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Effect of Rice Crop Residue Management Techniques and Nitrogen Levels on Growth and Yield of Succeeding Sorghum

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ABSTRACT: The present investigation was carried out during *rabi* season of 2021-22 on a sandy clay loam soil at the Agricultural College Farm, Bapatla to study the effect of various rice crop residue management techniques and nitrogen levels on growth and yield of sorghum. The experiment was laid out in split-plot design with four rice crop residue management techniques (M_1: No residue, M_2: Burning of residue, M_3: Incorporation of residue with rotovator without application of ANGRAU decomposer and M_4: Incorporation of residue with rotovator after application of ANGRAU decomposer as main plot treatments and four nitrogen levels (Control, 40 kg ha^{-1}, 80 kg ha^{-1} and 120 kg ha^{-1}) as sub plot treatments. Mean values for rice crop residue management techniques revealed that plant height, dry matter accumulation, test weight, grain yield were maximum with incorporation of residue with rotovator after application of ANGRAU decomposer (M_4). However, test weight showed non-significant results. Mean values for nitrogen levels revealed that highest plant height, dry matter accumulation, test weight, grain yield of sorghum were recorded with 120 kg ha^{-1} (S_4). Thus, Incorporation of residue with rotovator after application of ANGRAU decomposer (M_4) and application of 120 kg ha^{-1} (S_4) is an optimum and sustainable approach to enhance the growth and yield of succeeding sorghum.

Keywords: Rice crop residue, Nitrogen levels, Plant height, Test weight and succeeding sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is the fifth most important food crop of the world after wheat, maize, rice and barley. India is the second largest producer of sorghum in the world, it occupies an area of 5.13 m ha with a production of 4.37 mt and productivity of 852 kg /ha (*Directorate of Economics and Statistics*, 2021).

Continuous cropping with inorganic fertilizer causes decline in soil organic matter and loss of inherent fertility (Muhammad *et al*., 2011). This has led to the renewed interest in use of organic manures as sources of soil organic matter (Yaduvanshi, 2003). Among the available organic sources, crop residues are the most important sources of nutrients to the crop in addition to improving soil health. In India, total 516.3 tonnes of crop residues are being generated every year of which rice crop residues comprises 122.6 tonnes (Devi *et al.*, 2017). Crop residues are important natural resource for the stability of agricultural ecosystems.

Cereal crops (rice, wheat, maize, millets) contribute 70%, while rice crop alone contributes 34% to the crop residues. On an average, rice crop residues contain 0.7% N, 0.23% P and 1.75% K. Therefore, the amount of NPK contained in rice crop residues produced is about 22.13×10^6 and 26.26×10^6 t year^{-1} in Asia and world respectively. Recently, with the advent of mechanized harvesting, farmers have been burning *in-situ* large quantities of crop residues left in the field as which interfere with tillage and succeeding operations for the subsequent crop, causing loss of nutrients and soil organic matter. Burning of residues leads to loss of nutrients i.e. 80 per cent of N, 25 per cent of P, 21 per cent of K and up to 60 per cent of S (Mandal *et al.*, 2004) and also caused emission of 18 per cent black carbon which is second largest contributor in global warming (Ramanathan and Carmichael 2008).

The possible management options for rice residue are surface retention, use of incorporation of straw, mulching and removal of rice straw. Incorporation of rice straw immediately before sowing of succeeding crop decreased the grain yield due to immobilization of nitrogen (Chivenge *et al.,* 2020) because of wider C/N ratio of rice straw but it can be managed successfully if sufficient time is provided between residue incorporation and sowing of wheat crop .The rice straw comprises majority of the cellulose (36-37%) and hemicellulose (23-24%) encrusted by lignin (15-16%) along with a small quantity of protein, thereby making it high in the ratio of C: N and hence is resistant to the decomposition of microbes compared to the straws of wheat and barley (Sangwan and Deswal 2021). To alleviate such problems, lignocellulolytic microbes are utilized effectively to make the process economically viable and sustainably efficient. The microbial consortium showed efficient degradation of rice straw, which cellulose, hemicelluloses and lignin lost 71.7%, 65.6% and 12.5% of its weight, respectively, in 20 days at 15°C (Zheng *et al.,* 2020).

Of late, the area under rice fallow pulses is gradually declining due to severe attack of viral diseases (Mishra *et al.,* 2013). However, in areas where the water resources are frugal there is a prospective situation for taking up sorghum as an alternative crop to pulse during *rabi*. Further, the application of nitrogen even in balanced form may not sustain fertility under continuous cropping. A need based crop residue and nitrogen management plan should be developed duly considering quantity of crop residues being produced, availability of infrastructure and equipment for management of crop residue. Thus, the present investigation was therefore undertaken to study the effect of various rice crop residue management techniques and nitrogen levels on growth and yield of succeeding sorghum.

MATERIALS AND METHODS

An experiment was conducted with four rice crop residue management techniques M_1: No residue, M_2: Burning of residue, M_3: Incorporation of residue with rotovator without application of ANGRAU decomposer and M_4: Incorporation of residue with rotovator after application of ANGRAU decomposer as main plot treatments and four nitrogen levels (Control, 40 kg ha^{-1}, 80 kg $ha^{-1}$and 120 kg ha^{-1}) as sub plot treatments which was replicated thrice. It was carried out on sandy clay loam soils of Agricultural College Farm, Bapatla during *rabi,* 2021-22 and the soil was neutral in reaction, non saline, low in Organic Carbon, low in available Nitrogen, medium in available Phosphorus and medium in available Potassium. During the crop growth period, the weekly mean maximum temperature ranged from 29.7 to 33.3°C with an average of 31.7°C. The weekly mean minimum temperature ranged from 20.0 to 21.2°C with an average of 19.8°C. A total rainfall of 60.3 mm was received during the crop growth period. The test variety used for sowing was Mahalaxmi hybrid and crop was sown at 45 cm and 15 cm inter and intra row distance, respectively and adopted all the standard package of practices. Application of nutrients was done as per the treatments in the form of urea, single super phosphate and muriate of potash respectively. Nitrogen was applied in two equal splits *viz.*, at basal and knee high stage. Entire recommended dose of phosphorus 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} was applied at basal in the form of single super phosphate and muriate of potash, respectively at the time of sowing.

After harvest of rice panicles, residues of the rice crop were retained. Rice residues were added as per treatment in the four main plots. In residue removal plots, the residues were completely removed after harvest of the crop. Twenty five days were allowed for decomposition of crop residues with the application of ANGRAU decomposer during the year of experimentation. The data on plant height, drymatter accumulation, test weight and grain yield were recorded as per standard procedures. Statistical analysis of all the data are carried out following the analysis of variance technique for split plot design as outlined by Panse and Sukhatame (1985).

RESULTS AND DISCUSSION

Effect of rice crop residue management techniques and nitrogen levels on plant height. The calculated mean data related to plant height of sorghum at harvest as affected by rice crop residue management techniques and nitrogen levels have been summarized and presented in Table 1. The interaction at harvest was found to be non-significant.

Highest plant height values at harvest were recorded with Incorporation of residue with rotovator after application of ANGRAU decomposer (M_4) and least plant height of sorghum was observed with no residue (M_1). This might be due to residue incorporation along with microbial consortium fasten the decomposition process and released nutrients rapidly or reduced the losses of nutrients might have been utilized by the crop and produced comparable plant height under afore said treatments (Mukesh, 2019).

With respect to fertility levels, at harvest highest plant height of sorghum was obtained with application of 120 kg N ha^{-1} (S_4) and lowest plant height was observed with control (S_1) . This might be due to due to cell elongation, cell enlargement and more chlorophyll synthesis,resulted in better plant growth. The increase in plant height in response to higher levels of nitrogen was in conformity with the previous findings of researchers like Kaushik and Shaktawat (2005); Verma *et al.* (2005); Yakadri and Murali (2009)

Effect of rice crop residue management techniques and nitrogen levels on drymatter accumulation. Data pertaining to dry matter accumulation of sorghum at harvest as affected by rice crop residue management techniques and nitrogen levels are presented in Table 1. Interaction at harvest was found to be non-significant. A glance at the data indicates that highest drymatter accumulation was obtained with incorporation of residue with rotovator after application of ANGRAU decomposer (M_4) and lowest drymatter accumulation was obtained with no residue (M_1). This might be due to addition of microbial consortium 25 days before sowing for decomposition of residue also improved soil physical condition, enhanced availability of nutrients and growth parameters (height, tillers and leaves) and finally dry matter production and Organic matter added in soil in form of crop residue might have also released almost all the essential elements necessary for growth and development as reported by Mukesh (2019).

Among the nitrogen levels, at harvest highest dry matter accumulation was obtained with application of 120 kg N ha^{-1} (S_4) and lowest dry matter accumulation was observed with control (S_1). This might be due to adequate supply of nitrogen accelerated the growth of jowar. This inturn, put forth adequate photosynthetic surface and efficiency, in enhancing the carbohydrate metabolism, thus contributing to greater drymatter accumulation. Maintenance of balanced nutrition might have resulted in greater availability of nutrients from the soil. These results are in confirmity with the findings of Gutte and Karanjikar (2007).

Effect of rice crop residue management techniques and nitrogen levels on test weight. Test weight did not differ significantly among the rice crop residue management techniques and N levels taken for study. However interaction effect showed non significant results.

Effect of rice crop residue management techniques and nitrogen levels on grain yield. The data pertaining to grain yield of sorghum as affected by rice crop residue management techniques and nitrogen levels are presented in Table 1. However, Interaction was found to be non-significant. With respect to rice crop residue management techniques, highest grain yield was obtained with incorporation of residue with rotovator after application of ANGRAU decomposer (M_4) and lowest grain yield was obtained with no residue (M_1). This might be due to the application of microbial consortium increased residue decomposition and several rice physiological processes, which includes net photosynthetic rate, transpiration and internal CO_2 concentration, enhance crop growth components including plant height, number of leaves, and number of tillers and finally grain and straw yields (Deshmukh *et al*., 1988; Mukesh, 2019; Pandey and Agarwal 1991).

Among nitrogen levels, highest grain yield was obtained with application of 120 kg N ha $^{-1}$ (S_4) and lowest grain yield was obtained with control (S_1). This might be due to it might have promoted the growth of roots as well as functional activity resulting in higher extraction of nutrients from soil environment to aerial plant parts. The improvement in yield attributes with N consequently resulted in higher grain yield. The yield could be as a result of good drymatter production for grain filling as a result of greater number of leaves. These results are in complete agreement with the findings of Miko and Manga (2008); Lingaraju *et al.*, (2010); Sareen and Sharma (2010).

Table 1: Plant height (cm), Drymatter accumulation (kg ha^{-1}) , Test weight (g) and grain yield (kg ha^{-1}) at harvest of sorghum as influenced by rice crop residue management techniques and nitrogen levels during *rabi*, 2021-22.

Treatments	Plant height	Drymatter accumulation	Test weight	Grain yield
Rice residue management techniques				
M_1 - No residue	121.7	7640	23.8	3024
M_2 - Burning of residue	134.6	8584	23.9	3509
M_3 - Incorporation of residue with rotovator without application of ANGRAU decomposer	147.5	9427	24.2	3918
M_4 - Incorporation of residue with rotovator after application of ANGRAU decomposer	158.8	10247	24.3	4340
SEm (±)	2.46	214.2	0.44	116.3
CD (p=0.05)	8.5	741	NS	403
CV (%)	6.1	8.3	5.3	9
Nitrogen levels (kg ha^{-1})				
S_1 - 0	101.9	6573	23.1	2493
S_2 - 40	141.9	8871	23.6	3634
S_3 - 80	155.9	9700	24.5	4077
S_4 - 120	162.7	10753	25.1	4587
SEm (±)	2.72	257.6	0.53	129.1
CD (p=0.05)	8.0	752	NS	377
CV (%)	6.7	9.9	6.0	10
Interaction				
M × S	NS	NS	NS	NS
S × M	NS	NS	NS	NS

CONCLUSION

Based on the above results and discussion, it can be concluded that incorporation of residue with rotovator after application of ANGRAU decomposer (M_4) and application of 120 kg N ha $^{-1}$ (S_4) were found to be the most effective and sustainable approach to enhance the growth and yield of succeeding sorghum.

FUTURE SCOPE

Based on research work done, it can be used as reliable work for further reference. Studies need to be undertaken to evaluate the effect of timing of rice residue incorporation and nutrient management practices in rice-sorghum cropping system.

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Conflict of Interest. None.

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