Omonrice 12: 45-51 (2004)

EFFECT OF LONG-TERM APPLICATION OF ORGANIC AND BIO-FERTILIZER ON SOIL FERTILITY UNDER RICE - SOYBEAN- RICE CROPPING SYSTEM

Tran Thi Ngoc Son[1], Vu van Thu[1], Luu Hong Man[1]
H. Kobayashi[2] and R. Yamada[2]

ABTRACTS

The long term experiment on effect of organic and bio-fertilizer application have been conducted from 2000 up to 2003. This indicated fertilizer dose for soybean could be recommended at the rate of 60N- 60 $P_2 0_5$- 30 $K_2 0$ combined with composted paddy straw or inoculants viz., SB83 (Rhizobium fredii) and SB177 (Bradyhrizobium sp.) or both composted paddy straw and inoculants + 30N- 60 $P_2 0_5$- 30 $K_2 0$. Agronomic characters and grain yield of soybean were compared among the treatments to higher dose of inorganic fertilizer as T1 (100-60-30) as farmers' application. At the same time, the experimental results showed that application of organic and bio-fertilizer could be substantiated N inorganic fertilizer to an extent of 40 – 70 kg N ha^{-1} while some important agronomic characters and grain yield of rice –soybean- rice were comparable to the control (conventional dose applied by farmers) due to cumulative effect. Especially, the soil fertility viz., soil organic carbon content, soil available nitrogen, phosphorous and potassium built up significantly under application inorganic fertilizer combined with composted paddy straw or inoculants or both composted paddy straw and inoculants as compared to the treatments those applied only inorganic fertilizers.

Key words: composted paddy straw, inoculants, nitrogen, phosphorus, potassium, soil fertility organic carbon, soybean.

INTRODUCTION

Soil organic matter plays key role in maintainability of soil fertility and productivity. The effect of the organic mater may be either direct or indirect. Organic matter acts directly as a source of plant nutrients and indirectly influences the physical and chemical properties. Farming practices, which involve heavy application of chemical fertilizers, may cause depletion of certain nutrients in soil and certain others would generally accumulate in excess resulting in nutrient imbalance, which affects soil productivity. Among available means to achieve sustainability in agricultural production, organic manure and bio-fertilizer play an important and key role because they possesses many desirable soil properties and exerts beneficial effect on soil physical, chemical and biological characteristics. However, optimum and long term application of organic and bio-fertilizer doses as well as their effectiveness for upland crops have not been studied in details. In this regard, an attempt has been made to study on the long term influence of organic and bio-fertilizer on soybean under rice based cropping system.

MATERIALS AND METHODS

The experiment has been continuously conducted in farmer's field at Thoi Trinh hamlet, Phuoc Thoi village, O Mon district, Cantho province during 2003 Winter-Spring, Summer- Autumn, and Autumn - Winter of 2003. The initial soil pH was 5.64 (1:1 H_2O). Soil initial nutrient components were 1.03 % organic carbon, 0.108 % total nitrogen, 0.00158 % total P; total K: 1.85 %, available N: 0.277 meq/100g of soil, available P: 2.282 ppm, available K: 0.22 meq/100g of soil. The experiments were conducted on rice - soybean - rice. They were designed in a randomized complete block design with three replications. The treatments details as presented in table 1:

[1] Cuu Long Delta Rice Research institute, O Mon, Can Tho, Vietnam
[2] Japan International Research Center for Agricultural Sciences, Tsukuba, Ibaraki 305-8686, Japan

Table 1: Treatment structure

S. No.	Rice (Winter - Spring) Kg/ha $N:P_2O_5:K_2O$	Upland crop (Spring- Summer) Kg/ha $N:P_2O_5:K_2O$	Rice (Summer-Autumn) Kg/ha $N:P_2O_5:K_2O$
T1	80-60-30	Soybean: 100- 60 -30	70-60-30
T2	80-60-30	Soybean: 60 - 60 - 30	70-60-30
T3	80-60-30	Soybean: 30 - 60 -30	70-60-30
T4	80-60-30	Soybean: 00-60-30	70-60-30
T5	80-60-30	Soybean: inoculants+60-60-30	70-60-30
T6	80-60-30	Soybean: inoculants+30- 30-30	70-60-30
T7	80-60-30	Soybean: compost+60-60-30	70-60-30
T8	80-60-30	Soybean: compost+30 -60-30	70-60-30
T9	80-60-30	Soybean: inoculants+00 -00-00	70-60-30
T10	80-60-30	Soybean: compost+00 - 00- 00	70-60-30
T11	80-60-30	Soybean: compost+ inoculants +30 -60-30	70-60-30

The residual crop *viz*., rice was sown as such without disturbing the previous lay out adopting a seed rate of 100 kg ha^{-1}. Cultural practices and plant protection measures were followed as per the packages of practice to soybean and rice crops as conventional recommendation The NPK were applied in the form of urea, single super phosphate and muriate of potash, respectively. The composted paddy straw was incorporated in the soil one day prior to sowing at the rate of 2t ha^{-1}. The inoculants *viz.*, SB83 (*Rhizobium fredii*) and SB177 (*Bradyhrizobium sp*.) were inoculated with soybean seeds at the ratio of 1:10 (1g inoculants and 10 g of soybean seeds). One third of the N and full dose of P2O5, K_2O were applied basally. The remaining two third dose of N was applied at 20^{th} and 35 days after sowing (DAS). The soybean seeds were sown adopting a plant spacing of 40 x 20 cm, 3 plants/hill (plant population = 375,000 plants/ha).

Plant height, no. of soybean leaves, no. of nodules, weight of nodule and SPAD value were measured at two-week interval beginning from 40 days after sowing (DAS) and four weeks after sowing for rice and soybean, respectively.

Collection of soil samples: Composite representative soil samples were collected from the field for evaluating initial analysis. Then soil samples were collected from each plot at harvest stage for soybean. The soil samples were air dried gently beaten with a wooden mallet and sieved through two mm nylon sieve and stored in polythene bags.

The data obtained from the present investigation were subjected to statistical scrutiny by adopting IRRI-STAT and the results were interpreted

RESULTS AND DISCUSSIONS

3.1 Soil properties (Table 2)

3.1.1 Organic carbon: It was observed that the maximum value obtained under treatment T7 (C+60-60-30) and significantly different from control T1 (100-60-30). A build up of organic carbon due to organic waste + NPK application from 0.018 to 0.258 % might be due to the decomposition of complex organic matter and converting them to mineralized organic colloids, which are added to the soil organic matter (Son and Ramaswami 1997).

3.1.2 Soil available N, P and K: A clear-cut changes were observed on soil available nitrogen due to influence of treatments. Higher soil N value observed under T7 (C+60-60-30) following by T6 (I+30-60-30). This was due to the inherent N content of the waste material incorporated and transformation during composting and after application in the soil. The available P was found to be influenced by treatments. The available K varied from 43.44 to 60.51 meq/100g and the lowest value obtained under T10 (C+ 00-00-00)

Table 2: Treatmental influence on soil nutrient availability of soybean at harvest stage (2003)

No.	Treatments $N:P_2O_5:K_2O$ Kg/ha	Organic carbon (%)	Nutrient availability		
			N (meq/100g)	P (ppm)	K (meq/100g)
T1	100- 60 -30	1.142	0.321	2.255	48.00
T2	60 – 60 - 30	1.091	0.314	2.131	46.57
T3	30 – 60 -30	1.246	0.287	1.926	50.91
T4	00-60-30	1.189	0.302	1.851	46.96
T5	I+60-60-30	1.275	0.386	3.533	60.51
T6	I+30- 30-30	1.368	0.355	3.622	58.93
T7	C+60-60-30	1.400	0.572	4.067	59.36
T8	C+30 -60-30	1.239	0.476	3.556	59.22
T9	I +00 -00-00	1.079	0.370	2.511	43.44
T10	C+00 - 00- 00	1.160	0.397	2.449	45.52
T11	C+I +30 -60-30	1.175	0.456	2.887	58.05
	LSD 5%	0.221	0.081	0.669	5.25
	CV %	10.7	12.5	14.7	5.9

C: composted paddy straw; I: Inoculants SB 83 (*Rhizobium fredii*) and SB 177 (*Bradyhrizobium sp*)

3.2. Dynamic changes of soil nutrients under influence of different treatments

3.2.1 Soil organic carbon: A dynamic change of soil organic carbon varied with time from 2000 to 2003. The soil organic carbon value tended to be decreased under application of inorganic fertilizer alone. It was observed that the maximum value obtained under treatment T7 (C+60-60-30) and significantly different from control T1 (100-60-30). A build up of organic carbon due to organic waste + NPK application varied from 0.227 to 0.300 % in the case of application of composted paddy straw and from 0.079 to 0.208 % in the case of application of the inoculants *viz*., SB 83 (*Rhizobium fredii*) and SB 177 (*Bradyhrizobium sp*.). They helped in the process of decomposition of complex organic matter and converting them to mineralized organic colloids, which are added to the soil organic matter. (Table 3)

Table 3: Treatmental influence on soil organic carbon at harvest stage

No.	Treatments $N:P_2O_5:K_2O$ Kg/ha	Organic carbon (%)	
		2000	2003
T1	100- 60 -30	1.033	1.087
T2	60 – 60 - 30	1.067	1.091
T3	30 – 60 -30	1.067	1.146
T4	00-60-30	1.000	1.189
T5	I+60-60-30	1.067	1.275
T6	I+30- 30-30	1.000	1.368
T7	C+60-60-30	1.100	1.400
T8	C+30 -60-30	0.900	1.239
T9	I +00 -00-00	1.000	1.079
T10	C+00 - 00- 00	1.033	1.260
T11	C+I +30 -60-30	1.000	1.275
	LSD 5%	0.158	0.18
	CV %	9.10	9.7

C: composted paddy straw; I: Inoculants SB 83 (*Rhizobium fredii*) and SB 177 (*Bradyhrizobium sp)*

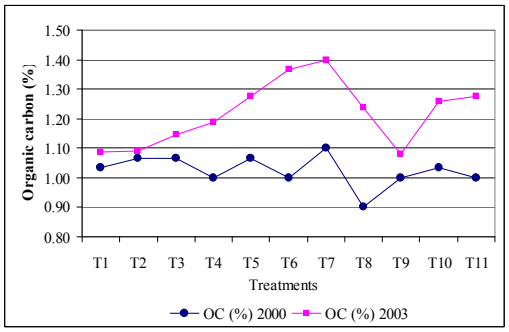

Figure 1: Dynamic changes of soil organic carbon (%)

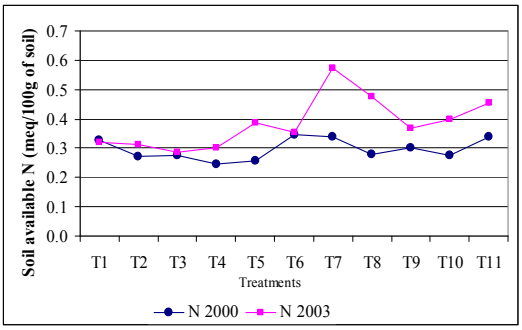

Fig.2 Dynamic changes of soil N availabilitv

3.2.2 Soil available nitrogen: A clear-cut changes were observed in soil available nitrogen due to influence of treatments from 2000 to 2003. The higher soil N value observed under T7 (C+60-60-30) following by T6 (I+30-60-30). This was due to the inherent N content of the waste material incorporated and transformation during decomposition process (Table 3 and Fig. 2)

Table 3: Treatmental influence on nitrogen availability of soybean at harvest stage

No.	Treatments $N:P_2O_5:K_2O$ Kg/ha	N availability (meq/100g)	
		2000	2003
T1	100- 60 -30	0.327	0.321
T2	60 – 60 - 30	0.270	0.314
T3	30 – 60 -30	0.277	0.287
T4	00-60-30	0.247	0.302
T5	I+60-60-30	0.257	0.386
T6	I+30- 30-30	0.347	0.355
T7	C+60-60-30	0.337	0.572
T8	C+30 -60-30	0.280	0.476
T9	I +00 -00-00	0.303	0.370
T10	C+00 - 00- 00	0.277	0.397
T11	C+I +30 -60-30	0.337	0.456
	LSD 5%	0.092	0.081
	CV %	17.7	12.5

C: composted paddy straw; I : Inoculants SB 83 (*Rhizobium fredii*) and SB 177 (*Bradyhrizobium sp)*

3.2.3 Soil available phosphorus:

The available P: A dynamic changes of soil available P from the year 2000 to 2003 was found to be influenced by treatments. The available P recorded in the year 2003 is relatively lower as compared to the year of 2000. However the treatments under application of composted paddy straw or inoculants obtained the higher values (Table 4 and Fig. 3)

4.4 Soil available K: was found to be influenced by treatments. The soil available K tended to be reduced under application of inorganic fertilizer alone whereas under application of composted paddy straw or inoculants obtained the higher values (Table 4 and Fig. 4)

Table 4 Treatmental influence on phosphorus and Potassium availability of soil at harvest

No.	Treatments $N:P_2O_5:K_2O$ Kg/ha	P availability (ppm)		Potassium(meq/100g)	
		2000	2003	2000	2003
T1	100- 60 -30	2.282	2.255	61.2	48.00
T2	60 – 60 - 30	2.720	2.131	57.0	46.57
T3	30 – 60 -30	3.977	1.926	56.0	50.91
T4	00-60-30	2.808	1.851	55.9	46.96
T5	I+60-60-30	2.808	3.533	56.5	60.51
T6	I+30- 30-30	3.393	3.622	56.1	58.93
T7	C+60-60-30	4.854	4.067	56.2	59.36
T8	C+30 -60-30	4.883	3.556	56.6	59.22
T9	I +00 -00-00	2.604	2.511	52.7	43.44
T10	C+00 - 00- 00	2.837	2.449	53.2	45.52
T11	C+I +30 -60-30	2.649	2.887	52.3	58.05
	LSD 5%	0.864	0.669	3.86	5.25
	CV %	13.2	14.7	4.10	5.9

C: composted paddy straw; I: Inoculants SB 83 (*Rhizobium fredii*) and SB 177 (*Bradyhrizobium sp)*

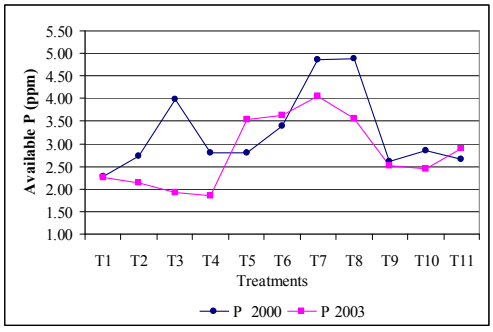

Figure 3: Dynamic changes of soil available P

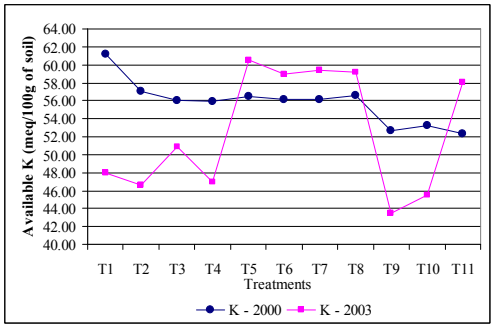

Figure 4: Dynamic changes of soil available K

3.3 Yield of crops

Yield and yield components of rice: Yield components of rice crop *viz.,* number of panicle per m^2 showed significant differences due to treatments T4 (00-60-30), T9 (I+00-00-00), T10 (C+00-00-00). Number of filled grains/panicle was showed significant differences due to treatments T9 (I+00-00+00). Unfilled grain percentage and 1,000 grain weight of rice were not significantly different due to treatmental influence, while the grain yield of rice was significantly differenct due to treatment influence. Treatment T7 (Compost +60-60-30) obtained the highest yield, then T1 (100 – 60 – 30), T5 (I+60-60-30), T8 (C+30-60-30) and T11 (C+I+30-60-30) subsequently ranked. This may be due to cumulative effect by soybean. The beneficial effect of organic waste could be attributed to the continued mineralization and release of nutrients from the organic manure as compared to the application of NPK alone. This also could be due to the role of leguminous N fixing capacity of soybean from the atmosphere. This is made available because of favourable microbial activity under rhizosphere system of leguminous crop under dry land condition. Finally, it led to the enhancement of the soil nitrogen use efficiency and helping in enhancing yield of rice crop which indicated in table 5 (Son and Kannaiyan 1999).

Table 5 Treatmental influence on grain yield of rice-soybean -rice cropping system in 2003

S. No.	Rice (Winter - Spring) (ton/ha)	Upland crops - soybean (Spring- Summer) (ton/ha)	Rice (Summer- Autumn) (ton/ha)
T1	6.166	2.573	2.666
T2	5.453	2.327	2.400
T3	5.366	2.273	2.333
T4	5.360	1.987	2.066
T5	6.233	2.600	2.733
T6	5.900	2.493	2.433
T7	6.300	2.553	2.833
T8	5.866	2.373	2.633
T9	5.400	2.173	2.166
T10	5.566	2.093	2.366
T11	5.883	2.573	2.633
CV (%)	6.1	5.7	8.7
LSD 5%	0.406	0.208	0.260

C: composted paddy straw; I: Inoculants SB 83 (*Rhizobium Freddie*) and SB 177 (*Bradyhrizobium sp*)

3.2.6 Yield and yield components of soybean (table 5)

Number of pods/plant: Among the treatments, the highest value obtained under T11 (Inoculants + compost + 30 - 60 - 30) which was on a par with control T1 (100-60-30), the rest ones recorded lower value as compared to control T1 (100-60-30). There was a close correlation between no. of pods per plant and grain yield (Fig .1)

Number of seeds/pod: Except two treatments viz., T4 (00-60-30) and T10 (compost + 00-00-00) recorded significantly lower value as compared to control T1 (100-60-30), the remaining treatments were on a par to control T1 (100-60-30)

The 100 grain weight: among treatments, the highest 100 grain weight was observed in T5 (Inoculants + 60 - 60 - 30) and the lowest in T4 (00-60-30). Significant differences in 100 grain weight among treatments were also noticed.

Soybean grain yield (Table 9 and Fig 1): the mean values of grain yield of soybean varied from 1.99 to 2.60 T ha^{-1}. The highest yield was recorded by treatment T5 (I +60-60-30) which was on a par with T11 (compost + Inoculants +30 - 60 - 30). This result showed that the lower dose of inorganic fertilizer conjunction with composted paddy straw or inoculants could have achieved the same grain yield of soybean under rice-based cropping system. This is in line with the finding of Ramaswami and Son (1996), Son and Ramaswami (1997), Son et al. (2000, 2001, 2002). There was a close relationship between number of pod per plant and grain yield ($Y = 0.0675 + 0.3778X$, $r = 0.900^{**}$)

CONCLUSIONS

The results indicated that fertilizer dose for soybean could be recommended as the rate of 60N- 60 $P_2 0_5$- 30 $K_2 0$ kg/ha, combined to composted paddy straw or inoculants or both composted paddy straw and inoculants + 30N- 60 $P_2 0_5$- 30 $K_2 0$. They could be obtained the same rice yield. Agronomic traits and grain yield of soybean were considered at the rate of higher dose of inorganic fertilizer as T1 (100-60-30) by farmer application. At the same time, results showed that the application of organic and bio -fertilizer could be substantiated for the N inorganic fertilizer to an extent of 40 – 70 kg N ha^{-1} while the agronomic traits and grain yield of soybean were comparable to the control (conventional dose applied by farmers). Especially, organic carbon content, soil available nitrogen, phosphorus and potassium maintained at a higher level under application inorganic fertilizer combined to composted paddy straw or inoculants or both composted paddy straw and inoculants as compared to the treatments those applied only inorganic fertilizers.

REFERENCES

Ramaswami PP and TTN Son. 1996. Quality compost from agricultural wastes. Paper presented at the national workshop on "Organic farming for sustainable agriculture". Water and land management training and Research Institute-Hyderabad, India.

Sharma AR and BN Mittra.1991. Direct and residual effect of organic materials and phosphorus fertilizer in rice based cropping system. Indian J. Agron.,36: 299-303

Son TTN and PP Ramaswami. 1997. Effect of organic wastes application on physical and chemical properties of heavy clay soil. Omon Rice 5: 48-55

Son TTN and S Kannaiyan.1999. Utilization of agricultural wastes for sustainable crop production. Page 109-127 in S. Kannaiyan (ed) Bioresources technology for sustainable Agriculture. Associated Publishing Company, New Delhi-110 005, India

Son TTN, Vu Van Thu and H Hiraoka, 2000. Effect of organic and bio-fertilizer on soybean and rice under rice based cropping system. Proceedings of the 2000 annual workshop of JIRCAS Mekong Delta Project:100 –110.

Son TTN, Vu Van Thu, Luu Hong Man, Duong Van Chin, Hirojuki Hiraoka and Hiromi Kobayashi, 2001. Effect of organic and bio-fertilizer on soybean and rice under rice based cropping system. Proceedings of the 2001 annual workshop of JIRCAS Mekong Delta Project: 43-53.

Son TTN, Vu Van Thu, Luu Hong Man and Hiromi Kobayashi. 2002. Effect of organic and bio-fertilizer on soybean and rice under rice based cropping system. Proceedings of the 2002 annual workshop of JIRCAS Mekong Delta Project: 58-68

SUMMARY IN VIETNAMESE

Nghiên cứu ảnh hưởng của phân hữu cơ và sinh học trên năng suất trong hệ thống luân canh lúa- đậu nành- lúa

Thí nghiệm dài hạn về đậu nành luân canh với lúa được thực hiện tại xã Phước Thới, huyện Ô Môn, tỉnh Cần Thơ, với các nghiệm thức bón phân khác nhau để tìm hiểu ảnh hưởng của phân hữu cơ và sinh học đối với sinh trưởng và năng suất của cây trồng do luân canh và phân bón. Kết quả thí nghiệm đến năm thứ tư cho thấy ở mức bón 60N- 60 P_20_5- 30 K_20 kết hợp với bón phân hữu cơ hoặc do bón phân vi sinh SB83 (*Rhizobium fredii*) và SB177 (*Bradyhrizobium* sp), hoặc cả hai kết hợp với liều lượng phân vô cơ ở mức 30N- 60 P_2O_5- 30 K_2O đạt kết quả về năng suất và các tính trạng nông học của cây trồng được nâng lên một cách có ý nghĩa. Chúng không khác biệt với lượng phân đối chứng (nông dân) ở mức bón 100N- 60 P_2O_5- 30 K_20. Đặc biệt độ phì của đất hàm lượng carbon hữu cơ, đạm, lân và kali hữu dụng ở các nghiệm thức bón phân hữu cơ hoặc do bón phân vi sinh được nâng lên một cách có ý nghĩa so với đối chứng (mức bón của nông dân) và các nghiệm thức