

# INTEGRATED NUTRIENT MANAGEMENT FOR A SUSTAINABLE AGRICULTURE AT OMON, VIETNAM

LUU HONG MAN, NGUYEN NGOC HA, PHAM SY TAN  
TAKAO KON<sup>1</sup>, HIROYUKI HIRAOKA<sup>1</sup>

## ABSTRACT

*Fungal inoculant (Trichoderma sp) in powder formula was used to treat into rice straw for decomposition then decomposed rice straw would be applied in combination with bio-organic phosphorus fertilizer as well as organic fertilizer. Organic fertilizer was applied alone or in combination with inorganic fertilizer (NPK) on heavy clay soil to study "integrated nutrient management for sustainable agriculture and environmental conservation" in long-term study. The data from two years on IR 64 showed that a continuous application of 100% organic fertilizer increased rice yield over control being 13.6 % and continuous application of 50% organic fertilizer in combination with 50% inorganic fertilizer increased rice yield over control being 18.6 %. The microbial population's dynamics in soil showed that the application of 50% organic fertilizer in combination with 50 % inorganic fertilizer exhibited higher microbial communities as compared to 100% inorganic fertilizer application and control treatment. Under conditions of continuous application of 100% organic manure, the appearance of major harmful insects and sheath blight disease was later, and microbial population in soil gave higher stabilization as compared to the application of 100% inorganic fertilizer.*

**Key words:** fertilizer, nutrient, manures, sustainable

## INTRODUCTION

The literatures on organic manures including the livestock manure, human excreta, crop residues and industrial organic wastes, and their efficient utilization or better crop production were previously reviewed ( Garg et al. 1971 ). The beneficial role of organic manure in increasing soil fertility, improving soil physical conditions and microbiological conditions of soil as well as crop yield were recognized by many investigators (Gaur et al. 1972, Anonymous 1974,

Subba Rao 1977, De Datta and Hundal 1984, Son and Ramaswami 1997).

The concept of integrated nutrient supply involving organic and chemical fertilizers combining has been developed. The effect of continuous application of ammonium sulphate and organic manures, viz FYM, green manure and ground nut cake singly as well as in combination on yield of lowland rice crop showed that the highest yield (10-year mean values ) was obtained with the basal dressing of FYM to supply 45 kg N / ha together with 45 kg N/ ha as ammonium sulphate, the increase over control was 520 kg paddy rice/ha. (Sahu and Nayak 1971). Each tonne of rice straw after being used for mushroom cultivation (SAM) was

---

<sup>1</sup> Japan International Research Center for Agricultural Sciences, JIRCAS, Japan

applied alone or in combination with chemical fertilizer (90 kg N/ ha) gave higher yield (50-60 kg paddy rice/ha) than control without SAM (Tan 1992).

Rice is the most important crop in Mekong Delta. With the introduction of high yielding rice varieties and adoption of intensive rice cultivation, large quantities of rice residues as straw, rice stubbles are available on farms. However, most of rice straw was burnt or removed after harvesting. These rice straw can not be applied or ploughed directly into the soil because of their wide C:N ratio. They are known to reduce the availability of important mineral nutrients to growing plants through immobilization into organic forms and also produce phyto-toxic substances during their decomposition (Martin et al. 1978; Elliott et al. 1981). To alleviate such problems, the rice straw materials, under intensive decomposition in heaps or pits with adequate moisture and suitable microbial inoculants could be used as organic manure (Gaur et al. 1990) in rice field. Therefore, decomposed rice straw with suitable fungal inoculant should be applied to study "integrated nutrient management for sustainable agriculture and environmental conservation" with the following objectives (1) to determine the effect of continuous application of organic fertilizer and inorganic fertilizer alone or in combination on rice yield and (2) their effects to microbial communities in rice soil condition.

## MATERIALS AND METHODS

Fungal inoculant (*Trichoderma* sp.) in powder formula was produced by

CLRRI's Microbiology Lab to make rice straw decomposed, and to treat into rice straw heap with adequate moisture supplying for decomposition. It took 30-45 days after inoculation, decomposed rice straw was used as organic manure.

The bio-organic phosphorus fertilizer was produced by Thien Sinh company in Ho Chi Minh city with the composition as followed: organic content = 15 %; total nitrogen = 1%; total phosphorus = 4 %; total potassium = 1%; Ca, Mg = 3%; Cu, Zn, Mo = 600 ppm and phosphorus solubilizer =  $3 \times 10^6$  CFU/g. The product was also used in this experiment.

This long-term experiment was conducted at CLRRI's experimental field under condition of heavy clay soil texture, soil pH = 5.2; total nitrogen=0.25%; total phosphorus = 0.06%; available phosphorus = 0.45 ppm; total potassium = 1.75 % and exchangeable potassium = 0.31 cmol/kg.

The experiment was stated in 1997's dry season. Germinated seeds of rice varietie "IR 64" (110-day growth duration) was broadcasted in the plot (80 m<sup>2</sup>) with 200kg/ha seed rate. The experiment including four treatments was conducted in randomized complete block design with four replications:

T1: Control ( 0 N - 0 P<sub>2</sub>O<sub>5</sub> - 0 K<sub>2</sub>O)

T2: 100% organic fertilizer (decomposed rice straw 6t/ha and bio-organic phosphorus fertilizer 1 t/ha were applied before sowing).

T3: 50% organic fertilizer + 50% inorganic fertilizer (organic fertilizer: decomposed rice straw 3 t/ha and bio-

organic phosphorus fertilizer 300 kg/ha was applied before sowing. Inorganic fertilizer: N application followed by SPAD value;  $\text{KNO}_3$  12 kg/ha was sprayed as following 1/3 at 30 days after sowing, 1/3 at 1-week before flowering and 1/3 at 1-week after flowering.)

T4: 100% inorganic fertilizer (120 N- 30  $\text{P}_2\text{O}_5$ - 30  $\text{K}_2\text{O}$  kg/ha in dry season and 80 N- 40  $\text{P}_2\text{O}_5$ - 30  $\text{K}_2\text{O}$  kg/ha in wet season were applied as  $\text{K}_2\text{O}$  and  $\text{P}_2\text{O}_5$  for basal application, 1/3 N at 1-week after sowing (WAS), 1/3 at 3 WAS and 1/3 at 7 WAS).

Hand weeding and IPM management were applied for treatments T1, T2, and T3. Weed and pest control in treatment T4 were followed by farmer's practices.

Soils were sampled before sowing to estimate the dynamics of microbial population in soil as following the above treatments. Microbial population was estimated by plate counting method, with the media:

- Nutrient agar medium for bacteria counting;
- PDA for fungi counting,
- Kenknight and Munaier's medium for Actinomycetes counting;

- Bristol's medium for algae counting (Subba Rao 1977).

## RESULTS AND DISCUSSION

### Effect of continuous application of organic fertilizer and inorganic fertilizer alone or in combination on rice yield

IR 64 was the most popular variety growing in Mekong Delta actually. The farmers' choice of the variety was due to high-yielding, short duration, moderate resistance to brown plant hopper, and some diseases, good eating quality. Table 1 indicated that in 1997's dry season (DS), there were non-significant differences in terms of grain yield among the treatments. However, the maximum yield was obtained in treatment T4, then T3. In 1997's wet season (WS), T4 significantly differed from T1 in higher yield.

In 1998's DS, there were non-significant differences in grain yield between T1 and T2 and among T2, T3, T4. However, T3 and T4 significantly differed from T1 in higher yield.

In 1998's WS, treatment T4 obtained the highest yield and significantly differed from T1. Non-significant differences between treatments T1 and T2; T2 and T3 were also observed.

OMONRICE 7 (1999)

Table 1. Effect of integrated nutrient management on grain yield of IR 64 at different seasons (1996 – 1998)

Treatment	DS	WS	DS.	WS
	1996-1997 (T/ ha)	1997 (T/ ha)	1997-1998 (T/ ha)	1998 (T/ ha)
T1	5.05	2.46	4.5	2.68
T2	5.07	2.86	5.43	3.33
T3	5.42	2.93	5.53	3.54
T4	5.44	3.10	6.23	4.00
F	Ns	*	*	*
CV %	9.50	5.80	11.5	12.2
LSD 5%	-	0.49	1.00	0.66

Table 2 showed that the continuous application of organic fertilizer (50%) in combination with 50% recommended dose of inorganic fertilizer was found to be equal in yield as compared to treatment in which 100% of inorganic fertilizer was applied alone and inorganic fertilizer was continuously applied alone. Their trend was significantly reaching higher yield than control treatment. It is obviously recorded in two seasons through mean values of rice yield. The treatment of continuous application of organic manure alone yielded over control 9.9% (Padalia 1975). The treatment in combination with inorganic fertilizer yielded over control 11-12 % (Tan 1992). In this experiment, we also

recorded that the treatment in which organic fertilizer was continuously applied for two seasons / year yielded over control 13.6 % and the treatment in combination with inorganic fertilizer yielded over control 18.6 %.

Increasing of rice yield could be due to return of available nutrients from decomposed rice straw to soil, then they have replenished macro and micro-nutrients to rice plants. Because rice straw under treating with *Trichoderma viride* for decomposition, 30-45 days after treating, the content of organic carbon and C/N ratio decreased, whereas the content of N, P, K, Mn, Fe, Zn, Cu in rice straw significantly increased (Son and Ramaswami 1997).

Table 2. Yield average of two seasons and percentage of grain yield over control

Treatment	Average of two D.S. (T/ ha)	Average of two W.S. (T/ ha)	Percentage of grain yield over control		
			DS	WS	2 crops/year
T1	4.75	2.57	-	-	-
T2	5.25	3.09	9.8	20.6	13.5
T3	5.47	3.23	14.6	26.1	18.1
T4	5.83	3.55	22.2	38.13	27.9
F	Ns	*	-	-	-
CV %	7.20	9.50	-	-	-
LSD 5%	-	0.37	-	-	-

During experiment process, we also recorded that the treatment plots in which inorganic fertilizer was applied alone, harmful insects and sheath blight disease occurred at early growth stages and caused serious problem. Otherwise, the treatment plots in which organic manure was applied alone or in combination with 50% inorganic fertilizer, the appearance of major harmful insects and sheath blight disease was later so that less serious problem was also observed.

It may be explained that the treating of *Trichoderma* fungi inoculant into sheath blight infested rice straw for decomposition as biological agent that inhibited the development of sheath blight disease caused by *Rhizoctonia solani* lead to decline the introduction of sheath blight disease into the rice field (Nagamani and Mew 1987, Man and Noda 1997)

#### **Microbial communities under rice soil conditions**

Essential to sustainable agriculture is maintenance of viable, diverse

population and functioning microbial communities in the soil. Soil organisms are one of the most sensitive biological markers, and the most useful agents for classifying disturbed or contaminated systems. The use of microorganisms and their functioning in terms of total numbers of microorganisms, total respiration rates, and enzyme activities for examination of environmental stresses and declining biological diversity needs to be investigated ( OTA 1987; Parkinson and Coleman 1991 ).

In the long-term experiment we have been only estimated the microbial population in soil. Table 3 showed that bacteria were often bigger populations than fungi, *Actinomycetes* and algae. The continuous application of organic manure also gave higher number of bacteria than in case of inorganic fertilizer application. This observation was also demonstrated and determined by Gaur et al (1990) that bacterial population due to incorporation of rice straw (10 tonnes / ha) in heavy clay soil was stimulated into a bigger population than fungi and *Actinomycetes*.

Table 3. Average of microbial population in two seasons (number of log<sub>10</sub>)

Treatment	D.S.				W.S.			
	Bact.	Fungi	Act.	Algae	Bact.	Fungi	Act.	Algae
T1	6.60	6.48	6.30	6.00	6.78	6.48	6.30	6.00
T2	6.78	6.48	6.60	6.30	6.90	6.48	6.48	6.30
T3	6.78	6.60	6.48	6.48	6.70	6.85	6.30	6.30
T4	6.60	6.48	6.48	6.00	6.70	6.30	6.30	6.30

The microbial communities in soil was greatly influenced by different types of organic fertilizer or inorganic fertilizer application. In general, the figure 1 showed that application of 50% organic fertilizer in combination with 50% inorganic fertilizer was exhibited in higher microbial communities as compared to inorganic fertilizer application alone and control treatment. The result also indicated that the microbial communities was greatly fluctuated in treatment plots in which inorganic fertilizer was applied alone.

Otherwise, the microbial communities were stabilized in other treatment plots in which organic fertilizer was continuously applied. It can be assumed that the continuous application of organic manure that is available as an energy and carbon source for stabilization of microbial population in soil. Therefore, the organic manure plays an importance role in nutrient supplement to chemical fertilizers for a sustainable agriculture and environmental conservation.

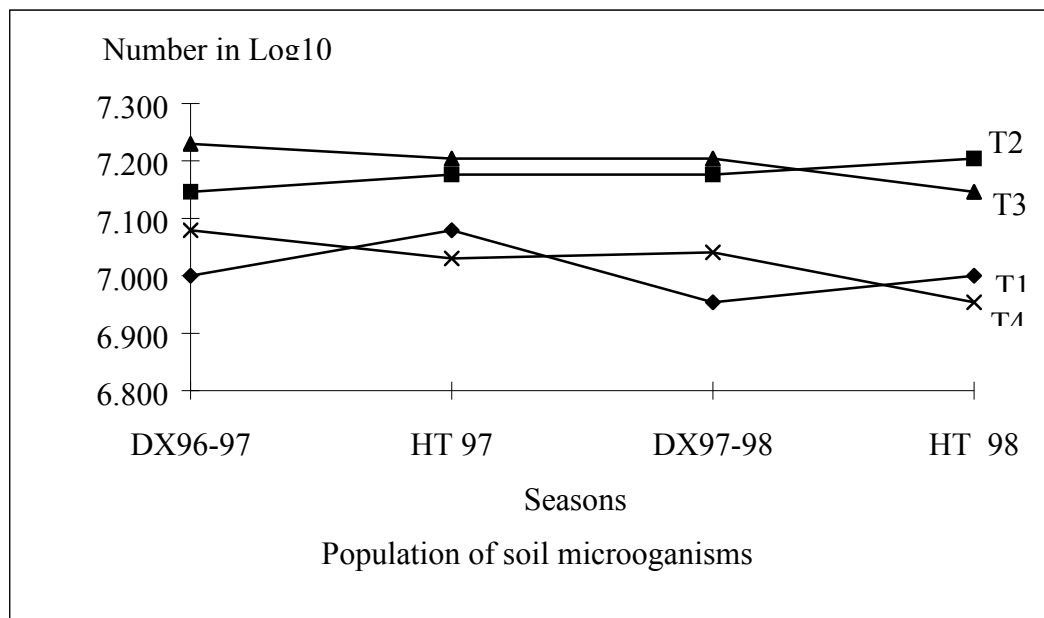


Figure 1. The fluctuation of microbial populations in soil at different seasons.

## CONCLUSIONS

The long-term rice experiment has been continuously conducted, recent results could be concluded as followed:

Continuous application of organic fertilizer over-yielded to control as 13 - 14%.

Continuous application of 50% organic fertilizer in combination with 50% inorganic fertilizer overyielded to control as 18 - 19%.

Continuous application of 50% organic fertilizer in combination with 50% inorganic fertilizer gave higher microbial communities as compared to 100% inorganic fertilizer application and control treatment.

Continuous application of 100% organic manure, the appearance of harmful insects and sheath blight disease were later so that less serious damages were obtained and microbial population in soil was higher stabilization and trend to increase as compared to application of 100% inorganic fertilizer.

## REFERENCES

- Anonymous 1974. Utilization of agricultural and animal wastes / by products draft status report. National committee on science and technology., New Delhi.
- De Datta SK and SS Hundal 1984. Effects of organic matter management on land preparation and structural regeneration in rice based cropping systems. In organic matter and rice. pp. 399-417. IRRI., Philippines.
- Elliot L, VL Cochran, and RI Papendick 1981. Wheat residues and nitrogen placement effects on wheat growth in green house. Soil. Sci., 131: 48-52.
- Garg AC, MA Idnani and TP Abraham 1971. Organic manures, I. C. A. R. Tech. Bull. (Agric. ) No. 32.
- Gaur AC, RV Subba Rao and KV Sadasivam 1972. Soil structure as influenced by organic matter and inorganic fertilizer. Labdev.J. Sci. Tech. India., 10-B:55
- Gaur AC, S Neelakantan and KS Dargan 1990. Organic manures. I.C.A.R. New Delhi. India.
- Man LH. and T Noda 1997. Trichoderma fungus as biological agent to *Rhizoctonia solani* and rice straw decomposition. Results on Science Research in CLRR. (1977-1997). Agriculture Publisher. Ho Chi Minh city. pp:137-143.
- Martin JP, RL Branson. and WM Jarrell 1978. Decomposition of organic material used in planting mixes and some effects on soil properties and plant growth. Agrochimica. 22: 248-261.
- Nagamani A and TW Mew 1987. Trichoderma- A potential biological control agent in the rice based cropping systems. 1-13. IRRI saturday seminar, Los Banos, Philippines.

- Office of Technology Assessment of U.S. Congress (OTA) 1987. Technologies to maintain biological diversity. OTA-F330. Washington D.C.,U. S Government printing office:331p.
- Padalia CR 1975. Effect of N, P & K fertilizer with and without farmyard manure on high yielding variety of rice. *Oryza* 12(10): 53-58.
- Parkinson D and DC Coleman 1991. Microbial communities, activity nad biomass. *Agric. Ecosyst. Environ*, 34: 3-33.
- Shau BN and BC Nayak 1971. Soil fertilizers investigations under continuos application of  $(\text{NH}_4)_2\text{SO}_4$  alone and in combination with the organic manures in the Bhubaneswar long-term fertility trial. *Proc. Int. Symp. Soil Fert. Evaluation. Vol. I held at Newdelhi*.pp. 873-879.
- Son TTN and PP Ramaswami 1997. Bioconversion of organic wastes for sustainable agriculture. *OMON RICE*. (5): 56 - 61.
- Subba Rao NS 1977. Soil microorganisms and plant growth. Oxford & IBH publishing Co.PVT.LTD. pp. 192 - 207.
- Tan PS 1992. Organic manure for high yielding rice. *OMON RICE*. ( 2): 64-68.

## TÓM TẮT

### **Quản lý dinh dưỡng tổng hợp ứng dụng phân compost từ chế phẩm vi sinh trên ruộng lúa**

Chế phẩm nấm *Trichoderma* được sử dụng để xử lý phân hủy rơm rạ, rơm rạ đã phân hủy được bón phối hợp với phân lân sinh học như dạng phân hữu cơ. Phân hữu cơ được bón riêng lẻ hoặc phối hợp với phân vô cơ (NPK) trên nền đất sét nặng nhằm nghiên cứu dài hạn về " Quản lý dinh dưỡng tổng hợp cho nền nông nghiệp bền vững và bảo vệ môi trường". Kết quả của hai năm nghiên cứu trên giống lúa IR64 cho thấy: nếu bón liên tục 100% phân hữu cơ cho năng suất tăng hơn đối chứng là 13.6% và nếu bón kết hợp 50% phân hữu cơ với 50% phân vô cơ cho năng suất tăng hơn so với đối chứng là 18.6%. Kết quả khảo sát về quần thể vi sinh vật đất cho thấy rằng, khi bón 50% phân hữu cơ phối hợp với 50% phân vô cơ (NPK) cho quần thể vi sinh vật cao hơn nghiệm thức bón đơn thuần 100% phân vô cơ (NPK) và nghiệm thức đối chứng. Kết quả cũng cho thấy khi bón liên tục 100% phân hữu cơ côn trùng và bệnh đốm vằn xuất hiện trễ hơn và ít gây thiệt hại cho cây lúa và quần thể vi sinh vật đất ổn định hơn và có chiều hướng gia tăng hơn so với bón đơn thuần 100% phân hữu cơ.