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Study on Residue Management Options in Combine Harvested Rice Field in Relation to Yield and Economic Benefits of Succeeding Rice Crop

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ABSTRACT

Background: Paddy straw is a good source of plant nutrients. *In-situ* incorporation of paddy straw affects the growth and development of succeeding rice crop by immobilization of soil available nutrients. To overcome this, paddy straw incorporated with additives and its effect on rice growth and development was studied.

Methods: A field experiment was conducted at Agricultural College and Research Institute, Killikulam during October 2014 to February 2015, to study the residue management options in combine harvested rice and its effect on yield and economic benefits of rice crop. The experiment was laid out in randomized block design and replicated thrice. The treatments comprised rice residue without and with additives (25 kg additional N ha^{-1} as basal, bio-mineralizer (2 kg t^{-1} rice residue), cow dung slurry (5%). The additives applied individually, combination of two and combination of all additives.

Result: Different rice residue management practices exerted significant influence on succeeding rice crop. Increased number of productive tillers (409), number of grains per panicle (162), panicle length (23.8 cm), number of filled grains per panicle (132) and spikelet filled percentage (87) was recorded by T_8, where straw incorporated with application of 25 kg additional N ha^{-1} as basal + bio-mineralizer (2 kg t^{-1} of rice residue) + cow dung slurry (5%). The same treatment recorded highest grain yield of 7395 kg ha^{-1} and straw yield of 8440 kg ha^{-1} and it reflected as maximum value of ` 1,13,646 ha^{-1}, 69,079 ha^{-1} and 2.55 of gross return, net return and B:C ratio, respectively.

Key words: Additives, Bio-mineralizer, Cow dung slurry, Incorporation, Rice straw.

INTRODUCTION

Every year, around 140 mt of paddy straw was burned in India, which causes sever air pollution (Prasanthkumar and Vallal kannan, 2018). 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). Though the nutrient availability of rice straw is well known 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). 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). To overcome these problems, combine harvester paddy straw is incorporated along with additional N source, Bio mineralizer, cow dung slurry and its combinations to know the effect on succeeding rice crop yield and economic benefits. Keeping the above factors in mind, the present study was undertaken with the objectives *viz*., to study the effect of paddy straw incorporation on yield and yield attributes of rice crop and find out the economics for various residue management options.

MATERIALS AND METHODS

The field experiment was conducted at Agricultural College and Research Institute, Killikulam during *Pishanam* season of October 2014 - February 2015, to study the yield and economic benefits of rice crop under different rice residue management options. The farm is geographically situated in the southern part of Tamil Nadu at 8°46′ N latitude and 77°42′ E longitude at an altitude of 40 m above mean sea level. 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 (Table 1). 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 + 25kg

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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. Rice variety ADT (R) 45 with the duration of 110 days was used as a test variety. 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 [The gross plot size and net plot size is 45 m^2 (7.5 m × 6.0 m) and 38.5 m^2 (7.0 m × 5.5 m) respectively] except control. 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. After 15 days, every plot was individually puddled and levelled properly and rice transplanted with recommended dose of fertilizers. Apart from the treatment, all the cultural practices for lowland rice strictly followed as per TNAU crop production guide**.** The observations on yield attributes and yield were measured at the time of harvest. The harvest index was worked out using the formula (HI = Economic yield / Biological yield) suggested by Donald (1962). The cost of cultivation, gross return, net return and benefit cost ratio were computed for each treatment, considering the prevailing market rate for inputs, produce and wages paid to labourers at central farm, Agricultural College and Research Institute, Killikulam (Table 2).

The computed data were subjected to statistical analysis as per the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of residue management on yield attributes

The various residue management practices significantly influenced the productive tillers, number of grains per panicle, panicle length, number of filled grains per panicle and spikelet filled percentage of rice crop (Table 3). Incorporation of straw alone without additives (T_1) registered reduced number of productive tillers (335), number of grains per panicle (129), panicle length (19.4 cm), number of filled grains per panicle (108) and spikelet filled percentage (72) of rice crop. This was due to the temporary immobilization of N (Nicolardot *et al*., 2001), it leads to poor growth and development and subsequently decreased number of productive tillers per m^2, total number of grains, filled grains and spikelet filled percentage, it might cause overall reduction in biological yield.

When additives are used with straw incorporation, yield attributes were improved significantly. In overall, combination of all additives further increased the number of productive tillers (409), number of grains per panicle (162), panicle length (23.8 cm), number of filled grains per panicle (132) and spikelet filled percentage (87) in T_8. 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 (Sangakara *et al*., 2014). Application of 25 kg additional N at basal balanced the N, which was immobilized by straw incorporation due to wide C:N ratio (Huang *et al*., 2008 and Mary *et al*., 1996). 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 (Balasubramanian, 1980). These results are in line with findings of Patnaik *et al*. (1989) and Sharma and Bali (1998). Test (1000 grains) weight was not much influenced by residue management practices as the variation was non-significant between treatments.

Table 1: Physico-chemical characteristics of the experimental field.

Particulars	Value
I. Mechanical Analysis	
Coarse sand (per cent)	35.8
Fine sand (per cent)	28.5
Silt (per cent)	7.7
Clay (per cent)	27.3
Texture	Sandy Clay Loam
II. Chemical Analysis	
Available N (kg ha^{-1})	246 .00
Available P_2O_5 (kg ha^{-1})	18.75
Available K_2O (kg ha^{-1})	236.00
Organic carbon (per cent)	0.56
pH (1:2 soil water suspension)	7.00
EC (dS m^{-1}) (1:2 soil water suspension)	0.31

Table 2: Unit cost of inputs and produce.

	Item	Unit	Cost (`)
Inputs			
1.	Tractor charge	Per hour	300.00
2.	Bio mineralizer	1 kg	50.00
3.	Rice (ADT (R) 45) seeds	1 kg	26.00
4.	DAP	1 kg	23.80
5.	Urea	1 kg	5.41
6.	Muriate of Potash	1 kg	16.80
7.	Monocrotophos 36% SL	1 lit.	395.00
8.	Carbendazim 50 % WP	1 kg	550.00
9.	Butachlor	1 lit.	300.00
Produces			
1.	Paddy grain	1 kg	12.00
2.	Paddy straw	1 kg	3.00
Labour wages			
1.	Men	Per day	256.00
2.	Women	Per day	256.00

Table 3: Effect of rice residue management on yield attributes of rice crop.

Treatments	No. of productive tillers m^{-2}	No. of grains $panicle^{-1}$	Panicle length (cm)	Filled grains $panicle^{-1}$	Spikelet-filled percentage	Test weight (g)
T_1	335	129	19.4	108	72	17.37
T_2	381	152	21.6	124	79	17.46
T_3	370	138	20.1	113	77	17.12
T_4	371	141	20.5	115	77	17.36
T_5	389	156	22.1	126	81	17.2
T_6	395	158	22.3	130	82	17.37
T_7	375	149	20.9	122	78	17.29
T_8	409	162	23.8	132	87	17.59
T_9	352	133	19.7	109	73	17.3
SEd	12.1	5.0	0.69	4.0	2.5	0.56
CD(P=0.05)	26.10	10.38	1.67	8.3	5.4	NS

Table 4: Effect of rice residue management on yield and economics of rice crop.

Treatments	Grain yield	Straw yield	Harvest index	Cost of cultivation (`ha^{-1})	Gross income (`ha^{-1})	Net income (`ha^{-1})	B:C Ratio
T_1	5250	6020	0.466	43782	81900	38118	1.87
T_2	6615	7580	0.466	43917	102510	58593	2.33
T_3	6015	6870	0.467	44282	92940	48658	2.10
T_4	6230	7130	0.466	43932	97095	53163	2.21
T_5	6960	7960	0.466	44417	106860	62443	2.41
T_6	7160	8170	0.467	44067	110670	66603	2.51
T_7	6540	7480	0.466	44432	100650	56218	2.27
T_8	7395	8440	0.467	44567	113646	69079	2.55
T_9	5370	6140	0.467	43782	84540	40758	1.93
SEd	243	288	0.015	-	-	2479	0.10
CD (P=0.05)	522	618	NS	-	-	5318	0.21

Effect of residue management on yield

Grain and straw yield was significantly influenced by different residue management practices (Table 4). Among the different treatments, rice straw incorporated without additives (T_1) registered the lowest grain and straw yield of 5250 kg ha^{-1} and 6020 kg ha^{-1} respectively than other treatments. Direct incorporation of straw into soil is known to reduce the availability of nutrients to the growing plants by formation of organic complexes (Martin *et al*., 1978).

Incorporation of rice straw with different additives significantly increased the grain and straw yield than incorporation of straw alone (T_1). Among these, T_2 recorded higher grain and straw yield of 6615 kg ha^{-1} and 7850 kg ha^{-1}. This was on par with T_4 and T_3, which recorded the grain yield of 6230 and 6015 kg ha^{-1} respectively and straw yield of 7130 kg ha^{-1} and 6870 kg ha^{-1} respectively. Among the combined application of additives, T_6 recorded the higher grain and straw yield of 7160 kg ha^{-1} and 8170 kg ha^{-1}. This was on par with the T_5 registered 6960 kg ha^{-1} of grain yield and 7960 kg ha^{-1} of straw yield. In overall, combined application of all additives significantly enhanced the grain and straw yield than all other treatments. The T_8 significantly registered the highest grain yield of 7395 kg ha^{-1} and straw yield of 8440 kg ha^{-1}. The increase in yield with this treatment was 11.8 per cent over T_2 and 40.9 per cent over straw incorporation without additives. This was due to the integrated effect of bio-mineralizer and cow dung slurry on rapid straw decomposition (Joshi *et al*., 2013; TNAU portal, 2015; Fitriatin *et al*., 2014). 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*., 2009; Dhar *et al*., 2014). Also, combination of all additives with straw incorporation improves the soil physical, chemical and biological properties (Arshadullah *et al*., 2012), it leads to better availability of nutrients to crop plant and subsequently more number of productive tillers, number of filled grains per panicle results in highest grain yield, straw yield and harvest index. Similar findings also reported by Singh *et al*. (2002) in lentil crop. These results are in line with the findings of Jayadeva *et al.* (2010) and Polthanee *et al.* (2011). The control (T_9 - no residue) significantly registered lesser grain yield of 5370 kg ha^{-1} and straw yield of 6140 kg ha^{-1}. The value of harvest index did not vary much due to the influence of residue management practices.

Effect of residue management on economics

The maximum gross return of `1,13,646 $ha^{-1}$ and `1,10,670 ha^{-1}

were obtained in T_8 and T_6. The lowest gross return of 81900 ha^{-1} was obtained in T_1. Among various residue management practices, T_8 recorded the highest net return of 69,079 ha^{-1}. Next to this T_6, registered the net return of 66,603 ha^{-1} and were on a par with each other. The higher yield realized under the above treatments would be the reason for more economic return as against the cost of cultivation with higher net gain and B:C ratio. These results are conformity with the findings of Vijayakumar (1997), Hemalatha (2001) and Sridhar (2003).

CONCLUSION

From the experiment result and discussion, it could be enlightened that application of 25 kg additional N ha^{-1} as basal, bio-mineralizer (2 kg t^{-1} of rice residue) and cow dung slurry (5%) could be considered as a better option for achieving higher productivity and profitability in combine harvested rice field.

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