Technical Bases for Sustainable Organic Farming

Michinori NISHIO
Ex-professor of the University of Tsukuba
Nagakuni 814-12, Tsuchiura, Ibaraki, 300-0817 Japan

Summary

It was stressed that technologies needed for organic farming differ depending on the target level of yield or income of farming system. In regions of high precipitation and high temperature, paddy rice production is sustainable as far as yield level is low. The scientific base of this fact was analyzed by nitrogen balance. On the other hand, it was shown that intensive vegetable production by organic farming in Japan frequently applies too much excess nutrients and cannot maintain long-term fertility. The importance of controlling mineral nitrogen level through organic material application was pointed out. The scientific base of nitrogen-controlling technology was explained. It was also discussed that holistic production management systems are required to establish organic faming defined by the Codex Alimentarius Commission.

1. Introduction

In old days, crop production was very hard work, especially in regions of high precipitation and high temperature. One of the reasons was vigorous proliferations of weeds, pathogens and pests. This is easily understandable by the fact that the most famous ancient civilizations were developed in the low-precipitation areas surrounding the Nile, the Tigris and the Euphrates, and the Hwang Ho. In these areas, irrigation stimulated crop growth and low precipitation suppressed the growth of detrimental organisms. Crop production in regions of high precipitation and high temperature has recently been relieved by the use of chemical pesticides.

In regions of high precipitation and high temperature, crop production was also seriously limited by nutrients in old days. In upland soils, high temperature accelerates the decomposition of soil organic matter and high precipitation washes out nutrients, although in flooded paddy soils high temperature accelerates to some extent N availability by biological N (nitrogen) fixation. Nutrient supply has recently been greatly improved by chemical fertilizer.

These facts indicate that if we do not use chemical fertilizer and pesticide, crop production will become again very difficult in regions of high precipitation and high temperature. Thus, organic farming in these regions requires more advanced technologies founded on the sound scientific bases than other regions.

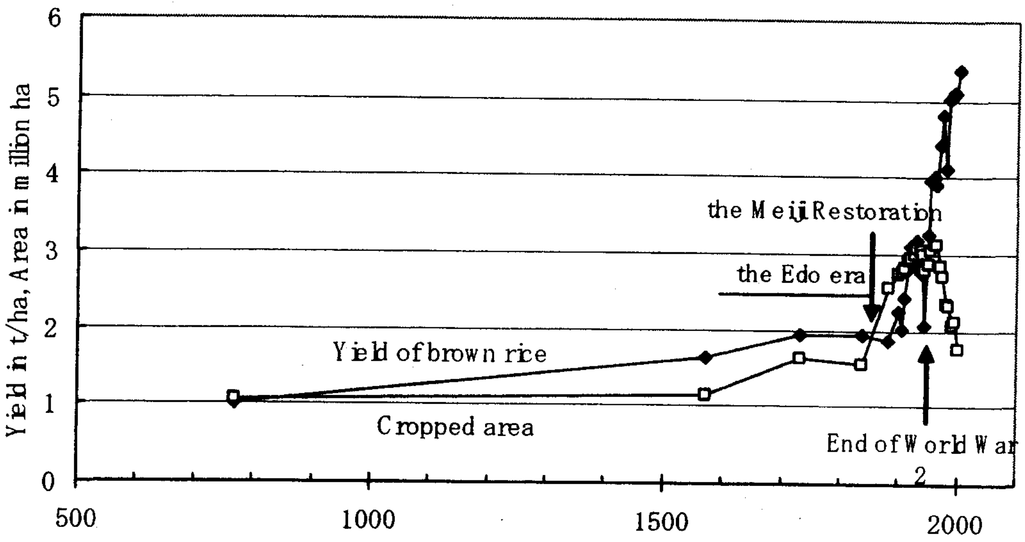

Fig. 1 Changes of yield of brown rice and area cropped with paddy rice in Japan

2. Paddy rice production in old Japan

In old days before chemical fertilizer and pesticide emerged, we practiced organic farming. As an example, I would look back on the historical change of rice yield in Japan. An old record suggests that the yield of brown rice gradually increased from 1 t/ha (1.25 t/ha of rough rice) in the 8th century and came close to 2 t/ha (2.5 t/ha of rough rice) in the 18th and the early 19th centuries (Fig. 1).

In the 8th century, it may be true that no nutrient was applied. Then, was it possible to get 1 t/ha of brown rice without any fertilizer?

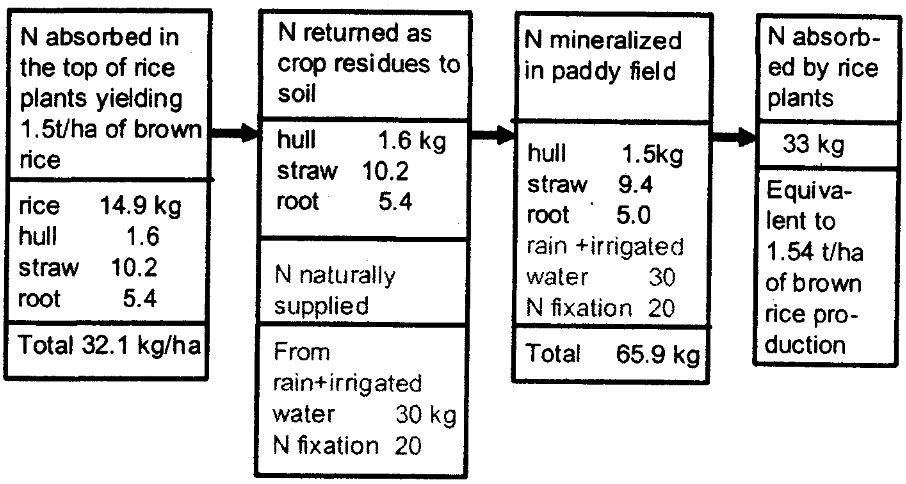

Fig.2 Speculated N balance of paddy field without any fertilization (Nishio, 1998)

I tried to estimate N balance in paddy field which received no fertilizer, by assuming that old varieties have the same N balance as modern varieties (Fig. 2). If we can yield 1.5 t/ha of brown rice, 32.1 kg/ha of N are to be absorbed in the top of rice plants. If we return all residues except brown rice to soil, 17.2 kg/ha of N are to be carried back to soil. The amount of N mineralized from crop residues was calculated by the simulation equation on organic material decomposition in paddy soil, which was developed by the research project of Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF, 1985). The simulation equation shows that the amount of N mineralized increases following the repetitions of cultivation. When cultivations are continued for 50 years, it is speculated that crop residues returned to soil give 15.9 kg of mineralized N. In addition to this, natural N supplies are to be expected; 30 kg from rain and irrigated water and 20 kg/ha from biological N fixation. Thus, 65.9 kg/ha of mineral N are expected to be available for the next rice plants. If we assume that rice plants absorb 50 % of mineral N in soil, they can absorb 33 kg/ha of N and yield 1.5 t/ha of brown rice. Therefore, N balance suggests that paddy field can sustainably produce 1.5 t/ha of brown rice without any fertilizer. In reality, however, climate conditions and detrimental organisms reduce the yield. So, yield of 1 t/ha in the 8th century may be reasonable.

During the 18th and the early 19th centuries, yield increased and came close to 2 t/ha of brown rice. In this period, Japanese farmer gathered fallen leaves in forest and made compost. It is said that farmer collected fallen leaves from 4 to 5 ha of forest to make compost for 1 ha of paddy filed. I estimated the area of forest necessary to make sufficient amount of compost to release 50 kg of mineral N in paddy filed (Table 1).

Table 1 Estimation of forest area needed to make sufficient amount of compost to release 50 kg of mineral N in paddy field

	Dry matter of litter, t/ha·y[1)]	N in litter, kg/ha·y[1)]	N remained in compost made of litter collected from ha of forest, kg/ha·y[2)]	Forest area needed to release 50 kg of mineral N from compost, ha[3)]
Temperate evergreen coniferous forest	4.6±1.4	33±13	23	5.4
Temperate deciduous broadleaved forest	4.1±1.0	45±17	32	3.9

1) Tsutsumi (1987)
2) Assumption was made that 30 % of N are lost during composting.
3) Assumption was made that 40 % of N are mineralized from compost in paddy field.

It was suggested that 5 ha of coniferous forest and 4 ha of broadleaved forest are needed to release 50 kg of mineral N from compost. Extra 50 kg of mineral N can produce another 1.2 t of brown rice. Thus, in addition to natural soil fertility, application of compost made of fallen leaves is estimated to be able to support yield of 2.7 t/ha of brown rice (3.4 t/ha of rough rice). Considering yield reduction by the damages due to climate conditions and detrimental organisms, yield of 2 t/ha of brown rice in the 18th and the early 19th centuries may be reasonable.

Rice yield in Japan began to increase steadily after the Meiji Restoration in 1686 and very rapidly after World War 2 following the increased consumptions of chemical fertilizer and pesticide.

If Japanese farmer had a large land area, 2 t/ha of brown rice (2.5 t/ha of rough rice) in combination with winter crops would be enough to meet family budget of Japanese farmer. But, this yield level is too short to sustain family budget of farmer, who has only 2.1 ha of farmland on average. The target level of yield or income of faming system differs on social and economic conditions of a country or a region, and technologies needed differ depending the target level of yield or income of farming system.

3. Is natural farming reasonable?

As the history of rice yield in Japan suggests, organic farming without chemical fertilizer and pesticide has a risk of farming of low yield and heavy labor. Although there are many types of organic farming, some farmers are undergoing organic farming of low yield and heavy labor. Some of them are supporters of natural farming. Although there are several types of natural farming, Fukuoka's farming is famous.

Masanobu Fukuoka, a Japanese farmer, advocated natural farming in 1975 in his book, "the One-Straw Revolution", which was translated in English and published by Rodale Press in USA. His natural farming has 4 principles; 1) no cultivation, 2) no chemical fertilizer or prepared compost, 3) no weeding by tillage or herbicides and 4) no dependence on (disinfecting) chemicals. There are many his supporters. Is natural farming is really reasonable? If so, organic farming may be easy to practice.

He published in 1976 another book, "Natural Farming" in Japanese, in which his cultivation practices were described in more detail. His main cropping system was a combination of paddy rice and naked barley. In early October clover seeds were sown on drained soil on which paddy rice is still standing. Naked barley seeds were sown two weeks earlier than rice harvesting in late October. In mid-November rice seeds embedded in little clay pellets were sown on soil on which barley seedlings were growing. In June, after harvesting barley, barley straws were scattered on soil. Rice seedlings emerged between barley straws and grew with clover. Water was flooded in panicle forming stage. In this cropping system, nutrient sources were straws of rice and barley, clover, and chicken droppings of 3-6 t/ha. Yields were 5.85-12.09 t/ha of brown rice and 5.89-6.5 t/ha of naked barley.

I tried to calculate N balance of his cropping system and I could not prove that the sufficient amounts of N were available to support his high yields of paddy rice and naked barley. I examined carefully his book and found the description that he applied 800 kg/ha of calcium cyanamide (176 kg N/ha) to barley. Calcium cyanamide filled up the shortage of N balance in my calculation. Apart from the argument that the use of chicken droppings and calcium cyanamide should contradict his second principle "no chemical fertilizer or prepared compost", I speculate that his cropping system with chicken droppings and calcium cyanamide may support the high yields after about 10-years continuation of his system. In the initial stage earlier than 10 years, however, N mineralized from straws of rice and barley may be too small to support the high yields. I found also the description that he used DCPA (propanil) or sodium cyanide to control weeds and wilt clover. Thus, I cannot find that Fukuoka's natural faming has the sound scientific base.

I speculate that Fukuoka made many trials to establish his cropping system. It may be probable that he finally abandoned chemical fertilizer and herbicide when his soil got powerful mineralizing ability of straw and simple weed vegetation after many years.

4. Intensive organic farming

Most of Japanese farmers have small area of farm land, that is, 2.1 ha/holding on average in contrast to 18.7 ha in EU (15) and 176.5 ha in USA. Farmers of small farmland are forced to adopt a strategy to get high yield by intensive farming. So, most organic farmers in Japan are performing intensive crop production by making use of purchased organic fertilizers, compost and non-chemical biocidal methods.

A field survey was carried out to compare the chemical properties of vegetable fields under organic farming with those under conventional farming. It showed that organic soils had higher T (total)-C and T-N contents and lower solid ratio than conventional soils (Fig. 3). These findings reflect that organic soils have received larger amounts of organic materials than conventional soils. It is also noted that half of organic soils surveyed had higher base-saturation percentage and higher contents of exchangeable potassium and available phosphate than conventional soils. These indicate that excess dose of nutrients through organic materials is common in vegetable production by organic farming.

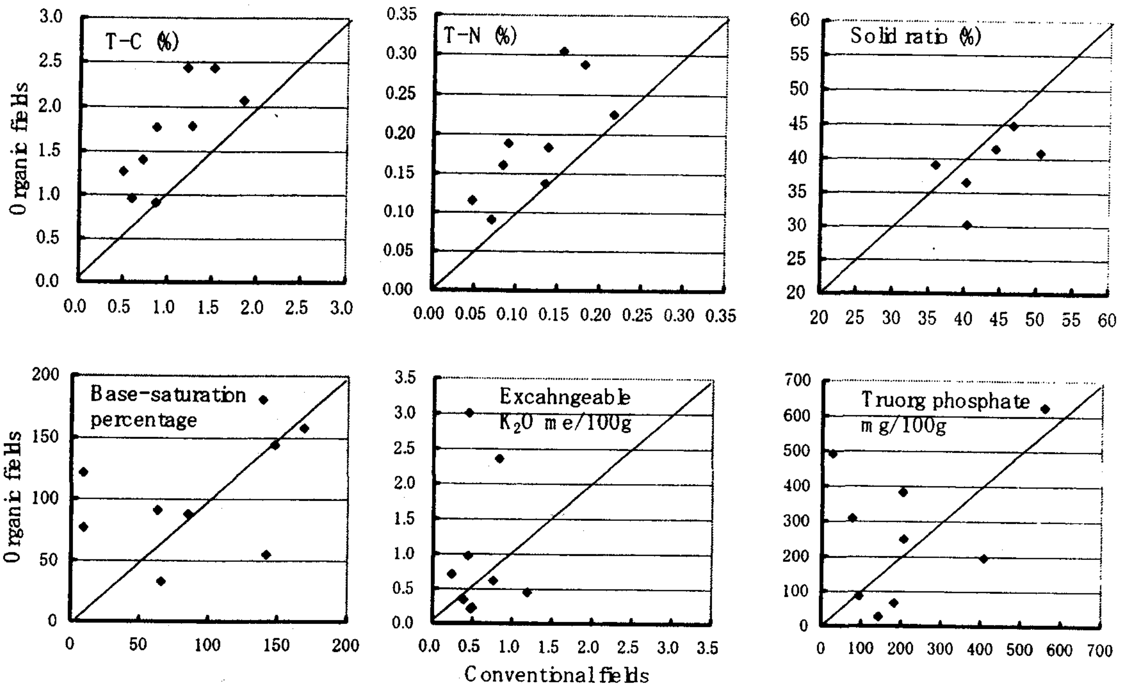

Fig. 3 Comparison of chemical properties of vegetable field soils (7 upland soils and 2 greenhouse soils) under organic farming with those under conventional farming (Taki and Kato, 1998)

Table 2 Chemical properties of soils in plow layer of vegetable greenhouse (Hori et al. 2002)

Field	T-C %	T-N %	pH (H_2O)	EC(1:5) mS/cm	Truorg P mg P_2O_5 /100g	CEC meq /100g	Base-saturation %	Exchangeable cations Mg/100g			MgO /K_2O
								K_2O	CaO	MgO	
A	8.8	0.83	7.1	0.89	695	28.9	144	273	703	204	0.7
B	4.2	0.36	7.3	0.31	206	16.4	110	141	295	85	0.6
C	3.1	0.36	6.9	1.23	101	18.9	126	47	459	116	2.5
D	5.1	0.44	7.1	0.74	114	18.9	120	73	445	92	1.3
E	2.1	0.21	6.8	0.34	43	12.6	96	21	267	39	1.9
Reference			6.0 – 6.5	0.3 – 0.8	40 – 80	>15	80	15 – 50	250-320	50 – 75	1.1 – 2.9

Another survey on greenhouse soils, on which vegetables were organically cropped 4-5 times in a year, indicates also the excess accumulation of nutrients in soils (Table 2). To clarify the excess input of plant nutrients by intensive organic farming, nutrient balance in Field A of Table 2 was estimated by using chemical fertilizer equivalents (CFE). CFE has been empirically determined and represents the efficiency of nutrients in organic fertilizer and other organic materials in comparison with chemical fertilizer to crop growth. The result suggests that total CFE nutrient inputs in a year were larger by 3.4 times in N, 13.0 times in phosphate and 4.1 times in potassium than nutrients absorbed by crops (Table 3).

Table 3 Estimate of nutrient balance in Field A (calculated from data of Hori et al. 2002)

		Amounts applied ton x repletion	Total nutrient applied kg	CFE[1] nutrient content kg	Total CFE nutrient kg	Amounts absorbed by top of crop, kg: breakdown		Amounts absorbed by top of crop, kg: total
		/ha·y						
N	FCaM[2]	8 x 5	640	192	1,278	Komatsuna[5], 4 crops	333	378
	BMC[3]	4 x 5	760	456		Cucumber, 1/4 crop	22	
	FChM[4]	3 x 5	900	630		Tomato, 1/4 crop	23	
P_2O_5	FCaM[2]	8 x 5	440	264	1,631	Komatsuna, 4 crops	101	125
	BMC[3]	4 x 5	1,200	600		Cucumber, 1/4 crop	14	
	FChM[4]	3 x 5	1,096	767		Tomato, 1/4 crop	10	
K_2O	FCaM[2]	8 x 5	1,200	1,080	2,106	Komatsuna, 4 crops	405	509
	BMC[3]	4 x 5	420	378		Cucumber, 1/4 crop	50	
	FChM[4]	3 x 5	720	648		Tomato, 1/4 crop	54	

[1]CFE: chemical fertilizer equivalent
[2]FCaM: fermented cattle manure
[3]BMC: Bokashi[6] mixed with compost
[4]FChM: fermented chicken manure
[5]Komatsuna: a leaf vegetable
[6]Bokashi: Organic fertilizer mixture decomposed by microorganisms for a short period

As these examples show, soils managed by intensive organic farming have the chemical properties similar to those of conventional soils. They are inevitably to result in the deterioration of soil productivity and may cause environmental pollution by discharging nitrate and phosphate from soil to water. Stockdale et al. (2001) cited in their review many studies indicating that there is surplus N in organic farming, which may be lost by nitrate leaching. Further, there is a risk that intensive organic farming increases nitrate concentration in vegetables as conventional farming.

5. What is organic farming?

Farming with too excess or too short nutrient supply is never sustainable.

We should recall the concept of organic faming of the Codex Alimentarius Commission's "Guidelines for the Production, Processing, Marketing and Labelling of Organically Produced Foods" (2001). The guidelines emphasize that "organic agriculture is one among the broad spectrum of methodologies which are supportive of the environment", and define organic farming as follows;

"Organic agriculture is holistic production management systems which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. An organic production system is designed to:

a) enhance biological diversity within the whole system;
b) increase soil biological activity;
c) maintain long-term soil fertility;
d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources;
e) rely on renewable resources in locally organized agricultural systems;
f) promote the healthy use of soil, water and air as well as minimize all forms of pollution thereto that may result from agricultural practices;
g) handle agricultural products with emphasis on careful processing methods in order to maintain the organic integrity and vital qualities of the product at all stages;
h) become established on any existing farm through a period of conversion, the appropriate length of which is determined by site-specific factors such as the history of the land, and type of crops and livestock to be produced".

Production of crops other than paddy rice, depending only on on-field nutrient flow without complementing external nutrient input, is never sustainable. Following the repetitions of such crop production, nutrients available for crop growth inevitably decrease, because most of nutrient absorbed by crop are taken out for human consumption and some come into a pool of un-recyclable soil organic matter. Thus, organic farming should complement nutrient by organic materials produced off-field. If we apply organic materials to soil, it incidentally enhances biological diversity and soil biological activity. However, it is not easy to maintain long-term soil fertility avoiding environment pollution, because the prediction or control of mineralization of organic materials is much more difficult than chemical fertilizer. It can be said that organic farmers are adjusting the application amounts of organic materials by empirical learning and feeling.

Japanese Agricultural Standard of Organic Agricultural Products (MAFF, 2000), which was legislated on the basis of the Codex Alimentarius Commission's guidelines, does not define the maximum amounts of organic materials to be applied or the necessity to control nutrient level in proper range. This may be due to two reasons. One is the lack of social awareness to the importance of the proper application of organic materials, because most consumers believe a misunderstanding that while chemical fertilizer is toxic, organic materials are safe. The other is the technical difficulty to control nutrient level in organic soil.

6. Prediction of mineral N release from organic materials

Organic farmer uses many kinds of organic materials such as marketed organic fertilizers, crop residues, compost, farmyard manure and others. Their nutrient contents and decomposition features are quite different. Of three major nutrients, the release of mineral potassium from organic materials is easily predictable, because potassium exists not as bound form but only as ion form in biomass and almost all of potassium are rapidly released to soil, when dead organic materials get wet with rain or soil water. However, the release patterns of mineral forms of N and phosphorus are quite diverse among organic materials. Thus, the control of the level of available N and phosphorus in soil through organic material application is much more difficult than chemical fertilizer.

Marketed organic fertilizers, e.g. oil cakes of soybean, rape and rice bran, fish meal and meat meal, are rapidly mineralized. Most of them release 50-65 % of total N as mineral N within 200 days after added to soil. CFE N contents of them are generally regarded as 60-70 % of ammonium sulfate. Therefore, the prediction of mineral N release from marketed organic fertilizers is not difficult.

Difficult problems are encountered in compost and crop residues. Some works have attempted to predict N mineralization from compost and crop residues. The most reliable work is, I believe, the simulation equation on organic material decomposition developed by the research project of MAFF (MAFF 1985, Shiga 1997).

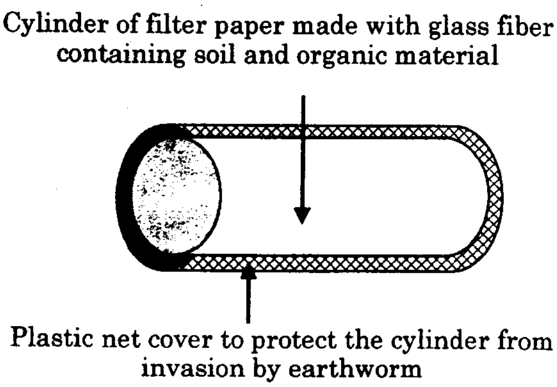

Fig. 4 Soil cylinder to determine the decomposition process of organic material in soil (schematic representation of the method of Meada and Onikura (1977))

In the research project, cylinders made of glass-fiber filter paper, which contain fresh soils mixed with organic materials at a rate of 5% T-C of soil weight, were embedded in paddy soil for 5 years (Fig. 4), and soils in the cylinders were analyzed for T-C and T-N every year. The amounts of remaining T-C and T-N in the soils are used to determine parameters of the following simulation equation.

Accumulation rate Y_t

$$= a \times 0.01 \times \frac{1-0.01^t}{1-0.01} + c \times 0.63 \times \frac{1-0.63^t}{1-0.63} + f \times 0.955 \times \frac{1-0.955^t}{1-0.955}$$

Release rate when a definite amount of the organic material was continuously applied every year

$$= 1 - Y_t$$

t = year
$a + c + f = 1$
a, c, f = ratios of fractions of different decomposition rates in organic material

Examples of parameters of some organic materials are shown in Table 4. These parameters were obtained with organic matter decomposition in Japanese paddy field. Their values may differ in tropical and subtropical regions. Although data were collected only for 5 years, C and N contents of soil predicted by the simulation equation coincided very closely with actual values of a paddy filed applied with rice-straw compost for more than 50 years.

The simulation equation indicates that N mineralized from un-decomposed residues of the organic material applied in the precedent years cumulates to N released from the organic matter applied this year. Therefore, even when a definite amount of the organic material was applied every year, the amount of N mineralized form the organic material changes from year to year.

Table 4 Examples of parameters of simulation equation of organic material (MAFF, 1985)

	C			N		
	a	C	f	A	C	F
Excess sludge	0.54	0.41	0.05	0.65	0.28	0.07
Fully fermented rice-straw compost	0.12	0.28	0.60	0.15	0.11	0.74
Medially fermented rice-straw compost	0.10	0.40	0.49	0.03	0.18	0.79
Immaturely fermented rice-straw compost	0.22	0.36	0.42	-0.06	0.26	0.80
Cattle feces compost	0.10	0.15	0.75	0.04	0.15	0.81
Dried cattle feces	0.30	0.51	0.19	0.10	0.58	0.32
Pig feces-sawdust compost	0.22	0.41	0.36	0.02	0.34	0.64
Rice root	0.19	0.72	0.09	-0.35	0.63	0.72
Rice straw	0.60	0.32	0.08	-0.40	0.95	0.45
Rice hull	0.13	0.92	0.21	0.19	-0.11	0.92
Wheat straw	0.50	0.30	0.14	-1.83	1.63	1.20
Sawdust	0.17	0.85	0.32	-0.03	-2.77	3.80

We can predict N mineralization from organic materials by this simulation equation. Figs. 5 and 6 show the changes of the rate of mineral N release as percentage of T-N of the organic material added, when a definite amount of the organic material was continuously applied every year

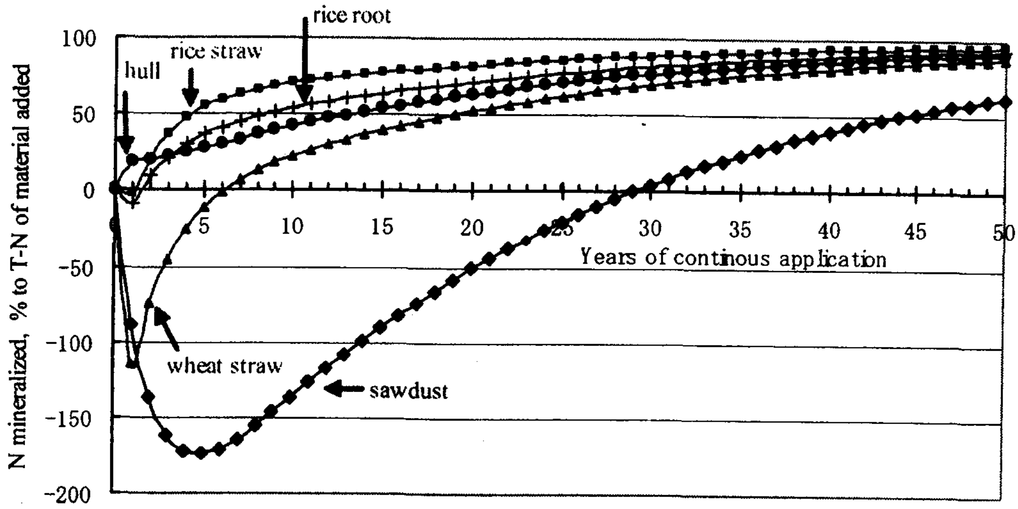

Fig. 5 Change of the rate of mineral N release as percentage of T-N of the organic material, when a definite amount of the organic material was applied every year (crop residues and sawdust)

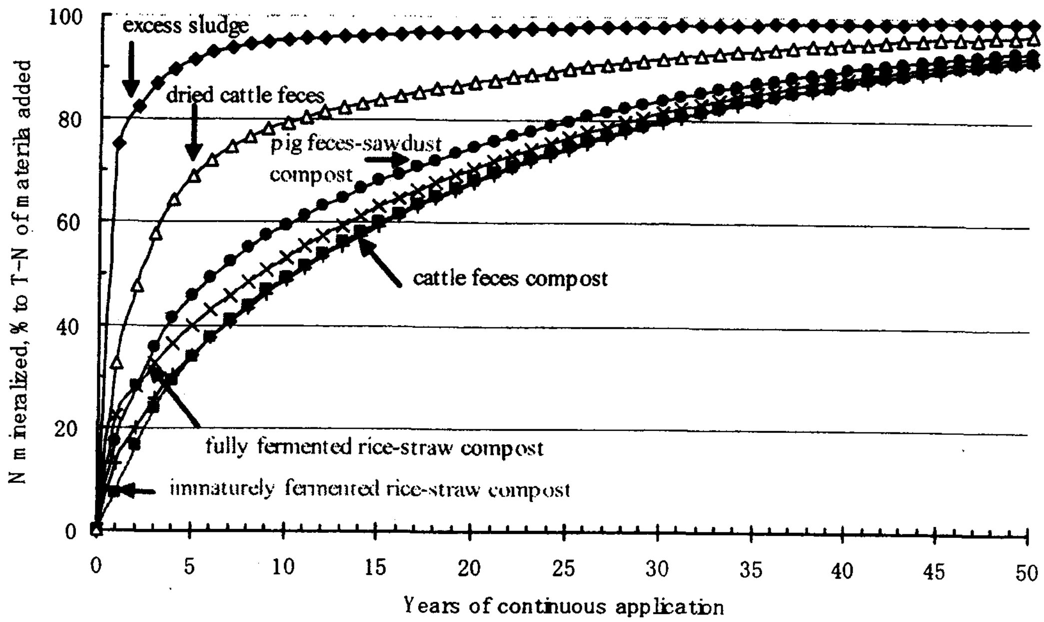

Fig. 6 Change of the rate of mineral N release as percentage of T-N of the organic material, when a definite amount of the organic material was applied every year (compost and other materials of C/N ratio lower than 20)

In the early years of continuous applications of crop residues and sawdust of C/N ratio higher than 20, N immobilization predominates; rice straw and rice root for 1 year, wheat straw for 6 years and sawdust for 28 years (Fig. 5). Although we have not the data of barley straw, barley straw may have a similar decomposition feature to wheat straw. Thus, there is a possibility that the conversion period of 2-3 years in usual case is not enough to release mineral N sufficient for crop growth from straws.

In the case of compost and other organic materials of C/N ratio lower than 20, N mineralization predominates without immobilization (Fig. 6). By further application of the organic material, release of mineralized N continues to increase. After many years it finally reaches the maximum level, at which all of total N contained in the organic material applied are mineralized in a year (equilibrium state).

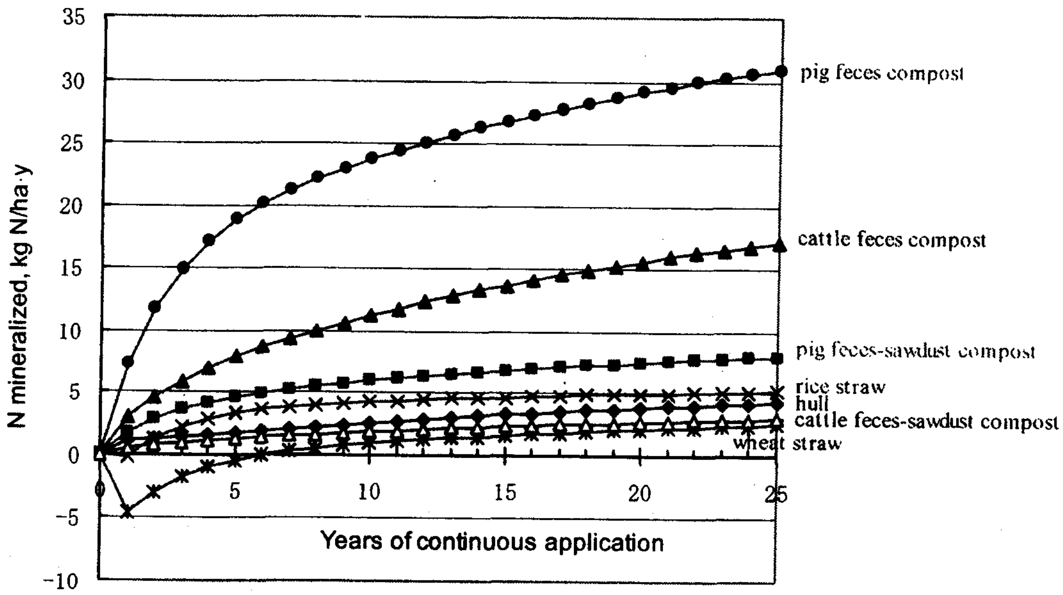

Fig. 7 Simulated mineral N release from 10 t FW/ha·y of organic material continuously applied for 25 years

If we multiply N content of the organic material by the mineralization rate in Figs. 5 and 6, we can get the annual amount of N mineralized from the organic material. Fig. 7 shows simulated mineral N release from 10 t FW (fresh weight)/ha·y of typical organic materials continuously applied for 25 years. It is obvious that even when a definite amount of a certain organic material is annually applied, the annual amount of mineral N released from organic material continues to increase up to the final level.

This figure explains reasons of some failures made by organic farmers. One is a case of natural farming which uses only crop residues on-field. Even if 10 t/ha of rice straw or wheat straw is annually applied, mineral N released is only 5.1 or 2.5 kg/ha, respectively, after 25-year continuous application. This small amount of mineral N can support only very low level of yield.

The other is a case of intensive organic farming. Farmer has a tendency to input a relatively large amount of organic material, because N mineralization rate of organic matter is small for several years. If farmer keeps the identical amount of organic material every year, mineralized N increases year by year and soon becomes surplus exceeding the desirable level.

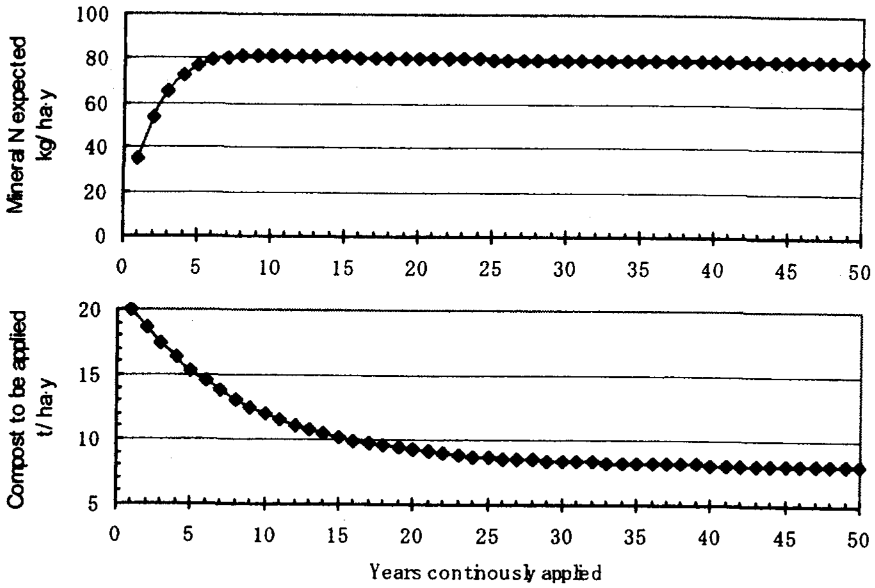

Fig. 8 An example to control the N level mineralized form pig feces-sawdust compost to 80 kg/ha·y by adjusting the annual amount of application.

In order to achieve sustainable soil management, it is necessary to adjust the mineral N in soil to the desired level determined by crop kind, targeted yield, soil and climatic conditions. We can attempt to attain this tough problem by the application of the simulation equation. For example, if the desired level of mineral N is 80 kg/ha·y, we can keep this level by controlling the application amount of pig feces-sawdust compost containing 1 % of T-N. Fig. 8 shows an example of the result of the application of the simulation equation. If 20 t/ha of the compost is applied in the first year, the application amount of the compost is to be gradually reduced from the second year as Fig. 8 shows.

Although the control method of mineral N level by the simulation equation has not been yet in practical use by farmer, it will give scientific base for the development of a new technology to manage nutrients in organic farming.

7. Organic farming requires holistic production management systems

Some organic farmers are attempting to produce crops by displacing chemical fertilizer and pesticide to organic material and non-chemical sanitation method, while keeping cropping system similar to conventional farming.

A typical example is of intensive vegetable production. It is well known that crop rotation is invariably needed in upland faming to maintain soil fertility and avoid enrichment of soil-borne plant pathogens and nematodes. But, most of vegetable farmers of conventional farming in Japan cultivate continuously a single kind of vegetable by using chemical fertilizer and soil fumigant. This behavior of vegetable farmer was induced by the following reasons; 1) since cereal crops except rice have been almost completely disappeared from upland field in Japan by the pressure of imported cheap cereals, vegetable farmer has been forced to grow vegetables and cannot find alternative crops to rotate, 2) since wholesale market gives a preference of pricing to a vegetable producing center, which regularly supplies products of a larger amount than a certain level, farmer has to produce a specific kind of vegetable in cooperation with other farmers, 3) since the competition among vegetable producing centers is very hard to fulfill consumer's demand of high quality, vegetable farmer should acquire high level of cultivation skill. Many organic vegetable growers switched from intensive vegetable cultivation of conventional farming wish to keep continuous cropping system just like farmers of Table 2. They input nutrients by purchased organic fertilizer and compost and sterilize soil by non-chemical means; e.g., solar-heating, heated steam or biological pesticide of antagonistic microbes to soil-borne pathogen and nematode.

Is this farming organic? Yes, it is organic, because it does not violate Japanese Agricultural Standard of Organic Agricultural Products. But, in view of the Codex Alimentarius Commission's guidelines, it may be organic farming of low grade, because it does not rely on renewable resources in local agricultural system and it does not promote the healthy use of soil.

If organic vegetable farmer wishes to entirely rely on renewable resources in local agricultural system, he will encounter very difficult problems in Japan. For example, if he wishes to make compost of fallen leaves, he cannot find forest to collect fallen leaves, because many forests in the suburbs of big cities have been disappeared by conversion to residences. Even if he could fortunately find a forest, he cannot get sufficient labor to collect fallen leaves, because members of his family have been decreased when compared with old times. Then, if he wishes to use animal feces of neighboring animal farm, he will wonder whether he can use animal feces or not. In Japan organic animal farm is very rare and conventional animal farm feeds animals with chemically synthesized antibiotics, copper, zinc and phosphate. Although Japanese Agricultural Standard of Organic Agricultural Products does not exclude the use of animal feces containing chemical substances added to feeds, many organic vegetable farmers have doubt about validity of compost made of such animal feces.

If organic farmer wishes to establish organic farming, which entirely rely on renewable resources in local agricultural system, it is necessary to establish organic animal production. In EU, areas of pasture, meadow and forage plants account for more than 50 % in total certified organic fields (Duchateau, 2003). Although MAFF proposed the draft of Japanese Agricultural Standard of Organic Animal Products in July 2004 to enforce it in the near future, we cannot expect rapid development of organic animal production in Japan.

Furthermore, if organic vegetable farmer wishes to promote the healthy use of soil, he should rotate vegetables with cereal crops and others, which do not have competitive ability with imported products.

8. Conclusion

As mentioned above, the establishment of sound organic farming requires not only new technologies but also structural changes of agricultural systems. The present agricultural systems of conventional farming have been historically established by natural, social and economic conditions of the nation or the region. Therefore, even with farmer's every possible effort, it is very hard to modify the local agricultural systems to those suited to organic farming. Consumer's help is needed for his effort.

However, I have some doubts on Japanese consumer's understanding of organic farming. I suspect that many Japanese consumers buy organic products because they believe that organic products are of better quality and more safety than conventional products. But, this is not always valid. The Codex Alimentarius Commission's guidelines describe in the foreword that "Organic agriculture practices cannot ensure that products are completely free of residues, due to general environmental pollution. However, methods are used to minimize pollution of air, soil and water." EU regulation on standard of organic production defines also in Article 10 that "No claim may be made on the label or advertising material that suggests to the purchaser that the indication shown in Annex V* constitutes a guarantee of superior organoleptic, nutritional or salubrious quality" (*: Indication that products are covered by the inspection scheme and logo) (EU, 2004).

As the Codex Alimentarius Commission's guidelines describe, minimization of pollution of air, soil and water is more important than the production of high quality products in organic farming. If organic farmer and consumer recognize this concept, we can construct technology and agricultural system to attain it. Furthermore, if farmer can actually improve local environment by organic farming, government can find basis to encourage organic farming by investing financial resources.

9. References

Codex Alimentarius Commission (2001) Guidelines for the Production, Processing, Marketing and Labelling of Organically Produced Foods <http://www.fao.org/DOCREP/005/Y2772E/Y2772E00.HTM>

EU (2004) Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Consolidated Text <http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991R2092_do_001.pdf>

Fukuoka, M. (1975) "The One-Straw Revolution". Hakujusha Co. (Tokyo). Republished in 1985 by Shunju Co. (Tokyo). 276p. (in Japanese)

Fukuoka, M. (1976) "Natural Farming". Jiji-Tsushin Co. (Tokyo) 310p. (in Japanese)

Hori, K., A. Fukunaga, Y. Urashima, Y. Suga and J. Ikeda (2002) Soil chemical characteristics of organic farming vegetable fields. Research Bulletin of National Agricultural Research Center of for Western Region. 1: 77-94 (in Japanese with English summary)

Duchateau, Koen (2003) Organic Farming in Europe ~A sustained growth over the period 1998-2000. 8p. <http://europa.eu.int/comm/agriculture/qual/organic/index_en.htm>

Maeda, K. and Y. Onikura (1977) A method to determine decomposition of applied organic matter under field conditions. Journal of Science of Soil and Manure, Japan 48: 567-568. (In Japanese)

MAFF (1985) Report of the research project on the prediction of the variation of soil organic matter level and the establishment of the standard of organic matter application. 166: 1-138. MAFF (in Japanese)

MAFF (2000) Japanese Agricultural Standard of Organic Agricultural Products

<http://www.maff.go.jp/soshiki/syokuhin/hinshitu/organic/eng_yuki_59.pdf>

Nishio, M. (1998) Development of Japanese agriculture and changes of soil. Agriculture and Horticulture 73: 89-95 (1998) (in Japanese)

Shiga, H. (1997) The decomposition of fresh and composted organic materials in soil. FFTC Extension Bulletins. <http://www.fftc.agnet.org/library/abstract/eb447.html>

Stockdale, E.A., N.H. Lampkin, M. Hovi, R. Keatinge, E.K.M. Lennartsson, D.W. Macdonald, S. Padel, F.H. Tattersall, M.S. Wolfe and C.A. Watson (2001) Agronomic and environmental implications of organic farming systems. Advances in Agronomy. 70: 261-327

Taki, K. and T. Kato (1998) Features of the soil in organic farming field. Research Bulletin of Aichi Agricultural Research Center. 30: 79-87 (in Japanese with English summary)

Tsutsumi, T. (1987) "Material Cycling in Forest". Tokyo University Press. p.82 (in Japanese)

DRAFT

APO SEMINAR ON ORGANIC FARMING FOR SUSTAINABLE AGRICULTURE

20 – 25 SEPTEMBER 2004, ARI, TAICHUNG, TAIWAN ROC

SEMINAR HIGHLIGHTS

INTRODUCTION

The Seminar on *Organic Farming for Sustainable Agriculture* was held from 20 to 25 September 2004 at the Agricultural Research Institute (ARI) in Taichung, Taiwan, Republic of China. It was organized by the Asian Productivity Organization in cooperation with the Council of Agriculture (COA) and the China Productivity Center, and implemented by the Food and Fertilizer Technology Center (FFTC) for the Asian and Pacific Region and ARI. The seminar aimed to: 1) discuss the current situation and recent developments in organic farming in member countries; 2) identify issues and problems in promoting organic farming for sustainable agriculture and improved farm incomes; and 3) suggest measures to address such issues and problems for future development.

A total of 16 participants from 13 APO member countries participated in the seminar. Six resource speakers were invited to provide valuable knowledge and information on: 1) the technical bases for sustainable organic farming; 2) overview of organic farming in Asia, with special regard to Taiwan experience; 3) diversified marketing systems of organic products and trade in Japan; 4) improving plant protection for the development of organic agriculture in Taiwan; 5) improved soil fertility management in organic farming; and 6) practical cases of organic farming: experiences and insights.

The country presentations, meanwhile, focused on the issues and accomplishments in the production, distribution and marketing of organic farm products, their regulation and certification; measures to ensure the quality and safety of domestically produced and imported organic products; and future directions of organic farming in view of the globalization trend and changing consumer preferences. Field visits were also made to organic farms in central Taiwan to get practical knowledge and lessons from successful organic management practices followed by such farms.

RESOURCE PAPERS

The papers presented by the resource speakers sought to address the basic question of how to tackle the various opportunities and challenges offered by organic farming to enhance the sustainability of agriculture in the Asian region. The papers provided valuable knowledge and inputs on the role of technology to ensure farm productivity and viability; environmental impacts and sustainability; marketing, promotion and distribution; and harmonization of regulations and certification systems.

Technical bases for sustainable organic farming
by Dr. Michinori Nishio, Former Professor, University of Tsukuba, Japan

In his presentation, Dr. Nishio emphasized that the establishment of sound organic farming requires not only new technologies but also structural changes of the agricultural systems. The present systems of conventional farming have been historically established by natural, social and economic conditions of the country or the region. Therefore, farmers will have difficulty in modifying local agricultural systems to suit the standards of organic farming. He further stressed that technologies needed for organic farming differ depending on the target level of yield or income of the farming system. In regions of high precipitation and high temperature, paddy production may be sustainable but yield level will be low. He presented the scientific basis of this fact through an analysis of the nitrogen balance in the paddy field.

Production of crops other than rice that depend only on on-field nutrient flow without complementary external nutrient input is never sustainable. Following the repetitions of crop production, nutrients available for crop growth inevitably decrease because most of the nutrients absorbed by the crop are taken out for human consumption while some become un-recyclable soil organic matter. Thus, organic farming should be complemented with nutrients from organic materials produced off-field. Application of organic materials into the soil enhances biological diversity and soil biological activity. However, it is not easy to maintain long-term soil fertility while avoiding environmental pollution. Prediction of mineral N release from organic materials is also important to control nutrient level in organic soil.

Dr. Nishio further pointed out that intensive vegetable production in Japan is characterized by frequent and too much application of purchased organic fertilizers, compost and non-chemical biocidal methods, which cause excess accumulation of nutrients in soils. Many organic vegetable growers maintain continuous intensive cropping system by sterilizing the soil through non-chemical means such as solar-heating and heated steam; or using biological pesticide such antagonistic microbes against soil-borne pathogen and nematode. Is this organic farming? Dr. Nishio explained that while these methods do not violate the Japanese Agricultural Standard of Organic Agricultural Products, these practices may be considered low grade based on the guidelines of the Codex Alimentarius Commission, because they do not rely on renewable resources within the local agricultural system and do not promote the healthy use of soil.

Dr. Nishio then expressed some doubts on the Japanese consumers' understanding of organic farming. He felt that many Japanese consumers buy organic products because they believe these are of better quality and safer than conventional products. However, this is not always true. He cited the Codex definition of organic farming as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system." He added that the Codex guidelines also state that "organic agriculture practices cannot ensure that products are completely free of residues, due to general environmental pollution. However, methods are used to minimize pollution of air, soil and water." He further cited Article 10 of the EU regulation on standard of organic production stating that "No claim may be made on the label or advertising material that suggests to the purchaser that the indication shown in Annex V (indication that products are covered by the inspection scheme and logo, EU 2004) constitutes a guarantee of superior organoleptic, nutritional or salubrious quality."

As the Codex guidelines describe, minimization of pollution of air, soil and water is more important than the production of high quality products in organic farming. Hence, Dr. Nishio pointed out that it is important for the organic farmer and the consumer to recognize this concept, so that the appropriate technology and agricultural system could be developed. Furthermore, if farmers can show that the local environment could be improved by organic farming, then government support in terms of investment is expected in order to promote and encourage this method.

COUNTRY PAPERS

The various country presentations had all emphasized the growing importance of organic agriculture in their respective country. The presentations specifically focused on the production, distribution and marketing, regulations and certification systems for organic farming, as well as the major issues and accomplishments/emerging trends with regard to individual country efforts to promote organic agriculture. In the above context and in light of recent worldwide concerns on food safety, particularly, in the aspect of chemical contaminations of food, measures that have been undertaken by government/private sectors and producers in enhancing/ensuring the quality and safety of domestically produced and imported organic produces/products were also emphasized. Likewise, future directions in terms of production, distribution and marketing of organic products, particularly in light of the globalization trend, rapid developments in organic farming and information-related technologies, and changing consumer preferences, among others, were discussed.

Development of organic agriculture in Asia

Asian governments have recently become interested in organic farming with the expansion of the market for organic products and their potential for promoting sustainable agriculture. Accordingly, almost all have put priority on organic certification and accreditation, even though the major constraints in organic farming in Asia are still at the level of farm production. The proliferation of public organic standards and inspection systems, however, seems to have caused confusion among Asian traders of organic products. Hence, international harmonization of these standards and systems need to be advocated.

Public-private sector partnership is also urgently needed if the rapid growth of organic agriculture in Asia is to be sustained. Re-orientation of government policies is required, including support for farm extension, development of post-harvest technologies, and supply chain management. Closer collaboration between NGOs, the private sector, farmers, scientists, and public authorities can ensure that the efforts of each group are not in conflict with one another and that synergy is achieved.

Technology for improving farm productivity

Most country papers emphasized the important role of research and development in providing the technology to enhance farm productivity, such as in the areas of plant protection using new biological tools and methods, soil management and organic fertilization, genetics and breeding to obtain natural resistance and to overcome biological stress, etc.

Many conventional farmers consider converting to organic farming due to the rapidly growing market for organic products and the prospect of higher prices. However, they are also aware that organic farming may entail some constraints and possibly higher costs, and are therefore unsure whether they will be economically better off in the end if they convert. Economic and financial evaluation may help them make a better assessment of the profitability of conversion. In this regard, the most important economic parameters that should be analyzed are: 1) possible fall in yields (with the possibility of recovery later); 2) difference in production costs (labor costs tend to increase in particular); and 3) price difference (organic prices tend to be higher, but not always).

While all these parameters vary over time, which implies that various scenarios should be considered, a crucial factor here is the availability of information and technology to ensure farm productivity and to cushion farmers from the impact of conversion.

Distribution and marketing

In most major organic product markets such as the industrialized countries, demand for organic products far outstrips domestic supply, and therefore imports are required to fill the gap. This represents a major opportunity for developing countries in Asia, but marketing and distribution appear to be a major constraint for small-scale farmers. Another issue is meeting the demanding quality and safety standards of major markets.

In many countries in the region, many factors contribute to additional costs in marketing the products: inspection and certification fees, segregated storage, fewer options to control post-harvest pests and diseases, need for careful handling to avoid dilution and contamination, appropriate packaging and labeling, and economies of scale. Organic producers comprise a smaller proportion of the agricultural industry with individual producers being usually small-scale and widely dispersed. Hence, more and more small-scale farms will need to form themselves into production and marketing teams to enlarge the scale of production and marketing.

Regulation and certification

In recent years, an expanding number of governmental regulations for organic products have developed worldwide in parallel with private systems. However, while the purpose of certification is to foster confidence of consumers and to enhance trade in organic products, the certification requirements and regulations today are becoming a major obstacle to the development of the organic industry, especially in the developing countries.

There is undoubtedly a need for harmonization of organic guarantee systems not only between the private and public sectors, but among countries and markets of the world to sustain and further enhance trade in organic products and the livelihood that this trade supports. A better understanding of the appropriate roles for government and private bodies in standard setting, certification and accreditation is required. An international mechanism for establishing equivalence among these systems is regarded as the best approach to the problem, one that respects diversity in organic agricultural systems and where variations in standards are allowed where appropriate.

MAJOR ISSUES AND RECOMMENDATIONS

On the final day, the participants held a general discussion about the major findings/learning from the seminar. During the discussion, the participating countries had an opportunity to briefly highlight the major issues confronting their country's production and marketing of organic products, as well as, some suggestions on how these could be addressed. The issues have been summarized as follows:

1. *Need for greater awareness among producers and consumers*

   This issue was cited by almost all the countries. In this regard, it was suggested that awareness of organic farming/products could be enhanced through appropriate research and extension programs, as well as, educational/training and promotional activities.

2. *Government policy and program support*

   To spur growth of the organic industry, especially, in the developing countries, there is a need for government to place higher priority on organic farming. To achieve this, relevant data on the impact of organic farming on the environment and people's welfare, as well as, its role in sustainable agriculture should be generated and disseminated for better appreciation, particularly, by policy-makers.

3. *Production and postharvest*

   To improve production of organic products there is a need to intensify research and development (R&D), undertake training/education of extension workers/farmers to enhance their technical know-how and improve farmers' access to the required inputs. Due to expected/possible decline in yield during the conversion period, there is a need also to provide some form of support or incentive to affected farmers. Infrastructure support including postharvest facilities for organic farming should also be provided.

4. *Marketing and promotion*

   There is a need also to develop appropriate marketing channels for organic produce, including the establishment of direct links between producers and consumers. In this regard, innovative forms of marketing should be explored such as on-farm marketing and agro-tourism. As part of the marketing promotion effort, consumer education should also be undertaken.

5. *Certification and regulation*

   Most of the countries felt the need to strengthen their certification and regulation of organic products. In this regard, several aspects were highlighted. One is the need to harmonize the standards for organic production and for this purpose the establishment of a regional accreditation organization is suggested. Another aspect is the need to promote awareness of the standards and regulations among the various stakeholders. The third is the need to improve access to the certification system considering that accreditation can be very costly, especially, for small farmers/producers.

6. *Information exchange*

In order to stimulate further the growth of an organic food industry in the region there is a need to establish/strengthen linkages/networking among countries in the region. In this regard, it is suggested that sharing of experiences and best practices on organic farming should be fast tracked through relevant networks and media.

CONCLUSION

Organic farming as a key to sustainable agriculture has captured the attention of many countries worldwide. As the discussions have shown, the interest in this type of agriculture is growing, especially, where there is evident degradation of resources essential to agricultural production, such as land, due to conventional farming systems. On the consumers' side, their concern for food quality and safety, as well as the protection of the environment, which first stimulated demand for organic products has since become the driving force in the development of organic agriculture, particularly in industrialized countries. Governments have responded by setting targets for the expansion of organic production, and new market opportunities have been developed as part of the strategy to address such concerns.

In most Asian countries, however, the area under organic production is still very small compared with those of the industrialized countries. There are enormous challenges facing the organic agriculture movement in the region. With Asia accounting for more than half of the world's population but with only one-third of the world's farmland, there is a need to integrate past and present practices to find new ways to meet increasing food demand. Through the introduction of technological and management improvements, organic farming could become an increasingly important part of the region's diversified agricultural production system toward attaining improved productivity, farm income, and food safety.