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IMPROVEMENT OF SOIL FERTILITY BY RICE STRAW MANURE

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ABSTRACT

A long-term experiment has being conducted on the effects of rice straw manure (RSM) on rice production and soil fertility. So far, rice was cultivated eleven times (6 wet seasons (WS) and 5 dry seasons (DS)) with chemical fertilizer and RSM applications designed for each 7 treatment. Compared with control treatment (no chemical fertilizer, no RSM), solo application of the RSM (6 t. ha^{-1}) increased average rice yield 13.52 % and 5.50 % in wet season (WS) and in dry season (DS), respectively. While, solo application of chemical fertilizer (NPK) increased the yield over the control 44.19 % in WS and 26.07 % in DS. Rice yields of treatments in which different doses of chemical fertilizer combined with RSM (6t. ha^{-1}) was applied were 37.18 to 49.30 % and 27.20 to 29.36 % more than the control in WS and DS, respectively. The result showed that we can decrease chemical fertilizer input 20 to 60 % from the present recommended application rate by using RSM without decreasing rice yield in wet season. While,chemical fertilizer input 40 to 60 % from the present recommended application rate by using RSM gave higher yield than treatment in which 100% chemical fertilizer application in dry season. Rice with high application of chemical fertilizer was more severely damaged by leaf blast disease, neck blast disease and grain discoloration than other treatments at the time of outbreak. The microbial population and their activity in the soil indicated that the solo application of chemical fertilizer and the control treatment had lower microbial population as compared with the treatment where RSM was applied solely or in combination with chemical fertilizer. There were positive correlations between the population of soil microorganisms and ETS activities, and, between the population of soil microorganisms and total protein in soil.

Keywords: Long-term field experiment,, rice straw manure, soil fertility, soil micro organisms

INTRODUCTION

Rice is the most important crop in Mekong Delta. With the introduction of high yield rice varieties and adoption of intensive rice cultivation, large quantity of rice straw is available on farms. However, most of rice straw was burnt or removed after harvesting. Rice straw can not be applied or ploughed directly into the soil because of their high C:N ratio. That is 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 solve such problems, rice straw can be composted in heaps or pits with adequate moisture and suitable microbial inoculants and be applied as organic manure (Gaur *et al.* 1990) onto rice field.

Cuu Long Delta Rice Research Institute (CLRRI) has collaborated with 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 (RSM) and inorganic fertilizer alone or in combination on rice yield and (2) their effects to microbial communities in paddy soil.

MATERIALS AND METHODS

Fungal inoculant (*Trichoderma* spp.) in powder-form was produced by CLRRI's Microbiology Department and applied to rice straw heap with adequate moisture to promote composting. Composted rice straw was applied into the experimental field 30 to 45 days after the inoculation.

The experiment started in 2000's wet season at the experimental field in CLRRI (Omon, Cantho city). From wet season 2000 to dry season 2005 germinated seed (IR64: 100-day growth duration) was broadcasted on the field (30 m^2 for each plot) at 200 kg ha^{-1} seedling rate; from dry season 2006 germinated seed (OM 2517: 90-day growth duration) was seeded by row- seeder with 100 kg ha^{-1} seedling rate. Seven treatments were prepared and the experimental field was set up with randomized block design with three replications:

T1: control (0 N - 0 P_2O_5 - 0 K_2O)
T2: 100% RSM (6 t.ha^{-1})
T3: 100% RSM (6 t.ha^{-1}) + 20% NPK (16N- 6P_2O_5 -6K_2O kg ha^{-1})
T4: 100% RSM (6 t.ha^{-1}) + 40% NPK (32N- 12P_2O_5 -12 K_2O kg ha^{-1})
T5: 100% RSM (6 t.ha^{-1}) + 60% NPK (48N- 18P_2O_5 -18 K_2O kg ha^{-1})
T6: 100% RSM (6 t.ha^{-1}) + 80% NPK (64N- 24P_2O_5 -24 K_2O kg ha^{-1})
T7: 100% inorganic fertilizer (wet season: 80N- 30P_2O_5 -30 K_2O kg ha^{-1}
and dry season: 100N- 30P_2O_5 -30 K_2O kg ha^{-1})

RSM and phosphorus fertilizer was applied at the time of land preparation before broadcasting rice seeds. Nitrogen fertilizer was applied in three splits: each one third was applied at 10, 20 and 30 days after sowing (DAS). Potassium fertilizer was applied in two splits: each half was applied at 10 and 30 DAS. Recommended fertilization rate in dry season is (100N- 30P_2O_5 -30 K_2O kg ha^{-1}) in the region.

Total-C, N and P concentrations measure in the experimental field surface soil taken after harvest of 1^{st} crop were 35.1 g C kg^{-1}, 3.3 g N kg^{-1} and 240 mg P kg^{-1} (in dry soil).

Soils microbial populations were estimated before sowing and at harvesting time. Total protein content in soil (mg kg^{-1} dry soil) (Herbert et.al. 1971) and electron transport system (ETS) activities (n mol INTF g^{-1} dry soil) or dehydrogenises (Chendrayan *et al.* 1980) were estimated at harvesting time. Soil was sampled at 10 days before harvesting to analyze chemical property of the soil.

Microbial populations were estimated by plate counting method, by using following media (Subbarao 1977):

- 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 measured by Chlorophyll meter (SPAD-502) at 50 DAS, disease- insect incidence during growth period and yield and yield components were recorded. The data under this study was statistically analyzed for a randomized complete block design by IRRISTAT program.

RESULTS AND DISCUSSION

Moisture content and Total-C,N, P and K concentrations of RSM applied into the field were shown in Table 1.

Table 1. Moisture and C, N, P, K concentration of RSM.

Season	Moisture (%)*	N (%)	C(%)	P(%)	K(%)
2003 WS	367	1.72	30.40	0.23	No-data
2004 WS	483	2.30	30.74	0.26	1.49
2005 DS	no-data	2.13	33.72	0.22	0.53

* Water/ dry mater (w/w)

According to the data, 22.1 to 25.6 kg N ha^{-1}, 6.1 to 6.7 kg P_2O_5 ha^{-1} and 7.7 to18.5 kg K_2O ha^{-1} was applied into the field accompanied with RSM (6 Mg ha^{-1}).

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

SPAD value in wet season (Table 2) and in dry season (Table 3) shows that the more chemical fertilizer was applied, the higher SPAD value was obtained. SPAD value at T7 was significantly higher than other treatment in wet season 2000. However, there was not significant difference between T4, T5, T6 and T7 in following seasons. Average SPAD values at T7 in wet season and dry season were significantly higher than other treatments. It was reported that SPAD value reflects nitrogen concentration in rice and the optimum value for high yield directly seeded rice ranges from 32 to 36 in dry season and 29 to 32 in wet season (Huan *et al.,* 1998, 2000). It seemed that SPAD value at T3, T4 and T5 agreed with the optimum range in wet season, and SPAD value at T4, T5, T6 and T7 agreed with the optimum range in dry season. There were positive correlation between SPAD value and grain yield (Fig. 1) in wet season and dry season, respectively.

Table 2. Effect of RSM and chemical fertilizer on SPAD value at 50 days after sowing of Wet Seasons

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	Average
T1	27.0	27.2	27.7	28.1	27.5a
T2	27.4	27.5	27.9	28.5	27.8a
T3	28.6	28.5	30.0	30.6	29.3b
T4	30.9	30.2	32.0	32.8	31.4c
T5	30.8	32.2	32.6	33.6	32.3cd
T6	31.7	32.9	33.1	34.6	33.1d
T7	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	-

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

Table 3. Effect of RSM and chemical fertilizer on SPAD value at 50 days after sowing of Dry Seasons

Treatment	D.S 2001	D. S 2002	D. S 2003	Average
T1	27.8	25.9	26.7	26.8 a
T2	28.2	26.5	29.6	28.1 b
T3	31.2	29.8	31.4	30.7 c
T4	35.1	31.2	31.7	31.7 d
T5	36.4	33.4	34.7	34.3 e
T6	36.4	33.6	35.2	35.0 e
T7	38.3	34.4	36.1	36.2 f
CV (%)	3.3	3.0	2.5	3.07
LSD (5%)	1.94	1.63	1.45	-

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

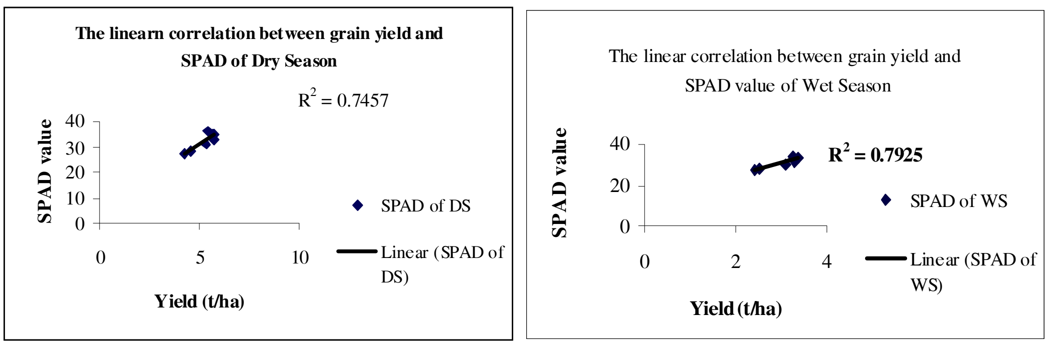

Figure 1. The correlation between SPAD index and grain yield
Note: The grain yield was average of 4 W.S. (2000-2003) and 3 D.S. (2001-2003)

There was not significant difference in average rice yield between T4, T5, T6 and T7 both in wet season (Table 4). However, treatment T4 and T5 gave higher grain yield as compared with treatment T7 in dry season (Table 5). Compared with T1, grain yield in T2 was 13.52 % and 5.50 % higher in wet season and dry season, respectively. While, solo application of chemical fertilizer (T7) increased the yield over the T1 44.19 % in wet season and 26.07 % in dry season. Rice yields of treatment in which different doses of chemical fertilizer combined with RSM were applied (T3, T4, T5 and T6) were 37.18 to 49.30 % and 27.20 to 29.36 % higher than T1 in wet season and in dry season, respectively.
In dry season 2003, grain yields were lower than other dry seasons because of outbreak of blast disease. Symptoms of leaf blast disease and neck blast disease were found at 35 and 85 DAS in the season. Rice at T6 and especially T7 was more severely damaged by the disease (Table 6).

In dry season 2005, grain discoloration at T6 and T7 was more severe than other treatments (Table 6). Nitrogen concentration in grain and straw taken at sampling time showed that N concentrations increased as applied chemical fertilizer increased (Table 7). It seemed that Silica (Si) concentrations in rice straw in treatments without RSM were lower than other treatments although the difference was not significant. As rice straw content much silica, replicated removal of rice straw at T1 and T7 might lead decrease of available Si in soil. It is reported that rice plant is more susceptible to fungal attack when N concentration was high and Si was low (Tisdale *et al.* 1985). We may decrease the risk of several diseases by decreasing chemical fertilizer input with RSM application.

These results shows that we can decrease chemical fertilizer input 20 to 60 % from the present recommended application rate by using RSM without decreasing rice yield in wet season. While, chemical fertilizer input 40 to 60 % from the present recommended application rate by using RSM gave higher yield than treatment in which 100% chemical fertilizer application.

Table 4. Effect of RSM and chemical fertilizer on rice yield of IR64 of Wet Season.

Treatment	W.S. 2000	W.S. 2001	W.S. 2002	W.S. 2003	W.S. 2004	W.S. 2005	Average	Grain yield over control (%)
T1	2.19	2.67	2.98	1.81	3.04	1.59	2.38 a	-
T2	2.23	2.91	3.20	1.83	3.69	2.36	2.70 b	13.52
T3	2.51	3.24	3.22	3.40	4.17	3.05	3.27 c	37.18
T4	2.66	3.53	3.26	3.63	4.46	3.51	3.51 d	47.41
T5	2.71	3.63	3.33	3.47	4.66	3.63	3.57 d	50.00
T6	2.90	3.71	3.42	3.47	4.27	3.56	3.55 d	49.30
T7	3.07	3.60	3.37	3.15	4.04	3.36	3.43 d	44.19
CV (%)	8.20	4.00	3.30	13.1	5.95	12.64	8.54	
LSD (5%)	0.37	0.24	0.19	0.68	0.42	0.68		

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

Table 5. Effect of RSM and chemical fertilizer on rice yield of IR64 (DS 2001-2005) and OM2517 (DS 2006).

Treatment	D. S. 2001	D.S. 2002	D. S. 2003	D.S. 2005	D.S. 2006	Average	Grain yield over control(%)
T1	4.32	4.78	3.49	3.84	4.86	4.26 a	-
T2	4.60	5.13	3.84	4.01	4.88	4.49 a	5.50
T3	5.50	6.05	4.36	5.12	6.05	5.42 b	27.20
T4	5.84	6.46	4.89	5.24	6.03	5.69 c	33.68
T5	5.94	6.76	4.49	5.39	6.12	5.74 c	34.81
T6	5.92	6.55	4.30	4.90	5.86	5.51 bc	29.36
T7	5.89	6.65	3.55	4.89	5.86	5.37 b	26.07
CV (%)	5.50	5.10	9.0	7.89	6.99	6.63	
LSD (5%)	0.52	0.55	0.65	0.47	0.71		

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

Table 6. Rice Blast disease of dry season 2003 and grain discoloration of dry season 2005

Treatment	Leaf blast disease (%) *	Neck blast disease (%)**	Grain iscoloration (%)
T1	1.48	1.38	34.60
T2	2.94	0.90	35.70
T3	12.54	1.42	40.03
T4	14.87	1.54	46.10
T5	30.70	2.66	44.97
T6	38.27	3.60	59.02
T7	72.00	4.52	60.50
CV (%)	26.5	22.5	11.2
LSD (5%)	11.62	0.91	9.15

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

- Grain discoloration of D.S.2005 was observed at harvesting time.

Table 7. N and SiO_2 concentration in straw and grain in dry season 2005

Treatment	N(%)		SiO_2 (%)	
	Straw*	Grain*	Straw**	Grain *
T1	0.57a	1.16a	8.97	4.27a
T2	0.58a	1.14a	9.54	4.39a
T3	0.59a	1.18a	9.17	3.59b
T4	0.67a	1.23a	9.19	3.50b
T5	0.69a	1.29ab	9.64	3.51b
T6	0.94b	1.40 bc	9.47	3.40b
T7	0.94b	1.49c	8.36	2.75 c

* Means in acolumn followed by the same letter are not significantly different at $p< 0.01$, based on LSD test
** Significant difference was not detected between treatments

Microbial communities under rice soil conditions

Sound and diverse microbial communities in soil are essential factors for sustainable agriculture. Soil organisms are some of the most sensitive sensor to detect degradation or contamination of arable soil. Populations or activities of soil microorganisms such as soil respiration and enzyme activities (ETS activities, Alkaline Phosphatase, Sulphatase, Asparaginase and so on) are indicators to monitor environmental stresses and declining of biological diversity (OTA 1987; Parkinson and Coleman 1991).

The continuous application of organic matter will energize the living soil micro-organisms, involved in biochemical activity of importance to soil fertility and plant nutrition (Gaur *et al.* 1990). In this long-term experiment we have estimated the microbial population, total protein content and electron transport system (ETS) activities or dehydrogenase in soil. Microbial population in wet season was higher than that in dry season in general (Tables 8 and 9). Microbial population in soil where RSM was applied was higher than that in soil without RSM application. Same tendency was found in ETS activities and soil protein content (Tables 10, 11, 12 and 13).

There were positive correlation between soil micro-organisms and ETS activities R^2 = 0.9894 and R^2 = 0.6272 in WS and DS, respectively (Figure 2). There were also positive correlation between soil micro-organisms and total protein content in soil R^2 = 0.9362 and R^2 = 0.6199 in WS and DS, respectively.

Table 8. Effect of RSM and chemical fertilizer on microbial population of soil in $\log_{10}$ of C.F.U/ g. dry soil (Wet season).

Treatment	W.S. 2000	W.S. 2001	W.S. 2002	W.S. 2003	W.S. 2004	W.S. 2005	Ave. W.S.
T1	7.84	7.73	7.04	5.79	7.70	6.14	7.04
T2	8.71	8.14	7.08	5.94	7.87	6.32	7.34
T3	8.77	7.92	7.04	6.20	7.94	6.38	7.38
T4	8.73	8.22	7.28	6.03	7.85	6.25	7.39
T5	8.74	8.30	7.23	6.06	8.14	6.27	7.46
T6	8.57	7.98	7.23	6.26	7.97	6.26	7.38
T7	7.93	7.70	7.00	5.93	7.83	6.24	7.11
*Before sowing	8.71						
Average	8.47	8.00	7.13	6.03	7.90	6.27	7.30
Sd	0.34	0.22	0.11	0.16	0.12	0.06	0.16

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 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	D.S 2006	Ave. D.S.
T1	6.48	7.20	6.43	7.19	6.70	6.80
T2	6.90	7.32	6.82	7.28	7.23	7.11
T3	6.78	7.76	6.78	7.24	7.18	7.15
T4	6.70	7.51	7.14	7.40	7.04	7.16
T5	6.95	7.08	6.78	7.41	7.15	7.07
T6	7.04	7.66	7.11	7.32	7.08	7.24
T7	6.78	7.04	6.76	7.26	7.00	6.97
Average	6.80	7.38	6.83	7.30	7.05	7.07
Sd	0.18	0.28	0.24	0.08	0.17	0.15

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

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	WS 2004	WS 2005	Ave. W.S.
T1	33.3	59.4	47.8	61.7	59.6	57.1	53.2
T2	53.2	60.4	51.9	84.7	76.1	83.0	68.2
T3	33.2	87.1	53.8	85.0	77.1	79.6	69.3
T4	33.1	61.5	60.9	98.2	84.3	76.5	69.1
T5	46.8	98.2	48.9	100.1	87.8	64.9	74.5
T6	33.4	86.9	74.6	102.4	62.6	61.2	70.2
T7	33.1	58.4	46.6	83.8	61.7	60.4	57.3
Average	38.0	73.1	54.9	88.0	72.7	68.9	65.9
Sd	8.8	16.9	9.8	14.0	10.6	10.4	7.7

Note: * ETS activities = nmol INTF per min-g dry weight of soil
INTF: iodonitrophenyl formazan

Table 11. Effect of rice straw manure and chemical fertilizer on ETS activities* of soil (Dry Season)

Treatment	DS 2001	DS 2002	DS 2003	DS 2005	DS 2006	Ave. D.S.
T1	67.0	75.6	52.5	75.5	69.5	68.0
T2	79.0	94.7	67.6	93.8	90.1	85.0
T3	75.0	105.4	75.9	111.3	106.5	94.8
T4	80.6	126.9	97.7	79.8	70.8	91.2
T5	87.8	87.2	73.0	78.6	79.0	81.1
T6	70.4	104.6	79.7	87.3	71.5	82.7
T7	61.5	73.4	62.7	73.2	66.8	67.5
Average	74.4	95.4	72.7	85.7	79.2	81.5
Sd	8.9	18.8	14.2	13.3	14.4	10.5

Note: * ETS activities = nmol INTF per min-g dry weight of soil
INTF: iodonitrophenyl formazan

Table 12. Effect of rice straw manure and chemical fertilizer on total protein* of soil (Wet Season)

Treatment	WS 2000	WS 2001	WS 2002	WS 2003	WS 2004	WS 2005	Ave. W.S.
T1	76.6	100.6	88.7	83.9	80.9	79.9	85.1
T2	93.3	132.2	119.3	98.2	96.1	91.5	105.1
T3	78.7	141.5	122.5	102.8	98.4	90.4	105.7
T4	90.5	149.1	115.0	114.6	87.9	120.6	112.9
T5	86.0	195.1	116.3	105.2	86.3	98.3	114.5
T6	79.7	139.3	132.7	124.8	86.2	90.1	108.8
T7	73.2	124.9	104.1	96.8	84.5	88.9	95.4
Average	82.6	140.3	114.0	103.7	88.6	94.2	103.9
Sd	7.5	28.7	14.1	13.1	5.8	12.8	10.4

Total protein content = mg / kg of dried soil

Table 13. Effect of rice straw manure and chemical fertilizer on total protein* of soil (Dry Season)

Treatment	DS 2001	DS 2002	DS 2003	DS 2005	DS 2006	Ave. D.S.
T1	118.6	104.5	77.3	85.9	78.9	95.5
T2	130.5	114.2	87.3	124.8	118.7	114.2
T3	115.1	111.9	94.1	94.9	90.7	104.0
T4	129.9	121.6	90.1	118.2	106.4	114.9
T5	137.6	113.3	89.6	125.2	113.1	116.4
T6	129.8	146.1	112.1	129.5	104.4	129.3
T7	95.5	108.7	86.5	73.9	78.9	91.2
Average	122.4	117.1	91.0	107.5	98.7	109.5
Sd	14.0	13.7	10.6	22.2	16.1	13.0

Total protein content = mg / kg of dried soil

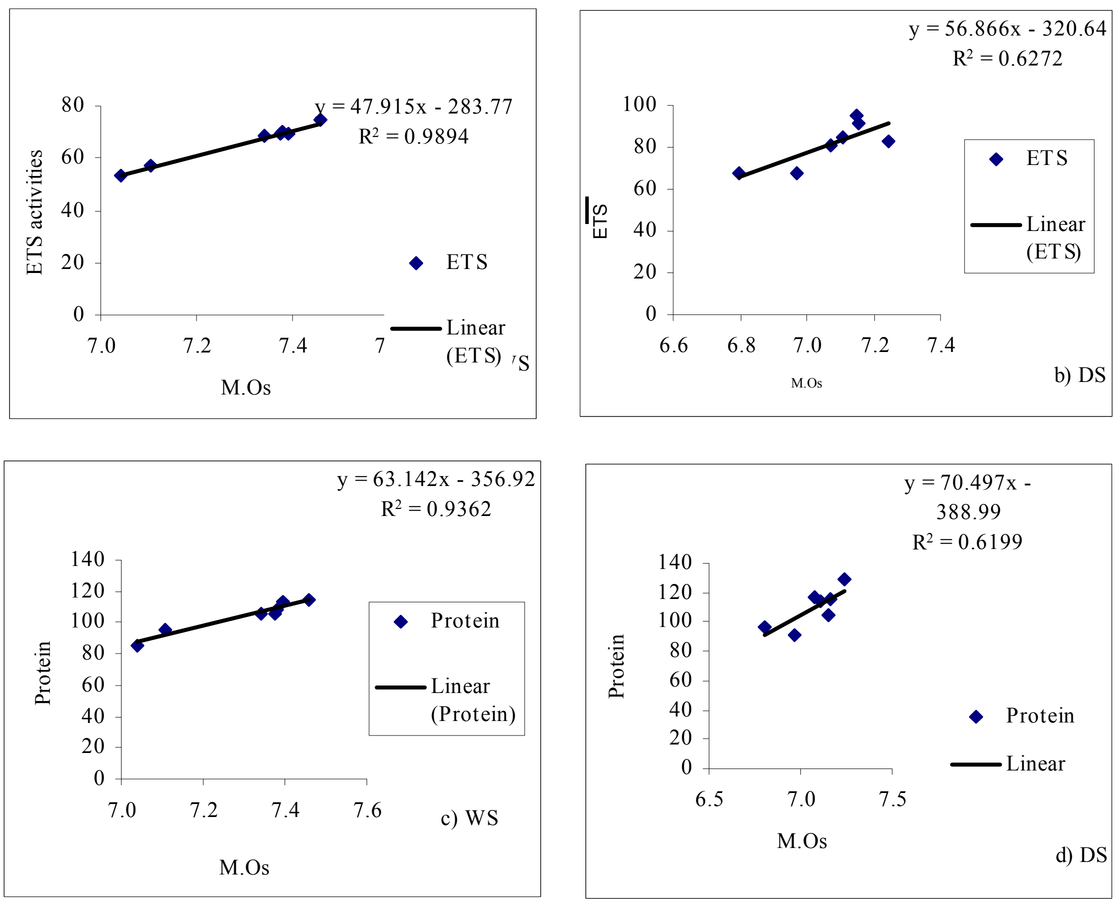

Figure 2. a,b) The linear correlation between soil micro-organisms and ETS activities
c,d) The linear correlation between soil micro-organisms and protein

CONCLUSIONS

The results of eleven seasons experiment leads following conclusions

1. In wet season, chemical fertilizer input can be decreased 20 to 60 % from the present recommended application rate by using RSM without decreasing rice yield or we may expect higher yield with that treatment.
2. In dry season, chemical fertilizer input can be decreased 40 to 60 % from the present recommended application rate by using RSM gave higher yield than treatment in which 100% chemical fertilizer application.
3. Rice grown in field where chemical fertilizer was applied at recommended level was damaged by leaf blast disease, neck blast disease and grain discoloration more severely than rice grown where less chemical fertilizer was applied.
4. Replicated removal of rice straw may cause the decrease of available silica in soil.
5. There was positive correlation between SPAD value and grain yield.
6. Microbial population in soil where RSM was applied was higher than that in soil without RSM application.
7. There were positive correlations between soil micro organisms and ETS activities, and between soil microorganisms and total protein content in soil.

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Cải thiện độ phì đất bằng phân hữu cơ có nguồn gốc từ rơm rạ

Rơm rạ sau thu hoạch được xử lý bằng chế phẩm sinh học (nấm *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 11 vụ lúa liên tục (6 vụ Hè Thu và 5 vụ Đông Xuân), kết quả ghi nhận được như sau:

Bón hoàn toàn phân hữu cơ rơm rạ (6 tấn / ha) gia tăng năng suất lúa so với đối chứng không bón phân 13,52% trong vụ Hè Thu (**HT**) và 5,50% trong vụ Đông Xuân (**ĐX**). Trong khi đó, bón hoàn toàn phân hóa học (NPK) cho năng suất cao hơn đối chứng 44,19% trong vụ **HT** và 26,07% trong vụ **ĐX**. Những nghiệm thức nơi mà phân hữu cơ rơm rạ được bón kết hợp với các mức phân hóa học (NPK) cho năng suất cao hơn đối chứng từ 37,18 % đến 49,30% trong vụ **HT** và từ 27,20% đến 29,36% trong vụ **ĐX**. Kết quả còn chỉ ra rằng khi áp dụng phân hữu cơ dài hạn chúng ta có thể giảm lượng phân hóa học theo mức khuyến cáo từ 20% đến 60 % mà không làm giảm năng suất so với lượng phân hóa học theo mức khuyến cáo. Trong khi đó, bón lót phân hữu cơ và bón kết hợp với 40% đến 60% phân hoá học cho năng suất cao hơn bón hoàn toàn phân hóa học (100% NPK) trong vụ Đông Xuân. Những nghiệm thức bón phân hóa học cao như nghiệm thức T6 (Rơm hữu cơ + 80% NPK) và T7 (100% NPK) biểu hiện phần trăm bệnh cháy lá, bệnh thối cổ gié và lem lép hạt cao hơn so với các nghiệm thức khác. 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 rơm rạ hữu cơ hay so với các nghiệm thức áp dụng phân rơm rạ hữu cơ được bón kết hợp với các mức phân hóa học khác nhau. Kết quả 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.