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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". The results on average of six continuous seasons showed that a complete application of RSM increased yield over control 4.70 % in wet season (WS) and 7.92% in dry season (DS). While, complete application of chemical fertilizer (NPK) increased yield over control 40.49 % in WS and 25.73% in DS. Treatments in which RSM combined with different doses of chemical fertilizer yielded over control from 32.96 – 44.46 % in WS and from 26.27 -32.41% in DS. The microbial population and their function in soil 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. A positive correlation between soil microorganisms and ETS activities and between soil microorganisms and total protein content in soil was also recorded.

Key words: NPK fertilizer, RSM, soil improvement, soil micro-organisms

INTRODUCTION

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 cannot 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 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 heap or pits with adequate moisture and suitable microbial inoculants could be used as organic manure (Gaur et al. 1990) in rice field.

The Cuu Long Delta Rice Research Institute (CLRRI) has collaborated to Japan International Research Center for Agricultural Sciences (JIRCAS) to carry out a long-term experiment in which rice straw was decomposed by suitable fungal inoculant to produce manure to study "improvement of soil fertility by rice straw manure" with the following objectives:

(1) To determine the effect of continuous application of rice straw manure and inorganic fertilizer alone or in combination on rice yield and
(2) To recognize 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 Department was applied 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 experiment stated in 2000's wet season. Germinated seeds of rice variety "IR64" (110-day growth duration) was broadcasted in the plot (30 m^2) with 200kg / ha seed rate. 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)

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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)

T7: 100% inorganic fertilizer (wet season: 0N- 30P$30P_2O_5$ -30 K_2O kg / ha

And 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 splits: 1/2 was applied at 10DAS and 1/2 at 30 DAS. The standard grower's practice at recommended rate in dry season will be applied as (100N- $40P_2O_5$ -30 K_2Okg / ha)

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

Microbial population was estimated by plate counting method, with the media (Subba Rao 1977).

1 Nutrient agar medium for bacteria counting.
2 PDA for fungi counting.
3 Kenknight and Munaier's medium for Actinomycetes counting.
4 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 was statistically analysed for a randomized complete block design by IRRISTAT program.

RESULTS AND DISCUSSION

1. Effect of rice straw manure and inorganic fertilizer in combination or alone application on rice yield:

IR64 is one of the most popular varieties in the 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 Nitrogen management in rice. The optimum SPAD value for high yielding varieties ranges 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 (Table 1) showed that SPAD value in treatments T4, T5,T6 and T7 ranged from 30.9 to 35.2 (2000 WS), from 30.2 to 33.1 (2001 WS), from 32.0 to 33.8 (2002 WS), and from 32.8-34.9% (2003 WS), the other treatments T1, T2 and T3 obtained SPAD value from 27.0 - 30.6. While, in dry season (table 2), the result also indicated that SPAD value in treatments T4, T5, T6 and T7 ranged from 35.1 to 38.3 (2001 DS), from 31.2 to 34.4 (2002 DS) and from 31.7 to 36.1 (2003 DS). Otherwise, treatments T1, T2 and T3 had SPAD value from 27.8 to 31.2 (2001 DS), from 25.9 to 29.8 (2002 DS) and from 26.7 to 31.4 (2003 DS). The result also showed that the treatment T7 statistically obtained the highest SPAD value as compared to other treatments in the first season (2000 WS). However, non-significant differences in term of SPAD value among treatments T4, T5 T6 and T7 were recognized in continuous seasons.

The result on average of SPAD value in WS (table 1) and DS (table 2) also indicated that the treatment T7 statistically offered the highest SPAD value as compared to other treatments and non–significant differences in term of SPAD value between treatment T5 and T6 was also observed.

Table 1. Effect of rice straw manure and chemical fertilizer on SPAD value at 50 days after sowing in wet seasons

Treatment	2000	2001	2002	2003	Average of four wet seasons
T1. Control	27.0	27.2	27.7	28.1	27.5a
T2. RSM (6t/ha)	27.4	27.5	27.9	28.5	27.8a
T3. RSM + 20 %NPK	28.6	28.5	30.0	30.6	29.3b
T4. RSM + 40% NPK	30.9	30.2	32.0	32.8	31.4c
T5. RSM+ 60%NPK	30.8	32.2	32.6	33.6	32.3cd
T6. RSM+80% NPK	31.7	32.9	33.1	34.6	33.1d
T7. NPK (DS:100:30:30) (WS: 80:30:30)	35.2	33.1	33.8	34.9	34.2 e
CV (%)	4.71	2.8	2.8	3.2	3.40
LSD (5%)	2.53	1.51	1.55	1.84	-

Table 2. Effect of rice straw manure and chemical fertilizer on SPAD value at 50 days after sowing of dry seasons

Treatment	2001	2002	2003	Average of three dry season
T1. Control	27.8	25.9	26.7	26.8 a
T2. RSM (6t/ha)	28.2	26.5	29.6	28.1 b
T3. RSM + 20 %NPK	31.2	29.8	31.4	30.7 c
T4. RSM + 40% NPK	35.1	31.2	31.7	31.7 d
T5. RSM+ 60%NPK	36.4	33.4	34.7	34.3 e
T6. RSM+80% NPK	36.4	33.6	35.2	35.0 e
T7. NPK (DS:100:30:30) (WS: 80:30:30)	38.3	34.4	36.1	36.2 f
CV (%)	3.30	3.0	2.5	3.07
LSD (5%)	1.94	1.63	1.45	-

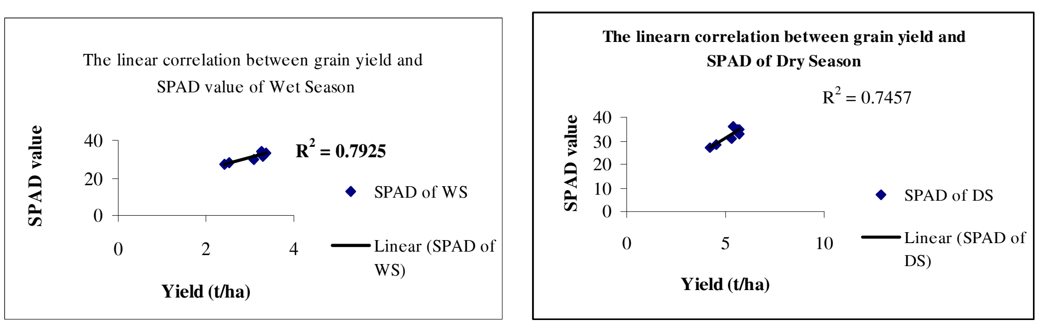

Fig 1. Correlation between SPAD index and grain yield.

There were positive correlations between SPAD value and grain yield R^2 = 0.7925 and R^2 = 0.7457 in wet season and dry season, respectively.

The result on yield (table 3) indicated that in 2000 wet season (WS), 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, and T4.

In 2001 WS, treatment T6 obtained the highest yield and significantly differed from T1, T2 and T3. However, T6 grain yield was not different from T4, T5 and T7. There were non-significant differences in grain yield between treatment T1 and T2, but these treatments was significant lower in grain yield as compared to treatment T3.

In 2002 WS, treatment T6 obtained the

highest yield and significantly differed from T1, T2 and T3. However, T6 grain yield was not different from T4, T5 and T7. There were non-significant differences in grain yield between treatment T2 and T3, but these treatments were significantly higher in grain yield as compared to treatment T1.

In 2003 WS, treatment T4 obtained the highest yield and significantly differed from T1 and T2. However, T4 grain yield was not different from T3, T5, T6 and T7. Non-significant differences in grain yield between T1 and T2 was also observed.

The result on yield (table 4) indicated that in 2000's dry season (DS), there were non-significant differences in grain yield among treatments T3, T4, T5, T6 and T7. However, these treatments performed higher yield than treatments T1 and T2.

In 2002 DS, maximum grain yield was obtained in treatment T5 and significantly differed from T1, T2 and T3. However, T5 grain yield was not different from T4, T6 and T7. There were non-significant differences in grain yield between treatment T1 and T2, but these treatments was significant lower in grain yield as compared to treatment T3.

In 2003 DS, treatment T4 obtained the highest yield and significantly differed from T1, T2 and T7. However, T4 grain yield was not different from T3, T5 and T6

Table 3. Effect of rice straw manure and chemical fertilizer on rice yield of IR64 in wet season.

Treatment	2000	2001	2002	2003	Ave. of WSs
T1. Control	2.19	2.67	2.98	1.81	2.41 a
T2. RSM (6t/ha)	2.23	2.91	3.20	1.83	2.54 a
T3. RSM + 20 %NPK	2.51	3.24	3.22	3.40	3.09 b
T4. RSM + 40% NPK	2.66	3.53	3.26	3.63	3.30 c
T5. RSM+ 60%NPK	2.71	3.63	3.33	3.47	3.28 bc
T6. RSM+80% NPK	2.90	3.71	3.42	3.47	3.37 c
T7.NPK (WS: 80:30:30)	3.07	3.60	3.37	3.15	3.26 bc
CV (%)	8.20	4.00	3.3	13.1	8.22
LSD (5%)	0.37	0.24	0.19	0.68	-

The above results also indicated that the 2003 DS obtained lower grain yield as compared to other DSs (2001 and 2002). Especially, treatment T7 in which complete application of chemical fertilizer (NPK) expressed the lowest yield that was caused by rice leaf blast disease at 35 days after sowing and neck blast disease at 85 days after sowing (table 5)

Table 4: Effect of rice straw manure and chemical fertilizer on rice yield of IR64 in dry season.

Treatment	2001	2002	2003	Average of three dry seasons
T1. Control	4.32	4.78	3.49	4.20 a
T2. RSM (6t/ha)	4.60	5.13	3.84	4.52 b
T3. RSM + 20 %NPK	5.50	6.05	4.36	5.30 c
T4. RSM + 40% NPK	5.84	6.46	4.89	5.73 d
T5. RSM+ 60%NPK	5.94	6.7`6	4.49	5.73 d
T6. RSM+80% NPK	5.92	6.55	4.30	5.59 cd
T7.NPK (DS:100:30:30)	5.89	6.65	3.55	5.36 c
CV (%)	5.50	5.10	9.0	5.85
LSD (5%)	0.52	0.55	0.65	-

The results (table 3 and 4) also indicated that grain yield of IR64 was increased by the continuous application of rice straw manure. Especially, from second season to the continuous seasons, average grain yield of treatment T4 in WS in which rice straw manure combined with 40% NPK was not significantly differed from treatment T7 (complete application of chemical fertilizer NPK). While result in DSs also indicated that, the average grain yield of treatment T4 obtained significantly higher yield than treatment T7. Continuous application of organic manure alone over yielded 9.9 % than control (Padalia 1975). Otherwise, application of organic manure in combination with inorganic fertilizer over yielded 11-12% than control (Tan 1992). In this experiment (table 4), we also recorded that treatment which completed application of rice straw manure over yielded 4.70% and 7.92 % than control in WS and DS, respectively.

The treatment in which complete application of chemical fertilizer (NPK) over yielded 40.49% and 25.73 % than control in WS and DS, respectively.

The treatment in which rice straw manure combined with different doses of chemical fertilizer (NPK) over yielded 32.96 – 44.46 % and 26.27 – 32.41 % than control in WS and DS, respectively.

Table 5. Rice Blast disease in 2003 dry season

Treatment	Leaf blast disease (%) *	Neck blast disease (%)**
T1. Control	1.48	1.38
T2. RSM (6t/ha)	2.94	0.90
T3. RSM + 20 %NPK	12.54	1.42
T4. RSM + 40% NPK	14.87	1.54
T5. RSM+ 60%NPK	30.70	2.66
T6. RSM+80% NPK	38.27	3.60
T7. NPK (DS:100:30:30)	72.00	4.52
CV (%)	26.50	22.50
LSD (5%)	11.62	0.91

* Number disease leaves/total leaves observation; using arcsine transformation; 35 days after sowing.
** Number disease panicles /total panicles observation; using square-root transformation $(X+0.5)^{1/2}$; 85 days after sowing.

Table 6. Effect of rice straw manure and chemical fertilizer on percentage of rice yield over control in wet season

Treatment	2000	2001	2002	2003	Average of four Wet Seasons
T1. Control	-	-	-	-	-
T2. RSM (6t/ha)	1.82	8.61	7.30	1.10	4.70
T3. RSM + 20 %NPK	14.61	21.34	8.05	87.84	32.96
T4. RSM + 40% NPK	23.46	32.20	9.39	100.0	41.26
T5. RSM+ 60%NPK	23.74	35.95	11.74	91.71	40.78
T6. RSM+80% NPK	32.42	38.95	14.76	91.71	44.46
T7. NPK (WS: 80:30:30)	40.02	34.83	13.08	74.03	40.49

Table 7. Effect of rice straw manure and chemical fertilizer on percentage of rice yield in dry season

Treatment	DS 2001	DS 2002	DS 2003	Average of three dry seasons
T1. Control	-	-	-	-
T2. RSM (6t/ha)	6.40	7.32	10.03	7.92
T3. RSM + 20 %NPK	27.31	26.56	24.93	26.27
T4. RSM + 40% NPK	35.18	35.14	40.11	36.81
T5. RSM+ 60%NPK	37.50	41.42	28.65	35.86
T6. RSM+80% NPK	37.01	37.02	23.21	32.41
T7. NPK (DS:100:30:30)	36.34	39.12	1.72	25.73

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 micro-organisms, total respiration rates, and enzyme activities (ETS activities: Alkaline Phosphatase. Sulphatase. Asparaginase...) is quite effective for examination of environmental stresses and declining biological diversity. It needs to be investigated (OTA 1987; Parkinson and Coleman 1991).

The continuous application of organics will energize the living soil microorganisms, involved in biochemical activity of importance to soil fertility and plant nutrition (Gaur et al. 1990). In this long- term experiment we have only estimated the microbial population, total protein content and electron transport system (ETS) activities or dehydrogenase in soil. The results (table 8 and 9) showed treatments in wet season obtained higher in microbial population than treatments in dry season. In general, the result on average number in WS and DS also indicated that plots in which rice straw manure was incorporated, obtained higher in microbial population as compared to plots in which rice straw manure was not applied (T1 and T7). This observation was similarly recorded in terms of ETS activities and total soil protein (mg/ kg of dried soil).

Table 8. Effect of rice straw manure and chemical fertilizer on microbial population of soil in log $_{10}$ of C.F.U/ g. dry soil.

Treatment	2000	2001	2002	2003	Average of four wet seasons
T1. Control	7.84	7.73	7.04	5.79	7.10
T2. RSM (6t/ha)	8.71	8.14	7.08	5.94	7.47
T3. RSM + 20 %NPK	8.77	7.92	7.04	6.20	7.48
T4. RSM + 40% NPK	8.73	8.22	7.28	6.03	7.56
T5. RSM+ 60%NPK	8.74	8.30	7.23		7.58
T6. RSM+80% NPK	8.57	7.98	7.23	6.06	7.51
T7. NPK (WS: 80:30:30)	7.93	7.70	7.00	6.26	7.14
* Before sowing	8.71			5.93	
Average	8.47	8.00	7.13	6.03	7.41
Sd	0.34	0.22	0.11	0.16	0.19

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

Table 9. Effect of rice straw manure and chemical fertilizer on microbial population of soil in log $_{10}$ of C.F.U/ g. dry soil.(Dry Season)

Treatment	2001	2002	2003	Average of three dry seasons
T1. Control	6.48	7.20	6.43	6.70
T2. RSM (6t/ha)	6.90	7.32	6.82	7.01
T3. RSM + 20 %NPK	6.78	7.76	6.78	7.06
T4. RSM + 40% NPK	6.70	7.51	7.14	7.11
T5. RSM+ 60%NPK	6.95	7.08	6.78	6.93
T6. RSM+80% NPK	7.04	7.66	7.11	7.26
T7. NPK (DS:100:30:30)	6.78	7.04	6.76	6.86
Average	6.80	7.38	6.83	7.00
Sd	0.18	0.28	0.24	0.18

Table 10. Effect of rice straw manure and chemical fertilizer on ETS activities* of soil in wet season

Treatment	2000	2001	2002	2003	Average of wet seasons
T1. Control	33.3	59.4	47.8	61.7	50.5
T2. RSM (6t/ha)	53.2	60.4	51.9	84.7	63.1
T3. RSM + 20 %NPK	33.2	87.1	53.8	85.0	64.7
T4. RSM + 40% NPK	33.1	61.5	60.9	98.2	63.4
T5. RSM+ 60%NPK	46.8	98.2	48.9	100.1	73.5
T6. RSM+80% NPK	33.4	86.9	74.6	102.4	74.3
T7. NPK (WS:80-30-30)	33.1	58.4	46.6	83.8	55.4
Average	38.0	73.1	54.9	88.0	63.5
Sd	8.8	16.9	9.8	14.0	8.6

Note: * ETS activities = n mol INTF per min-g dry weight of soil
INTF: Iodonitrophenyl Formazan

The result on average number of ETS activities (table 10 and 11) also indicated that the lowest value of ETS activities (u mol INTF per min-g soil) obtained in complete application of chemical fertilizer treatment (T7). in contrast to this the plot in which complete application of rice straw manure was found to be higher in value of ETS activities than treatment T7. While among treatments in which rice straw manure in combination with different doses of chemical fertilizer, only T6 and T4 exhibited the highest value of ETS activities in WS and DS, respectively.

Table 11: Effect of rice straw manure and chemical fertilizer on ETS activities* of soil in dry season

Treatment	2001	2002	2003	Average of three dry seasons
T1. Control	67.0	75.6	52.5	65.0
T2. RSM (6t/ha)	79.0	94.7	67.6	80.5
T3. RSM + 20 %NPK	75.0	105.4	75.9	85.4
T4. RSM + 40% NPK	80.6	126.9	97.7	101.7
T5. RSM+ 60%NPK	87.8	87.2	73.0	82.7
T6. RSM+80% NPK	70.4	104.6	79.7	84.9
T7. NPK (DS: 100-30-30)	61.5	73.4	62.7	65.8
Average	74.4	95.4	72.7	80.9
Sd	8.9	18.8	14.2	12.6

Table 12. Effect of rice straw manure and chemical fertilizer on total protein* of soil in wet season)

Treatment	2000	2001	2002	2003	Average of four wet seasons
T1. Control	76.6	100.6	88.7	83.9	87.4
T2. RSM (6t/ha)	93.3	132.2	119.3	98.2	110.7
T3. RSM + 20 %NPK	78.7	141.5	122.5	102.8	111.3
T4. RSM + 40% NPK	90.5	149.1	115.0	114.6	117.3
T5. RSM+ 60%NPK	86.0	195.1	116.3	105.2	125.6
T6. RSM+80% NPK	79.7	139.3	132.7	124.8	119.1
T7. NPK (WS:80-30-30) (DS: 100-30-30)	73.2	124.9	104.1	96.8	99.7
Average	82.6	140.3	114.0	103.7	110.1
Sd	7.5	28.7	14.1	13.1	12.8

Total protein content = mg / kg of dried soil

Table 13. Effect of rice straw manure and chemical fertilizer on total protein* of soil in dry season

Treatment	2001	2002	2003	Ave. of DSs
T1. Control	118.6	104.5	77.3	100.2
T2. RSM (6t/ha)	130.5	114.2	87.3	110.6
T3. RSM + 20 %NPK	115.1	111.9	94.1	107.2
T4. RSM + 40% NPK	129.9	121.6	90.1	113.5
T5. RSM+ 60%NPK	137.6	113.3	89.6	113.5
T6. RSM+80% NPK	129.8	146.1	112.1	129.5
T7. NPK (WS:80-30-30) (DS: 100-30-30)	95.5	108.7	86.5	96.9
Average	122.4	117.1	91.0	110.2
Sd	14.0	13.7	10.6	10.5

Total protein content = mg / kg of dried soil

In case of total soil protein, the result (table 12 and 13) showed that among treatments in which rice straw manure in combination with different dose of chemical fertilizer only treatment T5 and treatment T6 exhibited highest value of total soil protein in WS. While T5 performed the highest value of total soil protein in DS.

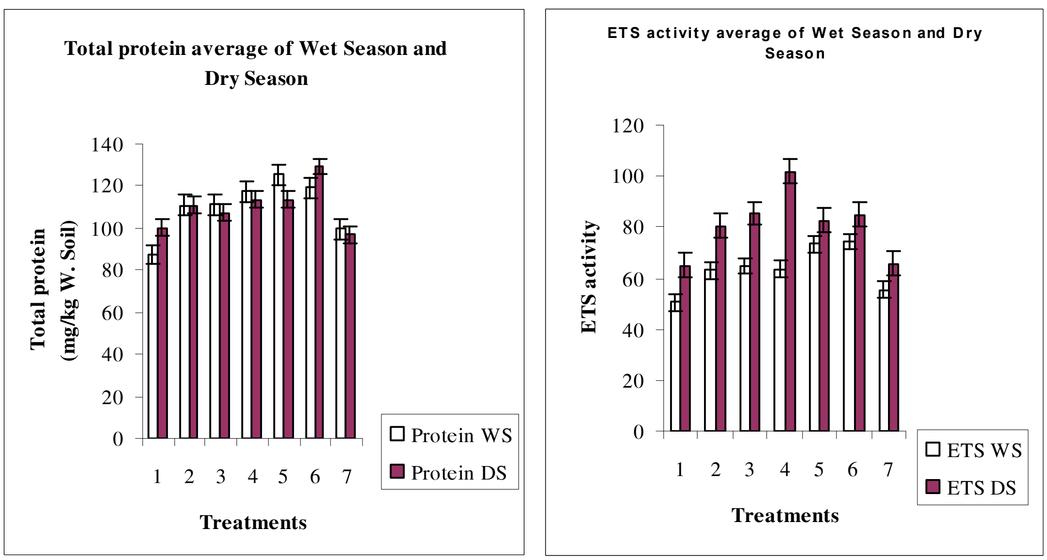

Fig 2. Average value of ETS activities and total protein content in soil.

The results in this long-term experiment (Fig. 3) showed that there were positive correlation between soil microorganisms and ETS activities R^2 = 0.7556 and R^2 = 0.5724 in WS and DS, respectively. Positive correlations between soil microorganisms and total protein content in soil R^2 = 0.892 and R^2 = 0.6853 in WS and DS, respectively were observed.

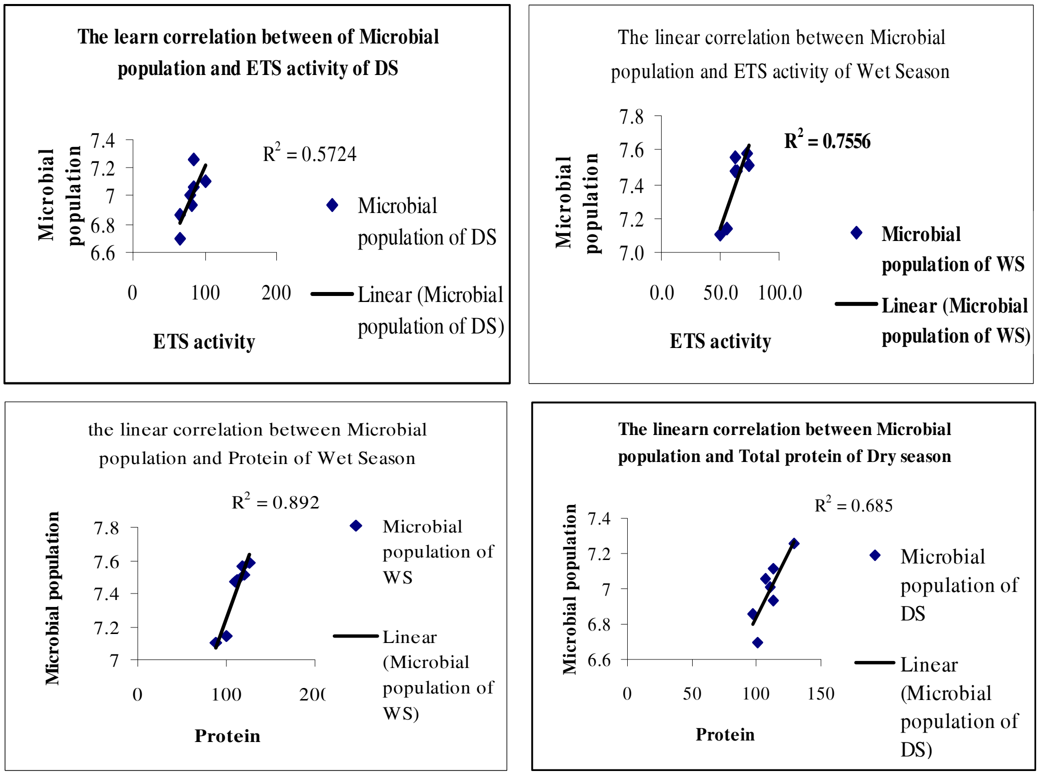

Fig 3. The linear correlation between soil micro-organisms and ETS activities; the linear correlation between soil micro-organisms and total soil protein.

CONCLUSIONS

The result on average value of three years could be concluded as following:

1. Application of rice straw manure increased yield over control 4.70% and 7.92 % in wet season and dry season, respectively.
2. Application of chemical fertilizer yielded over control 40.49 % and 25.73 % in wet season and dry season, respectively.
3. Rice straw manure combined with different doses of organic fertilizer yielded over control from 32.96 – 44.46 % and from 26.27 - 32.41 % in wet season and dry season, respectively.
4. There was positive correlation between SPAD value and grain yield.
5. Complete application of chemical fertilizer treatment and control treatment were lower microbial population in soil as compared to complete application of rice straw manure and treatments in which rice straw manure combined with different doses of chemical fertilizer.
6. There were a positive correlation between soil microorganisms and ETS activities and between soil microorganisms and total protein content in soil.

REFERENCES

Boy SA and MM Mortland. 1990. Enzyme interaction with clays and clay organic matter complexes. In: J. M. Bollag & G. Stotzky (eds.) Soil Biochem. 6, 1-28.

Burn RG. 1982. Enzyme activity in soil: Location and possible role in microbial activities. Soil Biocheme. 14, 423-427.

Chendrayan K,. TK Adhyya and N Sethunathan. 1980. Dehydrogenase and invertase activities of flooded soils. Soil Biol. Biochem. 12: 271-273.

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.

Gaur AC, S Neelakantan and KS Dargan. 1990. Organic manures. I.C.A.R. Newdlhi. India.

Herbert D, PJ Phipps and RE Strange. 1971. III. Chemical analysis of microbial cells. In Norris/Ribbon (eds.). Methods. Microbiol.5B: 249-252.

Huan TTN, TQ Khuong, Tadao Kon and PS Tan. 1998. OMON RICE. (6): 53-58.

Huan TTN, PS Tan and Hiroyuki Hiraoka. 2000. Optimun fertilizer nitrogen rate for high yielding rice based on growth diagonics in wet seeded culture of rice. Proceedings of the 2000 annual workshop of JIRCAS Mekong Delta project; Nov 14-17, 2000. 60-67.

IRRI 1991. IRRISTAT User's manual. Version 91.1. IRRI, 1991. 367 p.

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.

OTA.1987. Technologies to maintain biological diversity. Office of Technology Assessment of U.S. Congress 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.

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.

SUMMARY IN VIETNAMESE

Rơm rạ sau thu hoạch được xử lý bằng chế phẩm sinh học (Trichoderma sp) để tạo thành nguồn phân hữu cơ, và thông qua thí nghiệm dài hạn nhằm "cải thiện độ phì của đất từ nguồn phân hữu cơ rơm rạ ". Qua 6 vụ lúa liên tục, kết qủa ghi nhận được như sau: Bón hoàn toàn phân hữu cơ rơm rạ cho năng suất cao hơn đối chứng 4.70% trong vụ Hè Thu (HT) và 7.92% trong vụ Đông Xuân (ĐX). Trong khi đó, bón hoàn toàn phân hóa học (NPK) cho năng suất cao hơn đối chứng 40.49% trong vụ HT và 25.73% trong vụ ĐX. Những nghiệm thức nơi mà phân hữu cơ rơm rạ được bón kết hợp với các mức phân hoá học (NPK) cho năng suất cao hơn đối chứng từ 32.96% đến 44.46% trong vụ HT và từ 26.27% đến 32.41% trong vụ ĐX. Kết quả cũng cho thấy ở nghiệm thức đối chứng và nghiệm thức bón hoàn toàn phân hóa học có mật số vi sinh vật, tổng số protein, và chỉ số ETS hoạt động trong đất thấp hơn so với nghiệm thức bón hoàn toàn phân hữu cơ rơm rạ hay so với những nghiệm thức sử dụng phân hữu cơ rơm rạ được bón kết hợp với các mức phân hóa học khác nhau. Kết qủa này cũng ghi nhận được sự tương quan giữa mật số vi sinh vật với chỉ số ETS hoạt động và sự tương quan giữa mật số vi sinh vật với tổng số protein trong đất.
