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Alternative Rice Straw Management and Its Effect on Soil Nutrients

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Open burning of rice straw in field is a common practice in intensive rice growing areas. It is harmful to atmosphere and soil health because of air pollution and depletion of soil nutrients. Different methods of management of rice straw have been studied during this investigation. Rice straw has been incorporated into the soil with (25 kg of additional N ha^{-1} as basal + bio-mineralizer @2 kg t^{-1} of rice residue) and without additives; cow dung slurry @ 5 % individually or in combination of two or combined application of all the additives have been tested. Among these treatments, incorporation of straw with application of 25 kg of additional N ha^{-1} as basal + bio-mineralizer @2 kg t^{-1} of rice residue + cow dung slurry @ 5% (T_8) registered the highest soil available N, P and K status at tillering, flowering and post-harvest stages of the crop. The control plots without rice crop residue (T_9) recorded the lowest soil available N, P and K at all growth stages.

Key words: Rice straw, Soil incorporation, Bio-mineralizer, Cow dung slurry

Field burning of straw is often the most cost effective technique for quick disposal of by the rice farmers. While burning, some nutrients like carbon and nitrogen are released and not returned to the field (Bakker *et al*., 2013). Atmospheric pollutant emission, loss of nutrients, diminished soil biota, and reduced total N and C in the top soil layer are the major problems of rice straw burning. The gaseous emission have been estimated to be 110 Gg, 2306 Gg, 2 Gg, and 84 Gg, respectively for CH_4, CO, N_2O and NO_x from rice and wheat straw burning in India (Gupta and Sahai, 2015). On analysis of the burnt residue, it was found that burning resulted in 93 per cent loss of Nitrogen (N) and 20 per cent loss of Potassium (K) from the amount originally present in the straw. Hence, to avoid the soil nutrient losses and atmospheric pollution, *in-situ* incorporation of straw is the best option. Rice straw contains 0.5 to 0.8 % N, 0.16 to 0.27 % P 1.4 to 2.0 % K, 0.05 to 0.10 % S and 4 to 7 % silica (Si) in its dry matter (Dobermann and Fairhurst, 2002). But, this residue shows lower decomposition rate due to its higher C:N ratio (33) compared to cow dung and dhaincha (Chowdhury *et al*., 2002) Under such condition, if planting is taken up immediately after the incorporation of the straw from the preceding crop, the establishment of the succeeding rice crop may be very much hampered (Udayasoorian *et al*., 1997), due to poor soil nutrient availability coupled with immobilization. In order to overcome these problems, paddy straw harvested through combine harvester has been incorporated along with additional N source, bio-mineralizer, cow dung slurry and their combinations to find out the soil nutrient availability to the succeeding rice crop.

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Material and Methods

A field experiment was conducted at Agricultural College and Research Institute, Killikulam during *Pishanam* season of October 2014 - February 2015, to study the different rice straw management options in combine harvested rice field for using the rice straw as an organic manure, so as to avoid the burning of paddy straw in the field itself. The experimental site is situated in semi-arid tropical region of 8°46 N latitude and 77° 42 E longitudes and at an altitude of 40 m above MSL. The soil of the experimental field is sandy clay loam in texture, neutral in reaction and low in available N and medium in available P and K contents. Rice variety ADT (R) 45 with the duration of 110 days was used as the test variety in this experiment. After combine harvesting, the rice straw retained on the field was collected and quantified @ 5 t ha^{-1}. The rice straw was uniformly distributed to all the plots except control, based on the individual plot size. TNAU bio mineralizer was made into slurry by mixing with water (for 2 kg of material in 40 liters of water) and sprinkled on the straw of respective experimental plots @ 2 kg t^{-1} of rice residue on the next day of combine harvest of preceding rice crop *i.e.* 15 days ahead of transplanting. Cow dung slurry (5%) was prepared and sprinkled over the paddy straw in the corresponding treatment plots on the next day of combine harvest of preceding rice crop *i.e*. 15 days ahead of transplanting. The experiment was laid out in Randomized Block Design with nine treatments [T_1- Incorporation of rice straw as such with tractor mounted with half cage wheel and rotavator; T_2 - T_1 + 25 kg of additional N ha^{-1} as basal; T_3 - T_1 + Bio-mineralizer (@ 2 kg t^{-1} rice residue); T_4 - T_1 + Cow dung slurry (5%); T_5 - T_1 + 25 kg of additional N ha^{-1}

as basal + Bio-mineralizer (@ 2 kg t^{-1} rice residue; T_6 - T_1+ 25 kg of additional N ha^{-1} as basal + Cow dung slurry (5%); T_7 - T_1 + Bio-mineralizer @ 2 kg t^{-1} rice residue + Cow dung slurry (5%); T_8 - T_1 + 25 kg of additional N ha^{-1} as basal + Bio-mineralizer @ 2 kg t^{-1} rice residue + Cow dung slurry (5%); T_9 - Control (without residue) and replicated thrice. Eight different rice straw residue management techniques were randomly allotted in the experiment along with one control plot for comparison. The gross and net plot sizes were 45 m^2 and 38.5 m^2, respectively. Soil available N, P and K were estimated by Alkaline permanganate method, Olsen's method and Neutral normal ammonium acetate method, respectively. Data collected were subjected to statistical scrutiny as per the procedure given by Gomez and Gomez (1984). Wherever, the treatment differences were found to be significant (F test), critical differences were worked out at 5 % probability level and the values are furnished in the respective tables.

Results and Discussion

Available nitrogen

Soil available alkaline KMnO4-N status increased significantly with incorporation of rice straw along with microbial inoculants, organic and inorganic sources over control (Fig. 1). The soil available status of alkaline $KMnO_4$-N ranged from 268 to 306 kg ha^{-1} at tillering stage, from 237 to 277 kg ha^{-1} at flowering stage and from 213 to 254 kg ha^{-1} at post-harvest stages showing a decline towards rice crop maturity. Among the treatments, straw incorporation with application of 25 kg of additional N ha^{-1} as basal + Biomineralizer @2 kg t^{-1} of rice residue + cow dung slurry @ 5% (T_8) recorded the highest available N during the all growth stages of rice crop as 306, 277 and 254 kg ha^{-1} at tillering, flowering and Post-harvest stages, respectively. It is due to the combined application of all additives, which would have facilitated faster degradation. These results are in line with the findings of Mohantyet *al*. (2010). In treatment, where straw alone incorporated without additives (T_1) registered lower amount of alkaline $KMnO_4$-N of 271, 244 and 228 kg ha^{-1} at tillering, flowering and post-harvest stages, respectively and it was on par with control (T_9) where, no residue was incorporated. These results strengthen the findings of Bijay-Singh *et al.* (2008) and Gupta *et al.* (2007).

Table 1. Effect of rice straw incorporation on soil nutrients

Treatment	Available nitrogen (kg ha $^{-1}$)			Available phosphorus (kg ha $^{-1}$)			Available potassium (kg ha $^{-1}$)		
	Tillering	Flowering	Post-harvest	Tillering	Flowering	Post-harvest	Tillering	Flowering	Post-harvest
T_1	271	244	228	33.3	27.5	22.2	257	242	229
T_2	288	261	238	34.5	28.7	22.5	271	260	241
T_3	278	250	230	33.5	27.7	22.2	259	244	231
T_4	282	253	232	33.6	27.8	22.3	263	247	234
T_5	301	272	244	35.2	29.1	22.5	283	264	249
T_6	303	274	250	35.6	29.2	22.6	287	270	252
T_7	284	255	236	33.9	27.9	22.4	264	253	235
T_8	306	277	254	35.9	29.7	22.8	290	274	257
T_9	268	237	213	33.1	27.4	22.1	254	232	215
SEd	6.02	5.31	6.46	0.71	0.66	0.63	6.10	5.87	6.78
CD (P=0.05)	12.91	11.40	13.85	1.53	1.42	NS	13.09	12.58	14.54

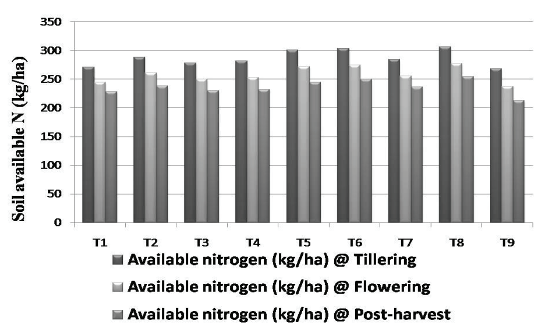

Fig. 1. Effect of rice straw incorporation on available nitrogen status (kg/ha) at various stages of rice crop.

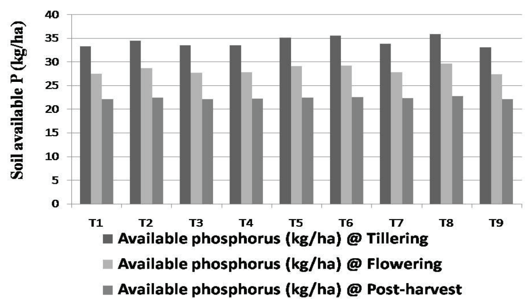

Fig. 2. Effect of rice straw incorporation on available phosphorus status (kg/ha) at various stages of rice crop.

Available phosphorus

The Olsen-P status of soil was influenced by the incorporation of rice straw along with microbial inoculants, organic and inorganic source over control (Fig. 2). The available status of Olsen-P extended from 33.1 to 35.9 kg ha^{-1} at tillering stage, from 27.4 to 29.7 kg ha^{-1} at flowering stage and from 22.1 to 22.8 kg ha^{-1} at post-harvest stage showing a decline towards rice crop maturity. Among the treatments, straw incorporation with application of 25 kg of additional N ha^{-1} as basal + Bio-mineralizer @ 2 kg

t^{-1} of rice residue + cow dung slurry @5% (T_8) registered higher available Olsen-P of 35.9 and 29.7 kg ha^{-1} at tillering and flowering stages, respectively (Table 1). Ghosh *et al.* (2011) also reported that, Phosphorus release from soil was significantly higher with straw incorporation than straw removal. Numerically, the highest soil available phosphorus was recorded (22.8 kg ha^{-1}) at post-harvest stage under straw incorporation with application of 25 kg of additional N ha^{-1} as basal + Bio-mineralizer @ @2 kg t^{-1} of rice residue + cow dung slurry@ 5% (T_8) and the lowest soil available phosphorus was recorded under control (T_9 - no residue) at post-harvest stages (Table. 1).

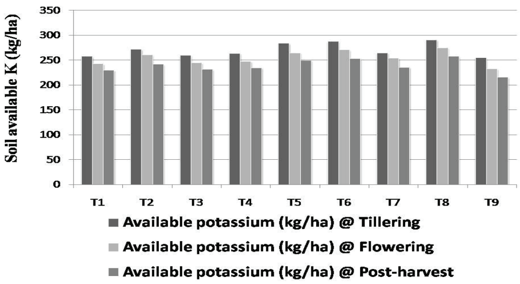

Fig. 3. Effect of rice straw incorporation on available potassium status (kg/ha) at various stages of rice crop.

Available potassium

Different residue management practices significantly influenced available K status of the experimental soil (Fig. 3). It ranged from 254 to 290, 232 to 274 and 215 to 257 kg ha^{-1} at tillering, flowering and post-harvest stages, respectively.With regard to treatment combinations, the treatment received incorporation of straw with application of 25 kg of additional N ha^{-1} as basal + Bio-mineralizer @2 kg t^{-1} of rice residue + cow dung slurry @5% (T_8) registered the highest available potassium of 290, 274 and 257 kg ha^{-1} at tillering, flowering and post-harvest stages, respectively(Table. 1). Addition of additives along with rice straw favoured the biodegradation process resulting in release of K in soil. The release of K from paddy straw occurs at a fast rate and about 70 per cent of total straw-K is released within 10 days after incorporation (Ghosh *et al.,* 2011). Singh *et al.* (2004) revealed that incorporation of rice straw caused a small, but significant increase in available K content in soil over straw removal treatments. The control (T_9 -no residue) treatment recorded the lowest soil available potassium of 254, 232 and 215 kg ha^{-1}at tillering, flowering and post-harvest stages, respectively because of slower decomposition rate. Among the individual additives, 25 kg of additional N shows the best performance than bio-mineralizer and cow dung slurry. This might be mainly because of the fact that 25 kg of additional N might have supplied energy to the microbes and substitute the Nitrogen demand, which might have been immobilized due to the formation of organic complex. In combined application of two additives, treatment T_6 and T_5 shows higher soil available nutrients than T_7. It may be due to the effect of 25 kg additional N. T_8 shows the highest soil available nutrients by combined action of all additives. Hence, 25 kg of additional N plays a significant role than bio-mineralizer and cow dung slurry in soil available nutrients.

Conclusion

Among the different rice straw management options, incorporation of straw with 25 kg of additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry could be the best option to manage the rice straw, registering the highest soil available N, P and K at all growth stages of rice crop. It may help for better nutrient uptake by the succeeding rice crop with enhanced yield by reducing nutrient immobilization.

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References

Bakker, R., Elbersen, W.,Poppens, R. and J.P. Lesschen. 2013. Rice straw and wheat straw. Potential feed stocks for the Biobased Economy. NL Agency Ministry of Economic Affairs, Netherland. p:31.

Bijay-Singh, Shan, Y.H., Johnson-Beebout, S.E.,Yadvinder-Singh and R.J. Buresh. 2008. Crop Residue Management for Lowland Rice-Based Cropping Systems in Asia. *Advances in Agronomy,* **98**: 117-199.

Chowdhury, M.A.H., Begum, R.,Kabir, M.R. and H.M. Zakir.2002. Plant and animal residue decomposition and transformation of S and P in soil**.** *Pak. J. Bio. Sci.,* **5 (7)**: 736-739.

Dobermann, A. and T.H. Fairhurst. 2002. Rice Straw Management. *Better Crops International,***16**: 7-9.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. II Ed., John Wiley and Sons, New York.pp.381.

Gupta, P.K. and S. Sahai.2015. Residue open burning in rice-wheat cropping system in India: an agenda for conservation of environment and agricultural resources. National Physical Laboratory, New Delhi, India, pp.50-54.

Gupta, R.K., Yadvinder-Sing,Ladha, J.K.,Bijay-sing, Singh, J., Sing, G. and H.Pathak.2007. Yield and phosphorus transformations in a rice-wheat system with crop residue and phosphorus management. *Soil Sci. Soc. Am. J.,* **71**: 1500-1507.

Mohanty, M., Probert, M. E., Sammi Reddy, K.,Dalal, R.C.,Rao, A.S. and N.W.Menzies.2010. Modeling N mineralization from high C:N rice and wheat crop residues. In: Proceedings of 19th World Congress of Soil Science: Soil solutions for a changing World, 1- 6 August 2010, Brisbane, Australia. pp.28-31.

Udayasooriyan, C., Govindasamy, K.N. and P. Subbiah. 1997. Effect of *Trichodermaviride*, additional nitrogen and farmyard manure on the productivity and sustainability of rice (*Oryza sativa*) – rice – groundnut (*Arachis hypogea*) system. *Indian J. Agron*., **42(1)**: 1-4.

Singh, Y., Singh, B.,Latha, J.K.,Khind, C.S.,Khera D.S.and C.S. Bueno.2004. Effects of residue decomposition on productivity and soil fertility in rice -wheat rotation. *Soil Sci. Am. J.,***68**: 854–864.

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