INFLUENCE OF RICE STRAW TREATED BY INDIGINOUS *Trichoderma* spp. ON SOIL FERTILITY, RICE GRAIN YIELD AND ECONOMIC EFFICIENCY IN THE MEKONG DELTA

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ABSTRACT

Annually, there is an approximately amount rice straw to an extent of 20 million tons, which are burnt or released directly to the canal or river leading to environmental pollution in the Mekong Delta. The rice straw source has not yet reused for rice crop as organic mater which need to improve soil fertility. In the above context, the objectives of this aimed to study the influence of composted rice straw treated by Trichoderma sp. on rice yield, rice soil fertility and economic effective. The research was conducted from 02/2010 to 07/2010 in Summer–Autumn at Long Kien village, Cho Moi district, An Giang Province. The treatments consisted of the untreated by Trichoderma spp., application of composted rice straw by Trichoderma spp.; burnt rice straw combined with inorganic NPK fertilizer from 0, 70, 100% (100 N - 60 P_2O_5 - 30 K_2O kg/ha). Composted rice paddy straw by Trichoderma spp. incorporated with 70% NPK (equal to 70 N- 42 P_2O_5-21 K_2O kg/ha), the grain yield obtained 5.32 ton/ha. This was considered equally as the conventional application by the farmers' dose at 100% (burnt rice straw + 100 N- 60 P_2O_5-30 K_2O kg/ha). The highest benefit cost ratio (B/C) was 2.52. The nutrient content in the rice soil viz., organic carbon, available N, P and exchangeable K also was improved significantly as compared to the conventional application by the farmers' dose. The application of composted rice straw by Trichoderma spp. with 70% (equal to 70N-42 P_2O_5-21K_2O kg/ha) could be partly contributed in reducing about 30% inorganic fertilizer cost, increased grain yield, benefit cost ratio and improved soil fertility.

Keywords*: benefit cost ratio, C/N ratio, rice straw, rice grain yield, soil available nutrients Trichoderma spp.*

INTRODUCTION

Rice production square in the Mekong Delta has 3.86 million hectare (General statistics Office, 2009). Moreover, with the introduction of high yielding rice varieties and adoption of intensive rice cultivation, large quantities of rice residues such as straw, rice stubbles are available on the fields. Annually, there is an approximately amount rice straw to an extent of 20 million ton. After harvesting, most of rice straw was burnt, released directly to the river, canals or removed without returning to rice soil leading to environmental pollution and reduce the availability of important mineral nutrients in soil. Although, the rice straw source can supply organic matter and improve soil fertility but rice straw cannot be applied or incorporated directly into the soil because of their wide C:N ratio. They are also known to reduce the availability of important mineral nutrients in growing plants through immobilization of organic forms and produce photo-toxic substances during their decomposition.

The long-term field experiment on rice conducted at Can Tho province shows that rice grain yield and soil available N, P and K are significantly improved by application of composted paddy straw compared to inorganic fertilizer application (Luu Hong Man *et al*., 2006 & 2007; Tran Thi Ngoc Son *et al*., 2009). In order to reduce the cost of chemical fertilizers, soil and water pollution and enhance income for farmers, the study was carried out to use rice straw surrounding farm by *Trichoderma* spp. This product is indiginous fungus isolated from the different

cropping systems viz., rice-rice, rice-rice- rice and rice-sugarcane in the Mekong Delta which can help faster decomposting rice paddy straw into organic manure for soil application and reduce the chemical fertilizer as well as enhance soil fertility.

MATERIALS AND METHODS

Materials: Fungal inoculants (*Trichoderma* spp.) in powder form that has been produced by CLRRI's Microbiology department to treat rice straw for faster decomposition that is used as organic manure. *Trichoderma* fungi was isolated from different rice cropping systems in the Mekong Delta (rice- rice season, rice-rice- rice season and rice-sugarcane) and *Trichoderma* spp. Fungi population reaches 10^8 -10^9 CFU/g

- Raw rice straw and composted rice straw by *Trichoderma* spp inoculant, rice variety OM 1490, inorganic fertilizer viz., Urea (46% N), super phosphate (16% P_2O_5), kali chlorua (60% K_2O)….

Methods: The experiment was conducted under field conditions during 02/2010 - 07/2010 at Long Kien village, Cho Moi district, An Giang province. The experiment was laid out in a randomized completely block design, including 8 treatments with three replications at farmer's field, each treatment was a plot size of 50 m^2 (5m x 10 m). The details of treatments as follow in table 1

Table 1. The treatments of experiment

Name	Fertilizer
T1	Raw rice straw
T2	Composted rice straw
T3	Raw rice straw + 70% NPK
T4	Composted rice straw + 70% NPK
T5	Burnt rice straw + 70% NPK
T6	Burnt rice straw + 100% NPK
T7	Raw rice straw + 100% NPK
T8	Composted rice straw + 100% NPK

- Fertilizer aplication
  + 100% NPK= 100 N- 60 P_2O_5- 30 K_2O kg/ha
  + 70% NPK = 70 N - 42P_2O_5- 21K_2O kg/ha

- Total nutrient content in raw rice straw: N total was of 0.57- 0.62 %; P_2O_5 total 0.05-0.065%; K_2O total 1.37-2.67%; organic carbon 48.3 - 50.4% and C/N ratio was reached 82.2 -86.8.

- Method of treatment for rice straw directly in the field by *Trichoderma* inoculants: After harvesting the previous rice crop, the rice straw was spread uniformly. Then the *Trichoderma* inoculant was sprayed at the dose of 4 kg/ha. The diluted water quantity ensured enough for wetting all rice straw (approximately about 320 - 400 liters/ha). Later on the soil was ploughed, supplied water for pudding. Finally rice seeds were sown after withdraw the water. The quantity of rice straw was 25 kg / 50m^2 at around 18-20% moisture content.

Table 2. Physical and chemical characteristics of experimental soils *

Characteristic	Average content
pH	4.29
Available N (ppm)	26.7
Available P (ppm)	36.5
Available K (ppm)	184
Organic matter (%)	2.08

**Soil samples were analyzed at Department of Soil Science, Cuu Long Delta Rice Research Institute, Thoi Lai District, Can Tho City*

- The initially characteristics of the soil is presented in Table 2. Low pH, low available nitrogen and phosphorus, moderately available potassium was reported.

- ***Details of data collection***

+ Rice sampling: Data of yield components (total number of tillers, effective number of tillers percent, plant height at harvest stage (cm), (%), panicle /m^2, panicle length (cm), total number of grain/panicle, filled grain percent (%), 1000 grain weight (g)) and grain yield (T/ha)

+ Soil sampling: Initial soil samples were taken from three locations in each replication using an auger to a depth of zero to 20cm, one day before the start of the experiment. While subsequent soil samples were taken randomly from 3 spots in each plot using the same implement and same depth, one day after harvesting stage including pH, organic carbon (%), available N, available P, available K (ppm).

+ Economics efficiency: total of cost (input cost) (VND/ha), gross return (VND/ha), benefit cost (VND/ha) and marginal benefit cost ratio (MBCR).

- ***Statistical analysis***: The data relating to each parameter were statistically analyzed by applying the technique of analysis of variance and significance was tested by Duncan test among treatment.

RESULTS AND DISCUSSION

Agronomic characteristics

- *Plant height at harvest stage:* The data on plant height at harvest are presented in table 3. Plant height ranged from 63.5 to 78.6 cm. There was significant different among treatments at 5% level. The lowest value obtained under T1 and the highest one obtained under high dose inorganic fertilizer T8 (100% NPK). Total number of tillers ranged from 402 to 473 tillers. There was no significant different among treatments. Effective number of tillers percent was recorded from 94.7 to 98.5%. There was no significantly different among treatments. Therefore, influence of rice straw treated by *Trichoderma* spp. fungi led to reduce about 30% use of NPK. The results are in agreement with the results of Luu Hong Man and Nguyen Ngoc Ha (2005), Tran Thi Tam (2007), Nguyen Kim Chung (2008), Tran Thi Ngoc Son *et al*., (2009).

Table 3. Effect of composted rice straw on rice agronomic characteristics

No.	Treatments	Plant height (cm)	Total no. of tillers /m^2	Effective of tiller (%)
T1	Raw rice straw	63.5 c	433	96.9
T2	Composted rice straw	71.2 b	402	96.2
T3	Raw rice straw + 70% NPK	72.2 ab	433	96.1
T4	Composted rice straw + 70% NPK	74.9 ab	433	97.7
T5	Burnt rice straw + 70% NPK	74.3 ab	473	98.5
T6	Burnt rice straw + 100% NPK	76.3 ab	421	97.5
T7	Raw rice straw + 100% NPK	74.8 ab	458	94.7
T8	Composted rice straw + 100% NPK	78.6 a	421	96.8
	CV (%)	5,0	15,8	2,2
	F	**	Ns	ns

100% NPK = 100N-60P_2O_5-30K_2O kg/ha; 70% NPK = 70N-42P_2O_5-21K_2O kg/ha;ns: not significant different

*** Means followed by the same letter (s) are not significantly different at 1% level based on DMRT*

Rice yield components

The data on rice yield components are presented in table 4. total of grains/panicle was recorded from 49.4 to 69.4 grains. There was significant different among treatments at 5% level. The lowest value obtained under T1 (49.4 grain) and the highest one obtained under high dose inorganic fertilizer T8 (69.4 grain). The highest filled grain percent was recorded under T4 treatment (87.1%) and lowest value under T1 treatment. There was significant different among treatments at 1% level. The panicle length was significantly higher in *Trichoderma* spp. incorporation treatment as compared to raw rice straw application and there was significant difference among treatments. The highest panicle length recorded under T6 and was on par to treatments viz., T3, T4, T7 and T8. The 1000 grain weight was noticed higher under application of composted rice straw by *Trichoderma* spp. combined with NPK than those of control treatments (T1 and T2 treatments). There was significant difference among treatments at 1% level.

Table 4. Effect of composted rice straw on rice yield components

No.	Treatments	Total of grain /panicle	Filled grain percent (%)	Panicle length (cm)	1000 grain weight (g)
T1	Raw rice straw	49.4 c	69.1 d	14.7 d	18.8 c
T2	Composted rice straw	55.3 bc	76.2 c	15.9 d	19.7 b
T3	Raw rice straw + 70% NPK	56.0 bc	82.6 ab	17.8 bc	21.4 a
T4	Composted rice straw + 70% NPK	61.9 ab	87.1 a	18.6 bc	21.1 a
T5	Burnt rice straw + 70% NPK	53.6 bc	86.7 a	17.6 c	21.6 a
T6	Burnt rice straw + 100% NPK	61.7 ab	84.3 ab	19.5 ab	21.9 a
T7	Raw rice straw + 100% NPK	64.1 ab	83.2 ab	18.9 abc	21.9 a
T8	Composted rice straw + 100% NPK	69.4 a	79.3 bc	20.3 a	21.2 a
	CV (%)	10.0	3.6	4.6	2.0
	F	*	***	***	***

*100% NPK = 100N-60P_2O_5-30K_2O kg/ha; 70% NPK = 70N-42P_2O_5-21K_2O kg/ha; ns: not significant different and *, *** Means followed by the same letter (s) are not significantly different at 1% and 1%o level based on DMRT, respectively*

Grain yield

The data shows in figure 1. The grain yield was recorded from 2.83 to 5.33 T/ha. There was significantly difference among treatments. The T4 treatment (5.32 T/ha) got higher grain yield than T1, T2, T3, T5 and was on par with T6, T7 and T8 treatment. Therefore, influence of rice straw treated by *Trichoderma* spp. fungi led to increased grain yield compared to raw rice straw application. The results are in agreement with the results of Luu Hong Man *et al.,* (2003), Tran Thi Ngoc Son *et al*., (2009)

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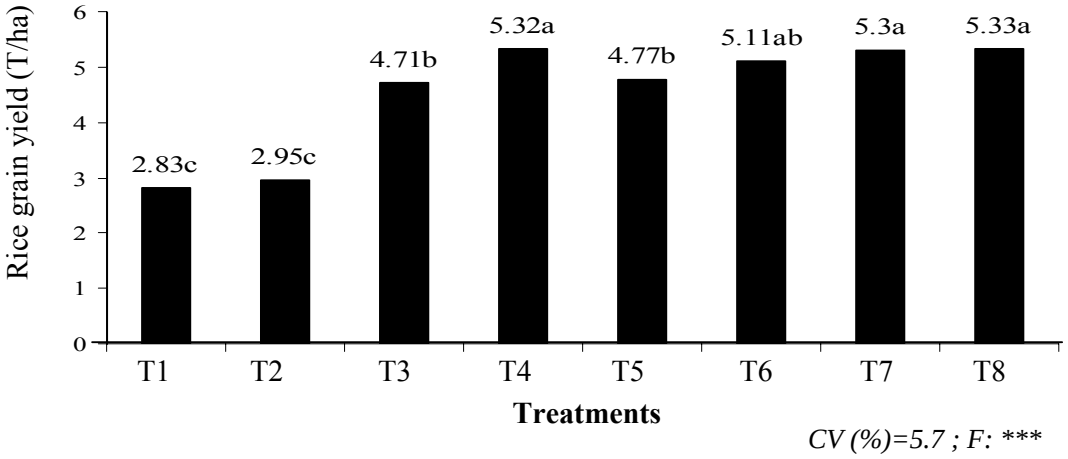

T1	*Raw rice straw*	*T5*	*Burnt rice straw + 70% NPK*
T2	*Composted rice straw*	*T6*	*Burnt rice straw + 100% NPK*
T3	*Raw rice straw + 70% NPK*	*T7*	*Raw rice straw + 100% NPK*
T4	*Composted rice straw + 70% NPK*	*T8*	*Composted rice straw+ 100% NPK*

*100% NPK = 100N-60P_2O_5-30K_2O kg/ha; 70% NPK = 70N-42P_2O_5-21K_2O kg/ha *** Means followed by the same letter (s) are not significantly different at 1%o level based on DMRT*

Figure 1. Effect of composted rice straw on rice grain yield (T/ha)

Soil fertility

pH value: the pH value ranged from 4.2 to 4.51. There was no significantly difference among treatments.

Organic carbon (%): There was significantly difference among treatment at 1% level. Application of composted rice straw by *Trichoderma* spp had higher organic carbon content than application of burnt rice straw or raw rice straw treatments.

Available nitrogen (ppm): The available N ranged from 15.4 to 41ppm. The highest available N was recorded under T4 treatment and the lowest was noticed under T1. There was significantly difference among treatments. All treatments having application rice straw by *Trichoderma* spp recorded higher available nitrogen than other ones.

Available phosphorus (ppm): The available P ranged from 44.9 to 72.7ppm. There was significantly difference among treatment. The highest available P obtained under T4 treatment and significantly difference among treatments.

Available potassium (ppm): The available K recorded from 127 to 259 ppm. There was significantly difference among treatments. The highest available K was noticed under T4 treatment and the lowest under T1 treatment.

Microorganism population (10^6/g soil): the microorganism was ranged from 110 to 1,009 x 10^6/g soil. The microorganism was recorded higher under rice straw treated by *Trichoderma* as compared than other one. (see in table 5)

Table 5. Effect of composted rice straw on soil fertility

No.	Treatments	pH	Organic carbon (%)	Available N (ppm)	Available P (ppm)	Available K (ppm)	Microorgani-sm population (10^6/g soil)
T1	Raw rice straw	4.23	2.76 cd	15.4 d	44.9 c	127 b	110
T2	Composted rice straw	4.37	2.39 d	24.8 c	51.9 c	136 b	288
T3	Raw rice straw + 70% NPK	4.34	3.51abc	35.2 ab	51.9 c	199 a	290
T4	Composted rice straw + 70% NPK	4.20	3.80 a	41.0 a	68.5ab	259 a	1009
T5	Burnt rice straw + 70% NPK	4.25	3.34abc	34.7 b	57.1 bc	220 a	213
T6	Burnt rice straw + 100% NPK	4.33	2.97bcd	36.0 ab	50.2 c	245 a	844
T7	Raw rice straw + 100% NPK	4.51	3.67ab	37.8ab	72.6 a	255 a	398
T8	Composted rice straw + 100% NPK	4.52	3.09abc	33.0 b	72.7 a	229 a	1004
	CV (%)	3,3	12,7	10,2	11,5	15,4	
	F	ns	**	***	***	***	

Soil samples were analyzed at Department of Soil Science, Cuu Long Delta Rice Research Institute, Thoi Lai District, Can Tho City

*100% NPK = 100N-60P_2O_5-30K_2O kg/ha; 70% NPK = 70N-42P_2O_5-21K_2O kg/ha **,*** Means followed by the same letter (s) are not significantly different at 5% and 1%o level based on DMRT, respectively*

Economic efficiency

Total input cost (VND/ha): It ranged from 3.497.500 to 8.057.000 VND/ha. Total input cost recorded lower under application of composted by *Trichoderma* spp as compared to other ones. The lowest value noticed under T1 treatment and the highest one was under T8 treatment.

Gross return: (VND/ha): The gross return ranged from VND 11,615,000 /ha to VND 21,865,000 /ha. The lowest value also noticed under T1 treatment and the highest one was under T8 treatment.

Benefit: Among treatments, the highest benefit was obtained to an extent of VND 15,612,000 /ha (T4 treatment) and the lowest one was noticed under T1 treatment

Table 6. Economic efficiency (Unit: VND 1,000)

No.	Treatments	Input cost	Gross return	Benefit	Marginal benefit cost ratio
T1	Raw rice straw	3,497	11,615	8,118	2.32
T2	Composted rice straw	3,677	12,107	8,420	2.29
T3	Raw rice straw + 70% NPK	6,020	19,323	13,303	2.21
T4	Composted rice straw + 70% NPK	6,200	21,812	15,612	2.52
T5	Burnt rice straw + 70% NPK	6,020	19,569	13,549	2.25
T6	Burnt rice straw + 100% NPK	7,877	20,938	13,061	1.66
T7	Raw rice straw + 100% NPK	7,877	21,709	13,832	1.76
T8	Composted rice straw + 100% NPK	8,057	21,865	13,808	1.71

100% NPK = 100N-60P_2O_5-30K_2O kg/ha, 70% NPK = 70N-42P_2O_5-21K_2O kg/ha. - Ure: VND 6,500 /kg; DAP: VND 13,000 /kg, Kali: VND 13,000 /kg, Trichoderma production:VND 70,000/kg, price of rice: VND 4,100 /kg

Marginal benefit cost ratio: The lowest marginal benefit cost ratio was obtained under treatment T6 (Burnt rice straw + 100%NPK) estimated as 1.66 and the highest value recorded under treatment T4 (Composted rice straw by *Trichoderma* spp+ 70% NPK) as accounted as 2.52.

CONCLUSION

Under application of composted rice straw by *Trichoderma* spp. conjunction with 70% NPK (equal to 70N-42 P_2O_5-21K_2O kg/ha), the grain yield obtain as 5.32 ton/ha equally as of the conventional application by the farmers' dose at 100% (burnt rice straw + 100N-60 P_2O_5-30 K_2O kg/ha) and the highest benefit cost ratio (B/C) are 2.52. The nutrient content in the rice soil viz., organic carbon, available N, P and exchangeable K also are improved significantly as compared to the conventional application by the farmers' dose (burnt rice straw +100% (100N-60P_2O_5-30K_2Okg/ha)). From the above result shows that under application of composted paddy straw by *Trichoderma* spp. conjunction with 70% (equal to 70N-42 P_2O_5-21K_2O kg/ha) can be partly contributed in reducing about 30% inorganic fertilizer cost, increased grain yield, benefit cost ratio and improve soil fertility

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ẢNH HƯỞNG CỦA RƠM RẠ XỬ LÝ TRỰC TIẾP BẰNG CHẾ PHẨM *Trichoderma* spp. BẢN ĐỊA ĐẾN NĂNG SUẤT LÚA, ĐỘ PHÌ NHIÊU ĐẤT VÀ HIỆU QUẢ KINH TẾ LÚA TẠI ĐỒNG BẰNG SÔNG CỬU LONG

Hàng năm rơm rạ ở Đồng bằng sông Cửu Long với khối lượng khoảng 20 triệu tấn được đem đốt bỏ hoặc thải trực tiếp xuống kênh rạch gây ô nhiễm môi trường. Nguồn rơm rạ sau thu hoạch chưa được tận dụng bón trở lại cho cây lúa trong khi đó đây là nguồn hữu cơ rất quý, có sẵn tại chổ có thể góp phần cải thiện độ phì của đất lúa khi được phân hủy nhanh. Xuất phát từ những lý do trên mục đích của nghiên cứu này nhằm đánh giá hiệu quả rơm rạ xử lý bằng chế phẩm *Trichoderma* spp. có nguồn gốc bản địa đến năng suất lúa, độ phì nhiêu đất lúa và hiệu quả kinh tế. Nghiên cứu được thực hiện từ 02/2010 đến 07/2010 tại xã Long Kiến, huyện Chợ Mới, tỉnh An Giang. Thí nghiệm được bố trí theo kiểu khối hoàn toàn ngẫu nhiên, 8 nghiệm thức, 3 lập lại với các nghiệm thức như bón rơm rạ không xử lý, rơm rạ có xử lý bằng *Trichoderma* spp. ở mức 5 tấn rơm tươi/ha hoặc đốt rơm kết hợp với các mức phân vô cơ như không bón phân vô cơ, bón 70% NPK (tương đương 70N-42 P_2O_5-21K_2O kg/ha) và 100% NPK (100N-60 P_2O_5-30 K_2O kg/ha). Khi bón rơm rạ xử lý bằng chế phẩm *Trichoderma* spp. (sau 4 tuần xử lý có tỷ số C/N là 20,2) kết hợp với 70% NPK (tương đương 70N- 42 P_2O_5- 21K_2O kg/ha) cho thấy năng suất lúa đạt 5,32 tấn/ha, tương đương với mức bón của nông dân (đốt rơm +100% NPK (100N- 60 P_2O_5- 30 K_2O kg/ha) và tỷ suất lợi nhuận đạt cao nhất là 2,52. Hàm lượng dinh dưỡng trong đất như carbon hữu cơ, đạm hữu dụng, lân hữu dụng và kali trao đổi được cải thiện rõ rệt so với bón theo tập quán của nông dân (đốt rơm +100% NPK (100N-60 P_2O_5-30 K_2O kg/ha) có khác biệt ý nghĩa thống kê. Từ các kết quả trên bước đầu cho thấy khi bón rơm rạ xử lý bằng chế phẩm *Trichoderma* spp. kết hợp 70% NPK(tương đương 70 N- 42 P_2O_5- 21 K_2O kg/ha) cho lúa Hè Thu có thể làm giảm 30% chi phí phân bón, ổn định năng suất lúa, tăng lợi nhuận và cải thiện độ phì nhiêu đất.