Review

DOI: 10.5582/ddt.2015.01050

An examination on the modern significance of "Yakushokudougen" in transferring to organic agriculture

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Summary **This study attempts to identify whether and why the difference in corruption progress exists between organic and conventional farm products by conducting two corruption experiments of farm products and separation experiment of bacteria, as well as farmer survey. The results of corruption experiments for Wenzhou mandarin oranges (*Citrus unshiu*) and polished rice showed that conventional farm products demonstrated fast-growing corruption with strong unpleasant smell distinctively different from organic farm products. The separation experiment of bacteria indicated a high possibility of fungus appearance in organic farm products and coccus or bacillus appearance in conventional farm products, which are significantly consistent with the results of two corruption experiments and the fact that organic farmers are strongly conscious of the use of fermented organic fertilizers with effective microorganism in their cultivation. These results offer empirical evidences for supporting the development of organic agriculture and the consumption expansion of organic farm products, but further works are necessary.**

Keywords: Organic farm product, sustainable agriculture, corruption experiment of farm product, separation experiment of bacteria, ishokudougen

1. Introduction

Among organic farmers and researchers, it was well known that organic farm products are good at storage or "become hard to decay" compared with conventional farm products. Many of them also regarded this as an evidence to claim the necessity of transferring the existing agriculture to organic farming. For example, Tsuruda (2011) introduced this as a common view of an organic farmers group (1996, Mogura farmers group), based on their farming practices (*1*). However, Kimura, well known for his natural farming practice "miraculous apple", demonstrated that organic rice was easier to decay than natural farming rice, and organic cucumber had fast-growing corruption even more than conventional farm products (*2,3*). However, no evidences have been offered to a rational explanation why the corruption of farm products is different between organic and other farming systems. Some observers therefore argued that the corruption of farm products occurs just because they are organic matters, no relation with the difference of farming systems (*4*).

This study identified whether the difference exists between organic and conventional farming systems by conducting two corruption experiments of farm products. Then, empirical examination is given based on the results of separation experiment of bacteria and some surveys from organic farmers' practices. Finally, the policy applications of this study are discussed.

2. Methods and results of corruption experiment

2.1. *Methods*

Wenzhou mandarin oranges (*Citrus unshiu*) and polished rice were used. Organic oranges were purchased from a farmer of Nakajima town, and conventional oranges from B town where is famous for its citrus production, and Ehime University Senior High School (EUSHS, Ehime, Japan). The experiment of oranges was conducted in the Laboratory of Agricultural Economics and Farm Management, Faculty of Agriculture at

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Ehime University. The procedure was as follows. *i*) The experimental jars were sterilized with boiled water. *ii*) Oranges were cut into half and put in the jars. *iii*) Sterilized water (20°C, 60 mL) was poured into the jars. Covers were put on the jar mouths for preventing the invasion of dust. *iv*) Jars were displayed under the sunlight to observe the corruption progress.

The experiment of rice was done with the same methods of orange experiment, for verifying the effects exhibited in orange experiment. The rice samples were purchased from farmers of Kihoku town (organic), Toon city (organic with duck-farming), and a supermarket of Ehime (conventional).

2.2. *Results*

The results of orange experiment are shown in Figure 1. The corruption progress was observed from the fourth day after the experiment started, and Figure 1 showed the state of the 39th day. The organic orange exhibited slow-growing corruption or good storable duration, with a sweet smell. By contrast, the conventional orange changed into burnt-blackish color with a stinking smell so much as to provoke nausea. The orange of EUSHS exhibited a state close to the organic orange. This may be caused from insufficient fertility management of the high school students, which consequently brought about the reduction of chemical fertilizer and agrichemical use.

However, one's likes or dislikes for a smell may depend on his/her tastes and experience to some extent, and therefore may not exist an absolute criterion for judging whether a smell is unpleasant or not. Funa-zushi, a famous traditional fish food of Shiga, could be a good example. A lot of persons are attracted by its unique fermentation smell and favorite to eat it, although it's strong smell or taste property. Its unique smell seems not unpleasant for them. However, we have never heard of a person who favorites the smell of animal wastes. Because of these facts, a smell test for students out of the corruption experiment was done just after the experiment. The results reported in Table 1 illustrate that all participants gave the same answers that organic orange did not have unpleasant smell, although the information of corruption experiment was not informed.

The results of rice experiment are shown in Figure 2. The organic rice exhibited a state almost without corruption indicating a good storable duration, followed by the organic duck-farming rice and conventional farm rice. White mold was observed on the surface of conventional rice, with unpleasant smell. Both organic rice and organic duck-farming rice appeared an amber color, but the latter looked slightly deeper with stronger smell. Ducks eat grass and feed, and finally excrete in paddy field every day in the growth period. The deeper color and stronger smell in the organic duck-farming rice may result in more accumulation of nitrogen than organic rice. As the difference of smells was extremely distinctive, a smell test as Table 1 was omitted.

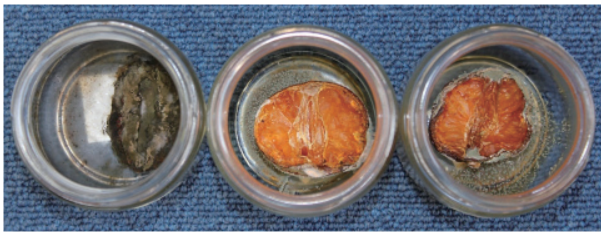

Figure 1. Results of corruption experiment: oranges. The state of corruption progress is exhibited in order of conventional, organic, and EUSHS oranges from the left.

Table 1. Results of smell test (oranges)

Participants	Conventional	Organic	EUSHS
Student 1	1	3	2
Student 2	1	3	2
Student 3	1	3	2
Student 4	1	3	2
Student 5	1	3	2
Student 6	1	3	2
Student 7	2	3	1
Student 8	1	3	2
Student 9	1	3	2

Strongly unpleasant is indicated as 1, a little unpleasant as 2, without unpleasent smell as 3.

Figure 2. Results of corruption experiments: rice. The state of corruption progress is exhibited in order of organic, conventional and organic duck-farming rice from the left.

3. Separation experiment of bacteria for organic and conventional farm products

3.1. *A brief review about the relation between farming system and bacteria*

Hika (2012) pointed out that an unpleasant smell comes from a corruption resolution and a pleasant smell from a process of fermentation. A corruption resolution is caused by putrefactive bacteria, while fermentation derived by lactic acid bacteria and yeast (*5*). These views suggest a causal relation between corruption, fermentation and smell. But his views have no explanation with the evidence from an experimental process of farm products or empirical survey. Some organic farmers and observers argued that the difference in corruption progress and smell is mainly resulted from the residual of over-used

Table 2. Process of separation experiment of bacteria

Time	Process and content of experiment	Notes
Dec. 17, 2014	Put oranges and rice in 50 ml of tubes and add RO water. Then start the culture of bacterium with 30°C. ↓	
Dec. 22, 2014	Culture with sabouraud agar plate ↓	
Dec. 23, 2014	Colonies appear. Collect the plates to 4°C. ↓	
Dec. 24, 2014	Culture with Sabouraud liquid medium ↓	
Dec. 26, 2014	Full growth ↓	
Dec. 27, 2014	Inject the full growth into silkworms ↓	
Dec. 28, 2014	Progress observation ↓	• A dead individual appeared after 27 hours. • 193 hours later, the silkworm injected a medium (sabouraud) lived. However, silkworms injected all samples died, except orange 7 (colony 2).
Jan. 4 , 2015	Progress observation end	

The experiment was conducted by professor SEKIMIZU Kazuhisa, the Laboratory of Microbiology, Graduate School of Pharmaceutical Sciences at the University of Tokyo (Tokyo, Japan).

nitrogen fertilizers and agrichemicals, particularly the remaining of nitrate nitrogen occurred by the excessive use of non-fully ripened compost (*2,3*). On the other hand, there also has a report indicating that the density of nitrate nitrogen in organic farm products is not necessarily lower than conventional farm products (Photo Synthesis Ltd.). However, these arguments are almost based on farmer's practices or empirical explanation, not accompanied with conclusive evidences.

As mentioned above, if the corruption of farm products causes from the decomposition process of organic matter by bacteria, the difference in corruption progress and smell may come from the difference in composition of microorganism attached to or living symbiotically within farm products. This hypothesis implies that different kind of microorganism may be detected out from farm products with different farming systems. To identify this, the separation experiment of bacteria was conducted under our request, by the Laboratory of Microbiology, Graduate School of Pharmaceutical Sciences at the University of Tokyo (Tokyo, Japan).

3.2. *Materials and results*

As the corruption experiments, Wenzhou mandarin oranges and polished rice were used. For the orange experiment, 2 samples of low-input organic oranges close to the natural farming products (orange 1, 3), 3 samples of organic oranges (orange 2, 4, 5) were obtained from farmers, and 3 samples without the organic JAS label were purchased from farmers' market (orange 6, 7, 8, Ehime). In the rice experiment, organic rice (A) used in former corruption experiment shown in Figure 2, a rice sample produced for farmer's family use (B), and a normal commodity rice sample purchased from the Ehime consumers' cooperative (C), were used. The procedure and results of the experiments are reported in Table 2 and 3 respectively.

3.3. *Examination on the results of experiments*

Table 3 indicates the characters of samples and the detected bacterium. The survival times of silkworms infected with the detected bacterium are also included as a reference indicator. The main results can be summarized as follows.

(*i*) Among five organic orange samples, only fungi were detected in orange 1, 3 and 5. In orange 2 and 4, fungi were observed in the small size and cocci G (+) in the large size of colonies.

(*ii*) In the three orange samples except the organic oranges, cocci G (+) in orange 6, bacillus G (-) and coccus G (+) in 7 and fungi in 8 were detected respectively.

(*iii*) In the rice experiment, fungi in the small size, cocci G (-) in the large size of colonies were observed. The difference between the organic and conventional farm products observed in the orange experiment, was not detected in neither sample.

(*iv*) A silkworm died after 27 hours from injection (rice C). The dead times of silkworms in the rice experiment were in order of the conventional (rice C), farmer's family use (rice B), and the organic (rice A), suggesting that the bacterium separated from conventional farm products have stronger pathogenicity and lethality than organic products. However the same results were not observed in the orange experiment. There have the cases that dead silkworms appeared after approximately 50 h from injection in organic farm products (orange 2-1: small, 4-2, 5-1: small), but also the case that silkworm survived until the end

Table 3. Composition of bacterium separated from oranges and rice

Samples (*)	Results of gram staining	Reference indicator: Survival time of silkworms infected with the samples									
		Date & time	12/27 15:30	12/28 18:30	12/29 18:20	12/30 11:50	12/31 17:50	1/1 23:51	1/2 17:40	1/3 15:45	1/4 16:20
		Elapsed time	0:00	27:00	50:50	68:20	98:20	128:21	146:10	168:15	192:50
Sabouraud liquid medium	–		50 µl×2	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
(Controll)	–		*i.h.*	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
Orange 1 1	Fungus			2/2	2/2	2/2	2/2	1/2	1/2	0/2	–
(Low input organic) 2	Fungus			2/2	2/2	2/2	2/2	2/2	2/2	0/2	–
Orange 2 1 (small)	Fungus			2/2	1/2	1/2	0/2	–	–	–	–
(Organic) 2 (large)	coccus G (+)			2/2	2/2	2/2	2/2	1/2	1/2	0/2	–
Orange 3 1	Fungus			2/2	2/2	2/2	2/2	1/2	0/2	–	–
(Low input organic) 2	Fungus			2/2	2/2	2/2	1/2	0/2	–	–	–
Orange 4 1	Fungus			2/2	2/2	1/2	0/2	–	–	–	–
(Organic) 2	coccus G (+)			2/2	1/2	0/2	–	–	–	–	–
Orange 5 1 (small)	Fungus			2/2	1/2	0/2	–	–	–	–	–
(Organic) 2 (large)	Fungus			2/2	2/2	1/2	0/2	–	–	–	–
Orange 6 1	coccus G (+)			2/2	2/2	2/2	2/2	1/2	1/2	0/2	–
(No organic label) 2	coccus G (+)			2/2	2/2	2/2	2/2	0/2	–	–	–
Orange 7 1 (large)	bacillus G (-)			2/2	2/2	2/2	2/2	2/2	1/2	0/2	
(No organic label) 2 (small)	coccus G (+)			2/2	2/2	2/2	2/2	2/2	2/2	1/2	1/2
Orange 8 1	Fungus			2/2	2/2	2/2	1/2	1/2	0/2	–	–
(No organic label) 2	Fungus			2/2	2/2	1/2	0/2	–	–	–	–
Rice A 1 (small)	Fungus			2/2	2/2	2/2	2/2	0/2	–	–	–
(Organic) 2 (large)	coccus G (-)			2/2	2/2	2/2	1/2	0/2	–	–	–
Rice B 1 (small)	Fungus			2/2	2/2	2/2	2/2	0/2	–	–	–
(Family use) 2 (large)	coccus G (-)			2/2	1/2	1/2	1/2	1/2	1/2	0/2	–
Rice C 1 (small)	Fungus			1/2	0/2	–	–	–	–	–	–
(Conventional) 2 (large)	coccus G (-)			2/2	2/2	2/2	2/2	2/2	0/2	–	–

* Choose 2 colonies from the plates of orange 1-8 and rice A-C respectively and inject the culture fluid. The difference in the size of the colonies is indicated by "large" or "small". Others are chosen by different cononies with the same size. The experiment was conducted by professor SEKIMIZU Kazuhisa, the Laboratory of Microbiology, Graduate School of Pharmaceutical Sciences at the University of Tokyo.

of experiment period in conventional farm products (orange 7-2: small). The difference between the farming systems was not found.

Although some issues such as why the bacterial species vary with the size of colonies and what kind of species of bacterium is it remain to confirming furtherly, a distinctive feature can be found in the above-mentioned. Fungi were detected out in all samples of organic farm products, indicating a high probability of fungus appearance, while other samples showed a high probability of coccus or bacillus appearance, or a low probability of fungus appearance including the cases of non-fungus appearance. These results may suggest a symbiotic relation between organic farm products and fungus. As well known, fungi are mainly comprised of yeast and saprobe, in which yeast is necessary for producing different fermented foods such as alcoholic drinks, miso, *etc*., while saprobe is known as a source for making physiologically active substance such as vitamins and enzyme. On the other hand, coccus and bacillus are known as pathogenic bacterium which causes different kind of infectious diseases. In context with this, the results of Table 3 may suggest a high consistency with the results of two corruption experiments in Figures 1 and 2, as well as Hika's views (*5*).

The evidences from farming practices may offer possible interpretation to the result that fungi were detected out in all organic farm products as shown in Table 3. Table 4 indicates the organic materials use in the production of sample farm products from farmer surveys. All organic farmers are strongly conscious of the use of microorganism and apply fermented organic fertilizers made by utilizing effective microorganism in their cultivation. The farmers of orange 1 and 3 which only fungi were detected out have 40 years of experience in low-input organic farming. The farmer of orange 5 utilized organic fertilizers with microorganism and minerals in his fertility management, and carried out the leaf surface spraying of mineral liquid fertilizers, amino acid materials and different kind of vinegars for promoting the work of enzyme, from three weeks to one week ago of harvesting. These evidences may suggest a causal dependence between the results of Table 3 and farmers' farming practices, although further research is necessary for identifying whether the bacterium or fungi detected are adhesive or symbiotic microorganism.

A problem is why different results were observed from organic farm products (orange 1-5 and rice A) in the separation experiment of bacteria. The reasons may be explained from the different farming practices of organic farmers.

The first reason may be from the difference in the kinds and quality of organic fertilizers used in farm

Table 4. Organic materials use in the production of sample farm products

Samples	Farming systems	Obtained routes of samples	Organic materials used	Years of organic farming
Orange 1	Low input organic	Farmer	Fermented manures (Bokashi) with the uses of fish wastes, *etc*.	40
Orange 2	Organic	Farmer	Bokashi with soil microorganism, fermented natural green liquid, wood vinegars, *etc*.	26
Orange 3	Low input organic	Farmer	Potting soil with native bacterium, fermented natural green liquid, fermented fowl droppings	40
Orange 4	Organic	Farmer	Fermented fowl dropping, Bokashi manures with fish wastes, fully ripened hog droppings compost	11
Orange 5	Organic	Farmer	Bokashi manures, fully fermented manures with the main constituent of fish powder, manures containing the ground oyster shell, natural magnesium sulfate, mineral energies, vinegars, *etc*.	15
Orange 6	No organic label	Farmers market	Unknown	Unknown
Orange 7	No organic label	Farmers market	Unknown	Unknown
Orange 8	No organic label	Farmers market	Unknown	Unknown
Rice A	Organic	Farmer	Native microorganism, home-made Bokashi fertilizers utilizing "Ehime AI-1"	10
Rice B	Farmer's family use	Farmer	Unknown	Unknown
Rice C	Conventional	Consumers' cooperative	Unknown	Unknown

The data of oranic farmers are from farmer surveys."Ehime AI-1" is a kind of microbial materials developed by the Ehime Industrial Technology Center, a liquid fermenting yeast, lactic acid bacterium, and bacillus natto by using molasses.

production. *e.g.*, the use of raw organic manure or non-fully ripened compost will lead to the corruption and therefore putrefactive bacterium. By contrast, the application of organic fertilizers with effective microorganism may result in the adhesion or symbiosis of microorganism in farm products. In this case, fungus may be detected from the farm products even if they are not produced by organic farming, like orange 8 in Table 3.

The second reason may be related to the period of transferring conventional farming systems to organic farming. The crops in the farmland with a short period of organic farming practice may be influenced by the residual of chemical fertilizers and agrichemicals used in the conventional farming period, which therefore lead to putrefactive bacteria detection.

The third reason may associate with the storage time and whether there is the invasion of putrefactive bacterium in the meantime. A long time from harvest to getting the sample may cause the invasion of putrefactive bacterium, and then lead to putrefactive bacteria detection regardless of the difference in farming systems or farmers' practices.

The fourth reason may come from the difference in production environment of the farm products. The six samples of organic farm products are obtained from different farmers. The difference in production conditions among the farmers may exert influence on the composition of microorganism attached to or living symbiotically within crops and therefore the results of experiments.

In any case, further evidences are needed.

4. Policy applications of the findings: the modern significance of "Yakushokudougen" in transferring to organic agriculture

The common point of two corruption experiments is that conventional farm products illustrated fast-growing corruption with strong unpleasant smell distinctively different from organic farm products. Furthermore, the separation experiments of bacterium indicated a high possibility of fungus appearance in organic farm products and coccus or bacillus appearance in conventional farm products, which are significantly consistent with the results of two corruption experiments and farmers' farming practices in Table 4. These findings suggest some policy applications, although further evidences are needed.

One of the policy applications is that these results suggest the necessity of reconsidering the significance of "Yakushokudougen". In Japanese agriculture, the ratio of organic farming is only 0.2-0.4%. This fact indicates that almost all farm products are produced by conventional farming. Our findings suggest that our dietary life, for a long time, has relied on the farm products that are easy to decay and with a high probability of appearance of pathogenic bacterium causing infectious diseases. It is therefore an important issue to consider how we should accept this.

There is a thought of "Yakushokudougen" in

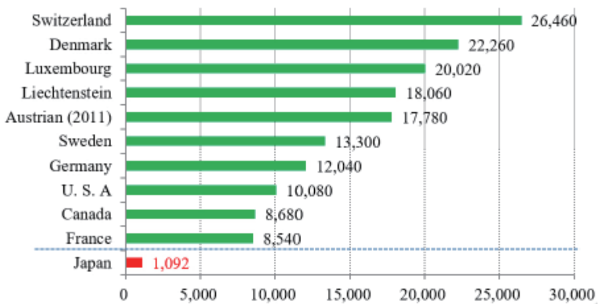

Figure 3. The 10 countries with the highest per capita consumption of organic food products and Japan: 2012. The figures are calculated by 1 euro = 140 JPY according to FiBL and IFOAM.

traditional Chinese medicine (Kampo medicine), which means that using medicinal herbs or food products in the daily meals is effective for preventing health from diseases or health improvement. It is also explained that a healthy and balanced diet by choosing the food products suitable for one's health can improve health and therefore reduce the medicine use. The meaning of "Yakushokudougen" is extended as "Ishokudougen" in Japanese, implying that a sound daily eating habit will lead to disease prevention and health improvement. This thought suggests that the health or life of people, and therefore the medical expenses to pay for them may be influenced by the food products that we choose or eat. Therefore, many Japanese organic farmers and researchers regard organic farm products as safe and trust-worthy food products, convinced of the thought of "Ishokudougen" (*2,3,6*). Hika argued that the farm products produced with the use of effective microorganism could improve the intestinal environment because of the work of useful enzyme, and then enhance the antioxidant or immune system of people (*5*). The results of this study may offer some evidences for these views.

According to the Ministry of Health, Labor and Welfare, the national medical expenses of Japan have increased year by year and reached 39,300 billion yen in 2013. This amount is equivalent to 10.9% of national income, 49.8% of domestic output of food industry, and 4.6 times of gross agricultural product. If the huge medical expenses are related with the results of this study, namely, conventional farm products become easy to decay and with a high possibility of appearance of pathogenic bacterium causing infectious diseases, the effort of transferring existing agriculture to organic agriculture may contribute not only to the environmental conservation and the establishment of a healthy dietary life, but also to the reduction of national medical expenses or fiscal improvement.

The results of this study also propose an issue about what the relationship between food and farming systems should be like. If the fertility management of farmers and the choice of farming systems (organic or conventional) bring substantial effects in the property of farm products as shown in the results of our experiments and exert influence on the health of people such as the antioxidant or immune system of one's body, as Hika argued, the problems of what kind of "food" is desirable for us and therefore what kind of "agriculture" should be chosen may arise as important policy issues. Furthermore, if the health of people is involved in the results of this study as mentioned, a farming system aimed to supply safer and more reliable farm products should be viewed as a rational choice. This therefore suggests a policy alternative to further develop organic farming or sustainable agriculture that supplies farm products with environmentally safe and trusted food.

According to the Ministry of Agriculture, Forestry and Fisheries, 28% of farm-job applicants want to adopt organic farming, and 65% show their interest in organic farming. Moreover, 44% of consumers have the experience of buying organic farm products, and 55% express a willing of buying organic food products. These surveys suggest a high level of awareness for organic farming and food products. But on the other hand, both organic farmers and farming area are only 0.2-0.4% of Japanese agriculture. One of the reasons is that the understanding of consumers is not enough for the further development of organic farming (*8,9*). As shown in Figure 3, per capita consumption of organic food products in Japan was 1,092 Japanese yen, while Switzerland with the highest level in the top 10 countries was 26,460 yen, and France in the last place of the 10 countries was 8,540 yen (*7*). The Engel's coefficients of Japan and the European countries are approximately in the first half of 20%, without significant difference. However, per capita consumption of organic food products exhibits a wide difference from 8 to 24 times. The reason that Japanese organic farming did not greatly extend may be right here.

To improve the current situation, both the effort of agricultural side and the true understanding of consumers are necessary. This study offers empirical evidences for supporting the development of organic agriculture and the consumption expansion of organic farm products, but further works are needed.

Acknowledgements

This study was supported in part by the Grant-in-Aid for Scientific Research (C) (2010-2012: 22580251 and 2013-2015: 25450325). The author thanks professor SEKIMIZU Kazuhisa (the Laboratory of Microbiology, Graduate School of Pharmaceutical Sciences at The University of Tokyo) for conducting the separation experiment of bacteria.

References

1. Shiro T. Fruit cultivation and organic agriculture. An invited lecture in the ninth open seminar of organic farming in Yamanashi, by the Council for Organic

Farming Technology. January 23, 2011. (in Japanese)
2. Akinori K. A Way to Natural Farming. Soshinsha Inc., 2007. (in Japanese)
3. Akinori K. What Apple Taught Us. Nikkei Publishing Inc., 2009. (in Japanese)
4. Izumi Y. Difference between organic JAS farming and natural farming. 2015. (*http://www.j-organic.org/different.html*) (in Japanese)
5. Teruo H. What is fermentation, what is corruption? – The roles of microorganism in distinguishing fermentation and corruption. Kenko Seikatsu Sengen. 2012:3-12. (in Japanese)
6. Masaaki K. Basic and Practice of Organic Farming. Nobunkyo Inc., 2005. (in Japanese)
7. FiBL and IFOAM, the World of Organic Agriculture: Statistics and Emerging Trends 2014.
8. Hu B. Economic Analysis of Sustainable Agriculture. Norin Tokei Kyokai Inc., 2007. (in Japanese)
9. Hu B. Agriculture and Environmental Issues under Rising Input Prices and Depression. Tsukuba Shobo Inc., 2012. (in Japanese)

(Received July 27, 2015; Revised August 4, 2015; Accepted August 25, 2015)