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Performance of Maize As Influenced by Crop Residue Management

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ABSTRACT

The present investigation was carried out at the Agricultural College Farm, Acharya N.G. Ranga Agricultural University, Bapatla during *kharif*, 2016 to assess the effect of crop residue management on growth and yield of maize. The experiment was laid out in Randomised Block Design with nine treatments consisting of rice straw, maize stalk and their composts along with 100 or 75 per cent of recommended dose of nitrogen by replicating thrice. The results indicated that the soil pH and EC were not markedly influenced by the imposed treatments, while significantly high organic carbon content was recorded with crop residue incorporation. Addition of various types and forms of crop residues was found to significantly influence the plant height, number of kernels per cob and test weight. Addition of 100 per cent nitrogen along with 25 per cent extra through maize compost recorded maximum growth, yield attributes and yield of maize followed by rice compost with same levels and maize compost with 75 per cent of recommended dose

Key words*: Composts, Inorganic fertilizer, Kernel, Rice straw, Maize stalk and Stover yield.*

Increasing demand of food to feed the ever-growing population along with rising cost of chemical fertilizers and depleting soil fertility owing to intensive cropping system necessitates judicious use of renewable (organic) and non-renewable (inorganic) sources of input energy production, which minimize the dependence of crop production on commercial source of energy. In the present situation of national energy crisis, the urgent need is to test easily available alternative sources of energy (farm yard manure, green manuring, rice straw, maize stalk, *etc)* for sustainable crop production and soil health (Singh *et al*., 1996).

Crop residues are important renewable organic sources of nutrients. They are usually generated in large quantities and hence, farmers opt for their burning to clear the field for next crop. Burning causes not only atmospheric pollution, but also loss of precious plant nutrients and valuable renewable organic matter resources (Ponnamperuma, 1984). The incorporation of crop residues may result in temporary immobilization of plant nutrients, due to their wider C:N ratio leading to nitrogen deficiency at early stage of crop growth even after application of recommended dose of nitrogen. Thus, addition of residues as composts can be a better option.

Maize *(Zea mays* L.) is the third dominant cereal crop next to wheat and rice. It plays a vital role in agricultural economy both as staple food and feed for livestock as well as raw material for industry because of its high production potential compared to any other cereal crop. The productivity of maize mainly depends on its nutrient management especially of nitrogen (Shah *et al*., 2003). It is a heavy feeder of nutrients hence, its continuous cultivation without proper nutrient management may deplete the soil nutrient reserves. The knowledge on optimum combination of crop residues and inorganic fertilizers added to improve the efficiency and economy of applied nitrogen with concomitant improvement in the soil fertility and productivity in maize is lacking.

Keeping this in view, the present experiment was planned to investigate the effect of integrated use of rice straw, maize stalk and their composts along with inorganic fertilizers on performance of maize.

MATERIAL AND METHODS

The present experiment was conducted at Agricultural College Farm, Bapatla during *kharif*, 2016 in randomized block design with three replications and nine treatments *viz*., T_1 - 100%

RDFN, T_2 - 100% RDFN + 25% N through rice straw, T_3 - 100% RDFN + 25% N through rice compost, T_4-100% RDFN + 25% N through maize stalk, T_5 - 100% RDFN + 25% N through maize compost, T_6 -75% RDFN + 25% N through rice straw, T_7 -75% RDFN + 25% N through rice compost, T_8 - 75% RDFN + 25% N through maize stalk and T_9 - 75% RDFN + 25% N through maize compost. The soil of the experimental field was clay in texture, alkaline in reaction (pH 7.64), medium in organic carbon (5.00 g kg^{-1}), low in available nitrogen (213 kg ha^{-1}), medium in available phosphorus (30.25 kg ha^{-1}) and high in available potassium (753 kg ha^{-1}). Raw crop residues were applied one month before one month before sowing and their composts were applied one week before sowing as per the treatments based on their nitrogen content. Maize hybrid pioneer-3396 was dibbled at 60 cm × 20 cm spacing. Entire phosphorus (60 kg P_2O_5 ha^{-1}) was applied as basal dose, while potassium (60 kg K_2O ha^{-1}) was applied in 2 splits, both uniformly to all the treatments. Nitrogen in the form of urea was applied as per the treatments in three splits. Soil samples were collected at knee high, tasseling and harvest of the crop and were analysed for pH, electrical conductivity (EC), organic carbon, N, P, K and S by standard methods.

RESULTS AND DISCUSSION

Physico-chemical properties of soil :-

The non-significant effect on soil pH and electrical conductivity due to application of raw crop residues or composts along with inorganic fertilizers (Table 1). This might be due to production of organic acids during mineralization of organic materials would have caused decrease in soil pH by Sarwar *et al.* (2008) and Sharma *et al.* (2013). Decrease in EC might be due to balanced fertilization, which might not have allowed an increase in salt concentration. The maximum pH and electrical conductivity was observed in inorganic treatment (T_1) at harvest stage of crop growth.

The highest organic carbon content (5.98 g kg^{-1}) was recorded in treatment supplied with 75% RDFN +25% N through rice straw (T_6) significantly and it was on par with all organic treated plots compared to 100% RDFN (5.12 g kg^{-1}). The significant increase in organic carbon content in all the treatments with organic source as compared to use of inorganic source alone might be due to direct incorporation of organic matter and enhanced root growth (which leads to the release of more root exudates and accumulation of biomass) (Bajpai *et al.*, 2006). Dhonde and Bhakare (2008) attributed the build-up of organic carbon to the continuous application of organic manures and proliferation of roots due to higher biomass production. Relatively higher organic carbon content at tasseling stage could be due to release of higher quantities of root exudates during peak growth stage.

Plant height

The data pertaining to the plant height at different stages are presented in table 2. At knee high stage, the plant height increased significantly with application of crop residues and composts. The highest plant height (155 cm) was recorded in treatment supplied with 100% RDFN + 25% N through maize compost (T_5), which was on par with all organic treatments supplied with 100% RDFN (T_2-T_4) and 75% RDFN +25% N through rice compost (T_7). The lowest plant height (131 cm) was recorded in treatment T_1 (100% RDFN), which performed similar to those treatments received 75% RDFN along organics.

At tasseling and harvest stages, levels of nitrogen or addition of organics did not show significant difference in plant height. The highest plant height of 280 and 292 cm, respectively at tasseling and harvest stages was recorded by the treatment 100% RDFN + 25% N through maize compost (T_5) while, the lowest plant height (255 and 268 cm, respectively) was recorded by T_1 (100% RDFN).

In general, relatively higher plant height was recorded in treatments integrated with organics and inorganic fertilizers compared to only inorganic treatment. The higher plant height under organic application may probably be due to the regular supply of the essential nutrients by continuous mineralization of organic manures, besides enhanced nutrient supplying capacity of soil and its favourable effect on growth parameters (Hati *et al.*, 2001). The results are coinciding with the findings of Ghosh (2003).

Significant variation in plant height might also be due to higher availability of nitrogen in

Table 1. Influence of raw crop residues and their composts on physico-chemical properties of soil at harvest.

Treatments	pH	EC (dS m^{-1})	OC (g kg^{-1})
T_1 : 100% RDFN	7.56	0.40	5.06
T_2 : 100% RDFN + 25% N through rice straw	7.41	0.39	5.85
T_3 : 100% RDFN + 25% N through rice compost	7.43	0.34	5.76
T_4 : 100%RDFN + 25% N through maize stalk	7.39	0.36	5.77
T_5 : 100% RDFN + 25% N through maize compost	7.41	0.35	5.65
T_6 : 75% RDFN + 25% N through rice straw	7.40	0.34	5.98
T_7 : 75% RDFN + 25% N through rice compost	7.43	0.36	5.80
T_8 : 75% RDFN + 25% N through maize stalk	7.41	0.35	5.82
T_9 : 75% RDFN + 25% N through maize compost	7.42	0.33	5.64
SEm±	0.20	0.02	0.16
CD	NS	NS	0.47
CV (%)	4.65	11.19	4.76

Table 2. Influence of raw crop residues and their composts on plant height (cm) of maize.

Treatment	Plant height		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	130	255	268
T_2 : 100% RDFN + 25% N through rice straw	146	277	279
T_3 : 100% RDFN + 25% N through rice compost	148	279	282
T_4 : 100% RDFN + 25% N through maize stalk	147	278	278
T_5 : 100% RDFN + 25% N through maize compost	155	280	292
T_6 : 75% RDFN + 25% N through rice straw	136	270	274
T_7 : 75% RDFN + 25% N through rice compost	143	271	275
T_8 : 75% RDFN + 25% N through maize stalk	139	271	273
T_9 : 75% RDFN + 25% N through maize compost	141	273	274
SEm±	4	8	7
CD @ 0.05	13	NS	NS
CV (%)	5	5	5

organic treatments resulting in more nitrogen uptake, better metabolization of carbohydrates into amino acids which in turn stimulate the cell division and cell elongation and thus allowed the plant to grow faster (Meelu *et al.*, 1994).

Significant effect of treatments at knee high stage could be attributed to the supply of essential nutrients in required properties which might have improved plant metabolic activity especially in early growth stage of plant (Anburani and Manivannan 2002). The increase in plant height with higher level of nitrogen might be due to cell division and cell elongation as promoted by nitrogen. The increase in plant height in response to higher nitrogen levels was in conformity with the previous findings of Bharathi *et al.* (2010).

The present findings are in close agreement with those reported by Subbaiah and Mittra (1997), Das *et al*. (2001) and Shivakumar and Mishra (2001).

Yield Attributes of Maize

The data pertaining to yield attributes of maize are presented in table 3. The maximum cob length (19.43 cm) was found in the treatment which received 100% RDFN + 25% N through maize compost (T_5). The lowest cob length (17.63 cm) was recorded in 100% RDFN (T_1).

Number of kernels cob^{-1} of maize was significantly influenced by the imposed treatments. Application of 100% RDFN + 25% N through maize compost (T_5) resulted in maximum number of kernels cob^{-1} (626) and it was on par with all organic treatment in combination with 100% RDFN and superior to the remaining treatments. The lowest number of kernels cob^{-1} (540) was found in the treatment, which received inorganic fertilizer alone.

The test weight ranged from 14.19 to 16.42 g. The highest test weight was found in treatment supplied with 100% RDFN + 25% N through maize compost (T_5). However, it was on par with all organic treatments at higher doses of nitrogen and maize compost with 75% RDFN (T_9). The lowest (14.19 g) was recorded in T_1 (100% RDFN).

The positive response of crop to higher level of nitrogen beneficial effects of organic manures in supply and transportation of growth stimulating materials through phloem tissues might have resulted in enhanced cell division and grain number. Similar results were also obtained by Raisi and Nejad (2012). The increase in yield attributes might be ascribed to the supply of nitrogen at higher levels, which increase photosynthetic activities and translocation of photosynthates, which might have promoted the growth, better partitioning of photosynthates in to yield attributes and eventually produced large size of ear head, as well as more grain of higher weight that ultimately increased the yield. Similar results on yield attributes were also reported by Singh *et al.* (2003) and Mishra (2012).

This could also be due to the enhanced mineralization of organics at higher dose of nitrogen resulting in supply of all essential nutrients in required proportions. These results closely resembled with those of Subbaiah and Mittra (1997) and Hemalatha *et al.* (2000).

Kernel yield

The results pertaining to kernel yield are presented in table 4, the kernel yield of maize was found to be significantly influenced by application of raw crop residues and composts. The highest kernel yield (5878 kg ha^{-1}) was recorded with application of 100% RDFN + 25% N through maize compost (T_5) and the lowest kernel yield (4859 kg ha^{-1}) was obtained in 100% RDFN (T_1) treatment. Among all, the treatment supplied with 100% RDFN + 25% N through maize compost (T_5) was found significantly superior to all except the treatments with 100% RDFN +25% N through rice compost (T_3) and 75% RDFN + 25% N through maize compost (T_9).

Perusal of the data revealed that treatments supplied with organics outperformed inorganic treatment. At lower levels of nitrogen (75%), rice straw recorded relatively higher kernel yield when compared to maize stalk. However, when applied as composts maize compost resulted in higher yield over rice compost.

The increase in kernel yield under organic manure treated plots might be due to better and continuous availability of nutrients for plants up to cob development which ultimately increased the kernel yield (Farhad *et al.*, 2009). Combined application of organic residues and inorganic fertilizers has better result on soil fertility as well as higher productivity of crops (Ravankar *et al.*, 2005). Zamir *et al.* (2014) also recorded an improved kernel yield in maize where maize straw was incorporated as organic mulch. Yadavindersingh *et al.* (2004) observed that incorporation of organic N in soil either as green manure or crop residue improved the soil fertility and substantially reduced the requirements of fertilizer N and increased crop yield. The combined use of organic and chemical fertilizers will help to maintain soil productivity even under intensive cropping system.

The results obtained by Amujoyegbe *et al.* (2007) empha-sized that compost addition to soil increases yield by enhancing leaf N concen-tration, chlorophyll content and consequently boosting photosynthetic activities and ultimately enhancing the maize yield.

The balanced supply of all nutrients throughout the crop growth due to integration of organics with inorganic fertilizers. This further enhanced the nutrient activities resulting in increased number of grain per panicle and test weight and finally increase kernel yield (Walker *et al.*, 2004; Thakur *et al.*, 2011; Sushila and Giri, 2000). The enhanced uptake of K by rice and wheat improved the metabolic activities in the plants. The increase in yield components (maximum plant height and number of fertile tillers plant^{-1}) of rice as well as wheat crops were positively affected and ultimately these components contributed towards increase in grain yields of these crops (Sarwar *et al*., 2007).

Stover yield

The results of the stover yield are presented in table 4. The highest stover yield (7860 kg ha^{-1}) was recorded with application of 100% RDFN + 25% N through maize compost (T_5) and the lowest stover yield (6477 kg ha^{-1}) was obtained in T_1 (100% RDFN). The treatment supplied with 100% RDFN + 25% N through maize compost (T_5) was on par with all treatments except 75% RDFN + 25% N through rice straw (T_6) and inorganic treated plots (T_1).

The production of organic acids and growth promoting substances during decomposition of organic manures might have facilitated easy availability of macro as well as micronutrients. Adequate supply of nutrients to the crop helps in the synthesis of carbohydrates, which are required for the formation of protoplasm, thus resulting in higher cell division and cell elongation. Thus, an increase in stover yield might have been an account of overall improvement in the vegetative growth of the plant due to the application of organic manures in combination with inorganic N fertilizer. Similar, results were obtained by Makinde and Ayoola (2010) who reported that combined application of organic and inorganic fertilizers is effective for the growth of maize and improving the yields. This might be due to addition of organic material which can markedly increase soil productivity by providing essential plant nutrients and by improving physical properties (Shah *et al*., 2010). Kouyate *et al.* (2000) also reported an increase in cereal grain and stover yield when crop residues were incorporated compared with treatments where residues were removed.

The increased supply of nitrogen helped in faster cell division and multiplication, there by increased plant height and ultimately stover yield. Similar positive results of higher rates of nitrogen application on grain and straw yields were also reported by Singh *et al.* (2003) and Verma and Baigh (2012). The marked increase in grain and straw yield might also be due to mineralization of nutrients and the enrichment of soil fertility through the incorporation of wheat straw along with fertilizers resulting in increasing the availability and uptake of nutrients and their cumulative effect in the improvement of growth and yield attributes, such as plant height, number of effective ear heads m^{-2}, length of ear head and test weight.

Harvest index

Harvest index of maize did not differ significantly among the treatments. Numerically the highest harvest index (43.70%) was observed in T_5 (100% RDFN + 25% N through maize compost) and the lowest (41.21%) was observed in T_4 (100% RDFN + 25% N through maize stalk). Nagaraj *et al.* (2004) recorded non-significant on effect of application of organic manures like poultry manure and FYM on harvest index of maize.

CONCLUSION

The results of the study indicated that supplementation of 25% of RDN with raw crop residues / composts performed better with respect to plant growth, yield components and yield of maize over sole application of fertilizer nitrogen. Among different crop residues, maize compost with 100% RDFN was considered as the best treatment due to its favourable influence on performance of maize crop. Further, the comparable yield obtained due to maize and rice composts with 100% RDFN and maize compost with 75% RDFN indicated that integration of maize compost with inorganic fertilizer can save the fertilizer consumption to an extent of 25 per cent while, maintaining soil quality.

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Table 3. Influence of raw crop residues and their composts on yield attributes of maize at harvest.

Treatments	Length (cm)	Kernels per cob	100 seed test weight (g)
T_1 : 100% RDFN	17.63	540	14.19
T_2 : 100% RDFN + 25% N through rice straw	18.62	579	15.47
T_3 : 100% RDFN + 25% N through rice compost	18.25	586	15.93
T_4 : 100% RDFN + 25% N through maize stalk	18.20	582	15.88
T_5 : 100% RDFN + 25% N through maize compost	19.43	626	16.42
T_6 : 75% RDFN + 25% N through rice straw	17.73	549	14.95
T_7 : 75% RDFN + 25% N through rice compost	18.30	555	15.02
T_8 : 75% RDFN + 25% N through maize stalk	17.97	548	15.22
T_9 : 75% RDFN + 25% N through maize compost	18.07	550	16.24
SEm±	0.532	17.17	0.45
CD @ 0.05	NS	51.70	1.34
CV (%)	5.05	5.23	4.98

Table 4. Influence of raw crop residues and their composts on kernel and stover yield (kg ha^{-1}) of maize.

Treatments	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1 : 100% RDFN	4859	6477	42.98
T_2 : 100% RDFN + 25% N through rice straw	5266	7333	41.76
T_3 : 100% RDFN + 25% N through rice compost	5400	7249	42.25
T_4 : 100% RDFN + 25% N through maize stalk	5266	7501	41.21
T_5 : 100% RDFN + 25% N through maize compost	5878	7860	43.70
T_6 : 75% RDFN + 25% N through rice straw	5188	7088	42.20
T_7 : 75% RDFN + 25% N through rice compost	5303	7221	42.57
T_8 : 75% RDFN + 25% N through maize stalk	5162	7248	41.57
T_9 : 75% RDFN + 25% N through maize compost	5477	7270	42.97
SEm±	170	226	1.83
CD @ 0.05	512	680	NS
CV (%)	5.05	4.0	7.89

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