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Improvement of soil fertility by rice straw manure

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ABSTRACT

Rice straw manure (RSM) was produced by treating with fungal inoculant (Trichoderma sp) through a long-term experiment on " Improvement of soil fertility by rice straw manure"(RSM). The results showed that a complete application of RSM increased yield over than control 1.82 % in wet season (WS) and 6.40% in dry season (DS). While complete application of chemical fertilizer (NPK) increased yield over than control 40.02 % in WS and 36.4% in DS. RSM combined with different doses of chemical fertilizer increased yield over than control from 14.61 - 32.42 % in WS and from 27.31% - 37.50% in DS. In general, the result of two seasons (WS and DS) indicated that a complete application of chemical fertilizer and control treatment had lower microbial population in soil as compared to complete application of RSM or in combination with different doses of chemical fertilizer. There was possitive correlation between soil microorganisms and ETS (electron transport system) activities; a possitive correlation between soil microorganisms and total protein content in soil was also recorded.

Key words: ***RSM, NPK fertilizer, soil improverment, soil microorganisms***

INTRODUCTION

One of the biggest constraint in rice production in Mekong Delta are how to deal with large quantities of rice residues as straw, rice stubles in farm level. Actually, most of rice straw was burnt or removed after harvesting. These rice straw can not be applied or plouged directly into the soil because of their large C:N ratio. They are well-known to reduce the availability of important mineral nutrients for growing of plants through immobilization into organic forms and also to 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.

Cuu Long Delta Rice Research Institute (CLRRI) has collaborated to Japan International Research Center for Agricultural Sciences (JIRCAS) to conduct a long-term experiment in which rice straw manure was produced by treating with fungal inoculant to study "improvement of soil fertility by rice straw manure" to determine (1) the effect of continuous application of rice straw manure and chemical fertilizer on rice yield and (2) their effects to microbial communities and soil fertility.

MATERIALS AND METHODS

Fungal inoculant (*Trichoderma* sp.) in powder form produced by CLRRI's Microbiology Department was treated into heaps of rice straw with adequate moisture suppling for decomposition. It took 30-45 days after inoculation, decomposed rice straw was used as organic manure.

The experiment was started in 2000's wet season. Germinated seeds of rice varietie "IR64" (110-day growth duration) was broadcasted in the plot (30 m^2) with the seed rate of 200kg / ha. The experiment including seven treatments was conducted in randomized complete block design with three replications:

T1: control (0 N - 0 P_2O_5 - 0 K_2O)
T2: 100% rice straw manure (6 t/ha)
T3: 100% rice straw manure (6 t/ha) + 20% NPK (16N- 6P_2O_5 -6K_2O kg / ha)
T4: 100% rice straw manure (6 t/ha) + 40% NPK (32N- 12P_2O_5 -12 K_2O kg / ha)
T5: 100% rice straw manure (6 t/ha) + 60% NPK (48N- 18P_2O_5 -18 K_2O kg / ha)
T6: 100% rice straw manure (6 t/ha) + 80% NPK (64N- 24P_2O_5 -24 K_2O kg / ha)

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T7: 100% chemical fertilizer (in wet season : 80N- $30P_2O_5$ -30 K_2O kg / ha)
(in dry season : 100N- $30P_2O_5$ -30 K_2O kg / ha)

Rice straw manure (6t / ha) was basal application. Total phosphorus fertilizer (P_2O_5) was basal application. Nitrogen (N) was applied in three splits: 1/3 was applied at 10 days after sowing (DAS), then 1/3 at 20 DAS and 1/3 at 30 DAS. Potassium fertilizer (K_2O) was applied in two slipts: 1/2 was applied at 10DAS and 1/2 at 30 DAS.

Soil microbial populations were estimated at two times: before sowing and harvesting. Total protein content (mg / kg of dried soil) in soil (Herbert et al. 1971) and electron transport system (ETS) activities (nmol INTF per min-g dry weight of soil) or dehydrogenase (Chendrayan et al. 1980) were counted at harvesting time. Soils were sampled at 10 days before harvesting to analyze soil nutrient components.

Microbial populations were counted by plate counting method, with the media (Subba Rao 1977) as followed:

- nutrient agar medium for bacteria counting.
- PDA for fungi counting.
- Kenknight and Munaier's medium for Actinomycetes counting.
- Bristol's medium for algae counting .

SPAD value was recorded by Chlorophyll meter (SPAD-502) at 50 DAS, disease - insect incidence during growth cycle and yield and yield components were recorded. The data under this study were statistically analysed by IRRISTAT progame (IRRI, 1991)

RESULTS AND DISCUSSION

1. Effect of rice srtaw manure and chemical fertilizer application on rice yield.

IR64 is one of the most popular varieties cropped in Mekong Delta actually due to its high-yielding, short duration, moderate resistance to brown plant hopper, and some major diseases, good eating quality.

The SPAD meter (SPAD-502) test can be a useful tool for Nitrogen management in rice. The optimun SPAD values for high-yielding varieties ranged from 32 -36 for direct seeded in dry season and 29 -32 for direct seeded in wet season (Huan et al. 1998, 2000). The result in wet season (table1) showed that SPAD value in treatments T4, T5, T6 and T7 ranged from 30.9 to 35.2 ; the other treatments T1,T2 and T3 obtained SPAD values from 27.0-28.6. In dry season, the result also indicated that SPAD values in treatments T3, T4, T5, T6 and T7 ranged from 31.2 to 38.3. Otherwise, treatments T1 and T2 had SPAD values from 27.8 to 28.2.

In wet season, the result on yield (table 2) showed that there were non-significant differences in terms of grain yield among treatments T1, T2, T3; among treatments T3, T4, T5 and among treatments T5, T6, T7. However, T7 statistically gained much higher yield than treatments T1, T2, T3, T4. In dry season, the result also indicated that there were non-significant differences in terms of grain yield among treatments T3, T4, T5 , T6 and T7. However, these treatments performed higher yield than treatments T1 and T2 .

Continuous application of organic manure alone overyielded 9.9% than control (Padalia 1975). Otherwise, application of organic manure in combination with inorganic fertilizer overyielded 11-12% than control (Tan 1992). In this experiment, we also recorded that the treatment in which complete application of rice straw manure overyielded 1.82 % and 6.40% than control in WS and DS, respectively.

The treatment in which complete application of chemical fertilizer (NPK) overyielded 40.02% and 36.34% than control in WS and DS, respectively.

The treatments in which rice straw manure combined with different doses of chemical fertilizer overyielded 14.61-32.42% and 27.31-37.01% than control in WS and DS, respectively.

Table1. Effect of rice straw manure and chemical fertilizer on SPAD at 50 days after sowing

Treatment	SPAD index	
	2000 Wet season	2001 Dry season
T1. Control	27.0	27.8
T2. RSM (6t/ha)	27.4	28.2
T3. RSM + 20 %NPK	28.6	31.2
T4. RSM + 40% NPK	30.9	32.1
T5. RSM+ 60%NPK	30.8	35.1
T6. RSM+80% NPK	31.7	36.4
T7. NPK (WS:80-30-30) (DS:100-30-30)	35.2	38.3
CV (%)	4.71	3.30
LSD (5%)	2.53	1.94

Table 2. Effect of rice straw manure and chemical fertilizer on rice yield of IR64

Treatmant	2000 Wet season		2001 Dry season	
	Rice yield (t/ha)	Percentage of grain yield over control	Rice yield (t/ha)	Percentage of grain yield over control
T1. Control	2.19	-	4.32	-
T2. RSM (6t/ha)	2.23	1.82	4.60	6.40
T3. RSM + 20 %NPK	2.51	14.61	5.50	27.31
T4. RSM + 40% NPK	2.66	24.46	5.84	35.18
T5. RSM+ 60%NPK	2.71	23.74	5.94	37.50
T6. RSM+80% NPK	2.90	32.42	5.92	37.01
T7. NPK (100-30-30)	3.07	40.02	5.89	36.34
CV (%)	8.20	-	5.50	-
LSD (5%)	0.37		0.52	

There were possitive correlation between SPAD value and grain yield R^2 = 0.9369 and R^2 = 0.7603 in wet season and dry season, respectively (Fig. 1).

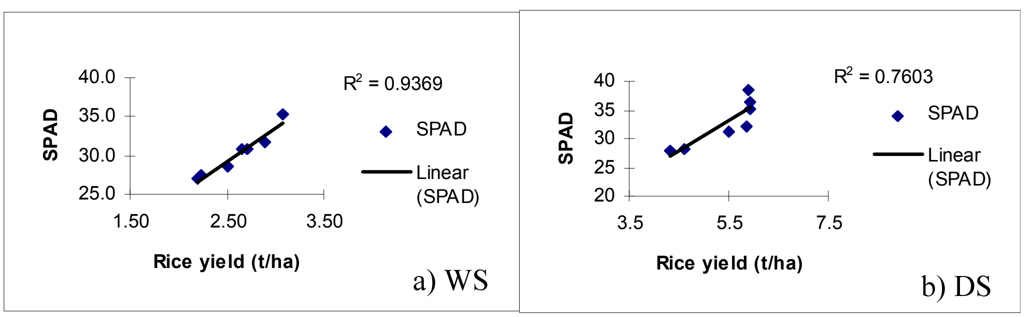

Fig 1. The coorection between index SPAD and grain yeild

2. Microbial communities under rice soil conditions

Essential factors of sustainable agriculture are maintenance of viable, diverse population and functioning microbial communities in the soils. Soil organisms are one of the most sensitive biological markers, and the most useful agents for classifying disturbed or contaminated systems. The use of micro-organisms and their functioning in terms of total numbers of microorganisms, total respiration rates, and enzyme activities (ETS activities, alkaline phosphatase, sulphatase, asparaginase...) for examination of environmental stresses and declining biological diversity needs to be investigated (OTA 1987; Parkinson and Coleman 1991).

Table 3. Effect of rice straw manure and chemical fertilizer on microbial of soil.

Treatment	Microbial population (in log_{10})		
	2000 Wet season	2001 Dry season	Average
T1. Control	7.84	6.48	7.16
T2. RSM (6t/ha)	8.71	6.90	7.80
T3. RSM + 20 %NPK	8.77	6.78	7.77
T4. RSM + 40% NPK	8.73	6.70	7.71
T5. RSM+ 60%NPK	8.74	6.95	7.84
T6. RSM+80% NPK	8.57	7.04	7.80
T7. NPK (DS:100:30:30)	7.93	6.78	7.35
(WS: 80:30:30)	-		
* Before sowing	8.71*	-	-
Average	7.41	6.80	-
Sd	0.34	0.18	

Note:* sd of microbial population in wet season was not calculate to treatment of before

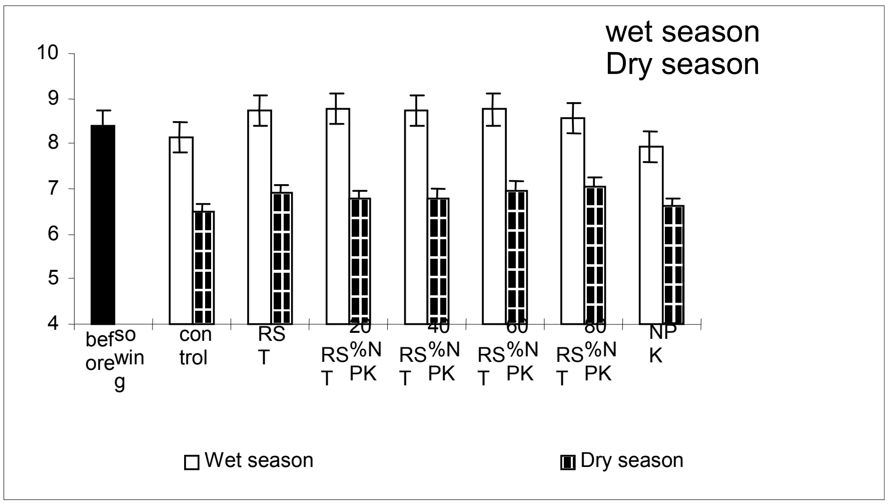

Fig 2. Microbial population (in log_{10}) per gram of dried soil

Table 4. Effect of rice straw manure and chemical fertilizer on ETS activities and total soil protein

Treatment	ETS activities*		Total protein content of soil **	
	2000 Wet season	2001 Dry season	2000 Wet season	2001 Dry season
T1. Control	33.3	67.0	76.6	118.6
T2. RSM (6t/ha)	53.2	79.0	93.3	130.5
T3. RSM + 20 %NPK	33.2	75.0	78.7	115.1
T4. RSM + 40% NPK	33.1	80.6	90.5	129.9
T5. RSM+ 60%NPK	46.8	87.8	86.0	137.6
T6. RSM+80% NPK	33.4	70.4	79.7	129.8
T7. NPK (WS:80-30-30) (DS: 100-30-30)	33.1	61.5	73.2	95.5
Average	37.43	73.96	82.6	122.4
Sd	8.81	8.69	7.5	14.02

Note: * ETS activities = n mol INTF per min-g dry weight of soil
INTF: Iodonitrophenyl Formazan
** Total protein content = mg/ kg of dried soil

The continuous application of organics will energise the living soil micro-organisms, involved in biochemical activity of importance to soil fertility and plant nutrition (Gaur et al. 1990). In this experiment, we have only estimated the microbial population, total protein content and electron transport system (ETS) activities or dehydrogenase in soil. In general, the result on two continuous rice crops (table 3) showed that plots where rice straw manure was incorporated, obtained higher in microbial population as compared to plots where the manure was not applied (T1, T7). This observation was similarly recorded in terms of ETS activities and total soil protein (mg/ kg of dried soil).

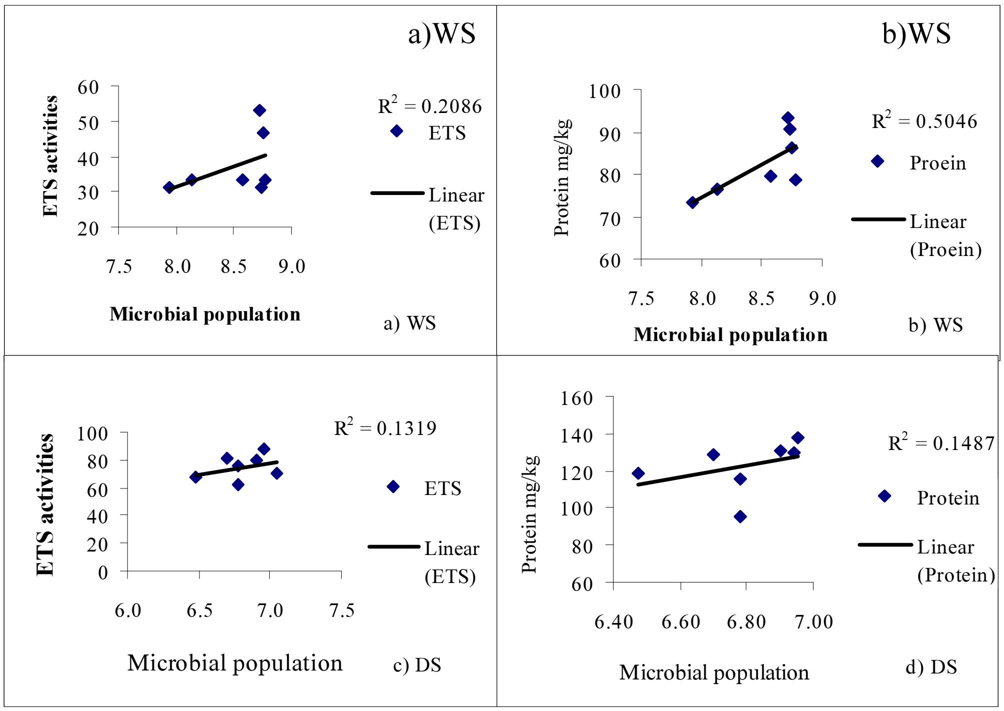

Fig 3. a,c) The linear correlation between soil micro-organisms and protein. b,d) The linear correlation between soil micro organisms and ETS activities.

The lowest value of ETS activities (n mol INTF per min-g soil) and total soil protein (mg/ kg of dried soil) obtained in complete application of chemical fertilizer treatment T7 (WS and DS), in contrast to this the plot in which complete application of rice straw manure was found to be the highest value of ETS activities and total soil protein (WS and DS). Among treatments in which rice straw manure in combination with different doses of chemical fertilizer, only treatment T5 (WS) and treatments T4, T5 (DS) exhibited higher value of ETS activities than control T1. While treatments T4, T5 (WS) and T5 (DS) performed higher value of total soil protein than control T1.

Nutrient cycle in soils is catalyzed by enzymes that are produced by organisms living in soil. Enzymes being assosiated with soil organisms may intracellularly located in cytoplasm such as ETS activities. Other enzymes attached the outer sufaces of living cells. " Abiotic " enzymes have dissociated from living biomass either by excretion or after the death of their producer cells. The latter ones become usually immobilized by absorption to the internal or external surfaces of clay, or by forming complexes with humic colloids through copo-limerization, entrapment or adsorption (Boyd and Morland 1990) and abiotic enzymes at low level are required to induce depolymerization enzymes by soil microbial community (Burns 1982).

The results in this long-term experiment (Fig. 3) showed that there were possitive correlation between soil microorganisms and ETS activities R^2 = 0.2086 and R^2 = 0.1319 in WS and DS, respectively; possitive correlation between soil microorganisms and total soil protein content R^2 = 0.5046 and R^2 = 0.1487 in DS and WS, respectively.

CONCLUSIONS

The primary result in this long-term experiment could be concluded as following:

1. Application of rice straw manure increased yield over control 1.82 % and 6.40% in wet season and in dry season, respectively
2. Application of chemical fertilizer increased yield over control 40.02 % and 36.40% in wet season and in dry season, respectively.
3. Rice straw manure combined with different doses of chemical fertilizer increased yield over control from 14.61 - 32.42 % and 27.31 - 37.01% in wet season and in dry season, respectively
4. Chemical fertilizer application treatment and control obtained lower microbial population in soil as compared to complete application of rice straw manure.
5. There were possitive correlation between soil microorganisms and ETS activities and between soil microorganisms and total soil protein content.

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SUMMARY IN VIETNAMESE

Rơm rạ sau thu hoạch được xử lý bằng chế phẩm sinh học để phân hủy nhanh tạo ra nguồn phân hữu cơ tại chỗ. Sử dụng nguồn phân hữu cơ rơm rạ này bón trực tiếp hoặc kết hợp với phân hóa học (NPK) nhằm " Cải thiện độ phì đất từ nguồn phân hữu cơ rơm rạ" , thí nghiệm sẽ được thực hiện dài hạn. Qua hai vụ thí nghiệm cho kết quả như sau: Bón hoàn toàn phân hữu cơ rơm rạ cho năng suất cao hơn đối chứng 1,82% trong vụ hè thu 2000 và 6,4% trong vụ đông xuân 2000-2001. Bón hoàn phân hóa học (NPK) tăng năng suất cao hơn đối chứng 40,02% trong vụ hè thu 2000 và 36,34% trong vụ đông xuân 2000-2001. Trong khi đó bón phân hữu cơ rơm rạ kết hợp với phân hóa học (NPK) cho năng suất tăng hơn đối chứng từ 14,61-32,42% vụ hè thu 2000 và 27,31 - 37,50% trong vụ đông xuân 2000-2001. Kết quả thí nghiệm cũng cho thấy mật số vi sinh vật, trọng lượng protein và chỉ số ETS hoạt động trong đất ở nghiệm thức bón hoàn toàn phân hữu cơ rơm rạ (T2) cao hơn nghiệm thức đối chứng (T1) và nghiệm thức bón hoàn toàn phân hóa học (T7). Kết quả này cũng đánh gía được mật số vi sinh vật với ETS hoạt động và với protein tổng số có sự tương quan.