https://doi.org/10.29321/MAJ.10.A03020

Madras agric. J. 66 (11): 737–743, November 1979

Economic Recycling of Crop Residues for Soil Fertility Improvement *

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A field experiment was conducted with IR. 20 rice to study the influence of graded doses of rice straw application (10, 15 and 20 tonnes/ha) with and without different sources of phosphrous (superphosphate, rock phosphate and slag) for photochemical nitrogen fixation for better yield. Efficiency of straw dose was compared with absolute control and NPK fertilization. Straw additions gave yield comparable with NPK and basic slag was found to be a better source of phosphatic fertilizer. As the dose of straw increased available phosphorus content also increased. Straw at 10 tonnes/ha and basic slag at 90 kg/ha gave higher amount of nitrogen fixation and yield of grain.

Nitrogen is the nutrient element that produces marked response by crops. The high cost of fertilizer N, however, discourages its usage by farmers. Through symbiotic and non-symbiotic biological fixation of N provides some relief, an other alternative to overcome reduced N application is to fix atmospheric N through photo-chemical means.

Application of rice straw or other similar organic matter along with rock phosphate or basic slag can fix atmospheric N and N so fixed is sufficient for two crops raised after application of these materials (Dhar, 1975; Dei, 1975). It has also been reported by Ismunadji (1975) that incorporation of rice straw was useful in potash deficient soils. Mandal and Mandal (1973) reported that addition of organic matter reduced fixation of phosphate. It was also reported that addition of straw increased the organic carbon and N content of the soil (Landecremer and De, 1970). Dhar (1975) observed that organic matter and calcium phosphate fixed atmospheric N and could replace fertilizer N, P and K in world agriculture. The present investigation was undertaken with view to find out the extent to which the photochemical N fixation is useful under Indian conditions.

MATERIAL AND METHODS

A field experiment was laid out in a randomised block design in an alluvial soil under wetland conditions with IR. 20 rice as test crop. A bulk crop of IR. 20 rice was raised before the experimentation to reduce fertility variation. The treatments tried for the present investigation were as follows :

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* Awarded Ramasastralu Munagala Prize in the year 1977.

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Treatment No.	Treatment Details
1.	Control
2.	N, P_2O_5 and K_2O at 180-90-90 kg/ha
3.	Straw @ 10 t/ha
4.	-do- + 90 kg P_2O_5 as superphosphate
5.	-do- + 90 kg P_2O_5 as rock phosphate
6.	-do- + 90 kg P_2O_5 as basic slag
7.	Straw @ 15 t/ha
8.	-do- + 90 kg P_2O_5 as superphosphate
9.	-do- + 90 kg P_2O_5 as rock phosphate
10.	-do- + 90 kg P_2O_5 as basic slag
11.	Straw @ 20 t/ha
12.	-do- + 90 kg P_2O_5 as superphosphate
13.	-do- + 90 kg P_2O_5 as rock phosphate
14.	-do- + 90 kg P_2O_5 as basic slag

TABLE I Initial soil analysis

pH	E. C. (m.mhos/cm)	Organic carbon (%)	Total nutrients (%)	Available nutrients (kg/ha)
8.1	0.6	1.27	N=0.113	N=420
			P=0.075	P=8
			K=1.00	K=128

The treatments were replicated three times. Straw and different phosphate sources were added to the respective treatment and allowed to decompose in the field under submerged conditions for 42 days At the time of transplanting, for NPK treatment, P and K and half the dose of N was applied and the remaining half N was applied at panicle initiation.

Initial soil was analysed for its total and available nutrients (Table I). Post-harvest soil samples were collected and analysed for the nutrient status following the standard methods of analysis. Nitrogen fixed in the soil was calculated as per the method prescribed by Dev and Tilak (1976).

RESULTS AND DISCUSSION

Data on yield of grain and straw, carbondioxide evolved, available N and P are reported in Table II. Total N content of the soil, N uptake and N fixed by the soil are reported in Table III.

(i) Yield of grain: Straw and straw with P treatments gave similar yield with inorganic NPK application. Dhar (1959 and 1975) observed that straw with P supplied N to the full requirement of the succeeding crop. Mishustin (1971) reported that addition of straw increased yield. There was no significant difference between levels of straw application; and between straw plus P. Dei (1975) observed that continuouc application of straw alone improved the soil fertility and yield of rice. Basis

slag as a source of P recorded higher yield of grain (4811 kg/ha) than superphosphate (4789 kg/ha) and rock phosphate (4235 kg/ha). Basic slag and superphosphate were significantly superior to rock phosphate in increasing the yield of grain. However, Dhar (1959) reported that basic slag and rock phosphate were better sources of phosphorus than superphosphate. The difference in behaviour might be due to soil reaction. Under moderately alkaline condition basic slag performs better than rock phosphate (Tisdale and Nelson, 1970).

(ii) Yield of straw : It was observed that NPK treatment recorded significantly higher yield of straw than straw alone and straw with phosphorus treatments. This might be probably because N addition enhanced vegetative growth more than grain yield. However, Majumdar and Chakraborthy (1974) reported that basic slag in combination with green vegetation and potash gave yield of straw in comparison with NPK treatment. The responsiveness might be due to application of green vegetation and potash.

TABLE II   Post-harvest soil analysis and yield.

Treatment No.	Available N (kg/ha)	Available P (kg/ha)	Organic carbon (%)	C/N ratio	CO_2 evolved (mg/100 g soil/day)	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of fertilizer (Rs.)	Yield in kg/Reinvestment on fertilizer	
									Grain	Straw
1.	324	6.7	1.55	17.4	4.60	4194	7083	...	...	...
2.	333	9.3	1.58	12.3	4.75	4520	18500	1530	2.95	12.10
3.	320	6.7	1.59	12.3	4.81	4600	7583	600	7.67	12.63
4.	333	6.7	1.47	11.4	4.90	4667	7233	1191	3.92	6.08
5.	320	6.7	1.55	12.6	4.95	4133	6683	867	4.76	7.69
6.	311	6.7	1.59	12.3	5.00	4861	7533	794	6.12	9.49
7.	333	10.7	1.53	12.0	4.80	4495	6466	900	4.99	7.18
8.	320	8.0	1.55	11.9	4.95	4733	8533	1491	3.18	5.73
9.	329	7.3	1.54	12.6	4.91	4461	6566	1169	3.82	5.62
10.	337	9.3	1.63	13.9	5.10	4588	6949	1094	4.19	6.35
11.	320	1.00	1.61	14.8	4.88	5356	6700	1200	4.46	5.58
12.	333	8.0	1.49	12.0	4.90	4967	8766	1791	2.77	4.90
13.	324	13.3	1.67	13.6	4.91	4111	6066	1469	2.80	4.13
14.	315	8.7	1.51	12.3	5.15	4989	7850	1394	3.57	5.63

(iii) *Available nutrients*: Available N content of the soil was higher in basic slag with 15 t straw treatment (337 kg/ha). Comparing NPK and straw alone and straw with P it was observed that NPK recorded higher (333 kg/ha) available N than the latter (325 kg/ha). Straw at 15 t/ha both with and without P recorded higher available N content than straw application at 10 and 20 t/ha. Yoshida and Padre (1975) reported that the loss of N in the soil-plant system was reduced by the addition of rice straw.

Available P content of the soil was higher in the NPK treated plot (9.3 kg/ha) than the straw with phosphorus plots. Available P content of the soil with reference to source of P was in the order of rock phosphate followed by basic slag and superphosphate. However, Deirt *et al.* (1971) observed that basic slag was superior to rock phosphate and superphosphate in releasing P. It was observed from the present investigation that as the level of straw application with P increased, the amount of available P increased.

(iv) *Organic carbon and C/N ratio*: There was not much difference in the organic carbon content between NPK

TABLE III Nitrogen Fixation (kg/ha)

Treatment No.	Initial soil N (1)	Added N (2)	Total (1+2)=A	Soil N after harvest (3)	Grain N uptake (4)	Straw N uptake (5)	Total (3+4+5) B	N fixed (B−A)	N fixed over control
1	2260	0	2260	2460	59	22	2541	281	100.0
2	2260	180	2440	2580	63	68	2711	271	96.5
3	2260	40	2300	2580	63	30	2673	373	132.7
4	2260	40	2300	2580	63	25	2670	370	131.7
5	2260	40	2300	2460	55	31	2546	246	87.6
6	2260	40	2300	2580	63	30	2673	373	132.7
7	2260	60	2320	2560	61	25	2646	326	116.0
8	2260	60	2320	2600	66	34	2700	380	135.2
9	2260	60	2320	2440	59	26	2525	205	73.0
10	2260	60	2320	2360	63	28	2451	131	46.6
11	2260	80	2340	2180	71	27	2278	−62	−22.1
12	2260	80	2340	2480	66	31	2577	237	84.4
13	2260	80	2340	2460	55	24	2539	199	70.8
14	2260	80	2340	2460	70	33	2563	223	79.4

and straw alone and straw with P treatments. It is probable that application NPK fertilizers might have added enough root residues to bring the level of organic matter to that with straw application. In general the organic carbon content of the soil at harvest was higher than the initial content.

It is observed from the C/N ratio of the soils that the control plot recorded a wider C/N ratio than the NPK and straw treated plots. It is interesting to note that even the high level of straw added plot recrded narrow C/N ratio than control indicating that there was quick mineralization of added straw and it might have also fixed higher quantity of N in the soil. Comparing the sources of P superphosphate recorded a narrow C/N ratio. Straw with P was superior to straw alone treatment. Novak (1974) reported that the percentage of immobilized inorganic N increased with increasing rates of straw applied. In the present study also it was observed that 20 t of straw recorded higher C/N ratio than 10 and 15 t.

(v) *Carbondioxide evolution*: Straw added to the rice soil undergoes decomposition and releases carbondioxide. This evolved carbondioxide increases the concentration of CO_2 in the crop microcilmate and enhances the yield. It was observed that all the treatments recorded higher CO_2 production than control. Straw alone and straw plus P recorded higher CO_2 production (4.94 mg/100 g soil/day) than NPK treatment (4.75 mg/100 g soil/day). As the dose of straw increased the CO_2 evolved also increased. Delrrick (1974) reported that repeated application of straw led to increased CO_2 production. This increased CO_2 production might be due to increased rate of cellulose decomposition and increased microbial load in the soil (Despekhov *et al.*, 1976). Addition of straw along with P released 4.98 mg CO_2/100 g soil/day than straw alone (4.83 mg CO_2/100 g soil/day). This might be because enhanced the migrobial activity in the soil.

(vi) *Nitrogen fixation:* It is interesting to note that even in control plot appreciable quantity of N was fixed. This might be because of the presence of roots and stubbles of the previous crop which might have acted as energy source for fixing atmospheric N. In NPK treatment 271 kg N/ha was fixed which was less than that in control plot (281 kg N/ha). It is probable that when easily available source of N is applied N fixation is inhibited. Novak (1972) recorded that when higher amounts of readily available N was applied, the percentage of mineralization was decreased. Application of straw alone at 10 t/ha had fixed 373 kg N/ha which was 32.7 per cent higher than in control. Similar results were recorded by Lande Cremer and De (1970) in Netherlands. Application of straw with P fixed 23 per cent higher N than that with straw alone. Minami and Maeda (1971) in their experiment to study the effect of successive application of rice straw on paddy fields concluded that rice straw increased the content of NH_4-N in the soil. Combaring the sources of P tried, superphasphate followed by basic slag had recorded 329 and 242 kg of N/ha. The least response was recorded in the case of rock phosphate. Comparing the amount of N fixed taking control as 100 it was observed that straw at 15 t/ha with superphosphate recorded the heighest N fixation value of 135.2 followed by straw alone at 10 t and straw at 10 t/ha plus basic slag (132.71).

(vii) Economics: Yield of grain and straw per rupee investment on fertilizer or straw was worked out. It was observed that straw alone at 10 t/ha recorded maximum return per rupee investment.

Application of basic slag at 90 kg/ha along with rice straw at 10 t/ha had fixed the highest quantity of N and gave economic return. Comparing sources of phosphate for yield of grain, basic slag was superior.

REFERENCES

DEI, Y. 1975. The effect of cereal crop residues on paddy soils. ASPAC *Food Fert. Tech. Ext. Bull.* **49**: 1-28.

DEIRT, J., P. G. MARAIAS and C.F.G. HEYNS. 1971. Residual effect of basic slag, super and rock phosphate in virgin soils. *Deciduous Fruit grower* **21**: 79-81.

DELRRICK, J. 1974. The variation of soil fertility parameters during long term manuring with straw. Landwirtschaflliche *Forschung* **302**: 167-77.

DESPEKHOV, B. A., T. I. KUZYAKINA and V. A. LAPYGINA. 1975. *Izvertia Timiryazevskoi setskokhozyoirt vennoi Akademii.* **4**: 33-40.

DEV, S. P. and K. V. B. R. TILAK. 1976. Effect of organic amendments on the nodulation and nitrogen fixation by soyabean. *Indian J. agric. Sci.* **46**: 252-56.

DHAR. N. R. 1959. Land fertility improvement. *J. Indian Soc. Soil Sci.* **7**: 1-25.

DHAR, N. R. 1975. Organic matter and calcium phosphate fix atmospheric nitrogen and can replace N, P, K in world agriculture. *Proc. Natn. Acad. Sci. India.* Sec. A. **45**: 53-84.

ISMUNADJI, M. 1975. The utilization of rice straw in Indonesia. ASPAC. *New Let. Food Fert. Tech.* **29**: 9-10.

LANDE CREMER. L. C. N. and L. DE. 1970. Some experimental results on the incorporation of straw and other organic manures in clay, sandy and half bog soils in the Netherlands. *Senderh-Landw. Forsch.* **25/II**: 1-8.

MAJUMDAR, S. K. and CHAKRABORTY. 1974. Effect of basic slag and organic matter over NPK manuring on the yield of IR 8 rice in laterite soil. *Indian Agric.* **18**: 253-56.

MANDAL, L. N. and K. C. MANDAL. 1973. Influence of organic matter and lime on the transformation of applied phosphate in acidic low land rice soils. *J. Indian Soc. Soil Sci.* **21**: 57-62.

MINAMI, M. and K. MEADA. 1971. Effect of successive application of rice straw on paddy fields in Hokkaido. *Bull. Hokkaio Perfectural Agrl. Expt. Sta.* **23**: 67-69.

MISHUSTIN, E. N. 1971. Use of straw as fertilizer. *Agrokhimiya* **8**: 49-54.

NOVAK, B. 1972. Effect of increasing amounts of 'N' on the microbial transformation of straw in soil. *Proc. Symp. Soil microbial. Symposia Biologica Hungarica*, **11**: 49-53.

NOVAK, B. 1974. Nitrogen immobilization as affected by straw. *Annali di Microbiologia ed Enzimologia* **24**: 151-57. *Abstr. Soils Fert.* **39**: 107, 1976.

TISDALE, S. L. and W. L. NELSON. 1970. *Soil fertility and fertilizers.* Collier-Macmillan Ltd., London.

YOSHIDA, T. and B. C. PADRE. 1975. Effect of organic matter application and watet regimes on the transformation of fertilizer nitrogen in a Philippine soil. *Soil Sci. Plant Nutr.* **21**: 281-92.