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A Vijayaprabhakar
Department of Agronomy, TNAU, Coimbatore, Tamilnadu, India

S Nalliah Durairaj
Department of Agronomy, AC&RI, TNAU, Killikulam, Tamilnadu, India

J Vinoth Raj
Department of Soil Science and Agricultural Chemistry, AC&RI, TNAU, Killikulam, Tamilnadu, India

Correspondence
A Vijayaprabhakar
Department of Agronomy, TNAU, Coimbatore, Tamilnadu, India

Effect of rice straw management options on soil available macro and micro nutrients in succeeding rice field

A Vijayaprabhakar, S Nalliah Durairaj and J Vinoth Raj

Abstract
There are numerous direct and indirect adverse impacts caused by residue removal on ecosystem, including depletion of the soil organic carbon (SOC). Important direct impacts of residue removal are low input of carbon (C) biomass, reduction in nutrient / elemental cycling and decrease in food / energy source for soil biota along with the attendant decline in soil quality. To overcome this, different rice straw management options and its effect on soil available nutrients were studied. Rice straw incorporated without and with additives (25 kg additional N ha^{-1} as basal, bio-mineralizer (2 kg t^{-1} rice residue), cow dung slurry (5 %) as individual, combination of two and combined application of all. Among this, Incorporation of straw with application of 25 kg additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry registered the highest soil available N, P, K and micro nutrients at tillering, flowering and post-harvest stages.

Keywords: rice straw, incorporation, bio-mineralizer, cow dung slurry, nutrients

Introduction

Field burning of straw is often the most cost effective technique for quick disposal of straw by the rice farmers. While burning, some nutrients like carbon and nitrogen are released and not returned to the field (Bakker *et al*., 2013) [1]. 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. 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 per cent N, 0.16 to 0.27 per cent P, 1.4 to 2.0 per cent K, 0.05 to 0.10 per cent S and 4 to 7 per cent silica (Si) in its dry matter (Dobermann and Fairhurst, 2002). At the same time rice straw have lower decomposition rate due to its higher C: N ratio (33) compared to cow dung and dhaincha (Chowdhury *et al*., 2002) [3] Under such condition, if planting is taken up immediately after incorporating the straw of preceding crop, the establishment of the succeeding rice crop may be hampered (Udayasoorian *et al*., 1997) [9] due to poor soil nutrient availability by immobilization. To overcome these problems, combine harvested paddy straw is incorporated along with additional N source, bio-mineralizer, cow dung slurry and its combinations to know the soil nutrient availability of succeeding rice crop field.

Materials 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. 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 a test variety in this experiment. After combine harvesting, the rice straw retained on the field was collected and quantified at 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 40 liters of water) and sprinkled on the straw of respective experimental plots at 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; T_2 - T_1 + 25 kg 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 additional N ha^{-1} as basal + Bio-mineralizer (2 kg t^{-1} rice residue); T_6 - T_1+ 25 kg 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 additional N ha^{-1} as basal + Bio-mineralizer (2 kg t^{-1} rice residue) + Cow dung slurry (5%); T_9 - Control (no 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 are 45 m^2 and 38.5 m^2 respectively. Soil available N, P, K and DTPA-Micronutrients (Fe, Mn, Zn, Cu) estimated by Alkaline permanganate method, Olsen's method, Neutral normal ammonium acetate method and DTPA extractant using atomic absorption photospectrometer respectively. Soil samples and the computed data were subjected to statistical scrutiny as per the procedure given by Gomez and Gomez (1984). Wherever, the treatment differences were found as significant (F test) critical differences were worked out at 5 per cent probability level and the values were furnished in the respective tables.

Result and discussion

Available nitrogen

Soil available alkaline KMnO4-N status increased significantly with incorporation of rice straw along with microbial inoculants, organic and inorganic source 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 additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry (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 degraded as faster. These results are in line with the findings of Mohanty *et al.* (2010) [8]. 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) [2] and Gupta *et al.* (2007) [7].

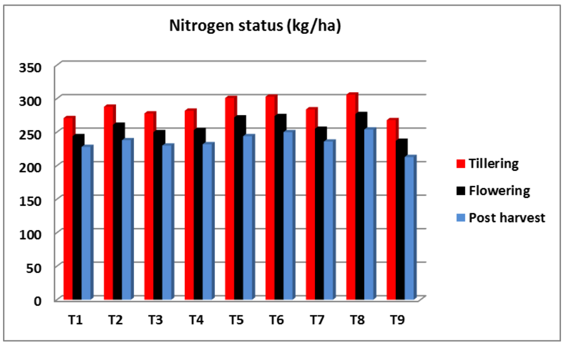

Fig. 1: Effect of rice straw incorporation on soil available Nitrogen status (kg/ha) at various stages of rice crop.

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 additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry (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 additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry (T_8) and the lowest soil available phosphorus was recorded under control (T_9 - no residue) at post-harvest stages (Table 1).

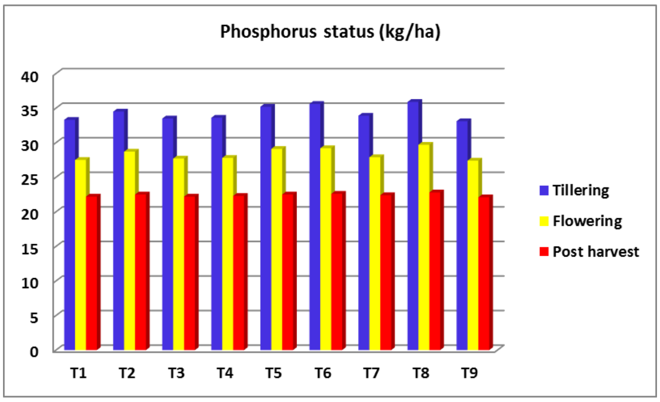

Fig 2: Effect of rice straw incorporation on soil available Phosphorus status (kg/ha) at various stages of rice crop

Available potassium

Different residue management practices significantly influenced available K status of the experimental soil (Fig. 3). It was 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 additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry (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) [10] 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. In overall, among the individual additives, 25 kg additional N shows best performance than Bio-mineralizer and Cow dung slurry.

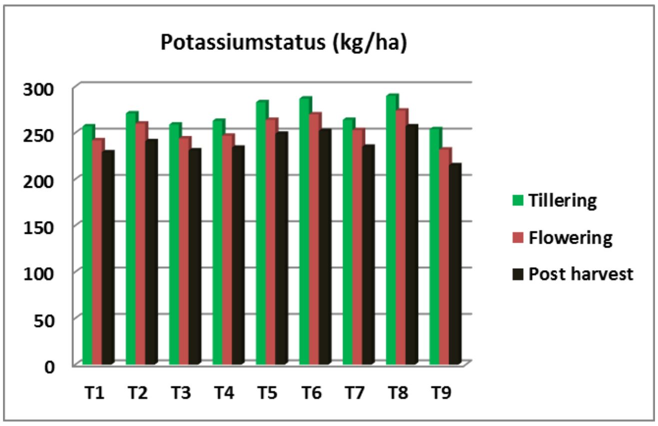

Fig 3: Effect of rice straw incorporation on soil available Potassium status (kg/ha) at various stages of rice crop

Because, 25 kg additional N supplies energy to the microbes and substitute the Nitrogen demand, which caused by immobilization due to their 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 is 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 additional N plays significant role than Bio-mineralizer and Cow dung slurry in soil available nutrients.

Table 1: Effect of rice straw incorporation on soil available N, P and K status (kg/ha) at various stages of rice crop.

Treatments	Available nitrogen (kg/ha)			Available phosphorus (kg/ha)			Available potassium (kg/ha)		
	TL	FL	PH	TL	FL	PH	TL	FL	PH
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

TL – Tillering; FL – Flowering; PH – Post Harvest

Available DTPA-Micronutrients (Fe, Mn, Zn, Cu)

Incorporation of rice straw with 25 kg additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry registered higher levels of DTPA-Fe, Mn, Zn and Cu and the lower values were recorded in control (straw removal) (Table 2).

Table. 2: Effect of paddy straw incorporation on DTPA-micronutrients content (mg kg^{-1}) at harvest stage of rice crop.

Treatments	DTPA-micronutrients (mg kg^{-1})			
	DTPA Fe	DTPA Mn	DTPA Zn	DTPA Cu
T_1	2.42	1.55	1.39	1.03
T_2	3.01	1.85	1.63	1.23
T_3	2.52	1.64	1.42	1.09
T_4	2.67	1.76	1.47	1.15
T_5	3.17	2.03	1.88	1.27
T_6	3.23	2.06	1.91	1.31
T_7	2.95	1.81	1.51	1.20
T_8	3.38	2.17	1.98	1.35
T_9	2.35	1.52	1.31	1.01
SEd	0.11	0.07	0.05	0.04
CD (P=0.05)	0.23	0.15	0.11	0.09

According to Sharma *et al.* (2001), increase in DTPA-micronutrients in residue incorporated plots might be due to addition of organic materials which have enhanced the microbial activities in the soil and release of chelating agents which could prevent micronutrients from precipitation, oxidation and leaching and also addition of these micronutrients through crop residues after their decomposition which leads to an increase of Fe, Mn, Zn and Cu in the soil solution. Gupta *et al.* (2007) [7] also found that the available soil Zn, Mn and Fe content were increased when rice straw was incorporated compared with straw removal (Fig. 4).

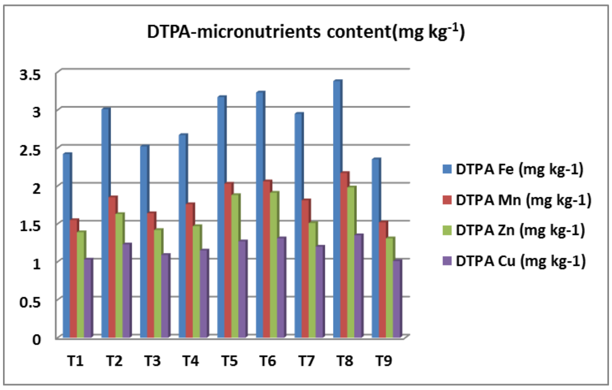

Fig 4: Effect of paddy straw incorporation on DTPA-micronutrients content (mg kg^{-1}) at harvest stage of rice crop

Conclusion

From the detailed discussion, Among the different rice straw management options, incorporation of straw with 25 kg additional N ha^{-1} as basal + bio-mineralizer + cow dung slurry is the best option to manage the rice straw, which registered the highest soil available N, P, K and micronutrients at all growth stages of rice crop. It will be results better nutrient uptake by succeeding rice crop and higher yield by reducing nutrient immobilization.

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