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Effect of different cutting heights of rice straw decomposition on yield attributes, grain yield and Stover yield of maize (*Zea mays*)

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Abstract
Field experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu during February 2020 to evaluate the impact of left-over rice straw after harvesting at different cutting heights (10 cm, 20 cm, and full rice straw) and microbial consortia on yield attributes, grain yield and straw yield. The experiment was laid out in split plot design and replicated thrice. The main plot contains different heights of rice straw i.e., 10 cm rice straw incorporation (M_1), 20 cm rice straw incorporation (M_2), full rice straw (M_3) and sub plots contains different microbial consortia along with cow dung and Urea i.e., Bio mineralizer (2 kg/tonne) (S_1), Bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2), Pleurotus (5 kg/ha) (S_3), Pleurotus (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_4), Silica solubilizing bacteria (5 kg/ha) (S_5), Silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6), Control (S_7). The rice straw residue produced by different cutting heights were 950, 1500, 4600 kg ha^{-1} for 10 cm, 20 cm and full rice straw, respectively. Rice straw with different heights decomposed with addition of microbial consortia, cow dung and urea increased the nutrient availability and uptake by succeeding maize crop. The higher yield attributes and yield were recorded in the full rice straw decomposition along with the spraying of bio-mineralizer (2 kg t^{-1}) + cow dung slurry (5%) + urea (1%) and it was on par with full rice straw decomposition along with the spraying of Silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%).

Keywords: Cutting, heights, rice, decomposition, maize, *Zea mays*

Introduction
Rice is harvested by manually or using machinery, in manual method some portion of straw was left over in the field while in machine harvesting total straw was left over in the field after removing the economic part. Jain (1993) [7] reported that in India, large quantities of crop residues are made available every year by paddy 326.2 mt, wheat 105.5 mt, maize 29.7 mt, sorghum 62.3 mt, barley 3.7 mt, pulses 15.7 mt, soybean 3.7 mt etc. and only a small portion of this being effectively utilized, but large quantities remain as waste. The farmers consider the left-over portion as a waste and they burnt in field itself. Rice straw can serve as a good source of nutrient recycling for plant growth and maintenance of soil fertility (Gaur, 1987; Cooperband, 2002) [6, 3]. Dobermann and Fairhurst (2002) [4] reported that 0.5 - 0.8% N, 0.16 - 0.27% P, 1.4 - 2.0% K, 0.05 - 0.10% S and 4 - 7% silica (Si). About one third of the residues produced are available for direct recycling on the land and if used can add 2.19 mt of NPK annually. The left-over rice straw from previous crop will be utilised as an organic source for nutrients by proper decomposition with microbial inoculants will increase soil health and crop yields.

Rice - maize is one of the cropping systems followed in wester zone of Tamil Nadu. Maize is an exhaustive crop which demands huge quantity of fertilizers. It responds positively to applied nutrients either through organic or inorganic sources. Increasing production solely through the use of inorganic fertilizers will result in environmental pollution as well as soil health degradation. Therefore, combining crop residues, bio agents, and chemical fertilizer will maintain productivity and soil health. To achieve sustainable productivity, use an integrated approach to managing plant nutrients. The main aim of the study was to establish the best residue management practice to improve soil health and productivity of maize.

Materials and Methods

Field experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu during February 2020 to evaluate the impact of left-over rice straw after harvesting at different cutting heights (10 cm, 20 cm, and full rice straw) on microbial populations and decomposition rate. The experiment was laid out in split plot design and replicated thrice. The main plot contains different heights of rice straw i.e., 10 cm rice straw incorporation (M_1), 20 cm rice straw incorporation (M_2), full rice straw (M_3) and sub plots contains different microbial consortia along with cow dung and Urea i.e., Bio mineralizer (2 kg/tonne) (S_1), Bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2), Pleurotus (5 kg/ha) (S_3), Pleurotus (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_4), Silica solubilizing bacteria (5 kg/ha) (S_5), Silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6), Control (S_7).

Rice is harvested manually with sickle as per the treatments. For M_1 and M_2 treatment plots, rice straw was harvested by leaving 10 cm and 20 cm stubble heights from the ground level but in M_3 treatment plot only economic parts are harvested by leaving the total rice straw in field itself. The left-over paddy straw was chopped by using tractor mounted shredder in their respective plots. Strengthen the already presented bunds and buffer channels all around to avoid seepage of water along with the nutrients. Drainage channels were provided all around the experimental field for effective drainage. The bio mineralizer, SSB were made in to slurry with water in 2:40 proportion, cow dung slurry (5%) and urea (1%) were prepared and sprinkled on the rice straw as per the treatments schedule.

Results and Discussion

Yield attributes

Yield attributes are significantly influenced by the in-situ rice straw decomposition with different cutting heights and microbial consortia.

Number of rows per cob

With respect to in situ rice straw incorporation with different cutting heights, incorporation of full rice straw (M_3) registered significantly higher number of rows per cob (12.80) and the lower number of rows per cob (11.56) was recorded under 10 cm rice straw incorporation (M_1).

The data regarding to microbial consortia, higher number of rows per cob (12.85) was observed under the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2) and this was on par with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6) (13.60). The lower number of rows per cob were observed in the control plot i.e., without any microbial inoculant application (9.76).

The interaction effect of the *in-situ* paddy straw incorporation at different cutting heights and microbial inoculant showed the significant effect. The higher number of grain rows per cob was observed under full rice straw along with the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (M_3S_2) (15.00) recorded and it was on par with full rice straw incorporation along with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (M_3S_6) (14.84). The lower number of grain rows per cob was observed in full rice straw incorporation alone without any application of microbial consortia, cow dung and urea (M_3S_7) (9.37).

Number of grains per cob

Regarding to in-situ rice straw incorporation with different cutting heights, incorporation of full rice straw (M_3) registered significantly higher number of grains per cob (227.96) and the lower number of rows per cob (210.44) was recorded under 10 cm rice straw incorporation (M_1)

With respect to microbial consortia, higher number of grains per cob (245.33) was recorded under the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2) and this was on par with application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6) (241.85). The lower number of grains per cob were observed in the control plot i.e., without any microbial inoculant application (178.48).

The interaction effect of the *in-situ* paddy straw incorporation at different cutting heights and microbial inoculant showed the significant effect. The higher number of grains per cob was observed under full rice straw along with the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (M_3S_2) (262.09) and it was on par with full rice straw incorporation along with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (M_3S_6) (259.46). The lower number of grains per cob was observed in full rice straw incorporation alone without any application of microbial consortia, cow dung and urea (M_3S_7) (175.15).

Test weight

The in-situ rice straw incorporation with different cutting heights and application of microbial consortia not shown any significant effect on the test weight.

The analysis of yield components helps to understand better on the physiological basis and source-sink relationship of crop due to the effect of the different residue management practices adopted. Hence, the variation caused by the treatments on number of rows per cob, number of grains per cob, test weight was studied and discussed.

Among the treatments, full rice straw along with the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (M_3S_2) recorded higher grains per row, grains per cob and it was on par with full rice straw incorporation along with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (M_3S_6) (Fig. 1). It was due to the favourable soil environment caused by enhanced nutrient availability by microbial inoculants, which degrade the straw and release the nutrient gradually (Sangakkara *et al*., 2014) [14]. The C:N ratio was reduced by additives with straw and increased the nutrient availability and also increased photosynthetic accumulation and translocation of photosynthates and it might have caused increased crop growth and thus influenced the yield attributes (Balasubramaniyan, 1980) [2]. These results are in line with findings of Patnaik *et al*. (1979) [11] and Sharma and Bali (1998) [15].

Incorporation of straw alone causes temporary immobilization of N (Nicolardot *et al*., 2001) [10], it leads to poor growth and development and subsequently decreased number of number of rows per cob, number of grains per cob it might cause overall reduction in biological yield.

Table 1: Effect of treatments on grain rows per cob and grains per cob

	Grain rows per cob				Grains per cob			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	12.24	13.17	14.42	13.28	224.92	236.71	252.37	238.00
S_2	12.70	13.84	15.00	12.85	229.69	244.22	262.09	245.33
S_3	10.33	10.49	10.31	10.38	183.20	195.23	185.33	187.92
S_4	10.97	11.25	11.60	11.27	203.23	207.89	213.95	208.36
S_5	12.12	12.96	14.10	13.06	223.45	232.80	247.36	234.54
S_6	12.43	13.55	14.84	13.60	225.82	240.28	259.46	241.86
S_7	10.17	9.74	9.37	9.76	182.75	177.54	175.16	178.48
Mean	11.56	12.14	12.80		210.44	219.24	227.96	
	M	S	MxS	SxM	M	S	MxS	SxM
S.Ed	1.28	2.76	4.61	4.78	1.28	2.76	4.61	4.78
CD	3.58	5.60	9.63	9.71	3.58	5.60	13.23	13.02

10 cm rice straw incorporation (M_1), 20 cm rice straw incorporation (M_2), full rice straw (M_3) and sub plots contains different microbial consortia along with cow dung and Urea i.e., Bio mineralizer (2 kg/tonne) (S_1), Bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2), Pleurotus (5 kg/ha) (S_3), Pleurotus (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_4), Silica solubilizing bacteria (5 kg/ha) (S_5), Silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6), Control (S_7).

Table 2: Effect of treatments on grain yield and stover yield (kg ha^{-1})

	Yield (kg ha^{-1})				Stover (kg ha^{-1})			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	5428	5842	6395	5888	12062	12430	13323	12605
S_2	5635	6138	6650	6141	12250	12788	13571	12870
S_3	4580	4653	4574	4602	10905	10821	11156	10961
S_4	4864	4992	5142	4999	11312	11345	11427	11361
S_5	5376	5744	6250	5790	11947	12487	13021	12485
S_6	5510	6007	6580	6032	11978	12781	13429	12729
S_7	4509	4320	4157	4329	11272	11077	10939	11096
Mean	5129	5385	5678		11675	11961	12409	
	M	S	MxS	SxM	M	S	MxS	SxM
S.Ed	37	55	96	96	115	160	280	276
CD	104	112	207	194	318	324	604	561

10 cm rice straw incorporation (M_1), 20 cm rice straw incorporation (M_2), full rice straw (M_3) and sub plots contains different microbial consortia along with cow dung and Urea i.e., Bio mineralizer (2 kg/tonne) (S_1), Bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2), Pleurotus (5 kg/ha) (S_3), Pleurotus (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_4), Silica solubilizing bacteria (5 kg/ha) (S_5), Silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6), Control (S_7).

Grain yield and stover yield

In situ rice straw incorporation with different cutting heights shown significant effect on grain and stover yield. Incorporation of full rice straw (M_3) registered significantly higher grain yield (5678) and stover yield (12409) and the lower grain yield (5128) and stover yield (11675) was recorded under 10 cm rice straw incorporation (M_1).

The data regarding to microbial consortia, higher grain yield (6141) and stover yield (12869) were observed under the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (S_2) and this was on par with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (S_6) i.e., grain yield (6032) and stover yield (12729). The lower grain yield (4328) and stover yield (11096) were observed in the control plot i.e., without application of microbial inoculant.

The interaction effect of the *in-situ* paddy straw incorporation at different cutting heights and microbial inoculant showed the significant effect. The higher grain yield (6650) and stover yield (13571) was observed under full rice straw along with the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) (M_3S_2) (18) Recorded and it was on par with full rice straw incorporation along with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%) (M_3S_6) i.e., grain yield (6580) and stover yield (13428). The lower grain yield (4157) and stover yield (10939) was observed in full rice straw incorporation alone without any application of microbial consortia, cow dung and urea (M_3S_7).

The residue management practices significantly affected the grain and stover yield of maize due to their positive influence on growth and yield attributes (number of grains per cob, number of rows per cob).

The grain and straw yield significantly enhanced by straw incorporation with additives compared to control (straw alone incorporation. Straw incorporated with 25 kg additional N ha^{-1} as basal + bio-mineralizer (2 kg t^{-1} rice residue) + cow dung slurry (5%) recorded highest grain and straw yield (Fig. 1, 3) than all other treatments. This was due to the integrated effect of bio-mineralizer and cow dung slurry on rapid straw decomposition (Fitriatin *et al.*, 2014) [5]. At the same time, 25 kg additional N substitute the N needs of crop as it was immobilized by wide C:N ratio at initial stage of incorporation (Singh *et al.*, 2005; Singh *et al.*, 2008) [16, 17]. Also, combination of all additives with straw incorporation improves the soil physical, chemical and biological properties (Arshadullah *et al.*, 2012) [1], it leads to better availability of nutrients to crop plant and subsequently a greater number of number of grains per cob and number of rows per cob results in highest grain yield and straw yield. These results are in line with the findings of Thangaraj and subramaniyan (1993) [18], Man *et al.*, (2002) [9], Pheav *et al.*, (2004) [12], Thuy *et al.*, (2008) [19], Jayadeva *et al.*, (2010) [8] and Polthanee *et al.*, (2011) [13].

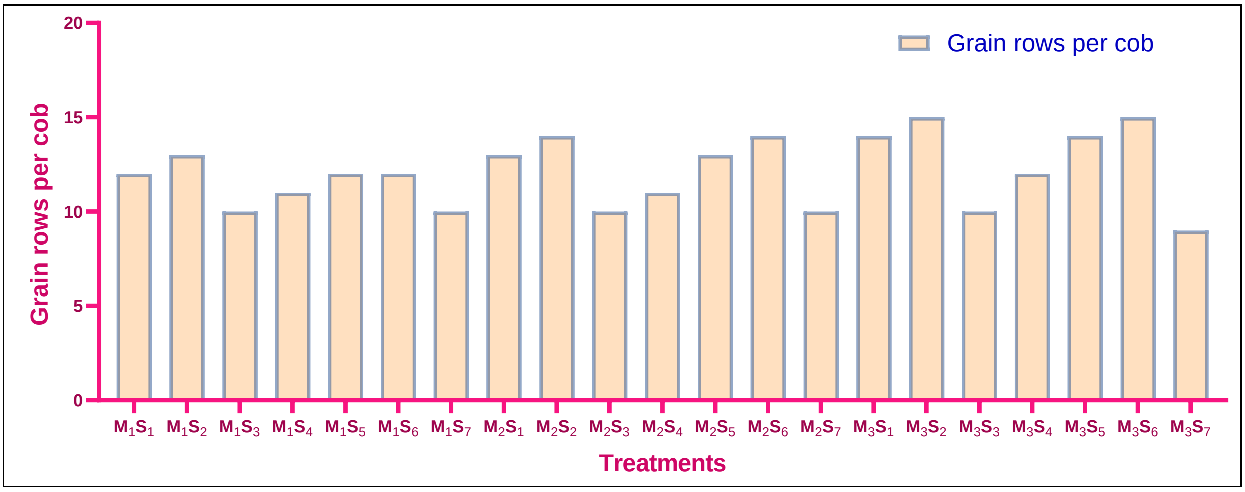

Fig 1: Effect of treatments on grain rows per cob

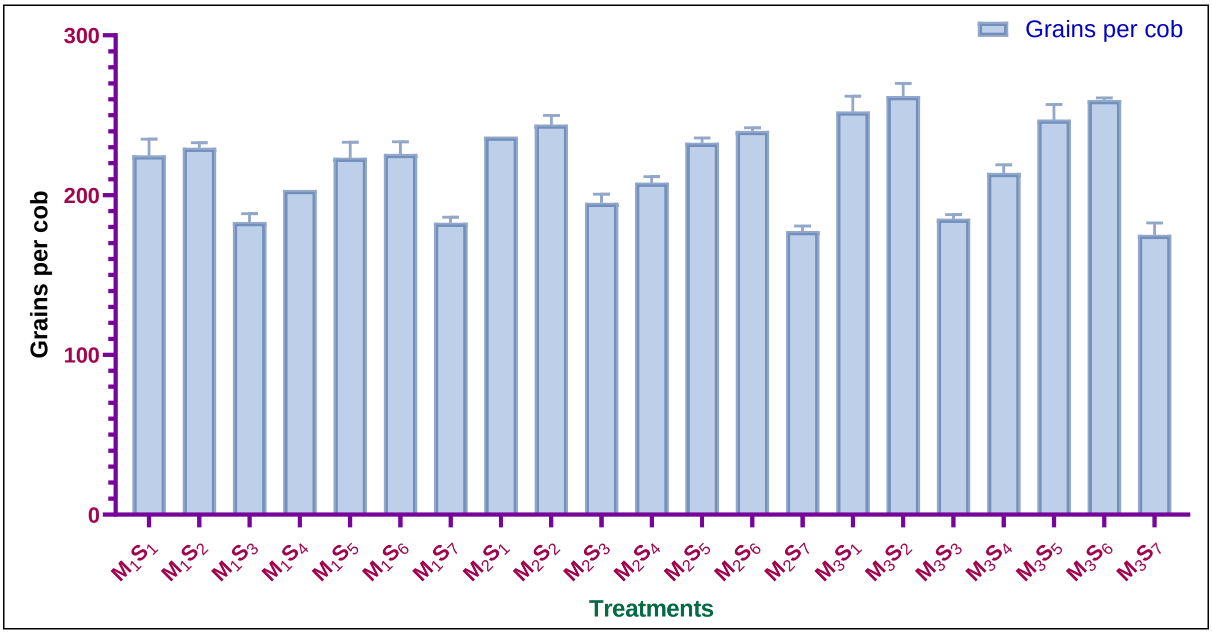

Fig 2: Effect to treatments on Grains per cob

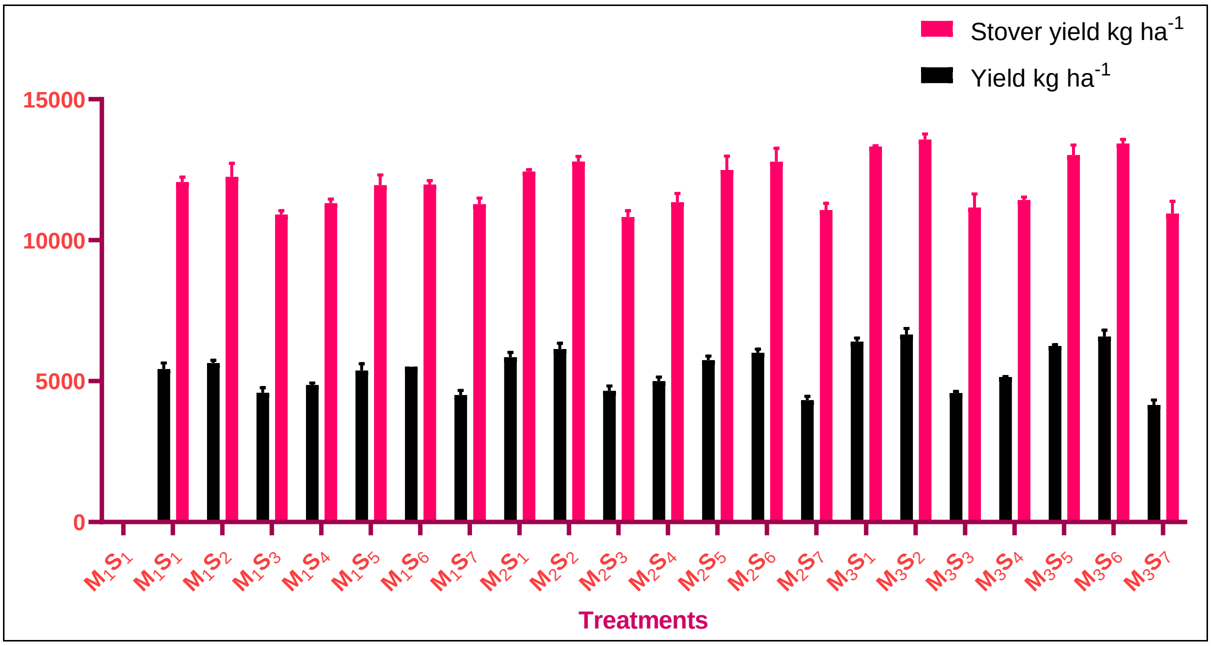

Fig 3: Effect of treatments on grain yield and stover yield

Conclusion

The study concluded that the higher yield attributes, grain yield and stover yield was observed under full rice straw along with the application of bio mineralizer (2 Kg/tonne of residue) + Cow dung slurry (5%) + Urea (1%) recorded and it was on par with full rice straw incorporation along with the application of silica solubilizing bacteria (5 kg/ha) + Cow dung slurry (5%) + Urea (1%). The lower yield attributes, grain yield and stover yield was observed in full rice straw incorporation alone without any application of microbial consortia, cow dung and urea (M_3S_7).

Future scope

The future scope of this research area is to quantify crop residue, decomposition and nutrient releasing pattern to be recorded on weekly interval. Analyzing the uptake and partitioning of nutrients in the subsequent crop. Microbial population and the species involved in the trial also to be examined.

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