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IMPROVEMENT OF SOIL FERTILITY BY RICE STRAW MANURE

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ABSTRACT

A long-term experiment has been conducted to understand effects of rice straw manure (RSM) on rice production and soil fertility. So far, nine seasons have been passed including five wet seasons (WS) and four dry seasons (DS)) with chemical fertilizer and RSM applications. Seven treatments including control (no chemical fertilizer, no RSM) were observed. Solo application of RSM (6 t.ha^{-1}) increased average rice yield 8 % and 7 % in WS and in DS, respectively. While, solo application of chemical fertilizer (NPK) increased yield over the control 39 % in WS and 26 % in DS. Treatments in which different doses of chemical fertilizer combined with RSM (6 t.ha^{-1}) was applied, overyielded 34 to 44 % and 28 to 37 % as compared to the control in WS and DS, respectively. The result showed that reducing chemical fertilizer input 40 to 60 % from the present recommended application rate by using RSM did not decrease rice yield or gained higher yield than chemical fertilizer treatment. High application treatments of chemical fertilizer were more severely damaged by leaf blast and neck blast at the time of outbreak. Microbial population and their activity in soil indicated that the solo application of chemical fertilizer and the control treatment exhibited lower microbial population as compared to RSM (solely applied or combined to chemical fertilizer). There were positive correlations between soil microorganism population and ETS activities; soil microorganism population and total protein in soil.

Key words: 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 yielding 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 to directly incorporate into soil because of their high C:N ratio. That is known to reduce 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) to understand their effects to microbial communities in paddy soil.

MATERIALS AND METHODS

Fungal inoculant (*Trichoderma* sp.) 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). 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. 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 Mg ha^{-1})
T3: 100% RSM (6 Mg ha^{-1}) + 20% NPK (16N-6P_2O_5 -6K_2O kg ha^{-1})
T4: 100% RSM (6 Mg ha^{-1}) + 40% NPK (32N-12P_2O_5 -12 K_2O kg ha^{-1})
T5: 100% RSM (6 Mg ha^{-1}) + 60% NPK (48N-18P_2O_5 -18 K_2O kg ha^{-1})
T6: 100% RSM (6 Mg 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 1st 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}).

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 and dry seasons, respectively.

Table 2. Effect of RSM and chemical fertilizer on SPAD value at 50 days after sowing in wet seasons

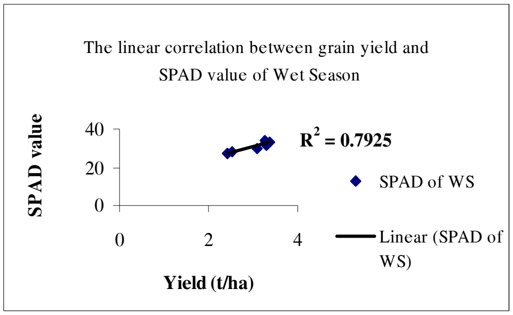
Treatment	2000	2001	2002	2003	Average
T1	27.0	27.2	27.7	28.1	27.5a
T2	27.4	27.5	27.9	28.5	27.8a
T3	28.6	28.5	30.0	30.6	29.3b
T4	30.9	30.2	32.0	32.8	31.4c
T5	30.8	32.2	32.6	33.6	32.3cd
T6	31.7	32.9	33.1	34.6	33.1d
T7	35.2	33.1	33.8	34.9	34.2 e
CV(%)	4.71	2.8	2.8	3.2	3.40
LSD5%)	2.53	1.51	1.55	1.84	-

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	2001	2002	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.



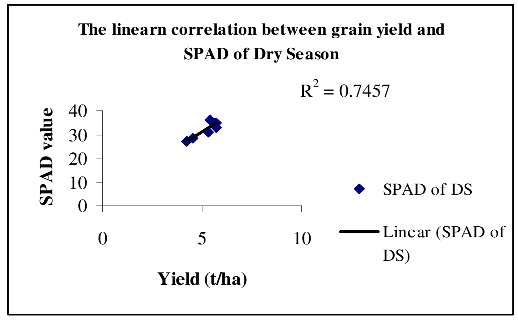


Figure 1. The correlation between SPAD index and grain yield
Note: The grain yield was average of 4 WSs (2000-2003) and 3 DSs (2001-2003)

There was no significant difference in average rice yield between T3, T4, T5, T6 and T7 both in rainy season and dry season (Tables 4 and 5). Treatment T2 overyielded 8.0 % and 7.0 % as compared to check in wet and dry seasons, respectively. Solo application of chemical fertilizer (T7) overyielded 39.0% and 26.1% as compared to T1 in wet and dry seasons, respectively. Rice yields of treatments in which different doses of chemical fertilizer combined with RSM were applied (T3, T4, T5 and T6) were 33.8 to 44.5 % and 28.0 to 37.0 % higher than T1 in wet and in dry seasons, respectively.

In 2003 dry season, grain yields were lower than other dry seasons because of outbreak of blast disease. Typical symptoms of leaf blast and neck blast were found at 35 and 85 DAS. Rice plants in T6 and especially T7 were more severely damaged by the disease (Table 6).

In 2005 dry season, grain discoloration in T6 and T7 was more severe than other treatments (Table 6). Nitrogen concentration in grain and straw taken at sampling time increased when 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 with abundant 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 40 to 60 % from the present recommended application rate by using RSM without decreasing rice yield or we may expect higher yield with that treatment.

Table 4. Effect of RSM and chemical fertilizer on rice yield of IR64 of wet seasons

Treatment	2000	2001	2002	2003	2004	Average	Grain yield over control (%)
T1	2.19	2.67	2.98	1.81	3.04	2.54 b	-
T2	2.23	2.91	3.20	1.83	3.69	2.77 b	8.03
T3	2.51	3.24	3.22	3.40	4.17	3.30 a	33.80
T4	2.66	3.53	3.26	3.63	4.46	3.53 a	42.35
T5	2.71	3.63	3.33	3.47	4.66	3.55 a	43.28
T6	2.90	3.71	3.42	3.47	4.27	3.55 a	44.46
T7	3.07	3.60	3.37	3.15	4.04	3.41 a	38.97
CV (%)	8.20	4.00	3.30	13.1	5.95	18.35	
LSD(5%)	0.37	0.24	0.19	0.68	0.42	**	

Table5.Effect of RSM and chemical fertilizer on rice yield of IR64 of dry seasons

Treatment	2001	2002	2003	2005	Average	Grain yield over control (%)
T1	4.32	4.78	3.49	3.84	4.11 b	-
T2	4.60	5.13	3.84	4.01	4.39 b	7.04
T3	5.50	6.05	4.36	5.12	5.26 a	28.03
T4	5.84	6.46	4.89	5.24	5.61 a	36.72
T5	5.94	6.76	4.49	5.39	5.66 a	36.98
T6	5.92	6.55	4.30	4.90	5.49 a	31.21
T7	5.89	6.65	3.55	4.89	5.24 a	26.13
CV (%)	5.50	5.10	9.0	7.89	16.5	
LSD (5%)	0.52	0.55	0.65	0.47	**	

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 in 2003 dry season and grain discoloration in 2005 dry season

Treatment	Leaf blast disease (%) *	Neck blast disease (%)**	Grain discoloration (%)
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 2005 dry season

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

2. 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).

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 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 = 0.9315 and R^2 = 0.6827 in WS and DS, respectively (Figure 2). There were also positive correlation between soil micro-organisms and total protein content in soil R^2 = 0.9555 and R^2 = 0.6615 in WS and DS, respectively.

Table 8. Effect of RSM and chemical fertilizer on soil microbial population in log_{10} of C.F.U/ g. dry soil in wet seasons.

Treatment	2000	2001	2002	2003	2004	Average
T1	7.84	7.73	7.04	5.79	7.70	7.22
T2	8.71	8.14	7.08	5.94	7.87	7.54
T3	8.77	7.92	7.04	6.20	7.94	7.57
T4	8.73	8.22	7.28	6.03	7.85	7.62
T5	8.74	8.30	7.23	6.06	8.14	7.69
T6	8.57	7.98	7.23	6.26	7.97	7.60
T7	7.93	7.70	7.00	5.93	7.83	7.27
*Before sowing	8.71					
Average	8.47	8.00	7.13	6.03	7.90	7.50
Sd	0.34	0.22	0.11	0.16	0.12	0.18

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 in dry seasons

Treatment	2001	2002	2003	2005	Average
T1	6.48	7.20	6.43	7.19	6.82
T2	6.90	7.32	6.82	7.28	7.08
T3	6.78	7.76	6.78	7.24	7.14
T4	6.70	7.51	7.14	7.40	7.18
T5	6.95	7.08	6.78	7.41	7.05
T6	7.04	7.66	7.11	7.32	7.28
T7	6.78	7.04	6.76	7.26	6.96
Average	6.80	7.38	6.83	7.30	7.07
Sd	0.18	0.28	0.24	0.08	0.15

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

Treatment	2000	2001	2002	2003	2004	Average
T1	33.3	59.4	47.8	61.7	59.6	52.4
T2	53.2	60.4	51.9	84.7	76.1	65.3
T3	33.2	87.1	53.8	85.0	77.1	67.2
T4	33.1	61.5	60.9	98.2	84.3	67.6
T5	46.8	98.2	48.9	100.1	87.8	76.4
T6	33.4	86.9	74.6	102.4	62.6	72.0
T7	33.1	58.4	46.6	83.8	61.7	56.7
Average	38.0	73.1	54.9	88.0	72.7	65.30
Sd	8.8	16.9	9.8	14.0	10.6	8.33

Note: * ETS activities = n mol 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 in dry seasons

Treatment	2001	2002	2003	2005	Average
T1	67.0	75.6	52.5	75.5	67.7
T2	79.0	94.7	67.6	93.8	83.8
T3	75.0	105.4	75.9	111.3	91.9
T4	80.6	126.9	97.7	79.8	96.3
T5	87.8	87.2	73.0	78.6	81.7
T6	70.4	104.6	79.7	87.3	85.5
T7	61.5	73.4	62.7	73.2	67.7
Average	**74.4**	**95.4**	**72.7**	**85.7**	**82.0**
Sd	**8.9**	**18.8**	**14.2**	**13.3**	**11.0**

Note: * ETS activities = n mol 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 in wet seasons

Treatment	2000	2001	2002	2003	2004	Average
T1	76.6	100.6	88.7	83.9	80.9	86.1
T2	93.3	132.2	119.3	98.2	96.1	107.8
T3	78.7	141.5	122.5	102.8	98.4	108.8
T4	90.5	149.1	115.0	114.6	87.9	111.4
T5	86.0	195.1	116.3	105.2	86.3	117.8
T6	79.7	139.3	132.7	124.8	86.2	112.5
T7	73.2	124.9	104.1	96.8	84.5	96.7
Average	82.6	140.3	114.0	103.7	88.6	105.8
Sd	7.5	28.7	14.1	13.1	5.8	10.82

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 seasons

Treatment	2001	2002	2003	2005	Average
T1	118.6	104.5	77.3	85.9	96.6
T2	130.5	114.2	87.3	124.8	114.2
T3	115.1	111.9	94.1	94.9	104.0
T4	129.9	121.6	90.1	118.2	115.0
T5	137.6	113.3	89.6	125.2	116.4
T6	129.8	146.1	112.1	129.5	129.4
T7	95.5	108.7	86.5	73.9	91.2
Average	122.4	117.1	91.0	107.5	109.5
Sd	14.0	13.7	10.6	22.2	13.

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 wich rice straw manure in combination with different dose of chemical fertilizer only treatment T5 exhibited highest value of total soil protein in W.S. While, the treatment T6 performed highest value of total soil protein in DS.

The results in this long-term experiment (Fig 2) showed that there were positive correlation between soil micro-organisms and ETS activities $R^2 = 0.9315$ and $R^2 = 0.6827$ in WS and DS, respectively; positive correlation between soil micro-organisms and total protein content in soil $R^2 = 0.9555$ and $R^2 = 0.6615$ in WS and DS, respectively.

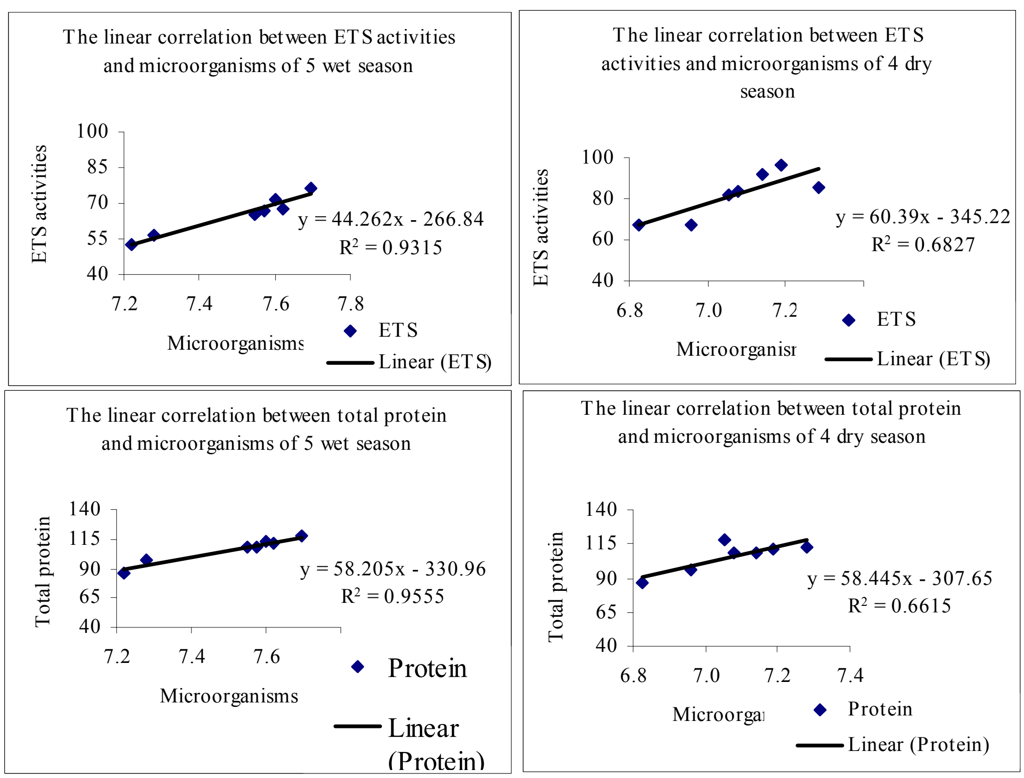


Figure 2. The linear correlation between soil micro-organisms and ETS activities; the linear correlation between soil micro-organisms and total soil protein.

Table 14. Effect of rice straw manure and chemical fertilizer on chemical components of soil (2005 Dry Season)

Treatment	Carbon (%)	Total N (%)	Exchangeable K Meq /100 g	Total P_2O_5 (%)
T1. Control	3.82	0.304	0.22	0.052
T2. RSM (6t/ha)	3.91	0.319	0.21	0.051
T3. RSM + 20 %NPK	3.93	0.310	0.21	0.056
T4. RSM + 40% NPK	3.81	0.306	0.20	0.053
T5. RSM+ 60%NPK	3.73	0.328	0.20	0.058
T6. RSM+80% NPK	3.90	0.320	0.20	0.060
T7. NPK (DS 100-30-30)	3.71	0.305	0.19	0.060
CV(%)	5.96	4.93	12.46	6.67
LSD 5%	ns	ns	ns	0.007

Note : The chemical parameters of RSM applied in 2005 DS recorded as following :
Carbon = 33.72 %; N= 2.13 %; Total P_2O_5= 0.51% and Total K_2O= 0.64 %

The result on chemical components of soil in 2005 dry season (table 14) also indicated that there were non-significant differences in term of Carbon (%); Total N (%) and exchangeable K (Meq/100g) among treatments. However, significant differences in term of total P_2O_5 (%) among treatments were recorded. Treatment T6 and T7 recorded the highest value in term of total P_2O_5 (%) and significantly differed from the other treatments.

Table 15. Effect of rice straw manure and chemical fertilizer on SiO_2 concentration of rice straw and rice grain (2005 Dry Season)

Treatment	SiO_2 in rice straw (g/ kg)	SiO_2 in rice grain (g/kg)
T1. Control	89.133	42.233
T2. RSM (6t/ha)	94.867	43.433
T3. RSM + 20 %NPK	91.000	35.367
T4. RSM + 40% NPK	91.433	34.533
T5. RSM+ 60%NPK	95.967	34.700
T6. RSM+80% NPK	94.100	33.333
T7. NPK (DS 100-30-30)	83.133	27.133
CV (%)	7.32	6.75
LSD 5%	11.899	4.304

Heavy applications of nitrogen are known to make rice plants more susceptible to fungal attack because of decreases in silicon concentration in straw (Tisdale et al. 1985). In this long-term experiment, the result in 2005 dry season (table 15) also indicated that the treatment T7 in which complete application of NPK gave the lower concentration of SiO_2 in rice straw and lowest concentration of SiO_2 in rice grain as compare with the other treatments, in contrast to this the plot in which complete application of rice straw manure was found to be highest concentration of SiO_2 in rice grain than treatment T7. These results also explain that the continuous application of rice straw manure may cause the high concentration of SiO_2 in rice straw and rice grain and lead to rice plants more resistant to rice blast, neck blast disease and grain discoloration (table 15).

CONCLUSIONS

From nine seasons results, we can conclude that

1. Chemical fertilizer input can be decreased 40% to 60 % from the present recommended application rate by using RSM without decreasing rice yield, and higher yield would be expected
2. Rice grown in field where chemical fertilizer was applied at current recommended level was more severely damaged by leaf blast disease, neck blast disease and grain discoloration than one grown under less chemical fertilizer application.
3. Replicated removal of rice straw may cause the decrease of available silica in soil.
4. There was positive correlation between SPAD value and grain yield.
5. Microbial population in soil where RSM was applied, exhibited higher than that in soil without RSM application.
6. There were positive correlations between soil micro organisms and ETS activities, soil microorganisms and total protein content in soil.

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

Rơm rạ sau thu hoạch được xử lý bằng chế phẩm sinh học (*Trichoderma s*p) 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 9 vụ lúa liên tục (5 vụ Hè Thu và 4 vụ Đông xuân), kết quả ghi nhận được như sau:

Bón hoàn toàn phân hữu cơ rơm rạ (6 tấn /ha) cho năng suất cao hơn đối chứng 8 % trong vụ Hè Thu (**HT**) và 7 % trong vụ Đông Xuân (**ĐX**). Trong khi đó, bón hoàn toàn phân hóa học (NPK) cho năng suất cao hơn đối chứng 39 % trong vụ **HT** và 26 % 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 33 % đến 44% trong vụ **HT** và từ 28 đến 37 % trong vụ **ĐX.** Kết quả còn chỉ ra rằng khi áp dụng phân hữu cơ chúng ta có thể giảm lượng phân hoá học từ 40- 60 % mà không làm giảm năng suất so với lượng phân hóa học theo mức khuyến cáo. Những nghiệm thức áp dụng phân hóa học NPK cao như nghiệm thức T6 và T7 biểu hiện phần trăm bệnh cháy lá, bệnh thối cổ gié và lem lép hạt cao 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 hay so với các nghiệm thức sử dụng phân hữu cơ rơm rạ 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.