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Integrated nutrient management for a sustainable agriculture at Omon, Vietnam

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ABSTRACT

Fungal inoculant (Trichoderma sp) in powder product 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 combined with inorganic fertilizer (NPK) in heavy clay soil to address "integrated nutrient management for sustainable agriculture " in long-term study. The average data from two-rice crop system of four years with IR 64 showed that a continuous application of 100% organic fertilizer increased rice yield over control 13.9% and continuous application of 50% organic fertilizer in combination with 50% inorganic fertilizer increased rice yield over control 22.5%. 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 apperance 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.

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 and microbiological conditions 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 applicatipon of ammonium sulphate and organic manures, *viz* FYM, green manure and groundnut 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 overcontrol was 520 kg paddy rice/ha (Sahu and Nayak 1971). Each tonne of rice straw after being used for mushroom cultivation (SAM) was applied alone or in combination with chemical fertilizer (90 kgN / 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 stubles become abundant on farms. However, most of rice straw was burnt or removed after harvesting. These rice straws cannot be applied or plouged directly to incorporate into 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

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management for sustainable agriculture and enviromental 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) to understand their effects to microbial communities in rice soils.

MATERIALS AND METHODS

Fungal inoculant (*Trichoderma* sp.) in powder formula was produced by CLRRI's Soil Microbiology Lab to make rice straw decomposed, and to treat into rice straw heap with adequate moisture suppling for decomposition. Decomposed rice straw was used as organic manure at 30-45 days after inoculation.

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 x 10^6 CFU/g. The product was also used in this experiment.

The long-term experiment has been 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 has been started since 1997's dry season. Germinated seeds of rice cultivar "IR 64" (110-day growth duration) was broadcasted in the plot (80 m^2) with the seed rate of 200kg / ha. The experiment including four treatments was conducted in randomized complete block design with four replications

T1: control (0 N - 0 P_2O_5 - 0 K_2O)

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 included: decomposed rice straw 3 t / ha and bio-organic phosphorus fertilizer 300 kg / ha was applied before sowing. Inorganic fertilizer included: N application folowed by SPAD value; 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 P_2O_5- 30 K_2O kg/ha in dry season and 80 N- 40 P_2O_5- 30 K_2O kg/ha in wet season were applied as K_2O and P_2O_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 soils 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

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

IR 64 is one of the most popular variety growing in Mekong Delta actually due to its high-yielding, short duration, moderate resistance to brown plant hopper, and some major diseases, good eating quality.

Table 1 indicated that in 1997's dry season (DS), there were non-significant differences in grain yield among the treatments. However, the maxium yield was obtained in treatment T4, then T3.

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

In 1999's DS, treatment T4 obtained the highest yield and significantly differed from T1 and T2. Non-significant differences between treatments T1 and T2; T3 and T4 were observed.

In 2000's DS, treatment T3 obtained the highest yield significantly differed from T1 and T2 but T3 grain yield was not different from T4. There were non-significant differences in grain yield between T1 and T2; T3 and T4.

Table 1: Effect of integrated nutrient management on grain yield of IR 64 at four dry seasons (1996 – 2000)

Treatment	DS 1996-1997 (T/ ha)	DS 1997- 1998 (T/ ha)	DS. 1998-1999 (T/ ha)	DS 1999-2000 (T/ ha)
T1	5.05	4.50	4.02	5.54
T2	5.07	5.43	4.71	6.23
T3	5.42	5.52	4.89	6.74
T4	5.44	6.23	5.41	6.5
F	ns	*	*	*
CV %	9.50	11.5	10.9	7.5
LSD 5%	-	1.00	0.83	0.76

Table 2 indicated that in 1997's wet season (WS), there were significant differences of grain yield among the treatments T2, T3, T4. But treatment T4 performed higher in grain yield than treatment T1.

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

In 1999's WS, treatment T3 obtained the highest yield and significantly differed from T1. Non-significant differences between treatments T1 and T2; among T2, T3 and T4 were also observed.

In 2000's WS, the maxium yield was obtained in treatment T4 and significantly differed from T1. Non-significant differences in grain yield between T1 and T2; T2 and T3; T3 and T4 were also recorded.

Table 2: Effect of integrated nutrient management on grain yield of IR 64 at four wet seasons (1997 – 2000)

Treatment	WS 1997 (T/ ha)	WS 1998 (T/ ha)	WS 1999 (T/ ha)	WS 2000 (T/ ha)
T1	2.46	2.68	2.23	2.33
T2	2.86	3.33	2.60	2.57
T3	2.93	3.54	3.03	3.21
T4	3.10	4.00	2.88	3.66
F	*	*	*	*
CV %	5.9	12.2	11.7	17.6
LSD 5%	0.49	0.66	0.49	0.83

Table 3 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 comapred 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 overyielded 9.9% than control (Padalia 1975). The treatment in combination with inorganic fertilizer overyielded 11-12 % than control (Tan 1992). In this experiment, we also recorded that the treatment in which organic fertilizer was continuously applied for two seasons / year overyielded 13.85 % than control and the treatment in combination with inorganic fertilizer overyielded 22.46% than control.

Increasing 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 3: Average yield through four seasons and percentage of grain yield over control

Treatment	Average of four D.S. (T/ ha)	Average of four W.S. (T/ ha)	Percentage of grain yield over control		
			DS	WS	2 crops/year
T1	4.78	2.42	-	-	-
T2	5.36	2.84	12.13	17.36	13.85
T3	5.64	3.17	18.00	30.99	22.46
T4	5.89	3.40	21.34	40.50	28.88
F	*	*	-	-	-
CV %	11.0	14.7	-	-	-
LSD 5%	0.82	0.35	-	-	-

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 apperance of major harmful insects and sheath blight disease was later so that less serious problems were also observed.

It may be explained that the treating of *Trichoderma* fungus 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 in the rice field (Nagamani and Mew 1987, Man and Noda 1997)

2. 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 soils. Table 4 showed that bacteria often developed 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 determided 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 4 :Average of microbial population in four seasons (number of $\log_{10}$)

Treatment	**D.S.**				**W.S.**			
	Bact.	Fungi	Act.	Algae	Bact.	Fungi	Act.	Algae
T1	6.70	6.30	6.48	6.00	6.78	6.48	6.30	6.00
T2	7.04	6.48	6.60	6.00	7.00	6.70	6.30	6.00
T3	6.78	6.60	6.60	6.30	6.78	6.78	6.48	6.30
T4	6.60	6.30	6.30	6.00	6.60	6.30	6.30	6.00

The microbial communities in soils 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 soils. Therefore, the organic manure plays an importance role in nutrient supplement to chemical fertilizers for a sustainable agriculture and environmental conservation.

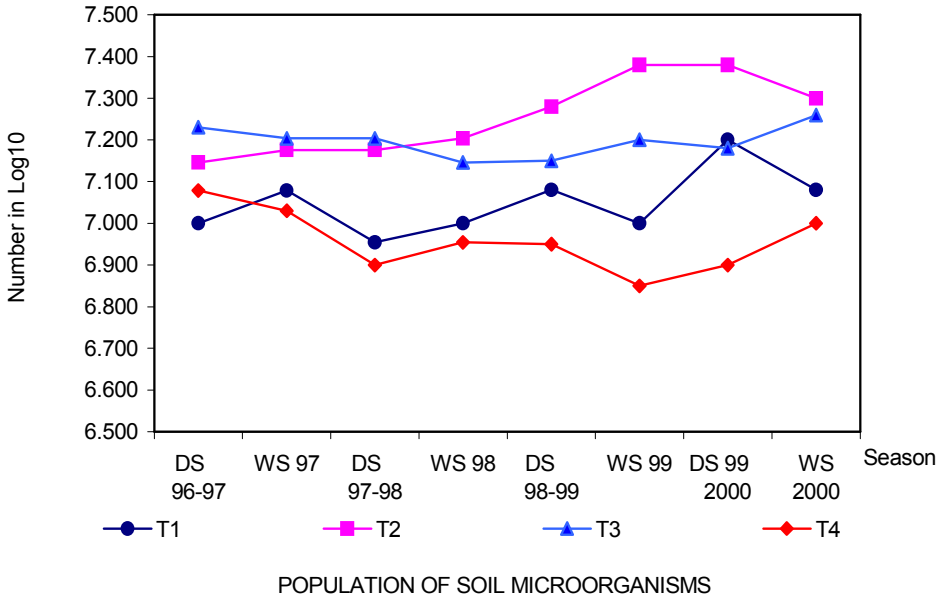

Figure 1. The fluctuation of microbial populations in soil at different seasons.

CONCLUSIONS

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

- Continuous application of organic fertilizer overyielded 13-14% than control
- Continuous application of 50% organic fertilizer in combination with 50% inorganic fertilizer overyielded 22 - 23 % than control
- 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 can lead the later apperance of harmful insects and sheath blight disease 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

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SUMMARY IN VIETNAMESE

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 lẽ 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 qủa 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 13,85% và nếu bón kết hợp 50% phân hữu cơ với 50% phân vô cơ cho năng suất tăng hơn so với đối chứng là 22,46%. Kết qủa 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 qủa cũng cho thấy khi bón liên tục 100% phân hữu cơ côn trùng và bệnh đốm vằn xuất hiện trể 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.
