaoduijie* project was launched in 2008 by the central government and refers to the signing of contracts with farmer cooperatives, with supermarket chains encouraged to procure fresh agricultural products directly from farmer cooperatives. This will help reduce intermediate links in the distribution channels of agricultural products and improve the quality and safety of agricultural products as well as farmers' incomes.

As for the Zhejiang provincial government, a series of relevant policies in support of big supermarket chains in building distribution centers and infrastructural facilities to adapt to *Nongchaoduijie* were also implemented. By the end of 2012, there were 27 supermarket chains in 11 major cities in Zhejiang Province that were participating in the *Nongchaoduijie* pilot program. The cities of Hangzhou, Ningbo and Quzhou each have four supermarkets chains, which have collaborated with 250, 215, and 232 farmer cooperatives respectively. Jiaxing city had only one supermarket and 25 farmer cooperatives that were participating in the *Nongchaoduijie* pilot program (Figure 3).

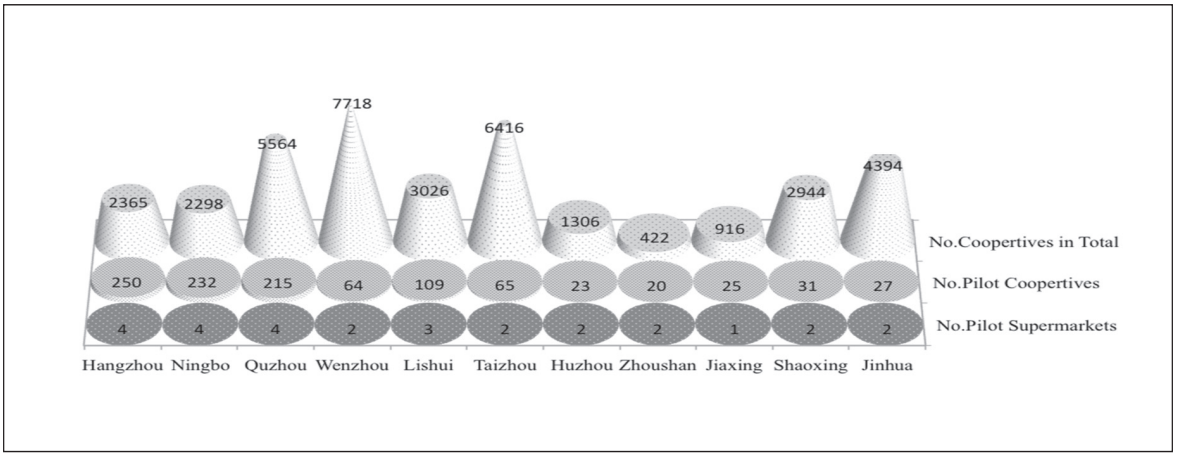

Figure 3. Nongchaoduijie participation in Zhejiang Province
Source: Zhejiang Province Department of Agriculture, 2013

4.2 Problems for Farmer Cooperatives and *Nongchaoduijie* Program

There has been very little research that has conducted any methodical evaluation of *Nongchaoduijie*. Although a few successful cases have been reported in the early stages of this program, there are still many complications. Among the most pressing are the difficulties farmer cooperatives have had in meeting the high requirements of supermarket chains in terms of volume. Also, supermarkets have not been able to make timely payment settlements for agricultural products delivered from cooperatives (Chen, 2011). Warehousing and logistics for small and medium-sized supermarkets without government subsidies have also been lagging behind. The transmission of market and technical information from retailers to producers is vital for *nongchaoduijie*.

Nongchaoduijie is not yet able to cover the majority of fresh produce aside from some fruits and vegetables. Supermarkets engaged in the fresh produce business often have a very small profit margin and merely employ it as means of attracting customers. Therefore, large supermarket chains are often reluctant to participate in *Nongchaoduijie* without government support. They prefer to establish their own production base or distribution center to ensure a stable supply, and yet this approach also requires supermarket chains' high economic strength as a guarantee.

Discussions

Research conducted by Deng (2010) argues that the role of recent government policies in promoting farmer cooperatives explains the great emergence of farmer cooperatives after 2007. Moreover, local officials' performance in promoting farmer cooperatives is usually counted as one of the items in the evaluation of their overall political performance. Although the number of farmer cooperatives has increased

extraordinarily after the newly enacted Farmer's Specialized Cooperative Law and its role in providing a legal environment for the establishment of cooperatives in China, it is still not apparent how to successfully develop and operationalize cooperatives. The development of cooperatives has been strongly influenced by political ideology; it is still the same today as it was in the past.

The *Nonchaoduijie* project is one of the measures intended to foster the vertical coordination of agricultural production under the current farming system. According to our research on the problems of *Nongchaoduijie* in Zhejiang Province, we found that the size of the farmer cooperatives has a huge impact on *Nongchaoduijie*, as large supermarket chains tend to work with farmer cooperatives with large-scale production and guaranteed stable supply. The Government sets very high entry barriers for supermarkets while supermarkets are also creating certain requirements such as size for their potential suppliers in the farmer cooperatives. Under these conditions, small and medium-sized supermarkets and cooperatives that cannot spread overhead costs over large volumes of product are excluded (Gale, 2012).

In this paper, we have looked at the evolution of farmer cooperatives, and then illustrated the current status of the development of farmer cooperatives in Zhejiang Province. Though this paper does not provide conclusive research findings, it does provide a foundation for future research based on the understanding of the key driving forces behind the great emergence of farmer cooperative in China.

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Multi-Dimensional Assessment of Resource, Environment and Economy of Biomass Use - A Case Study of Firewood Use in Households in Nishiwaga -

Daisuke KUNII, Daisuke SAWAUCHI and Takashi HAYASHI

Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries

Abstract

In this study, we propose a new assessment tool for woody resource projects. The tool includes estimation of the amount of available woody resource and matching of its supply and demand, and assessment of both environmental and economic performance as well. As a case study, we apply the tool to a project of firewood promotion in Nishiwaga, Japan. Using the tool, we estimate the amount of available woody resource and the transport cost of the resources by using Geographic Information System (GIS), and match its demand and supply by using linear programming, and finally calculate greenhouse gas (GHG) balance and economic impact both on a household and on local economy.

As a result, we found that only 36% of woody resource is actually available in Nishiwaga, and there is enough woody resource supply to cover its demand for firewood in Nishiwaga. However, we also found that when looking at each community, some communities will import woody resource from other communities in the town within next ten years even if they have enough available resource in their communities. This is because it is much cheaper to import than to supply domestically. In terms of environmental performance, the GHG reduction amounts to 1.9 CO_2-t per household per year. In the economic aspect, converting from kerosene to firewood increases money flow in the town and induces a positive economic impact on the local economy.

It would be thought that it is important to understand not resource potential but resource availability to ensure resource procurement and that it is also important to look at spatial constraint and transportation cost of resources as well as resource availability.

Introduction

In order to contribute to planning woody resource promotion policies, biomass utilization projects should assess not only its economicfeasibility but also its resource availability and environmental performance. It is important to estimate the amount of available resources for carrying out the projects. Without this assessment, the projects might be difficult in procuring resources, and their environmental and economic performance might not achieve their targets. There are a lot of studies about assessment of biomass projects from the viewpoints of resource availability, environment and economy. However, most of them are studied individually.

Therefore, in this study, we propose an assessment tool for woody resource project from multi-dimensional aspects of resource, environment and economy. As a case study, we apply this tool to a project of firewood promotion in Nishiwaga, Japan. Using this tool, we estimate the amount of available woody resource and the transport cost of the resources by using Geographic Information System (GIS), and match its demand and supply by using linear programming, and finally calculate the reduction amount of greenhouse gas (GHG) and economic impact both on a household and on local economy.

Study area

This study focuses on the project about the use of unused thinned wood as firewood at households in Nishiwaga in Iwate prefecture. Nishiwaga is located in the southwest of Iwate prefecture (Figure 1). There are 2,493 households and the population is 7,093 in 2010 (Nishiwaga-machi (2010)). The area of this town is 590 km^2, and 90% of this town is covered with forest.

Methods

In this study, the procedure includes the following five steps. At first, we estimate the available amount of firewood and supply cost of firewood per 1 m^3 by forest subcompartments, based on the forest registration and geographic information data. Second, we estimate the demand of firewood by each community

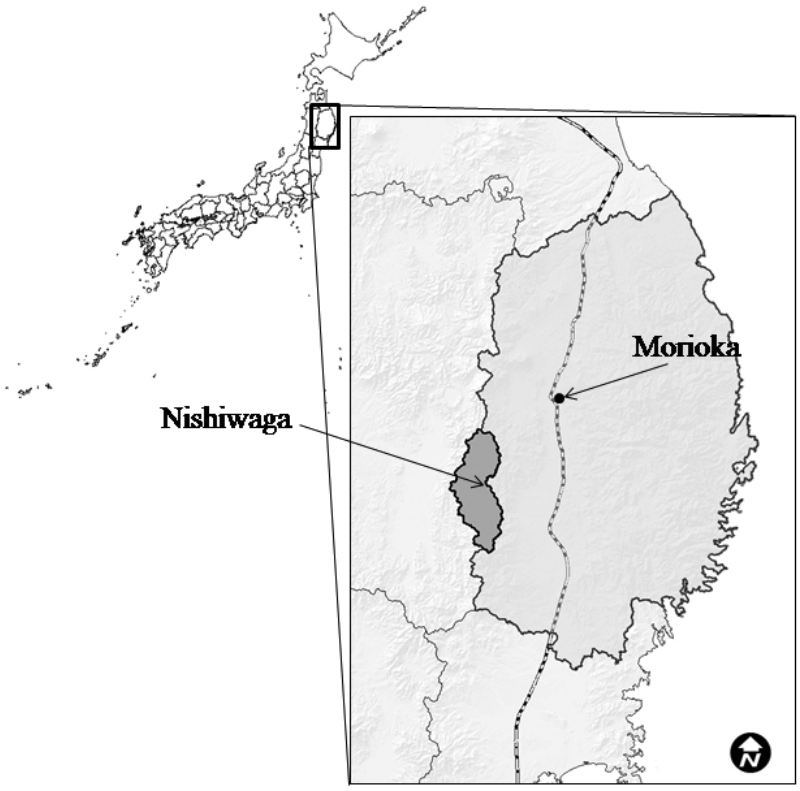

Figure 1. Location of Nishiwaga.

of Nishiwaga, from the statistics data of this town. Third, using the available amount data of firewood, the supply cost and the demand, we perform demand-supply matching by linear programing. We determine the carry-out amount of firewood to each community from each forest subcompartment. Then we compare the available amount and the carry-out amount of firewood. Fourth, we estimate the amount of GHG reduction. Finally, we evaluate the monetary flow in the town and economic effect on the surrounding area by means of Input-Output analysis.

In this analysis, we set the following assumption.

Evaluation of the resource: The households that use wood-burning stoves in Nishiwaga increase from 24.8% (613 households in 2006) to 50% (1,237 households in 2006) of total households, and all of wood-burning stove households from 2006 to use firewood from thinned wood of Japanese cedar. All these wood-burning stove users (1,287 households in 2006) are targets of our estimation.

Evaluation of environmental and economic impact: For negative impact on environment and economy due to the reduction of kerosene purchase cost, increased ratio of households (624 households) from 24.8% to 50% are the target of our estimation. For the positive impact on economy by the purchase of firewood, We target households that purchase firewood (242 households) . The target households are 38.9% of the increased number of households.

Results

Evaluation of resource

As a result of resource analysis with GIS, we confirm two things as follows. First, there are 10,081 subcompartments of Japanese cedar forest in Nishiwaga and its volume is 1.72 million m^3. On the other hand, the number of available forest subcompartments with the mean gradient of less than 35 degrees is 9,889 and the volume is 0.62 million m^3, 36 % of total abundance. There is a large difference between forest resource potential and its available amount as argued by Yoshioka et al. (2012). Therefore, it is important to clearly separate forest resource potential from its available amount. The available amount from the result of this analysis is more than 100 times of the annual demand (5,407 m^3) in this town.

Second, Figure 2 shows self-sufficiency of firewood after 10 years in each community. The self-

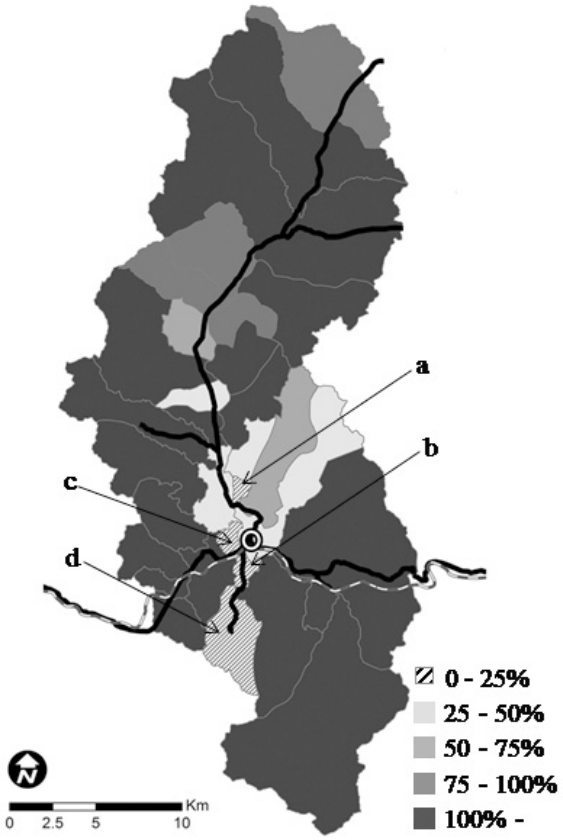

Figure 2. Self-sufficiency of firewood after 10 years in each community.
Note: Black lines are major roads, dashed line is a JR line, and double circle is location of the Yuda government office building.

sufficiency ratio is more than 75% in many communities but in some communities the ratio becomes less than 25% (the communities a, b, c, and d in Figure 2). Then, focusing on the communities with the self-sufficiency of less than 25%, we can recognize two types (Table 1) of community. One is the communities (a and b), where only small amount of firewood is available and they can cover the demand only for 4 to 6 years. This is because communities a and b are located in the center of the town, and the forest areas are small compared to the required amount of firewood. The other is communities (c and d). In these communities, the self-sufficiency ratio is extremely low although there is enough amount of firewood to cover the demand of the communities for more than 50 years.

We think that this is because extraction cost is higher than import cost from other communities.

These results imply that it is important to evaluate the use of woody resource with the premise of the available amount and, to match between the available amount and demand considering spatial distribution

Table 1. Self-sufficiency of firewood after 10 years in communities with the current self-sufficiency of less than 25%.

Community Name	Potential in the community (m^3)	Available amount (m^3)	Demand (m^3/year)	Duration (year)	Self-sufficiency in 10 years later (%)
a	5,554	2,006	338	5.9	1.2
b	2,547	867	222	3.9	0.4
c	24,777	8,949	144	62	7.7
d	39,019	14,192	55	258	12.6

and cost.

Evaluation of environmental impact

The amount of kerosene replaced with firewood by the increased number of households (624 households) is 475 kiloliters (762 liter per household). Based on our assumtion, we estimate that the reduction of GHG in the entire town is 1,183 t-CO_2 per year, and the reduction per household is 1.9 t-CO_2 per year.

Evaluation of economic impact

In terms of the impact on local economy, funds for kerosene that remain in the town are the only retail margin since all kerosene is imported. The retail margin is estimated at only 6.49 million yen whereas the kerosene sale is 39.3 million yen. For firewood, if all of 624 households (50% of households in the town) purchase firewood, the expense is 39.3 million yen, which is the same as kerosene expense. 61.1% of households procure firewood by themselves and 38.9% use funds to purchase firewood. Therefore, the expense and the funds that remain in the town are 15.3 million yen and 12.6 million yen respectively. Here we assume that 38.9% of households purchase firewood from the forest owners' association in Nishiwaga. There is a large difference between the funds of kerosene and firewood that remain in the town, even though the same amount of money is spent as the heating cost.

We calculate the induced increase of the product in the southern Iwate prefecture by using the Input-Output analysis. The net fund of the town is the increase of 6.05 million yen, because the funds for kerosene decrease to 6.49 million yen and the funds for firewood increases to 12.55 million yen (Figure3). Therefore, the induced production value is estimated

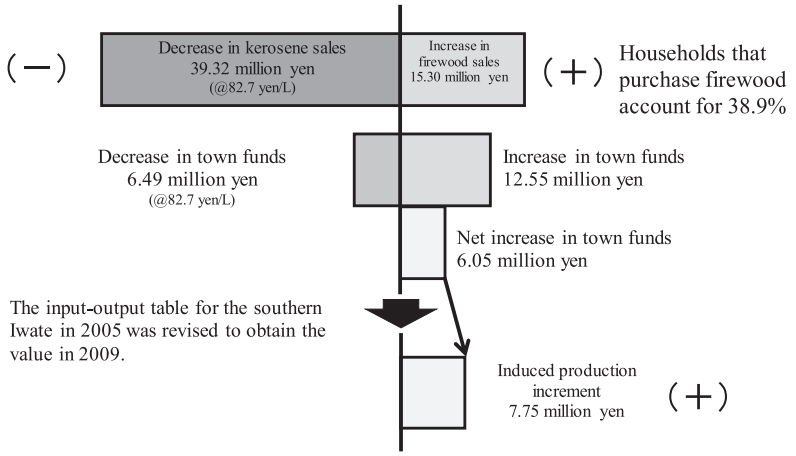

Figure 3. Induced economic impact by the usage of firewood in southern Iwate.

at 7.75 million yen. It is shown that the change of fuel from kerosene to firewood increases fund that remains in the town and produces a positive economic effect there.

Conclusion

From these results, we found that it is important to understand that not resource potential but resource availability ensures resource procurement, looking at spatial constraint and transportation cost of resources as well. All these aspects which are resource, environment and economy are considered by the tool proposed in this study. This tool can be applied not only to woody resource but also to other types of biomass for energy. We believe it can contribute to more practical policy making for local resource use.

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Spectral and Thermal Mapping of Desert Surface Sediments for Agricultural Development

Magaly KOCH[1] and Ahmed GABER[2]

[1]Center for Remote Sensing, Boston University, Boston, USA
[2]Geology Department, Faculty of Science, Port-Said University, Port-Said, Egypt

Abstract

A combination of multispectral, thermal and microwave data obtained from space and supported by ground measurements are used to investigate the surface sediment characteristics of a desert plain area in Egypt (El-Gallaba Plain, NW of Aswan). This plain once hosted an ancestral river system that is nowadays largely covered by aeolian and gravelly sands, and thus, only detectible with radar and thermal images. The methodology consists of extracting thermo-physical and textural parameters to guide and improve supervised spectral classification results. The results show that surface mineralogy (obtained from spectral information) correlates strongly with surface emissivity, whereas grain size and surface roughness strongly correlates with apparent thermal inertia. Furthermore, several broad strips of thermal cooling-anomalies are arranged in a linear fashion and diagonally crossing the alluvial basin. The sediments within these strips show very different textural, thermo-physical and compositional characteristics with respect to the surrounding areas suggesting that they were deposited under different depositional environments such as structurally controlled linear basins. These tectonic depressions were confirmed by ground penetrating radar and could be promising areas for groundwater accumulation and exploration enabling agricultural development in the El-Gallaba Plain of the Western Desert in Egypt.

Introduction

The aim of this work is to determine to what extent multisensor satellite data (operating in the optical, thermal, microwave spectral region) can be used to characterize and map desert surface sediments in an effort to aid soil and water resources exploration for land use planning. Such planning efforts are aimed to reclaim desert land for agricultural use in order to cope with increasing food and water demands for a growing population. The implementation of large agricultural activities in desert environments requires detailed knowledge about the soil and water characteristics, quality and availability. However such information is often incomplete or nonexistent, as for example in the *El-Gallaba Plain*, located northwest of Aswan in the Western Desert of Egypt. This is a desert plain area that contains a large fluvial fan (30 x 60 km^2) from an ancestral river system that was once active long before the river Nile even existed. Nowadays the fluvial deposits are largely covered by aeolian and gravelly sands and thus mostly detectible with radar and thermal images. The El-Gallaba basin has been subject of past and present-day research with respect to its deltaic and fluvial deposits and complex tectono-geomorphic history (Hinz et al., 1993; Thurmond et al., 2004; Gaber et al., 2011; Roden et al., 2011).

The methodology presented in this work consists of (1) processing multi-spectral, thermal (ASTER) and microwave (RADARSAT-2) data for identifying main surface covers, especially gravelly (fluvial) soils, and migrating sand dunes / sand sheets, (2) extracting thermo-physical (kinetic surface temperature, emissivity, and thermal inertia) and textural properties (grain size, surface roughness), (3) correlating surface mineralogy with textural and thermal properties, and (4) validating satellite-derived products with field observation and measurements (ground penetrating radar GPR).

Thermal Surface Material Mapping

Desert surface materials can be characterized through a combination of thermo-physical data (e.g. albedo and thermal inertia) and mineralogy. Studies have shown that for instance dust, duricrust and rocks show very characteristic combinations of albedo and thermal inertia that enable mapping their distribution even in planetary environments such as Mars (Jones et al., 2014). Furthermore, when desert surfaces are covered by a thin layer of dust and sand,

thermal properties of the underlying consolidated layers may be detectable by thermal sensors, providing geologist with a valuable mapping tool (Kahle et al., 1976). Such thermal properties are emissivity, radiant temperature and thermal inertia, which are used to describe the behavior of materials to heat radiation (Sabins, 1997).

Thermal inertia (TI) is a measure of the ability of a material to store and conduct heat, and correlates strongly with material density, particle size and degree of cementation. In other words, TI measures the resistance of a material to changes in temperature. It is possible to estimate TI from space only indirectly by using a model. Thus the inferred parameter is called apparent thermal inertia (ATI) and is a unit less value (Cracknell and Xue, 1996). ATI is computed from surface albedo and diurnal temperature differences, which means that ideally minimum and maximum surface temperature should be known. This limits its estimation to a few satellite sensors such as MODIS and ASTER. Emissivity on the other hand is a measure of the ability of a material to absorb and radiate incident solar radiation, and is dependent on the chemical composition of the material. This property is often used for surface mineralogy mapping.

For our study area we searched for ASTER thermal pairs (day and night images) that would be as close in time as possible. However for most geological applications ATI can be estimated with sufficient accuracy if image pairs are acquired within a period of a few days or weeks (Kahle and Alley, 1985). We therefore selected two ASTER thermal images acquired on 6th (night) and 28th (day) of January 2011 to calculate the thermal parameters. However, in order to calculate the albedo all ASTER reflective bands are required as this parameter is a measure of the fraction of incident visible to near infrared radiation reflected by the surface. Thus an image of February 5th, 2008 (representing the same season) was selected due to the fact that ASTER's SWIR detectors stopped working shortly after that date.

The thermal bands processing consisted of (1) converting AST-09T product to thermal radiance, (2) running an atmospheric correction, (3) calculating kinetic surface temperature, (4) extracting surface emissivity by applying the emissivity normalized method in ENVI, and (5) estimating ATI using the equation $\frac{1\text{-}A}{\Delta T}$, where A is albedo and ΔT is the day-night temperature difference.

Albedo and emissivity are two parameters that are positively correlated and related to mineralogy. A 2-D scatterplot showing this relationship was used to threshold the emissivity map into main desert surface units (rock outcrops, alluvial fans, gravelly and sandy surfaces). This step allowed classifying the study area into main thermo-physical units that were used in a later step to extract and locate endmember spectra for individual units.

The variation of thermal inertia is inversely proportional to surface temperature (day – night) differences (Fig. 1) and can be related to lithologic units. Surface materials with low ATI rapidly heat during

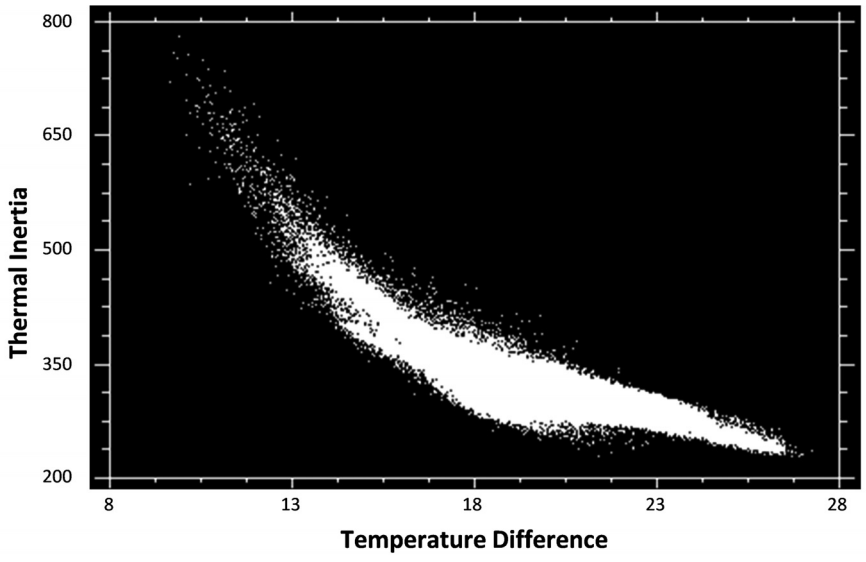

Figure 1. Linear relationship between thermal inertia and day/night temperature difference.

the day and cool during the night. An example of this behavior is loose drift sand. The opposite are dense (and dark) materials with high ATI such as bedrock outcrops covered with desert varnish (causing a darkening effect on the surface). The ATI and emissivity maps were compared in a later step to surface mineralogy and surface roughness in order to infer subsurface geological structures that are not visible on optical images alone.

Spectral Surface Material Mapping

Spectral classification was performed on all nine reflective bands of ASTER. Therefore an image of 5th of February 2008 was selected to avoid the problem with the SWIR radiometer failure that occurred in April 2008. Unfortunately no day-night thermal pair was acquired during that time, so the thermo-physical properties had to be extracted from a later ASTER image pair (January 2011). It was assumed that desert environmental conditions were quite similar during both image acquisitions.

The thermo-physical units that were obtained from the albedo-emissivity relationship described in the previous section constituted the basis for extracting endmembers representing different surface materials. The Sequential Maximum Angle Convex Cone (SMACC) spectral tool (available in ENVI) was used to find endmembers of pure surface materials per thermo-physical unit. A total of eight units were individually searched for endmembers resulting in eight representative spectral curves. The endmembers and their locations were visually inspected and compared to Google Earth images and field photos whenever available. Furthermore, the endmembers were matched against a set of ASTER spectral libraries (http://speclib.jpl.nasa.gov/) in order to determine their true identity.

Once the identity of the spectra was established, a supervised Spectral Angle Mapping (SAM) classification was performed using the eight endmembers as reference vectors and a similarity angle of 0.1 radians. This resulted in a classified image with the following class labels: class1 (sandstone), class 2 (limestone), class 3 (calcareous gravel), class 4 (marl/shale), class 5 (drift sand), class 6 (calcareous tufa), class 7 (shadows/water), and class 8 (gravel/flint).

Correlation of Surface Material with Thermal and Radar Properties

The application of SAM classification to map surface constituents (mineralogy) using reference vectors derived with the aid of thermo-physical units was further explored by running a set of zonal statistical measures in ArcGIS. For each SAM class (except class 7 shadow/water) the mean emissivity and standard deviation was calculated (Table 1). The results confirm that emissivity relates to the composition of the surface showing generally higher values for dense rocky surfaces (class 1 = sandstone, and class 2 = limestone) and lower values for loose grainy surfaces (class 5 = drift sand, and class 8 = gravel/flint).

To further explore the relationship between grain size (or rock fragmentation) and surface sediment type, RADARSAT-2 full polarimetric data were processed to obtain three sets of parameters describing the predominant SAR scattering mechanism: alpha angle which is associated with the type of dominant scattering mechanism, entropy which is a measure of scattering randomness, and anisotropy which describes whether one or several scattering phenomena coexist. Table 2 summarizes this relationship and confirms that the smoothest surfaces are the nearly flat sandstone peneplain (class 1), and the sandy (class 5) and gravelly (class 8) plains of El-Gallaba. In addition, supervised classification of the full polarimetric radar data was performed to further classify the El-

Table 1. Correlation of spectral classes and emissivity.

Sedimentary Classes	Emissivity 2008	
	Mean	STD
Class 1	0.813112	0.028543
Class 2	0.917156	0.012801
Class 3	0.879791	0.036844
Class 4	0.85161	0.032497
Class 5	0.794511	0.028276
Class 6	0.899818	0.022294
Class 8	0.795379	0.02419

Table 2. Correlation of spectral classes and radar scattering mechanism.

Sedimentary Classes	SAR Scattering Mechanism (Mean)		
	Alpha	Entropy	Anisotropy
Class 1	10.667876	0.276344	0.122423
Class 2	16.97365	0.397083	0.056789
Class 3	17.359285	0.428084	0.085935
Class 4	15.815497	0.406366	0.120726
Class 5	11.552115	0.314189	0.283767
Class 6	17.989788	0.461051	0.185498
Class 8	11.960143	0.321885	0.253435

Gallaba plain sediments into five classes, namely two gravel classes, two mixtures of gravel and sand, and one sand class. The resulting classes were compared to the ATI map and the ATI mean/std. per class was computed. The gravels show generally higher thermal inertia than the loose drift sand (Table 3).

Moreover, the sandy and gravelly surfaces of El Gallaba Plain enclose a very interesting thermal phenomenon that appears especially obvious on the emissivity map (Fig. 2). Several broad strips of thermal cooling anomalies appear arranged in a linear fashion and diagonally crossing the desert basin. Variations

Table 3. Correlation of radar classes and apparent thermal inertia.

Sedimentary Classes	Apparent Thermal Inertia (ATI)	
	Mean	STD
Gravel-1	331.28165	19.265427
Gravel-2	319.21512	27.982611
Gravel/Sand-1	315.40887	17.431963
Gravel/Sand-2	311.52066	22.307337
Sand	309.74426	16.990351

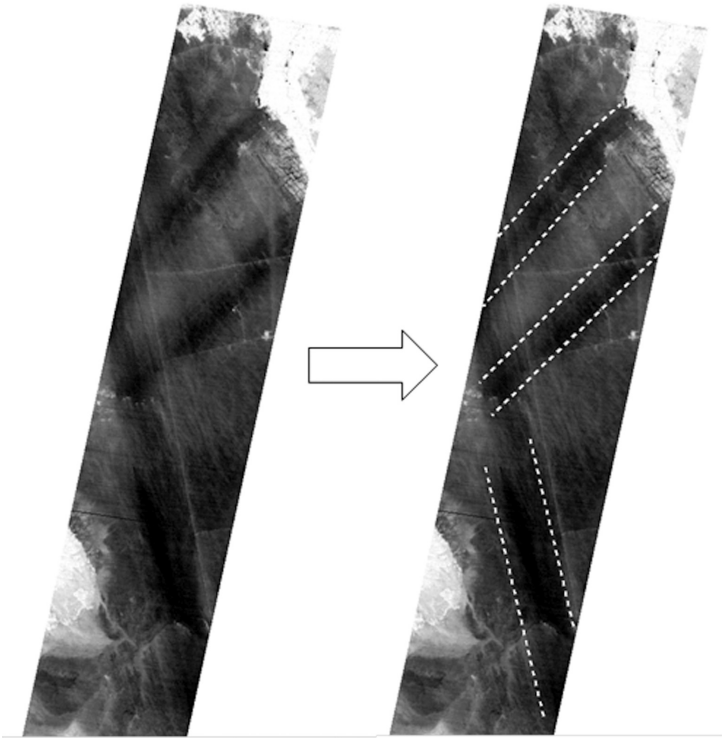

Figure 2. Thermal anomalies indicating possible sedimentary block boundaries.

in emissivity values seem to respond to lithological boundaries and/or tectonic disturbances, and thus, seem to mark fault zones delimiting dropped blocks. The sediments within these strips show very different textural, thermo-physical and compositional characteristics with respect to the surrounding areas suggesting that they were deposited under different depositional environments such as structurally controlled linear basins.

Field surveys using ground penetrating radar (GPR) were run across the thermal boundaries to confirm the nature of these anomalies. The GPR profiles reveal obvious offsets in the subsurface stratigraphy suggesting the presence of highly fractured zones flanking the thermal anomaly strips. This strongly suggests the existence of graben-like structures. The detected buried channels and/or depositional environments and faults may well form good groundwater traps or recharge conduits. Consequently, the structurally controlled El-Gallaba Plain basin could be a promising area for groundwater accumulation and exploration enabling much needed agricultural expansion west of the Nile.

Conclusion

The integration of multisensor data (optical, thermal, microwave) shows promising results in terms of mapping desert surface lithology and near surface features such as fault zones or paleochannels covered by a thin layer of sands and gravels. Surface mineralogy seems to be strongly related to emissivity whereas grain size seems to correlate best with apparent thermal inertia (ATI). Being able to map gravel content, size, and type from space opens up an important mapping tool for determining suitability of soils for irrigated agriculture in areas where detailed soil maps are lacking. Another potential application of this mapping tool is to determine the relative age of gravelly surfaces by detecting their smoothness or roughness and their coating (desert varnish). This would allow drawing valuable conclusions about the paleo-environmental history of desert fluvial landscapes.

Acknowledgement

The authors would like to thank the USGS Earth Resources Observation and Science (EROS) Center for providing the ASTER data, and the Canadian Space Agency (CSA) and MDA for providing the RADARSAT-2 data as part of the SOAR-EI project no. 5138.

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Study on the Use of Small Multi-Copter (UAV) in Agriculture

Naoto KUROIWA, Mizuho AKAMATSU, Yui SATO and Michiaki OMURA

Graduate School of Agricultural Science, Tohoku University

The use of the Unmanned Aerial Vehicle (UAV) has been increasing in various fields, from the military to commercial fields; particularly in environmental measurements and in agriculture, it is used for the spreading of pesticides as well as general observation. Due to the high cost of the UAV in combination with the fragmented and smaller scale farming styles in Japan, however, it is difficult to popularize the use of UAV. In this study we attempt to understand the needs of farmers and explore the possibility of the use of Micro-UAV in the agricultural sector in Japan. We took aerial views using Micro-UAV and researched how to improve the efficiency and how the pictures that were taken in the air could be applied on the spot. As a result, we found that there was a possibility to make use of them in examining the location of soil, e.g. in the case of damage by wildlife.

Vertical Distribution of Radiocesium in Pasture Soils after Pasture Renovation

Teruhiko HOSHINO, Toru UNO, Ryosuke TAJIMA, Toyoaki ITO and Masanori SAITO

Field Science Center, Graduate School of Agricultural Science, Tohoku University

Pastures in Kawatabi Field Science Center Tohoku University were contaminated with radiocesium due to Fukushima Dai-ichi nuclear power plant accident in 2011. As a countermeasure against the contamination, the pastures were renovated by plowing followed by rotary tilling and seeding. To clarify the effect of renovation on vertical distribution of radiocesium in the renovated pastures, we collected soil samples from the pastures and measured their concentration of radiocesium by gamma spectrometry. Before the pasture renovation, a large proportion of radiocesium was distributed in surface soil, such as root mat layer. After renovation, the greater part of radiocesium was found to distribute in sub-surface layer below 10 cm depth. However, in some pastures where gravels were often found in the surface layer, a large part of radiocesium was still distributed in the uppermost layer.

Greenhouse Gas Emission of Rice Production System in the Philippines Based on Life Cycle Inventory Analysis

Elmer G. BAUTISTA[1] and Masanori SAITO[2]

[1]Philippine Rice Research Institute
[2]Field Science Center, Graduate School of Agricultural Science, Tohoku University

In the present study, we estimated Greenhouse Gas (GHG) emission from rice production system in the Philippines from seedbed preparation to harvesting and threshing based on national statistics 2006-2007. Since rice production area in the country is mostly dichotomized as irrigated or rainfed area cultivated twice a year, we used different emission factors of soil processes for each area. We included emissions from farming activities such as fertilizer, agricultural machine, and fuel as well as those from water buffalo (carabao) as draft animal widely used among Philippine rice farmers. Results showed that the total GHG emission of rice production in the Philippines was 13.3 Tg CO_2 eq. yr^{-1}, comprised of 3,920 kg CO_2 eq. $ha^{-1}crop^{-1}$ in irrigated area and 1,381 kg CO_2 eq. $ha^{-1}crop^{-1}$ in rainfed area. These corresponded to 0.93 kg CO_2 eq. kg $grain^{-1}$and 0.47 kg CO_2 eq. kg $grain^{-1}$, respectively. A large proportion of the emission was derived from soil processes such as CH_4 and N_2O emissions from soil. Emission from carabao was 50 kg CO2 eq. ha^{-1} irrespective of water management. Emissions from fuel and other farming activities were 140 kg CO_2 eq. $ha^{-1}crop^{-1}$ in irrigated area and 111 kg CO_2 eq. $ha^{-1}crop^{-1}$ in rain-fed area.

Energy Production from Fish Waste in Large-scale Anaerobic Digestion

Kenji TAKISAWA[1], Gen YOSHIDA[2], Chika TADA[1], Yutaka NAKAI[1] and Yasuhiro FUKUDA[1]

[1]Graduate School of Agricultural Science, Tohoku University
[2]Research Institute of Environment, Agriculture and Fisheries

Marine product processing industry discharges large amounts of fish waste. Incineration is a general method of treating fish waste, but it demands high treatment energy because of its high water content. On the other hand, fish waste has a potential for a raw material for anaerobic digestion because of its high chemical oxygen demand (COD). In this study, it was investigated to produce energy from fish waste in a 27 m^3 anaerobic digestion reactor. Exhaust heat from a seafood-processing factory was used to prompt the heating of the reactor. Oyster shell was added to the reactor in order to reduce the fermentation inhibition by high ammonium concentration because it supplied calcium ion which could reduce the inhibition. The garbage in processing cod in a seafood-processing factory was used as a raw material. Activated sludge was also added along with the garbage in order to adjust C/N ratio which can reduce the ammonium concentration. Biogas volume, pH, COD, ammonium concentration and organic acids were measured with time. If this system receives 1 ton of fish waste per day, it will generate up to 500,000 kWh of electricity per year. Therefore, this system might serve as an emergency power supply resource in times of disaster.

Escherichia coli in Tuul River, Mongolia

Moe TAKADA[1], Chika TADA[1], Yu YOSHIHARA[1], Yasuhiro FUKUDA[1], Tuner BALDAN[2] and Yutaka NAKAI[1]

[1]Graduate School of Agricultural Science, Tohoku University
[2]Mongolian State University of Agriculture

Tuul River crossing over Ulan Bator, the capital of Mongolia, is important for a water source in the surrounding area. In recent years, the number of livestock has been increasing, and the river has been in dager of its water deterioration by overgrazing. *Escherichia coli* is known as an important marker representing fecal contamination in the survey of water quality. Here, in order to show the water pollution by *E.coli*, we analyzed contaminating *E.coli* in surface water samples of Tuul River, and its neighboring pools.

Water samples were collected from three points of the river at Terelji (upper), Gachort (middle), Lun (downstream). Besides these three points, we selected pond and well at Erdene near the river. These collected samples were diluted with sterilized water into 10 and 100-fold dilution. And 100 μL from each sample were plated on desoxycholate-hydrogen sulfide-lactose (DHL) media, which was selected for *E.coli*. Plates were incubated at 36.5 ℃ for 24 hrs. Colonies were formed and counted, and contaminations of *E.coli* in the surface water were calculated as colony-forming units per ml (CFU/ml).

E.coli was detected from the all samples. The number of *E.coli* CFU/mL was 93, 47, 1.3×10^2, 1.3×10^2 and 4.1×10^3 at Terelji, Gachort, Lun, pond and well, respectively. These results suggest that the water possess a potential risk for intestinal infectious disease such as gastroenteritis, which was caused by pathogenic *E.coli*.

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Enrichment and Characterization of an Ammonia-Oxidizing Archaeon of Moderate Thermophilic Taumarchaeotal Group I.1a from Cattle Manure Compost

Yumi MORI[1], Fuyumi TOJO[1,2], Yasuhiro FUKUDA[1], Chika TADA[1] and Yutaka NAKAI[1]

[1]Graduate School of Agricultural Science, Tohoku University
[2]Akita Prefectural University

Composting is a technique that is widely used to change organic solid waste such as animal manure to the fertilizer. In the composting process, ammonia in fresh manure and the one produced from organic N in the process of composting volatile especially in the high-temperature phase of composting. It causes malodor and results in large loss of nitrogen in the fertilizer. A recent study showed that ammonia-oxidizing archaea was one of the dominant microbes throughout the composting. This ammonia-oxidizing archaea may contribute to preventing ammonia volatilization. In this study, we constructed the ammonia-oxidizing archaeal enrichment culture to obtain pure culture. We investigated the archaeal and bacterial community composition in enriched culture derived from cattle manure compost.

Compost sample was collected from a field-scale facility in Tohoku University in September 2009. Samples were suspended in ion exchange water, and were inoculated into inorganic liquid medium containing 10 mM NH_4+-N. The liquid cultures were incubated at 46°C for 2 weeks. Serial passages were performed continuously over 4 years. DNA was extracted to be used for clone analysis. Only one archaean clone that had been dominated in compost was existed in the passaged culture, which was genetically related to Candidatus Nitrososphaera gargensis,. On the other hand, bacterial clones were sorted 5 OTUs (Operational Taxonomic Unit) and clones related to Brevibacillus accounted over 60 %. All bacterial clones were heterotroph. These results indicated that the community composition in the passaged culture was simple containing only one species of ammonia-oxidizing archaea and a few species of heterotrophic eubacteria.

Methane Production Using Cattle Rumen Fluids and Its Application to Reduce Volume of Radiation-polluted Biomass

Yasunori BABA[1, 2], Chika TADA[1], Yasuhiro FUKUDA[1], Masanori SAITO[1] and Yutaka NAKAI[1]

[1]Graduate School of Agricultural Science, Tohoku University
[2]Research Fellow of the Japanese Society for the Promotion of Science

Introduction

The solubilization of lignocellulose components (cellulose, hemicellulose, and lignin) is a rate-limiting step in methane production from plant biomass. On the other hand, rumen fluid (the contents of the first stomach of cattle; slaughterhouse waste) contains lignocellulose-degrading microbes and enzymes. In the present study, rapeseed stem was used as a model of plant biomass, and was pretreated by rumen fluid for methane production. In addition, solubilizing the radiation-polluted biomass by using this treatment for removing cesium was also attempted.

Results and Discussion

Rapeseed was solubilized by pretreatment, and volatile fatty acids were produced. Methane fermentation of pretreated rapeseed was performed, and the methane production of pretreated rapeseed was increased 1.6 times compared with untreated rapeseed. The plant cell wall-degrading enzyme activities (cellulase and xylanase) were determined, and those activities of pretreatment were 10-100 times higher than those of methane fermentation. These results suggest that the plant cell wall was well hydrolyzed during the pretreatment, allowing greater methane production. Additionally, as a result of treating the radiation-polluted biomass by rumen fluid, radioactive cesium was found in liquid fraction. Thus, a possibility that cesium would be removable from the polluted biomass by using this method was also suggested.

Fundamentals for Improving Phosphorus Cycle in Soil-Plant Systems

Masami NANZYO

Graduate School of Agricultural Science, Tohoku University

Among natural resources used as fertilizers, P and K are major concern due to their economically available amount in the world. Phosphorus is considered more limited than K although new P resources may be found.

Seventy to eighty percent of P resources are input in agricultural soils as P fertilizers. However, P recovery rate is generally low, less than 20 percent in many cases, in crop production in the agricultural fields due to fixation by soils. The P recovery rate depends on many factors such as soil properties, kind of crops, management of soils and fertilizers, etc.

In order to improve P cycling in the agricultural soil-plant systems, one method may be to prevent P fixation and increase P uptake by plants. Brassica plants and buckwheat show interesting root growth in P-deficient Andosols. Roots of these plants cover slow release P fertilizer particles and these roots separate P fertilizer particles and Andosols to prevent P fixation by soil. P recovery rate by Japanese radish can be improved up to around 40% and the radish growth is good enough to be marketable. As the slow release P fertilizers, pelletized chicken manure and pelletized swine manure are effective. These fertilizers contain well-crystalized struvite ($MgNH_4PO_4 \cdot 6H_2O$) that contain not only P but also N.

Another method may be harvesting of vivianite ($Fe_3(PO_4)2 \cdot 8H_2O$) from paddy field soils. Plow layer soil is gradually reduced after flooding the paddy fields. Under the reducing conditions, vivianite crystals form on the aged rice roots, old plant debris and in the bulk soil. Lowland soils are suitable for vivianite formation. The many crystal aggregates of vivianite are larger than 0.05 mm in diameter. However, the vivianite crystals disappear with the development of oxidizing conditions after drainage. Thus, it is important to collect the crystal aggregates under reducing conditions from soil. Further challenging point is to separate the vivianite crystal aggregates effectively from soils to improve purity.

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