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Influence of residual maize crop residue management techniques and fertilizer levels on growth and productivity of zero till maize in rice-maize sequence

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ABSTRACT

A field trial was conducted on a sandy clay loam soil during *rabi* seasons of 2020-21 and 2021-22 at the Agricultural College Farm, Bapatla to investigate the residual effect of maize crop residue management techniques and fertilizer levels on growth and productivity of zerotill maize in rice-maize sequence. The experiment was laid out in split-split plot design with four maize crop residue management practices (M_1: Exportation of maize stover, M_2: *In-situ* burning of maize stover (farmers practice), M_3: Mulching maize stover with rotary mulcher and M_4: Incorporation of maize stover with rotovator) as main plot treatments and three fertility levels (100% RDF, 75% RDF and 50% RDF) as sub plot treatments applied to *kharif* preceded rice and three fertility levels (100% RDF, 75% RDF and 50% RDF) as sub-sub plot levels applied to succeeding maize. Results revealed that incorporation of maize stover with rotovator (M_4) applied to preceding rice significantly improved plant height (cm), days to 50% tasseling and 50% silking, cob length (cm), cob girth (cm), test weight (g) and grain yield of maize. Mean values for fertiliser levels revealed that plant height (cm), days to 50% tasseling and 50% silking, cob length (cm), cob girth (cm), test weight (g) and grain yield were registered with application of 100% RDF (S_1) applied to preceding rice and application of 100% RDF applied to succeeding maize. Thus, incorporation of maize stover with rotovator (M_4) along with application of 100 % RDF applied to preceding rice and application of 100% RDF (S_1) to succeeding maize is an optimum and sustainable approach to enhance the growth and productivity of zero till maize in rice-maize system.

Key words: *Maize crop residue, Fertility levels, Plant height, Days to 50% silking, Cob length, and grain yield*

Introduction

Rice - pulse sequence was a dominant cropping sequence in Krishna agro-climatic zone of Andhra Pradesh. The area under this sequence has declined due to late planting of rice in consequence of delay in onset of monsoon and severe incidence of yellow mosaic virus on pulse crop (Mishra *et al.*, 2013). In the changed scenario, maize is rapidly becoming a viable alternative for farmers as a component crop in a rice-based system. The profitability and increased productivity of maize are the driving forces behind these improvements. Rice-maize systems are predominantly practiced in India's south and north-east, with acreage of more than 0.5 million ha. Andhra Pradesh has the greatest rice-maize acreage

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in south India, where this system is rapidly expanding using resource-saving technology, primarily zero tillage (Jat *et al.*, 2009).

Management of stover after maize harvest poses an enormous challenge to all maize farmers around the globe. Maize stover contains 9.16 kg N, 2.08 kg P, 15.78 kg K, 5.17 kg Ca, 3.62 kg Mg and 1.54 kg S per ton (Mukesh, 2019). Nowadays, the use of maize stalk as animal fodder is gradually decreasing and instances of on field burning of stover is increasing due to non availability of agriculture labor for timely harvesting, increase in transportation costs and lack of sufficient time to take up next season crops. Maize stover burning contributes more than 80% of the entire biomass open burning emissions (Permadi and Oanh, 2013). The beneficial effects of stover burning on productivity are generally restricted to the short term. As opposed to that, removal of crop residues reduces the fertility of the soil. Recycling of nutrients (N, P, and K) through crop residue incorporation and retention is one of the desirable alternatives for minimizing this problem, since it may lead to proper disposal and assist overcome deficits of other nutrients. Fertilizer application is one of the largest expenses for farmers growing cereal crops and yet much of the N, P and K used to supplement crop needs are lost to the environment due to the low nutrient use efficiency of cereal crops. Over or under N, P and K fertilizer application can lead to a reduction in crop yield, in addition to creating conditions which favor nutrient losses to the environment, poor soil quality and plant nutrition.

In general, agro inputs (organic manure, residue, and fertilisers) provided to the primary crop have a residual effect on consecutive crops. Many authors in various cropping systems have reported the positive influence of residual agro inputs on crop productivity. Bharathi and Poongothai, (2008), Bilkis *et al.* (2018) and Kumari *et al.* (2018). Keeping all of this in mind, the current study was undertaken to investigate the residual influence of maize crop residue management practises and fertility levels on growth and productivity of zerotill maize in a rice-maize sequence.

Materials and Methods

An experiment was conducted with four maize residue management practices M_1: Exportation of maize stover, M_2: *In-situ* burning of maize stover (farmers practice), M_3: Mulching maize stover with rotary mulcher and M_4: Incorporation of maize stover with rotovator) as main plot treatments applied to preceding rice and three fertility levels (100% RDF, 75% RDF and 50% RDF) as sub plot treatments applied to preceding rice and three fertility levels (100% RDF, 75% RDF and 50% RDF) as sub-sub plot treatments applied to *rabi* maize. At the end of *kharif* season, after harvest of rice crop, maize was sown as a zero tillage crop with 36 treatments. The experiment was conducted on a sandy clay loam soil during *rabi* seasons of 2020-21 and 2021-22 at the Agricultural College Farm, Bapatla. This trial was laid in a split-split plot with three replications. The experimental soil was slightly alkaline in reaction; E.C was non-saline in nature and below the critical point, low in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. The average maximum and minimum temperatures were 31.6 ^{0}C and 20.0 ^{0}C during *rabi,* 2020-21 and 31.7 ^{0}C and 19.8 ^{0}C during *rabi,* 2021-22, respectively. A total rainfall of 23 mm and 60.3 mm received during *rabi* seasons of 2020-21 and 2021-22, respectively. The test variety used for sowing was Pioneer P-3396 and crop was sown at 60 cm and 20 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 3 equal split doses *viz.,* at basal, knee-high and tasseling stage. During both years of study, the entire prescribed dose of phosphorus and potassium was applied at the time of sowing in the form of single super phosphate and muriate of potash, respectively. Recommended fertilizer dose of rice and maize for Krishna-Godavari of Andhra Pradesh is 120-60-40 kg NPK ha^{-1} and 240-80-80 kg NPK ha^{-1}, respectively. After harvest of maize cobs, residues of the maize crop were retained. Maize 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. Ninety five days were allowed for decomposition of crop residues during both the years of experimentation. The data on growth attributes, yield attributes and grain yield were recorded as per standard procedures. All data are statistically analysed using the analysis of variance technique for split plot design as described by Panse and Shukhatme (1978). Statistical significance was tested by applying F-test at 0.05 level of probability.

Results and Discussion

Effect of maize crop residue management practices and fertility levels imposed to *kharif* rice and fertility levels applied to succeeding zerotill maize on growth and yield of maize

Plant height (cm) at harvest

From Table 1, the taller plants of maize at harvest recorded when the preceding rice was supplied with incorporation of maize stover with rotovator (M_4) found significantly superior to the rest of the treatments. These treatments were followed by M_3 and M_2 which were comparable. The lower values of plant height of *rabi* maize at all the growth stages noticed with exportation of maize stover (M_1) in rice was significantly inferior to all the treatments during both the years of study. The increased plant height in M_4 plot might be due to increased nitrogen availability from the decomposition of crop residue and it has created a positive effect on availability of nutrients to the succeeding maize crop resulted in enhanced plant height. The results were in agreement with the research findings of Dhar *et al.* (2014) in rice-wheat cropping system and Dinesh Kumar *et al.* (2019) in rice-maize cropping system.

In terms of rice residual fertility levels, applying 100% RDF in preceding rice resulted in a considerable increase in plant height of succeeding maize at harvest as compared to the other treatments. This could be because of the residual effect of NPK application coupled with favourable growing conditions. The present findings are in line with the earlier study conducted by Burio *et al.* (2004), who showed comparable results with increasing levels of N, P, and K.

With increasing dose of fertilizers from 50% RDF to 100% RDF have significantly increased the plant

Table 1. Growth attributes of zerotill maize as influenced by maize crop residue management practices and fertility levels applied to *kharif* rice crop and fertility levels to *rabi* maize, 2020-21 and 2021-22

Treatments	2020-21			2021-22		
	Plant height (cm) at harvest	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Days to 50% tasseling	Days to 50% silking
Residual response of maize crop residue management practices						
M_1- Exportation of maize stover	216.2	65	70	217.8	64	70
M_2- In-situ burning of maize stover (farmers practice)	233.6	63	69	236.9	62	68
M_3- Mulching maize stover with rotary mulcher	241.5	63	68	244.9	62	67
M_4- Incorporation of maize stover with rotovator	256.8	62	67	260.2	61	66
S.Em±	3.85	0.9	1.0	4.18	1.0	0.9
CD (p = 0.05)	13.3	NS	NS	14.5	NS	NS
CV (%)	8.4	7.4	7.6	9.2	8.3	6.7
Residual response of fertility levels						
S_1-100% RDF	254.5	63	68	258.9	62	67
S_2- 75% RDF	236.8	63	68	239.8	62	68
S_3- 50% RDF	219.8	64	70	221.2	63	69
S.Em±	2.47	0.5	0.7	3.20	0.7	0.7
CD (p = 0.05)	7.4	NS	NS	9.6	NS	NS
CV (%)	6.3	5.0	6.0	8.0	6.9	5.8
F_1-100% RDF	253.6	62	68	258.3	61	67
F_2- 75% RDF	236.9	63	69	239.0	62	68
F_3- 50% RDF	220.6	65	69	222.6	64	69
S.Em±	2.17	0.9	0.6	2.78	0.9	0.6
CD (p = 0.05)	6.2	NS	NS	7.9	NS	NS
CV (%)	5.5	8.7	5.1	7.0	8.4	5.4
Interaction						
M x S	NS	NS	NS	NS	NS	NS
M x F	NS	NS	NS	NS	NS	NS
S x F	NS	NS	NS	NS	NS	NS
M x S x F	NS	NS	NS	NS	NS	NS

height applied to succeeding maize. This could be owing due to increased nutritional availability and utilisation, which leads to greater absorption, cell division, and cell elongation. Hari Krishna, (2018) observed a similar outcome of taller plants at higher fertility levels.

Days to 50 Percent tasseling and Days to 50 Percent silking

Days to 50 percent tasseling and days to 50 percent silking of *rabi* maize was not affected by the maize crop residue management practices and fertility levels applied in *kharif* rice and fertility levels to *rabi* maize and the interaction during two years of the experiment (Table 1).

Cob length (cm) and cob girth (cm)

The cob length and cob girth in *rabi* maize was noticeably influenced by maize crop residue management practices and fertility levels given to preceding rice and fertility levels imposed to maize. However, the interaction between them could not reach level of significance (Table 2).

The cob length and cob girth in *rabi* maize was significantly higher in rice preceded plots received with incorporation of maize stover with rotovator (M_4) followed by M_3 and M_2 treatment and in converse preceded rice plots with exportation of maize stover (M_1) registered statistically lower cob length and girth in maize during both years of the study. The higher cob length with M_4 treatment might be due to incorporation of organic material which may have released all macro and micro nutrients essential for plant growth, encouraged microbial population and improved physical condition of soil that leads to increase in yield contributing characters

Table 2. Yield attributes and grain yield of zerotill maize as influenced by maize crop residue management practices and fertility levels applied to *kharif* rice crop and fertility levels to *rabi* maize, 2020-21 and 2021-22

Treatments	2020-21				2021-22			
	Cob length (cm)	Cob girth (cm)	Test weight (g)	Grain yield (kg ha^{-1})	Cob length (cm)	Cob girth (cm)	Test weight (g)	Grain yield (kg ha^{-1})
Residual response of maize crop residue management practices								
M_1- Exportation of maize stover	12.3	11.0	24.9	6413	13.2	10.8	25.3	6694
M_2- In-situ burning of maize stover (farmers practice)	14.7	12.2	25.3	7259	15.0	11.8	25.7	7509
M_3- Mulching maize stover with rotary mulcher	15.9	14.2	26.2	8017	16.2	14.1	26.5	8250
M_4- Incorporation of maize stover with rotovator	17.1	15.8	26.4	8683	17.5	16.5	26.9	8883
S.Em ±	0.34	0.29	0.33	103.9	0.38	0.33	0.38	138
CD (p = 0.05)	1.2	1.0	NS	359	1.3	1.1	NS	478
CV (%)	11.9	11.2	6.7	7.1	13.1	12.8	7.7	9.5
Residual response of fertility levels								
S_1-100% RDF	16.4	14.4	26.0	8283	16.8	14.8	26.5	8572
S_2- 75% RDF	15.0	13.8	25.7	7709	15.3	13.3	26.1	7950
S_3- 50% RDF	13.6	11.7	25.4	6787	14.2	11.8	25.7	6980
S.Em±	0.16	0.19	0.25	77.6	0.29	0.22	0.28	94
CD (p = 0.05)	0.50	0.6	NS	233	0.90	0.70	NS	283
CV (%)	6.4	8.6	5.8	6.1	11.4	10.1	6.4	7.2
Fertility levels applied to maize								
F_1-100% RDF	16.1	14.3	25.8	8425	17.0	14.5	26.3	8690
F_2- 75% RDF	14.9	13.2	25.7	7657	15.4	13.2	26.1	7899
F_3- 50% RDF	14.0	12.4	25.5	6698	14.0	12.3	25.9	6913
S.Em±	0.21	0.23	0.23	67.7	0.29	0.26	0.26	83
CD (p = 0.05)	0.6	0.7	NS	192	0.80	0.70	NS	237
CV (%)	8.3	10.5	5.4	5.3	11.2	11.9	6.0	6.4
Interaction								
M x S	NS	NS	NS	NS	NS	NS	NS	NS
M x F	NS	NS	NS	NS	NS	NS	NS	NS
S x F	NS	NS	NS	NS	NS	NS	NS	NS
M x S x F	NS	NS	NS	NS	NS	NS	NS	NS

(Verma *et al.,* 2003).

Among the fertility levels applied to *kharif* rice, application of 100% RDF (S_1) resulted in increased cob length and cob girth in maize and was significantly superior to other treatments. The lower dose of fertility level *i.e.,* 50% RDF resulted in lower values of cob length and cob girth. Ginting *et al.* (2003) and Tabibian *et al.* (2012) expressed that 'the residual effects of NPK fertilizers applied on the same site for consecutive many years, affect soil chemical properties, improving soil quality and thus, it leads to increase in yield attributes.

With respect to fertility levels given to *rabi* maize, higher cob length and cob girth was noticed in 100% RDF (F_1) treatment which was found to be statistically superior to 75% RDF (F_2) and 50% RDF (F_3). The findings of Meena *et al.* (2013) and Venkat Rao *et al.* (2014) are consistent with the preceding findings.

Test weight (g)

Data analyzed for test weight (g) of maize presented in Table 2 revealed that the maize crop residue management practices and fertility levels given to preceding rice and graded levels of fertilizers applied to maize did not influence the test weight of maize. Their interaction was also found to be non significant during both years of investigation.

Grain yield (kg ha^{-1})

Data pertaining to grain yield of zerotill maize as influenced by maize crop residue management practices and fertility levels given to preceding rice and graded levels of fertilizers applied to maize are presented in Table 2.

Computation and analysis of the data related to grain yield of zerotill maize with respect to maize crop residue management practices imposed to *kharif* rice crop indicated that grain yield of maize was registered with incorporation of maize stover in proceeding rice with rotovator (M_4).

Data on grain yield of zero-till maize with regard to maize crop residue management practices imposed to *kharif* rice crop were computed and analyzed, and revealed that grain yield of maize was registered with incorporation of maize stover with rotovator (M_4) in previous rice crop and it was found statistically superior to other treatments. These treatments were followed by M_3 and M_2 treatment. With the exportation of maize stover (M_1), a considerable drop in grain production was observed. The percentage increase in yield with incorporation of maize stover with rotovator was 35.4% and 32.7% over residue removal during 2020-21 and 2021-22 respectively. The superiority of M_4 treatment in earlier rice crop for realization of higher yields in maize might possibly be due to incorporation of residue that provided positive impact on maintaining the buildup of soil organic matter, which in turn, helped in improving the soil's structure, pore size and water-holding capacity, increase in microbial population in rhizosphere of maize. Current results are in accordance with the findings of Hari Narayan, (2017), Kumari *et al.* (2018) and Mukesh Kumar, (2019).

With respect to fertility levels given to preceding rice crop, application of 100% RDF (S_1) recorded highest grain yield of maize which was remarkably superior to 75% RDF (S_2) and 50% RDF (S_3). Grain yield of 8283 and 8572 kg ha^{-1} were obtained during 2020-21 and 2021-22, respectively with 100% RDF recording an increase of 22.0% and 22.8% over 50% RDF (S_3) during both the years. This could be because of increased amount of leftover nutrients linked with the increased fertility levels used in the previous rice harvest, which affected crop growth and yield attributes, ultimately enhancing the grain yield of the succeeding maize. The findings were consistent with those of Rathiya *et al.* (2020) and Pradhan *et al.* (2021), who found that leftover nutrients had a favourable effect on the yield of the next crop that recorded the highest grain yield.

With an increase in fertility level given to zerotill maize, the higher grain yield of maize was significantly increased from 50% RDF to 100% RDF respectively in both years of the experiment. The response to increased level of N, P and K could improve physiological processes, plant metabolism and development. Maize being an exhaustive feeder could use this nutrient for increasing the physiological processes of plants thereby resulting in higher grain yields. The nutrients augment the supply of carbohydrates to kernels, boosting yield components like cob length, cob girth and number of kernels cob^{-1} might have a direct impact on the production of grain yield. These results are in accordance with Venkata Rao *et al.* (2016) and Lakshmi *et al.* (2017) who found that revealed that maximum grain production in zero-till maize was achieved by applying a high dose of nitrogen.

Conclusion

Based on a two years field trial, it was determined that there is a positive residual effect on succeeding maize crop, significantly highest growth attributes, yield attributes and grain yield was recorded with incorporation of maize stover with rotovator along with application of 100 % RDF applied to preceding rice and application of 100% RDF to succeeding maize. Thus, incorporation of maize stover with rotovator along with application of 100% RDF applied to preceding rice and application of 100% RDF to succeeding maize were found to be more effective and sustainable approach to enhance the growth and yield of zerotill maize in rice-maize sequence.

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Conflict of Interest

The authors declare that they have no conflict of interest

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