Growth, yield attributes and yield of rice as influenced by paddy residue and nitrogen management options under rice-rice cropping systems.

ABSTRACT

A field experiment was conducted during 2021-22 and 2022-23 at Regional Agricultural Research Station, Arepally, Warangal district. It is situated in the Central Telangana Zone. A total of 18 treatments replicated thrice in factorial RBD design. The study is conducted to know the impact of paddy residue and nitrogen management options on growth, yield attributes and yield of rice. The results of the experiment revealed that there is no significant effect on plant height, number of tillers per hill and panicle length. Productive tillers per hill, Number of grains per panicle, 1000 seed weight (gms) significantly effected by both the factors and there is no significant interaction between the two factors. Grain yield, straw yield was significantly effected by both paddy straw and nitrogen management options under rice-rice cropping systems.

Keywords: Grain yield, straw yield, plant height, panicle length, 1000 seed weight.

Introduction: India is the second largest producer of Rice after China. The area, production and productivity of Rice in India about 44.79 M ha, 112.41 million tones and 2578 kg ha^{-1} respectively.InIndia,majorricegrowingstatesareWestBengal,Punjab,UttarPradesh,Tamil Nadu, Andhra Pradesh, Telangana, Bihar, Odisha *etc*. The area and production of rice in Telangana is 2 million hectares and 6.6 million tons respectively. The area under rice cultivationinthestatehasincreasedto2.7Mha(2019-20)asagainst1.9Mhain2013-14and also production increased in leaps and bounds from 5.7 mt in 2013-14 to 9.8 mt in 2019-20 (Directorate of Economics and Statistics, Government of India, Socio Economic Outlook, 2020).

Rice is the most residue producing crop in Asia (826 million tons) contributing 84% of total production of the world. Traditionally, rice straw is removed from fields for use as cattle feed and other purposes in South Asia. On average, rice crop residues contain 0.7% N, 0.23% Pand1.75%K.Therefore,theamountofNPKcontainedinricecropresiduesproducedisabout 22.13×10^{6}and26.26×10^{6}t$year^{-1}$inAsiaandtheworld,respectively(Goswami*etal*.,2019).

From the farmers' point of view, burning may be seen as the most suitable method of disposing of rice straw. It is not only a cost-effective method but it acts as an effective pest controlprocedure(AdamJohn,2013).

Burningofcropstubblecausestheairpollutionandlead to loss of huge biomass, *i.e*. organic carbon, plant nutrients, the entire amount of C, approximately 80–90% N, 25% of P, 20% of K and 50% of S present in crop residues are lost in the form of various gaseous and particulate matters, resulting in atmospheric pollution and global warming (Kaur *et al*., 2019). Incorporation in the soil poses challenges in intensive systems with two to three cropping rounds per year. This is due to the insufficient time for decomposition, leaving the straw with poor fertilization properties for the soil and hindering cropestablishment.Asaresult,open-fieldburningofstrawhasincreaseddramaticallyoverthe last decade, despite being banned in most rice-growing countries because of pollution and the associated health issues. Therefore, it is important to look for sustainable solutions and technologies that can reduce the environmental footprint and add value by increasing the revenues of rice production systems (Hung *et al*.,2020).

Materials and Methods: A field experiment was conducted during 2021-22 and 2022-23 at Regional Agricultural Research Station, Arepally, Warangal district. It is situated in the Central Telangana Zone. The experiment was conducted in Factorial randomized block design. The soil was sandy clay loam in texture. The variety choosed for rice is KNM-118 spacing adopted for rice 20 X 15 cm, plot size of 5 X 4 =20 Sq. Meters.

Treatmental details:

Factor 1 (paddy straw management options) Factor 2 (fertilizer N levels). Among paddy straw management options it has burning (one week before land preparation), incorporation (a week before land preparation consortium is sprayed, week after its spray paddy straw will be incorporated) ,Cutting and removal of straw (one week before land preparation paddy straw removed and consortium will be sprayed, week after spray paddy straw is incorporated) .

Among fertilizer N levels $T_1$100 % RDN (33.3% during transplanting, 33.3% maximum tillering stage (30 DAT) and 33.3 % panicle initiation stage (60 DAT), T_2 100% RDN (40% during transplanting, 30% maximum tillering stage (30 DAT), 30% panicle initiation stage (60 DAT), T_3 100% RDN (10% during transplanting, 30% 15 days after transplanting, 30% maximum tillering stage (30 DAT) and 30% panicle initiation stage (60 DAT), T_4 100% RDN (15% during transplanting, 30% 15 days after transplanting, 30% maximum tillering stage (30DAT) and 25% panicle initiation stage (60 DAT), T_5 115% RDN (18 % during transplanting, 36% 15 days after transplanting, 36% maximum tillering stage (30 DAT) and 25% panicle initiation stage (60 DAT), T_6 130% RDN (20% during transplanting, 42% 15 days after transplanting, 42% maximum tillering (30 DAT) stage and 26% panicle initiation stage (60 DAT).

Microbial consortium: Consists of decomposers belonging to *genera Phanerochaeta, Asperigillus, Trichoderma.* RDF for *Rabi* rice - 120-60-40 kg N-P-K kg ha^{-1}. Recommended doses of phosphorus, potassium and FYM (10 t ha^{-1}) will be applied in equal quantities in all treatments. Five randomly selected plants from each plot were taken and measured for plant height (cm), number of tillers $hill^{-1}$, number of effective tillers per hill, number of grains per panicle, panicle length, test weight and average values were calculated.

Grain yield

Plants in the net plot area were harvested and threshed separately. Grains were dried under sun and grain yield adjusted to 12 per cent moisture. Grain yield per plot was recorded after cleaning. From this yield per plot, grain yield per hectare was computed and expressed as kg ha^{-1}.

Straw yield

After threshing the grain, the remaining straw was dried under sun and yield per plot was recorded and the yield per hectare was computed and expressed in kg ha^{-1}.

Results and discussion:

Growth parameters

Plant height (cm)

There is no significant effect of paddy straw and nitrogen management options on plant height and there is no interaction between two factors.

The highest plant height was observed in burning 43.34 cm at 30 DAT followed by cutting and removal 41.96 cm and least was reported in incorporation 40.68 cm.

With the factor 2 the highest was obtained in T_2 43.56 cm followed by T_1 42.92 cm and least was obtained in T_3 40.29 cm.

At 60, 90 DAT highest was reported in incorporation 76.51 cm and 101.20 and least was observed in cutting and removal 72.14 cm and 95.62 cm.

With factor 2 highest was obtained in T_6 79.53 cm, 104.29 cm followed by T_5 77.49 cm, 102.22 cm and least was reported in T1 at 60, 90 DAT respectively.

Number of tillers $hill^{-1}$

The highest number of tillers per $hill^{-1}$ was obtained in burning 11.36 least was observed in 10.86 incorporation at 30 DAT.

With factor 2 highest was reported in T_2 11.64 followed by 11.45 T_1 and least was reported in T_3.

At 60, 90 DAT highest was obtained in incorporation 12.51, 15.04 and least was reported in cutting and removal 11.94, 13.22.

With factor 2 highest was observed in T_6 13.24, 15.20 followed by T_5 12.83, 14.93 and least was observed in T_1 in 60, 90 DAT.There is no significant effect of paddy straw and nitrogen management options on number of tillers hill^{-1} and there is no interaction between two factors.

At harvest from the pooled data of two years the highest number of tillers per hill was obtained in 20.26 incorporation followed by burning 19.25 and cutting and removal 18.19 and there is significant effect of paddy straw on number of tillers per hill at harvest.

Among the different levels of nitrogen the highest was obtained in $T_6$21.74 which was on par with T_5 20.59 and the least was obtained in T_1 16.96 and there is significant effect on number of tillers per hill. There is no significant interaction between the two factors.

Yield attributes in rice

Panicle length

With the paddy straw and nitrogen management options there is no significant effect on panicle length (cm) and there is no significant interaction between the two factors.

At harvest the highest panicle length was observed in 22.06 (cm) incorporation followed by burning 21.25 (cm) and cutting and removal 20.50 (cm).

T_6 recorded the highest with different nitrogen dose at 22.44 cm, whereas T_1 reported the lowest at 20.25 cm.

Productive tillers per hill

With the paddy straw and nitrogen management options there is significant effect on Productive tillers per hill and there is no significant interaction between the two factors.

The highest was obtained in incorporation 15.39 followed by burning 14.27 and cutting and removal 13.15 among the paddy straw management options

With different levels of Nitrogen application the highest was obtained in T_6 16.76 which was on par with T_5 15.91 and the least was obtained in T_1 11.91.

1000 seed weight (gms)

Both paddy straw and nitrogen management significantly affected the 1000 seed weight (gms) and there is no significant interaction between the two factors.

At harvest highest 1000 seed weight gms was obtained in 23.72 gms incorporation which was on par with burning 22.78 gms and the least was obtained in cutting and removal 21.35 gms.

Among the nitrogen levels highest was obtained in T_6 23.84 gms which statistically on par with T_5 23.28 gms T_4 22.92 gms and T_3 22.39 gms and the least was observed in T_1 21.47 gms.

Number of grains per panicle

With the factor 1 highest was observed in incorporation 91.73 which was on par with burning 89.11 and least was observed in cutting and removal 85.65.

Among the nitrogen management options highest was observed in T_6 93.97 and it is on par with T_5 91.97, T_4 89.62, T_3 88.07 and least was reported in T_1 83.15.

(Banjara *et al*., 2019) reported that plant height, number of tillers, dry matter accumulation, number of leaves hill^{-1} and LAI was recorded significantly higher under treatment incorporation of rice straw as compared to burning and normal transplanting. The lowest yield attributes was obtained in T_1 and T_2 this is because of due to the fact that major share of N were applied during the early growth stages, produced lower grain yield. This may be attributed to the failure to synchronize the N supply as per demand of the crop at all the major system of crop growth crucial for higher yields (Chaudhary *et al*., 2013). Delayed application of N might be helpful in keeping the plant greener for long and thereby facilitating the higher production and translocation of photosynthetic towards economic parts (Dar *et al*., 2000).Significant difference was observed with application of different nitrogen levels in grain yield and yield attributing characters *viz*; tillers m^{-2}, panicle length, number of filled grains per panicle and thousands grain weight (Khatri *et al*., 2019).

Grain and straw yield (kg ha^{-1})

Under paddy straw management options, of pooled years the highest grain yield and straw yield was obtained in incorporation plots 7702.94 kg ha^{-1}, 9780.65 kg ha^{-1} followed by burning 7163.11 kg ha^{-1}, 9182.87 kg ha^{-1} and cutting and removal 6621.66 kg ha^{-1}, 8535.29 kg ha^{-1}.

Among the Nitrogen levels and time of application the highest grain and straw yield was obtained in $T_6$7955.36 kg ha^{-1}, 10056.46 kg ha^{-1}which was on par with T_5 and the least was obtained in T_1. Grain and straw yield was found in the order 130% RDN T_6> 115% RDN T_5>100% RDN T_4> 100% RDN T_3>100% RDN T_2 and 100% RDN T_1 with the yield.

The increase in yield with straw incorporation is due to returning of large part of nutrients back into soil that can be observed by the plant (Bakht *et al*., 2009) and straw adds organic matter to the soil (Huang *et al*., 2021) which improves soil physical, chemical, biological properties results in improved soil health which contributes to increased grain yield (Zhang *et al*., 2016;Wang *et al*., 2015). Paddy straw with wide C:N ratio showed higher nitrogen immobilization during its initial stage of decomposition, which was later released and potentially improved the available mineral nitrogen during subsequent rice growth stages thereby enhancing growth and yield (Xu *et al*., 2010). It seems to be possible that burning of paddy straw led to loss of soil nutrients and hence a possible decrease in soil fertility(Dobermann and Fairhurst, 2002), could be the reason for the lowest yields in burning treatment. Zhang *et al*., 2010 reported 7.5% yield increases in wheat crop grown with combination of fertilizer-N and crop residue return to soil. It has been ascribed to the fact that the straw returned to soils leads to large decrease in fertilizer-N losses (Grageda-Cabrera *et al*., 2011). With the increase of nitrogen fertilization grain yield increased. Similar significant results were reported by Sharma *et al.* (2021), Khatri *et al*. (2019) Singh and Sharma (2020) and Tian *et al*. (2018) that grain yield was increased with increasing nitrogen levels.

Fageria (2014) stated that higher nitrogen helps in the metabolism of protein and ultimately the metabolism of carbohydrate in the latter stages of growth which might be the cause for significantly higher production of total above ground biomass and ultimately higher production of straw.

Conclusions:

From the results of the present study it can be concluded that Paddy straw incorporation along with additional supply of Nitrogen *i.e*130% RDN, 115% RDN produced higher grain yield, straw yield and other growth and yield attributes in rice-rice cropping system. Thus, farmers are suggested to incorporate crop residues with nitrogen dose of 130% RDN or 115 % RDN into the soil instead of burning; which is environmentally hazardous to human and soil health.

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Table 1: Effect of paddy straw and nitrogen management on plant height (cm) at different stages in rice-rice cropping system

	30 DAT			60 DAT			90 DAT		
Treatments	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**
Burning	44.29	42.39	43.34	74.91	73.37	74.14	99.61	98.07	98.84
Incorporation	41.84	39.52	40.68	77.81	75.21	76.51	101.94	100.46	101.20
Cutting and removal	43.28	40.64	41.96	73.40	70.87	72.14	96.27	94.97	95.62
SE(m)±	0.83	0.84	0.82	1.76	1.87	1.79	3.14	3.17	3.15
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels and time of application									
T1	44.01	41.82	42.92	70.61	67.76	69.18	93.93	91.96	92.95
T2	44.63	42.48	43.56	71.92	69.63	70.78	95.53	95.78	95.65
T3	41.59	38.98	40.29	74.93	72.32	73.63	98.10	96.47	97.29
T4	42.27	39.84	41.06	76.10	73.87	74.98	99.86	98.00	98.93
T5	42.78	40.66	41.72	78.02	76.95	77.49	103.05	101.39	102.22
T6	43.52	41.33	42.43	80.68	78.38	79.53	105.16	103.41	104.29
SE(m)±	1.17	1.19	1.16	2.49	2.65	2.53	4.44	4.49	4.45
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS

T1:100 % RDN (33.3% during transplanting, 33.3% maximum tillering stage and 33.3 % panicle initiation stage
T2:100% RDN (40% during transplanting, 30% maximum tillering stage, 30% panicle initiation stage
T3:100% RDN (10% during transplanting, 30% 15 days after transplanting, 30% maximum tillering stage and 30% panicle initiation stage
T4:100% RDN (15% during transplanting, 30% 15 days after transplanting, 30% maximum tillering stage and 25% panicle initiation stage
T5:115% RDN (18 % during transplanting, 36% 15 days after transplanting, 36% maximum tillering stage and 25% panicle initiation stage
T6:130% RDN (20% during transplanting, 42% 15 days after transplanting, 42% maximum tillering stage and 26% panicle initiation stage

Table 2: Effect of paddy straw and nitrogen management on number of tillers per hill at different stages in rice-rice cropping system.

	30 DAT			60 DAT			90 DAT			After harvest		
Treatments	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**
Burning	11.46	11.26	11.36	12.49	12.17	12.33	14.74	14.37	14.55	18.70	19.80	19.25
Incorporation	10.96	10.76	10.86	12.70	12.32	12.51	15.27	14.82	15.04	19.71	20.82	20.26
Cutting and removal	11.24	10.97	11.10	12.07	11.81	11.94	13.39	12.71	13.22	17.66	18.72	18.19
SE(m)±	0.22	0.22	0.22	0.38	0.36	0.36	0.57	0.64	0.54	0.50	0.51	0.32
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.43	1.47	0.91
Nitrogen levels and time of application												
T1	11.57	11.33	11.45	11.51	11.17	11.34	13.35	12.87	13.11	16.33	17.58	16.96
T2	11.73	11.55	11.64	11.77	11.50	11.63	13.91	13.02	13.80	17.40	18.44	17.92
T3	10.70	10.46	10.58	12.27	11.98	12.12	14.41	13.81	14.11	18.00	19.48	18.74
T4	10.85	10.61	10.73	12.55	12.21	12.38	14.66	14.30	14.48	19.36	19.56	19.46
T5	11.11	10.90	11.01	12.99	12.67	12.83	15.07	14.78	14.93	19.73	21.44	20.59
T6	11.35	11.12	11.23	13.42	13.07	13.24	15.39	15.02	15.20	21.31	22.18	21.74
SE(m)±	0.30	0.31	0.31	0.53	0.50	0.51	0.80	0.91	0.76	0.70	0.72	0.45
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.02	2.07	1.28

Table 3 : Yield attributes of rice as influenced by different paddy straw management options and fertilizer N levels.

	Panicle length (cm)			Productive tillers per hill			Number of grains per panicle			1000 seed weight (gms)		
Treatments	**2021-22**	**2022-23**	**Pooled data**	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**Pooled data**	**2021-22**	**2022-23**	**pooled data**
Burning	21.06	21.45	21.25	13.77	14.78	14.27	90.15	88.06	89.11	22.60	22.97	22.78
Incorporation	21.86	22.27	22.06	14.94	15.84	15.39	93.05	90.040	91.73	23.51	23.93	23.72
Cutting and removal	20.32	20.69	20.50	12.58	13.73	13.15	86.98	84.31	85.65	21.16	21.53	21.35
SE(m)±	0.51	0.50	0.50	0.36	0.55	0.38	1.67	1.66	1.66	0.40	0.40	0.40
CD	NS	NS	NS	1.04	1.59	1.08	4.81	4.76	4.77	1.15	1.16	1.15
Nitrogen levels and time of application												
T1	20.05	20.45	20.25	11.38	12.44	11.91	84.33	81.97	83.15	21.28	21.66	21.47
T2	20.42	20.83	20.62	12.46	13.44	12.95	87.42	84.93	86.18	21.60	22.01	21.81
T3	20.83	21.17	21.00	13.03	13.89	13.46	89.08	87.06	88.07	22.22	22.56	22.39
T4	21.23	21.64	21.43	14.24	15.06	14.65	90.75	88.50	89.62	22.71	23.12	22.92
T5	21.71	22.08	21.90	15.40	16.42	15.91	93.35	90.59	91.97	23.09	23.46	23.28
T6	22.24	22.64	22.44	16.07	17.44	16.76	95.44	92.50	93.97	23.64	24.04	23.84
SE(m)±	0.72	0.71	0.71	0.51	0.78	0.53	2.37	2.34	2.35	0.57	0.57	0.57
CD	NS	NS	NS	1.47	2.25	1.52	6.80	6.73	6.75	1.63	1.63	1.63

Table 4 : Grain yield and straw yield (kg ha^{-1}) of rice as influenced by paddy straw management options and fertilizer N levels

	Grain Yield			Straw Yield		
Treatments	**2021-22**	**2022-23**	**pooled data**	**2021-22**	**2022-23**	**pooled data**
Burning	7081.0	7245.2	7163.1	9082.3	9283.3	9182.8
Incorporation	7630.9	7774.9	7702.9	9687.3	9873.9	9780.6
Cutting and removal	6524.4	6718.9	6621.6	8414.4	8656.1	8535.2
SE(m)±	185.79	177.7	140.84	235.04	243.64	190.54
CD	533.96	510.73	404.77	675.50	700.22	547.63
Nitrogen levels and time of application						
T1	6596.2	6766.5	6681.4	8685.8	8926.4	8806.1
T2	6353.4	6520.3	6436.8	8321.9	8530.0	8425.9
T3	7068.4	7235.5	7151.9	8968.9	9170.5	9069.7
T4	6978.9	7146.2	7062.5	8788.5	9007.7	8898.1
T5	7603.4	7770.9	7687.2	9645.3	9836.7	9741.0
T6	7872.1	8038.5	7955.3	9957.6	10155.2	10056.4
SE(m)±	262.74	251.31	199.17	332.39	344.55	269.47
CD	755.13	722.28	572.43	955.31	990.26	774.46