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GROWTH AND YIELD OF MAIZE (*Zea mays* L.) AS INFLUENCED BY CROP RESIDUES, RESIDUAL NUTRIENTS AND NUTRIENT MANAGEMENT PRACTICES

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ABSTRACT

During *rabi,* 2014 and 2015 at Agricultural College Farm, Mahanandi plant height of maize differed significantly due to residual nutrients (main plots), nutrient doses ± crop residues (sub plots) at harvest. Leaf area index differed significantly with respect to nutrient doses ± crop residues at harvest during the second year, but interaction was not significant. There was significant influence of residual nutrients and nutrient doses ± crop residues on the dry matter production of maize. Significantly higher grain yield of maize was recorded in N_3P_2 and N_3P_3 in both the years with respect to residual nutrients. With respect to crop residues significantly higher grain yield was recorded with F_2 (125% of F_1) which was however on par with F_4 (F_2 + *Kharif* crop residue incorporation) in both the years.

KEYWORDS: Maize, Nutrient doses, Crop residues, Plant height, Dry matter and Yield.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal food crop cultivated both in tropical and temperate regions of the world with the highest production and productivity as compared to rice and wheat. India is the sixth largest producer of maize with 22.36 million tonnes of production from 9.40 million hectares, with a productivity of 2.4 t ha^{-1}. Now it is time to refine agricultural research in the line of cropping system approach, recycling of residues and efficient management of important nutrients like nitrogen and phosphorus particularly for staple food crops of rice, wheat and maize.

Crop residues are the parts of crops left over after the usable portions have been removed. Crop residues incorporated into the soil can serve as a source of nutrient recycling for plant growth and maintenance of soil fertility (Cooperband, 2002). The estimated annual production of crop residues in India is 501 million tonnes, containing 8.02 million tonnes of NPK (MNRE, 2009). Jain (1993) reported that in India, large quantities of crop residues are made available every year and about one third of the residues produced are available for direct recycling on the land and if used can add 2.19 million tonnes of NPK annually.

MATERIAL AND METHODS

The field experiment was conducted at College Farm of Agricultural College, Mahanandi campus of Acharya N.G. Ranga Agricultural University during *rabi* seasons of 2014 and 2015, situated at 15.51°N latitude, 78.61°E longitude and at an altitude of 233.5 m above the mean sea level, in the scarce rainfall zone of Andhra Pradesh. A composite soil sample was collected at random from 0-30 cm soil depth and analyzed for physico-chemical properties prior to start of the experiments. The soil was sandy loam in texture, neutral in reaction, low in organic carbon and available nitrogen, high in available phosphorus and potassium. The experiment was conducted in the same plots of *kharif* season and was laid out in a split-plot design with three replications.

Treatments

There were nine main plots consisting of three nitrogen levels and three phosphorus levels of *kharif* season and four sub plots comprising of fertilizer and crop residue management practices.

Main plot treatments

Nine main plots (residual nutrients) consisting combination of three nitrogen levels 200, 250 and 300 kg N ha^{-1} (N_1, N_2 and N_3 respectively) and three phosphorus levels 40, 60 and 80 kg P_2O_5 ha^{-1} (P_1, P_2 and P_3 respectively) of *kharif* season.

Sub plot treatments

Four sub plots (nutrient doses ± crop residues) comprising of fertilizer and crop residue management

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practices. F_1 : Recommended dose of N and P_2O_5 (250 kg N and 80 kg P_2O_5 ha^{-1}) F_2 : 125% of F_1, F_3 : F_1 + *Kharif* crop residue incorporation and F_4 : F_2 + *Kharif* crop residue incorporation. A common dose of 60 kg K_2O ha^{-1} was applied to all the plots.

The crop was sown at a spacing of 75 cm × 15 cm. The test cultivar was P-3396 a single cross hybrid with the yield potential ranging from 7.5 to 8.0 t ha^{-1}. After harvest of the economic produce of *kharif* maize the stover was allowed to dry in the field itself and plot wise weight of the crop residue was recorded.

Plant height was recorded from the five tagged plants in each plot at harvest. It was measured from the base of the plant to the tip of the tassel and the mean plant height was expressed in cm. Leaf area was measured by using LI-COR model LI-300 leaf area meter with transparent conveyor belt (Model I-3050 A) utilizing an electronic digital display. Five plants from gross plot area to measure leaf area in cm^2. Leaf area index was calculated by dividing the total leaf area with corresponding land area as per the formula suggested by Watson (1952). Five plants from the destructive sampling area were cut to the base at harvest, sun dried and then oven dried at 60°C till a constant weight was obtained and expressed in kg ha^{-1}. Grain from net plot was sun dried sufficiently, cleaned thoroughly, weighed and expressed in kg ha^{-1}. The data recorded on various parameters during the course of investigation were statistically analyzed following the method of analysis of variance for split- plot design during *rabi* season as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Plant height

Irrespective of the treatments, plant height of maize progressively increased with age of the crop up to harvest. Variation in plant height was significant with respect to nutrient doses ± crop residues (sub plots) at harvest.

Table 1. Plant height (cm) of *rabi* maize at harvest as influenced by crop residues and nutrient management practices

	***Rabi,* 2014**					***Rabi,* 2015**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
N_1P_1	250	251	241	245	**247**	236	238	231	234	**235**
N_1P_2	237	244	242	245	**242**	225	232	230	230	**229**
N_1P_3	244	236	230	248	**239**	225	228	221	232	**227**
N_2P_1	225	238	239	249	**238**	212	239	230	229	**228**
N_2P_2	251	252	248	260	**253**	238	242	235	241	**239**
N_2P_3	246	248	236	248	**244**	237	229	224	230	**230**
N_3P_1	250	253	234	255	**248**	233	248	231	231	**236**
N_3P_2	259	261	249	243	**253**	237	248	223	248	**239**
N_3P_3	246	257	232	260	**248**	235	245	243	245	**242**
Mean	**245**	**249**	**239**	**250**		**231**	**239**	**230**	**236**	

	***Rabi,* 2014**		***Rabi,* 2015**	
	SEm ±	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**
NP	5.48	NS	6.93	NS
F	2.10	5.9	1.61	NS
NP at F	7.73	NS	8.09	NS
F at NP	10.97	NS	13.85	NS

Table 2. Leaf area index of *rabi* maize at harvest as influenced by crop residue and nutrient management practices

	Rabi, 2014					*Rabi,* 2015				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_1P_1	3.58	3.65	3.65	3.67	**3.64**	3.68	3.71	3.65	3.73	**3.69**
N_1P_2	3.63	3.64	3.56	3.75	**3.64**	3.35	3.57	3.20	3.76	**3.47**
N_1P_3	3.35	3.60	3.33	3.61	**3.47**	3.07	3.37	3.26	3.48	**3.30**
N_2P_1	3.52	4.02	3.36	3.53	**3.61**	3.44	4.10	3.40	3.52	**3.62**
N_2P_2	4.17	3.88	3.58	3.99	**3.91**	3.62	3.85	3.73	3.87	**3.77**
N_2P_3	4.04	4.08	3.56	3.83	**3.88**	3.74	3.88	3.83	3.91	**3.84**
N_3P_1	4.10	3.86	3.64	3.58	**3.80**	3.75	3.78	3.79	3.87	**3.80**
N_3P_2	3.53	4.14	3.72	3.78	**3.79**	3.74	4.01	3.58	3.67	**3.75**
N_3P_3	3.62	3.79	3.76	4.19	**3.84**	3.84	3.89	3.88	3.95	**3.89**
Mean	**3.73**	**3.85**	**3.57**	**3.77**		**3.58**	**3.80**	**3.59**	**3.75**	

	Rabi, 2014		*Rabi,* 2015	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	0.177	NS	0.131	0.39
F	0.121	NS	0.088	NS
NP at F	0.362	NS	0.264	NS
F at NP	0.355	NS	0.262	NS

There was some evidence of residual nitrogen effect on plant height of maize as higher plant height was observed in N_3P_2 (300 kg N + 60 kg P_2O_5 ha^{-1}) in the first year and N_3P_3 (300 kg N + 80 kg P_2O_5 ha^{-1}) in the second year, which might be due to the recovery of small percentage of nitrogen applied to previous maize crop. These results are in line with the findings of Felix *et al.* (2005) on the recovery of N fertilizers.

Application of 125% of recommended dose of N and P_2O_5 alone or along with crop residues expressed significant effect on plant height, as additional dose of fertilizer nutrients may be required for the mineralization of the incorporated crop residues as well as for the decomposition of the roots of the previous maize. These results are in conformity with the findings of Arshadullah *et al.* (2012), who documented the requirement of additional dose of nitrogen for rice crop when cultivated with straw incorporation. The lower plant height in 100% recommended dose of N and P_2O_5 along with crop residues might be due to the fact that un-decomposed residues with wider C: N ratio immobilized the N in the soil and released less N initially to the crop growth.

Leaf area index

Irrespective of the treatments, leaf area index of maize increased progressively with age of the crop.

Effect of residual nitrogen and phosphorus on LAI of succeeding maize was significant in the present investigation and the results are in accordance with the findings of Ahmad *et al.* (2007). There was evidence for residual effect of nitrogen as maximum LAI was observed in those plots which were supplied with more nitrogen in the previous season, which might be due to the recovery of small per centage of nitrogen applied to the previous maize crop. Similar response to the nitrogen applied in the preceding season was observed by Pandiaraj *et al.* (2015) on silty loam soils.

Table 3. Dry matter production (kg ha^{-1}) of *rabi* maize at harvest as influenced by crop residue and nutrient management practices

	Rabi, 2014					*Rabi,* 2015				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_1P_1	16441	18011	17114	16062	**16907**	15128	15664	15043	15589	**15356**
N_1P_2	16191	17163	16361	16240	**16489**	13986	14770	14075	15308	**14535**
N_1P_3	14762	16087	15941	15428	**15555**	13558	14513	14284	14824	**14295**
N_2P_1	15702	18855	16790	16133	**16870**	14165	16168	15448	15818	**15400**
N_2P_2	18273	17793	16935	17898	**17725**	15682	16582	16133	16629	**16257**
N_2P_3	18125	18211	16416	17792	**17636**	15815	16029	16302	16548	**16174**
N_3P_1	18927	19311	17327	17565	**18283**	15996	16096	16142	16603	**16209**
N_3P_2	16246	20574	18886	17874	**18395**	16337	17285	16477	16546	**16661**
N_3P_3	16396	18968	17306	17959	**17657**	16440	17098	17047	17139	**16931**
Mean	**16785**	**18330**	**17008**	**16995**		**15234**	**16023**	**15661**	**16112**	

	Rabi, 2014		*Rabi,* 2015	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	277.2	831	365.7	1096
F	168.1	473	183.1	515
NP at F	517.3	1507	600.2	NS
F at NP	554.4	1469	731.4	NS

The highest leaf area index was associated with the application of 125% of recommended dose of N and P_2O_5 alone (F_2), which was however, in parity with the application of 125% of recommended dose of N and P_2O_5 in combination with crop residue incorporation (F_4). Increase in leaf area index with increase in nitrogen levels along with crop residue incorporation was evident due to the favorable effect of nutrients on cell division and enlargement, resulting in production of more number of leaves as well as greater expansion of the individual leaf, there by consistent increase in leaf area per plant. These findings are in conformity with the results of Kiran (2004) and Mala (2008).

Dry matter production

Irrespective of the treatments, dry matter production of maize crop increased progressively with age of crop up to harvest.

Dry matter production differed significantly due to residual nutrient effects (main plots), nutrient doses ± crop residues (sub plots) and their interaction during both the years with exception with respect to interaction in the second year.

Effect of residual nitrogen and phosphorus on dry matter production of succeeding maize was significant and was in accordance with the findings of Verma *et al.* (2013). There was clear evidence of residual nitrogen effect as maximum dry matter was recorded in those plots which were supplied with more nitrogen in the previous season, which might be due to recovery of nitrogen applied to the previous maize crop. Similar response to the higher nitrogen levels applied in the previous season was observed by Pandiaraj *et al.* (2015) on silty loam soils. Dry matter production was not significantly affected by the rate of phosphorus applied in preceding season and observed inconsistent dry matter at different P levels. Similar response in soybean in ferralsols of West Kenya was noticed by Vandamme *et al.* (2014).

Table 4. Grain yield (kg ha^{-1}) of *rabi* maize as influenced by crop residue and nutrient management practices

	Rabi, 2014					*Rabi*, 2015				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_1P_1	6864	6999	6990	7024	**6969**	7055	7116	6998	7152	**7080**
N_1P_2	6954	6969	6813	7185	**6980**	6421	6838	6129	7197	**6646**
N_1P_3	6413	6890	6375	6919	**6649**	5881	6456	6252	6670	**6315**
N_2P_1	6746	7704	6431	6767	**6912**	5819	7421	6521	6749	**6628**
N_2P_2	7990	7436	6862	7649	**7484**	7130	7384	7148	7409	**7268**
N_2P_3	7738	7828	6815	7339	**7430**	7366	7433	7334	7493	**7406**
N_3P_1	7864	7406	6972	6852	**7273**	7183	7249	7261	7408	**7275**
N_3P_2	6765	7931	7129	7252	**7269**	7363	7677	6858	7024	**7230**
N_3P_3	6931	7259	7213	8026	**7357**	7359	7458	7441	7561	7455
Mean	**7140**	**7380**	**6844**	**7224**		**6842**	**7226**	**6882**	**7185**	

	Rabi, 2014		*Rabi*, 2015	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	144.4	433	321.5	964
F	110.1	310	135.3	381
NP at F	320.4	NS	476.5	NS
F at NP	288.9	NS	643.1	NS

Dry matter production of hybrid maize tended to increase progressively with advance in the age of the crop up to harvest. At all stages of crop growth, increasing the nitrogen levels from 100 to 125 % recommended dose of N and P_2O_5 ha^{-1} with and without crop residue incorporation resulted in increased dry matter production. Nitrogen, being the major constituent of chlorophyll, whose intensity is known to increase with added N supply, along with other nutrients released by the decomposition of crop residues could have promoted satisfactory plant growth under assured and continuous balanced supply of nutrients. Increased absorption of nutrients might have maintained higher meristematic activity with favorable effect on cell division and enlargement, resulting in increased plant height and production of larger leaves. The increase in source size (leaf area) might have resulted in better light interception and utilization of radiant energy, thereby enhancing the photosynthetic efficiency, which eventually resulted in higher dry matter accumulation under adequate nutrition. Enhanced dry matter production, as evidenced in this investigation corroborates with the previous findings of Kiran (2004), Felix *et al.* (2005) and Ahmad *et al.* (2007).

Grain yield

Variation in grain yield was significant due to residual nutrient effects (main plots) and nutrient doses ± crop residues (sub plots) but their interaction was not significant during both the years.

Graded levels of nitrogen exerted favorable influence on grain yield of maize. The highest yield was obtained with the application of 250 kg and 300 kg N ha^{-1} in the previous season but the response to phosphorus was marginal. Higher level of biomass accrual and efficient translocation of assimilates to the sink due to the sufficient and continuous supply of nitrogen and other nutrients throughout the crop period might be the findings of Kiran (2004).

The highest grain yield of hybrid maize was produced with the application of 125% recommended dose of N and P_2O_5 alone, however comparable with crop residue incorporation, application of 100% recommended dose of N and P_2O_5 alone, while it was found to be the lowest with the application of 100% recommended dose of N and P_2O_5 along with crop residue incorporation. The higher level of grain yield was due to the favourable influence of consistent and adequate availability of nutrients especially nitrogen throughout the crop growth period, which favoured the production of more photosynthates coupled with better partitioning to the sink, under higher level of nutrients. The results are in conformity with the findings of Singh *et al.* (2000) and Ramu (2005).

Application of 250 kg N and 60 kg P_2O_5 ha^{-1} during *kharif* season and 125% recommended dose of N and P either with or without incorporation of residues of previous season during *rabi* along with recommended dose of potassium was found to be the optimum fertilizer dose for maize - maize cropping sequence in southern agro climatic zone of Andhra Pradesh.

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