GOOD SOIL CARE PRACTICE IN THE TROPICS: TOWARD A NEW CHALLENGE

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ABSTRACT

The Japan International Research Center for Agricultural Sciences (JIRCAS), in collaboration with various partner institutions, has conducted some long-term field experiments on soil fertility management and disease control in Vietnam and Indonesia. The studies observed that by using locally available resources like rice straw manure, chemical fertilizer use could be significantly reduced with little yield reduction and that by introducing various crops and fallow, some disease occurrence could be reduced, resulting in more stable yield rotation practice in vegetable production. This paper discusses the importance of studying the interactions among crop, pest and soil for more sustainable and safer crop production in the tropics.

Key words: JIRCAS, soil management, Vietnam, Indonesia

INTRODUCTION

Recently, in Southeast Asia, with the slump of prices of rice and other cereals resulting from the weakening of demand and supply, the diversification of agriculture (e.g., shift to horticultural and other high value crops) in search of alternative income sources has become an important issue.

At the same time, the development of the rural economy and the drain of agricultural population as well as the rapid dissemination of high-yielding crop varieties have accelerated the tendency toward high-chemical input agriculture initiated by the Green Revolution. It has been pointed out that such tendency has resulted in crop yield stagnation and environmental degradation, growing concerns for food safety and the implementation of good agricultural practices (GAPs).

Therefore, it seems that there is more interest in establishing new soil management guidelines that can respond to these socioeconomic changes. JIRCAS has carried out relatively long-term soil management experiments in Vietnam (lowland), Indonesia (highland) and so on. These experiments have taught us some possibilities to establish such guidelines.

RICE STRAW COMPOST APPLICATION TRIALS IN MEKONG DELTA, VIETNAM

Continuous rice straw compost application trials have been conducted at Cuu Long Delta Rice Research Institute (CLRRI) (Cantho, Vietnam) (Man *et al.*) since the wet season of 2000. Rice (IR64, 100-day growth period) have been cultivated twice a year, and seven compost and chemical fertilizer treatments (Table 1) were applied in a randomized block design with three replications (30 m^2 for each plot):

Rice straw compost and phosphorus fertilizer were plowed in surface soil (0–5 cm deep) for land preparation. Pre-germinated seeds were broadcast at 200 kg ha^{-1}. Moisture content and Total C, N, P and K concentrations of the rice straw compost applied into the field are shown in Table 2.

Nitrogen fertilizer was equally split-applied at 10, 20 and 30 days after sowing (DAS), and potassium fertilizer was also equally split-applied at 10 and 30 DAS. Recommended rates were 100 N, 40 P_2O_5 and 30 K_2O kg ha^{-1} for

Table 1. Compost and chemical fertilizer treatment

T1	0%RSM*	0%CF**(0N-0P_2O_5-0K_2O)
T2	100%RSM(6Mg ha^{-1})	0%CF(0N-0P_2O_5-0K_2O)
T3	100%RSM(6Mg ha^{-1})	20%CF(16***or 20****N-6P_2O_5-6K_2Okg ha^{-1})
T4	100%RSM(6Mg ha^{-1})	40%CF(32***or 40****N-12P_2O_5-12K_2Okg ha^{-1})
T5	100%RSM(6Mg ha^{-1})	60%CF(48***or 60****N-18P_2O_5-18K_2Okg ha^{-1})
T6	100%RSM(6Mg ha^{-1})	80%CF(64***or 60****N-24P_2O_5-24K_2Okg ha^{-1})
T7	0%RSM*	100%CF(80***or 100****N-30P_2O_5-30K_2Okg ha^{-1})

*RSM: Rice straw compost
**CF: Inorganic Chemical Fertilizer
***: Application in wet season
****: Application in dry season

Table 2. Moisture and C, N, P, K concentration of RSM

Season	Moisture (%)*	N(%)	C(%)	P(%)	K(%)
2003 WS	367	1.72	30.4	0.23	no data
2004 WS	483	2.30	30.7	0.26	1.49
2005 DS	353	2.13	33.7	0.22	0.53

*water/dry matter (w/w)

Table 3. Effect of RSM and chemical fertilizer on SPAD value at 50 DAS in wet season

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	Average
T1	27.0	27.2	27.7	28.1	27.5
T2	27.4	27.5	27.9	28.5	27.8
T3	28.6	28.5	30.0	30.6	29.3
T4	30.9	30.2	32.0	32.8	31.4
T5	30.8	32.2	32.6	33.6	32.3
T6	31.7	32.9	33.1	34.6	33.1
T7	35.2	33.1	33.8	34.9	34.2
CV (%)	4.7	2.8	2.8	3.2	3.4
LSD (5%)	2.53	1.51	1.55	1.84	-

Table 4. Effect of RSM and chemical fertilizer on SPAD value at 50 DAS in dry season

Treatment	DS 00-01	DS 01-02	DS 02-03	Average
T1	27.8	25.9	26.7	26.8
T2	28.2	26.5	29.6	28.1
T3	31.2	29.8	31.4	30.7
T4	35.1	31.2	31.7	31.7
T5	36.4	33.4	34.7	34.3
T6	36.4	33.6	35.2	35
T7	38.3	34.4	36.1	36.2
CV (%)	3.3	3.0	2.5	3.1
LSD (5%)	1.94	1.63	1.45	-

Table 5. Effect of RSM and chemical fertilizer on microbial population of soil in log_{10} of C.F.U/g dry soil (wet season)

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	WS 2004	WS Ave.
T1	7.84	7.73	7.04	5.79	7.70	7.22
T2	8.71	8.14	7.08	5.94	7.87	7.54
T3	8.77	7.92	7.04	6.20	7.94	7.57
T4	8.73	8.22	7.28	6.03	7.85	7.62
T5	8.74	8.30	7.23	6.06	8.14	7.69
T6	8.57	7.98	7.23	6.26	7.97	7.60
T7	7.93	7.70	7.00	5.93	7.83	7.27
*Before sowing	8.71					
Average	8.47	8.00	7.13	6.03	7.90	7.50
Sd	0.34	0.22	0.11	0.16	0.12	0.18

Note:*sd of microbial population in wet season was not calculated to treatment before sowing C.F.U/g dry soil.: cell forming unit/gram of dry soil

dry season. Total C, N and P concentrations in the surface soil were 35.1 g C kg^{-1}, 3.3 g N kg^{-1} and 240 mg P kg^{-1} in air-dried soil sampled after the first harvest, respectively.

SPAD (chlorophyll) meter was used to measure the nutrient situation of rice plants and it was observed that both in wet season (Table 3) and in dry season (Table 4), the more chemical fertilizer was applied, the higher the SPAD values. It was reported that an optimum SPAD value for directly seeded rice plants ranged from 32 to 36 in dry season and 29 to 32 in wet season (Huan *et al.* 1998, 2000). It appeared that rice plants in RSM treatments plus less chemical fertilizer would maintain the optimum range of nutrient concentration both in wet and dry seasons.

Soil microbial population in the wet season tended to be higher than that in the dry season (Tables 5 and 6), and the population in the RSM treatment was always higher. Similar tendency was found in soil electron transport system (ETS) activities and soil protein content (Data are not shown).

There was also no significant difference in average rice yield between T3, T4, T5, T6 and T7 both in the wet season and the dry season (Tables 7 and 8) except for that in the dry season of 2003, when rice plants suffered from blast disease (Table 9), and yields were

Table 6. Effect of RSM and chemical fertilizer on microbial population of soil in log_{10} of C.F.U/g. dry soil (dry season)

Treatment	DS 2001	DS 2002	DS 2003	DS 2005	DS Ave.
T1	6.48	7.20	6.43	7.19	6.82
T2	6.90	7.32	6.82	7.28	7.08
T3	6.78	7.76	6.78	7.24	7.14
T4	6.70	7.51	7.14	7.40	7.18
T5	6.95	7.08	6.78	7.41	7.05
T6	7.04	7.66	7.11	7.32	7.28
T7	6.78	7.04	6.76	7.26	6.96
Average	6.80	7.38	6.83	7.30	7.07
Sd	0.18	0.28	0.24	0.08	0.15

Table 7. Effect of RSM and chemical fertilizer on rice yield in wet season

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	WS 2004	WS Ave.
T1	2.19	2.67	2.98	1.81	3.04	2.54b
T2	2.23	2.91	3.20	1.83	3.69	2.77b
T3	2.51	3.24	3.22	3.40	4.17	3.30a
T4	2.66	3.53	3.26	3.63	4.46	3.53a
T5	2.71	3.63	3.33	3.47	4.66	3.55a
T6	2.90	3.71	3.42	3.47	4.27	3.55a
T7	3.07	3.60	3.37	3.15	4.04	3.41a
CV (%)	8.2	4.0	3.3	13.1	6.0	18.4
LSD (5%)	0.37	0.24	0.19	0.68	0.42	**

Means in a column followed by the same letter are not significantly different at P<0.05, based on LSD test.

Table 8. Effect of RSM and chemical fertilizer on rice yield in dry season

Treatment	DS 2001	DS 2002	DS 2003	DS 2005	DS Ave.
T1	4.32	4.78	3.49	3.84	4.11b
T2	4.60	5.13	3.84	4.01	4.39b
T3	5.50	6.05	4.36	5.12	5.26a
T4	5.84	6.46	4.89	5.24	5.61a
T5	5.94	6.76	4.49	5.39	5.66a
T6	5.92	6.55	4.30	4.90	5.49a
T7	5.89	6.65	3.55	4.89	5.24a
CV(%)	5.5	5.1	9.0	7.9	16.5

Means in a column followed by the same letter are not significantly different at P<0.05, based on LSD test.

Table 9. Blast disease in dry season 2003 and grain discoloration in dry season 2005

Treatment	Leaf blast disease(%)*	Neck blast disease (%)**	Grain discoloration** *(%)
T1	1.48	1.38	34.6
T2	2.94	0.90	35.7
T3	12.5	1.42	40.0
T4	14.9	1.54	46.1
T5	30.7	2.66	45.0
T6	38.3	4.52	60.5
T7	72.0	4.52	60.5
CV (%)	26.5	22.5	11.2
LSD (5%)	11.6	0.91	9.2

*Number of diseased leaves/total leaves observation; using arcsine transformation; 35 DAS
**Number of diseased panicles/total panicles observation; using square-root transformation $(X+0.5)^{1/2}$; 85 DAS
***Grain discoloration in D.S.2005 was observed at harvesting time.

lower as compared with those in the other years.

Our results indicated that chemical fertilizer could be reduced by 40–60% from the present recommended application rate and replaced with RSM without decreasing rice yield in the Mekong Delta region and that we could even expect higher yield when blast disease outbreak would occur.

CROP ROTATION TRIALS TO PREVENT CABBAGE CLUBROOT DISEASE IN THE WEST JAVA HIGHLANDS, INDONESIA

Crop rotation trials have been conducted in order to prevent cabbage clubroot disease at the Indonesian Vegetable Research Institute (Lembang, Bundung, Indonesia) since 2000 (Yamada *et al.*). Various vegetable crops have been grown three times a year, and each cropping season has one month of preparation for nursery and three months for growth. Cabbage (Green Coronet), carrot (Local Cisarua) and potato (Granola) are widely cultivated in the West Java Highlands and these were chosen as major crops in our rotation sequence.

Each major crop was grown both as a constituent of a rotation and as continuous cropping. Four series of rotation patterns were tested: a) cabbage-carrot-potato (R) or cabbage-potato-carrot (R2) series in a year; b) a fallow in dry season with two major crops (RF); c) corn (local var.) with R or R2 (RC, RC2); and d) R or R2 with leaf onion (local var.) and tomato (Arthaloka) as companion crops (RM). Each plot (10.8 m^2) had two replicates, and plant spacing was 60 cm row, 35 cm hill distance for cabbage, 5 lines, in 120 cm rows for carrot, 60 cm row, 30 cm hill distance for potato, and 60 cm row, 35 cm hill distance for corn, onion and tomato.

Lime was broadcast at a rate of 100 g m^{-2}. Manure was applied at a rate of 1 kg $plant^{-1}$ in wet condition for cabbage and potato, and moist manure was applied at a rate of 1 kg $plant^{-1}$ for cabbage and potato. Then, chemical fertilizer was applied at the following rates: 11.3-9.6-12.0 (N-P_2O_5-K_2O, g m^{-2}) for cabbage; 4.5-19.2-9.0 for carrot; and 10-10-10 for potato and corn. The fertilizer was applied on planting holes for cabbage and potato and to the whole area of seeding bed for carrot.

Conventional pesticides and fungicides were applied about once a week. Weeds were removed with a hoe. Some plant parts such as outer leaves and stems with unusually thick roots in cabbage, auxiliary stems in corn and excess leaves in carrot were also removed and moved out from the field. Aerial parts of potato plants were left in the field and decayed till harvest time.

Until 2002, six series of rotation had been examined. In the fourth season, cabbage yields in the rotation treatment ranged from 7.02 to 7.39 kg m^{-2} and were higher than those in the continuous cropping treatment (C: 2.57 kg m^{-2}). In the seventh season, cabbage yield in the rotation treatment ranged from 5.30 to 7.35 kg m^{-2} and were higher than those in C (4.50 kg m^{-2}). However, such difference tends to decrease at the later seasons (Fig. 1).

Cabbage of the C plots was attacked by clubroot, as indicated by wilting symptom from the early stage of growth. Fig. 2 shows the root damage score by clubroot at harvest time. Although half of the rotation treatment plots (R and R2) were also affected by clubroot in the fourth and seventh season, the high yields were still maintained. It was also suggested that both carrot and potato decreased the clubroot damage similarly and that it would be more important to lie land fallow for a host.

Kiriyama and Otomo (2003) reported that yield loss of cabbage was not considered severe until clubroot disease index reached 30%. It was also reported that trap crops such as resistant kale and turnip would also reduce the disease (Yamagishi *et al.* 1986). However, for longer periods, it is recommended that the fallow practice will be more useful to avoid accumulation of clubroot disease pathogen in soil.

CONCLUSIONS AND NEW CHALLENGES

Our soil management experiments led to the following tentative conclusions:

1. Chemical fertilizer can be reduced significantly without yield reduction with locally available resources like rice straw manure. It can be also expected that such alternative practice can reduce some disease occurrence and result in less pesticide application and more stable yield.

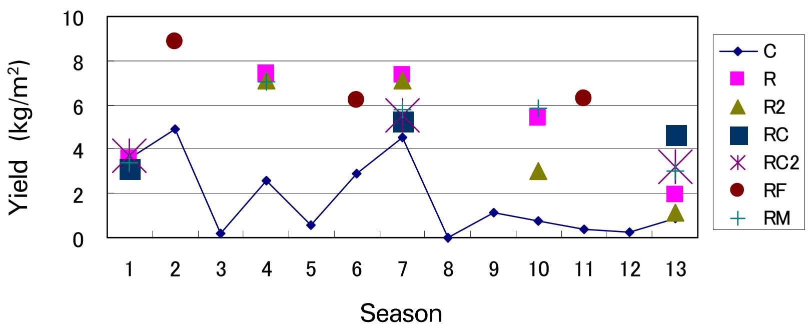

Fig. 1. Effect of crop rotation on cabbage yield.

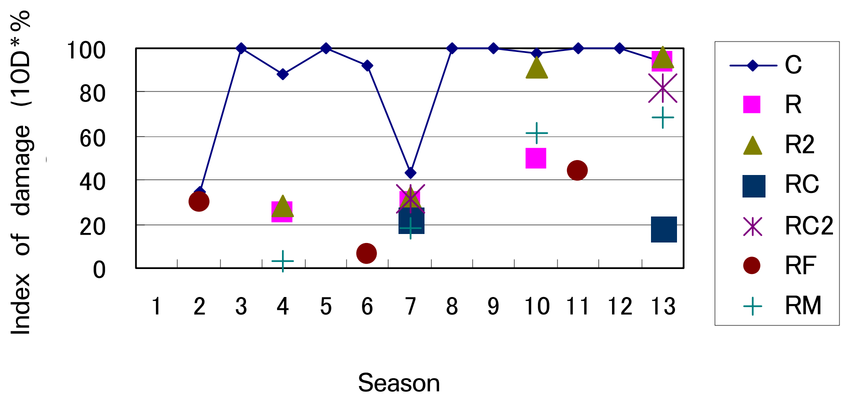

Fig. 2. Effect of crop rotation on cabbage root damage.

*:[OD=Σ(damage level x No. of plants)/(max. level x No. of all plants) x 100
Damage level: 0-3

2. Rotation practice, by introducing various crops and fallow, in vegetable production can reduce some disease occurrence and result in more stable yield and income generation.

Our conclusions were based on long-term treatments in Vietnam (9 seasons) and Indonesia (13 seasons). We also observed more stable yields in more than 20 year-long organic matter treatment as compared with chemical fertilizer-oriented treatment for corn-mungbean cropping system in Thailand. Unfortunately, our data collected from these experiments are typical agronomic data such as yield, disease occurrence and soil chemical composition. We feel that more attention should be paid on the interaction among crop, chemical nutrients, organic matter and soil microorganisms in tropical conditions.

Our experiments have paid little attention to reducing pesticide use. It has been said that the climate condition in the Southeast Asian region is favorable to weeds, insects, fungi and bacteria and that using pesticide is inevitable to produce high-quality products. It becomes apparent that some cultural practices can reduce pest occurrence considerably in this region, and it is necessary to study the interactions among the various cultural practices and pest occurrence in the region.

For 2006, we have a plan to initiate a regional research network on soil care practice and other cultivation practices in order to reduce chemical input and attain sustainable production in Thailand, Vietnam and Indonesia. The research will focus on the effects of long-term application of organic matter and biofertilizer in combination with some cultivation practices on crop productivity nutrient balance and microbial and physical properties in soil.

We would like to challenge this initiative in order to provide a better scientific basis to improve the present GAPs in the region and step up efforts to a next generation of GAPs.

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