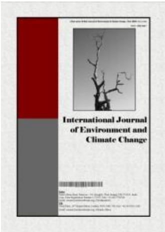

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Influence of Soil Amendments on Growth Parameters and Economics in Maize (*Zea mays* L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the efficacy of different soil amendments on plant growth parameters and economics in maize (*Zea mays* L).
Place and Duration of Study: Maize variety 900-M-GOLD was cultivated during rabi 2014-15 at College Farm, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana state, India.
Methodology: The Experiment was laid out in Randomized Complete Block Design (RCBD) with 6 treatments replicated four times. Treatments consist of T_1- vermicompost @ 5 t ha^{-1} ,T_2-FYM @ 10 t ha^{-1} , T_3-tanksilt @ 50 t ha^{-1} , T_4- biochar @10 t ha^{-1} ,T_5- control (without any fertilizer),T_6- RDF (NPK-200, 60, 50 kg ha^{-1}). Recommended Dose of Fertilizers was commonly applied from treatment T_1 to T_4.

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Results: There were no significant difference in plant population with the application of all the treatments. At harvest, significantly higher leaf area index recorded with application of tanksilt (1.67) which was on par with vermicompost (1.66), biochar (1.65), FYM (1.65), RDF (1.51) and significantly higher than control (0.80). Maximum gross returns (INR 1,31,283 ha^{-1}), net returns (INR 85,533 ha^{-1}) and BC ratio (2.87) were recorded with the application of tanksilt and minimum gross returns (INR 51,431 ha^{-1}), net returns (INR 24,781 ha^{-1}) and BC ratio (1.93) were recorded in the control.

Conclusion: It was determined that growth parameter viz., leaf area, leaf area index recorded significantly higher with tanksilt application which is on par with the application of vermicompost, biochar, FYM. Maximum gross returns (INR 131283 ha^{-1}), net returns (INR 85533 ha^{-1}) and BC ratio (2.87) were recorded with the application of tanksilt.

Keywords: BCR; leaf area index; maize; plant height and tanksilt.

1. INTRODUCTION

Maize (*Zea mays* L.) is an important food and feed crop among cereals which occupies first rank in the world followed by Rice and wheat respectively [1]. Because of its expanded use in the agro-industries, it is recognized as a leading commercial crop of agro economic value. In India, maize is the third most important cereal crop that provides food, feed, fodder and serves as a source of raw material for developing hundreds of industrial products viz., starch, protein, oil, alcoholic beverages, food sweeteners, pharma, cosmetics and bio-fuel etc[2]. Potential yield of maize is higher than that of either wheat or rice and we can expect maize to play a proportionally larger and more important role in world food security. Hence, it is called as the "Queen of cereals" [3]. Maize, a crop of worldwide economic importance together with rice and wheat provides approximately more than 30% of the food calories to more than 4.5 billion people. In India, maize is considered as third most important crop among the cereals and used as staple food in many developing countries [4]. Worldwide, maize is grown in an area of 197.20 m ha with production of 1148.49 Mt and productivity of 5824 kg ha^{-1} while 9.56 million ha with 28.77 Mt production and 3006 kg ha^{-1} productivity in our country [1]. In Telangana, maize occupies an area of 0.56 m ha with production and productivity of 2.99 Mt and 5347 kg ha^{-1} respectively [5]. Maize yields in India need to be increased significantly so as to meet food, feed and industrial needs. Maize yield and yield components showed positive response when biochar was used as soil amendment because it improves the field-saturated hydraulic conductivity of the sandy soil, as a result net water use efficiency also increased and more moisture and nutrients were available to the crop throughout the growing season [6]. Biochar amended soils resulted in better crop establishment and positively increased crop growth rate and net assimilation rate which resulted in higher corn productivity [7]. The nutrient needs of crop production systems can be met through integrated nutrient management and sustainable crop productivity in maize based cropping systems [8]. Application of FYM promotes seed germination and root growth of the crop plants by improving the water holding capacity and aeration of the soil. Therefore, high chances of considerable improvement in maize yield due to sole application of FYM and with conventional fertilizers [9]. Addition of tank silt to cultivated fields improves the physic-chemical properties of the soil which results in good crop growth and higher yields [10]. Application of vermicompost @ 2 t ha^{-1} recorded significantly higher plant height, leaf area index and yield of maize as compared to no organics [11].

Keeping in view the importance of soil amendments and integrated nutrient management, the present study was therefore conducted to compare different levels of synthetic fertilizer with soil amendments and investigate best possible combinations of organic and inorganic fertilizers.

2. MATERIALS AND METHODS

A field experiment was carried out at College Farm, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana state, India. Maize variety 900-M-GOLD was cultivated during *rabi* 2014-15 in Randomized Block Design (RBD) with 6 treatments replicated four times. Treatments consist of T_1- vermicompost @ 5 t ha^{-1} ,T_2-FYM @ 10 t ha^{-1} , T_3-tanksilt @ 50 t ha^{-1} , T_4- biochar @10 t ha^{-1} ,T_5- control (without any fertilizer),T_6- RDF (NPK-200, 60, 50 kg ha^{-1}).

Recommended Dose of Fertilizers was commonly applied from treatment T_1 to T_4. The plot size is 8.0 m × 5.0 m (40 m^2). Plant population was counted in the net plot area of 5 m × 4.2 m and converted to hectare. Test weight was calculated by taking five samples, each of 100 grains were collected randomly from the net plot produce, treatment wise and weighed, averaged and expressed in grams. The final plant population at harvest stage were recorded from each experimental plot and expressed in thousands per hectare. Plant height (cm) was measured from the base of the plant to the tip of the top most leaf before tasseling and to the tip of the tassel after tasseling of every tagged plant. Mean of five selected plants was reported as plant height at 30, 60, 90 days after sowing and at harvest expressed in cm. Leaf area was estimated on three plants in each plot at 30, 60, 90 DAS and harvesting stages. The area of total leaves was measured with digital leaf area meter (LI- 3100) and expressed in cm^2. Leaf area index was calculated by using the formula [12].

$$\text{LAI} = \frac{\text{Leaf area (cm}^2)}{\text{Unit ground area (cm}^2)}$$

Cost of cultivation (INR ha^{-1}): The market price of the inputs that were prevailing during the period of experiment and produce were considered for working out the cost of cultivation.

Gross returns (INR ha^{-1}): Gross returns (GMR) were calculated by multiplying the grain and stover yield with their respective prevailing market price.

Net returns (INR ha^{-1}): Net returns were calculated by subtracting the cost of cultivation from gross returns for each treatment.

Benefit cost ratio (BC ratio): Benefit cost ratio was calculated by dividing gross returns with cost of cultivation for each treatment.

$$\text{Benefit cost} = \frac{\text{Gross return (INR ha}^{-1})}{\text{Cost of cultivation (INR ha}^{-1})}$$

Statistically significance was tested by F-value at 5 % level of probability and critical difference was worked out where ever the effect were significant.

3. RESULTS AND DISCUSSION

3.1 Plant Population

Data in regard with plant population per plot was recorded at the time of crop harvest are depicted in Fig. 1 showed non-significant variation in plant population within all the treatments. Maximum number of plants ha^{-1} (63,333) was recorded with tanksilt and minimum (63,295) in control. There is no influence of applied amendments on seed germination and therefore no significant variation in plant population was observed. These findings are related to the findings of Mishra et al. [13].

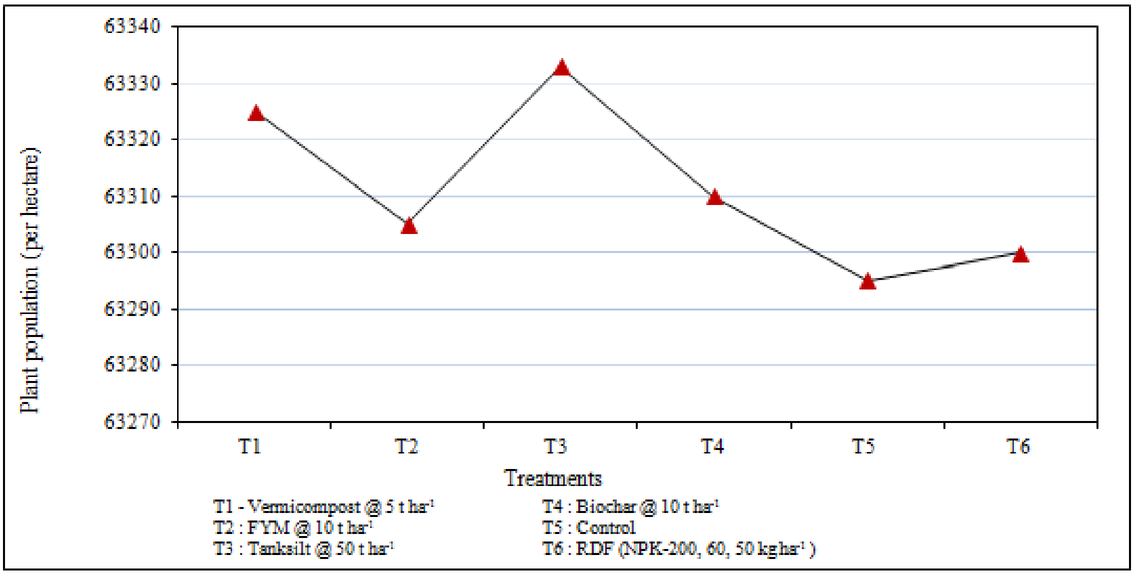

Fig. 1. Plant population at different growth stages of maize crop as influenced by different treatments

3.2 Plant Height

The plant height of maize in response to different integrated nutrient management treatments was furnished in the Fig. 2. No significant difference was observed with plant height due to different treatments at 30 days after sowing. At 60 DAS, there was significant difference observed among the treatments in terms of plant height. Application of tanksilt recorded significantly higher plant height (195.10 cm) which was on par with vermicompost (190.80 cm), biochar (188.60 cm), FYM (180.50 cm) and significantly higher than the RDF (176.50 cm) and control (120.10 cm). At 90 DAS, there was significant difference observed among the treatments in terms of plant height. Application of tanksilt recorded significantly higher plant height (241.20 cm) which was on par with vermicompost (238.20 cm), biochar (237.10 cm), FYM (235.10 cm), RDF (230.30 cm) and significantly higher than the and control (140.10 cm). At harvest there was significant difference observed among the treatments in terms of plant height. Application of tanksilt recorded significantly higher plant height (249.80 cm) which was on par with vermicompost (246.10 cm), biochar (245.20 cm), FYM (243.30 cm), RDF (238.90 cm) and significantly higher than the and control (148.10 cm). The effect of tanksilt, vermicompost, FYM, biochar and chemical fertilizer in combination was more pronounced with the advancement of crop growth indicating better effect on plant height of maize. It might be due to the improved fertility status of the soil through microbial and better utilization of plant nutrients by maize. Organic manures especially vermicompost supply nutrients to plant roots in balanced amount and stimulate growth, increased organic matter content of the soil including the "humic substances" that affect nutrient production and promote root growth which lead to better growth of maize plants resulting in taller plants. Similar findings were also reported by Biswasi et al. [14] and Naveen et al. [15].

3.3 Leaf Area Index (LAI)

Leaf area index computed at 30, 60, 90 days after sowing and at harvest differed significantly by the application of different soil amendments (Fig. 3). The leaf area index tends to increase up to 90 DAS, beyond which, it tends to decline towards harvest. Leaf area index was not significantly differed with different treatments at 30 days after sowing. At 60 DAS, significantly higher leaf area index recorded with application of tanksilt (3.34) which was on par with vermicompost (3.33), biochar (3.32), FYM

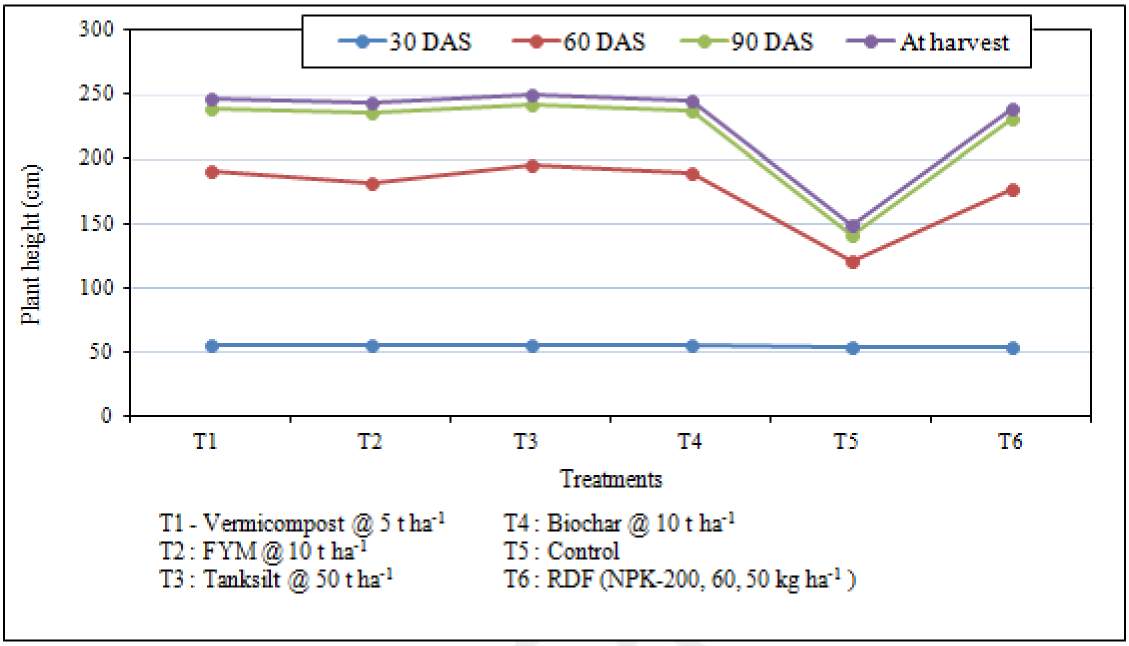

Fig. 2. Plant height at different growth stages of maize crop as influenced by different treatments

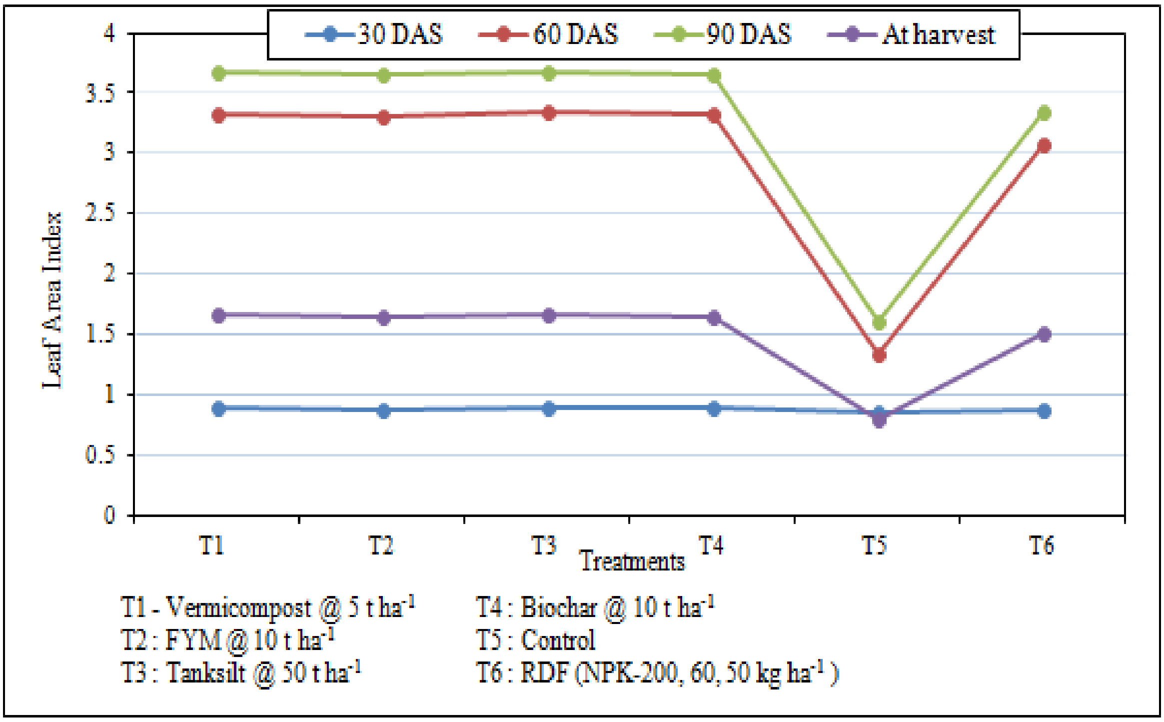

Fig. 3. Leaf area index at different growth stages of maize crop as influenced by different treatments

(3.31) and significantly higher than the RDF (3.07) and control (1.33). Application of all the amendments significantly increased the LAI compared to RDF and control. At 90 DAS, significantly higher leaf area index recorded with application of tanksilt (3.68) which was on par with vermicompost (3.67), biochar (3.66), FYM (3.66) and significantly higher than the RDF (3.34) and control (1.60). Application of all the amendments significantly increased the LAI compared to RDF and control. At harvest, significantly higher leaf area index recorded with application of tanksilt (1.67) which was on par with vermicompost (1.66), biochar (1.65), FYM (1.65), RDF (1.51) and significantly higher than control (0.80). Application of all the amendments significantly increased the LAI compared to control.

Leaf area index is principal important growth parameter in all crops, since the optimum leaf area is required for a maximum light interception, which results in higher photosynthesis [16]. The significant response to vermicompost or FYM application on leaf area index of maize might be due to addition of manures likely to increase the respiration rate, metabolism and growth of plants [17]. Further, the beneficial effect of organic manures on leaf area index might be due to synthesis of certain phytohormones and vitamins and more interception of solar radiation and synthesis of more chlorophyll, more photosynthetic rate and accumulation of more assimilates which resulted in higher leaf area index in maize [18].

3.4 Test Weight

The application of different amendments resulted increase in test weight than RDF applied plots and control (Table 1). The test weight of maize grain ranged from 18.41 g (control) to 30.78 g (tanksilt). The lowest test weight was produced from control plot where fertilizer was not applied. Among the various amendments, the test weight of maize followed the order of tanksilt > vermicompost > biochar > FYM. All the amendment application resulted in significant increase in test weight over the control but it was on par with the RDF applied plots. Application of amendments resulted in more availability of nutrients and causes the increased test weight of the grains. Results were in line with the findings of Adeyemo and Agele [19].

Table 1. Test weight (g) and yield (kg ha^{-1}) of maize as influenced by different treatments

Treatments	Test weight (g)	Yield (kg ha^{-1})
T_1 : Vermicompost @ 5 t ha^{-1}	30.71	7497
T_2 : FYM @ 10 t ha^{-1}	30.43	6325
T_3 : Tanksilt @ 50 t ha^{-1}	30.78	9054
T_4 : Biochar @ 10 t ha^{-1}	30.55	6667
T_5 : Control	18.41	3547
T_6 : RDF (NPK-200, 60, 50 kg ha^{-1})	28.84	5750
SEm±	0.83	246
CD (P = 0.05)	2.51	741

3.5 Yield

The application of different amendments resulted increases in grain yield than RDF applied plots and control (Table 1). The grain yield of maize ranged from 3547 kg ha^{-1} (control) to 9054 kg ha^{-1} (tanksilt). The lowest yield was produced from control plot where fertilizer was not applied. In RDF applied plots 5750 kg ha^{-1} of maize grain yield was recorded. Among the various amendments, the grain yield of maize followed the order of tanksilt > vermicompost > biochar > FYM. All the amendment application resulted in significant increase in grain yield over the RDF applied plots but the application of FYM was on par with the RDF applied plots. The increase in grain yield was 33.14, 30.38, 15.94 and 10 % in tanksilt, vermicompost, biochar and FYM applied plots respectively over RDF applied plots (5750 kg ha^{-1}). Application of amendments resulted in better soil physical environment as discussed earlier and also increased availability of nutrients by improving biological activity and also supplied nutrients directly which was resulted in more plant growth and biomass production which inturn reflected in grain yield of maize [20].

An increase in grain yield in biochar amendments plots include the effect of biochar on soil physio-chemical properties like enhance water holding capacity, increased cation exchange capacity (CEC) and providing a medium for adsorption of plant nutrients and improved conditions for soil micro-organisms [21]. The better growth in terms of leaf area index, dry matter accumulation and more cobs/plant could be the reason for increased grain yield [22]. Results were in line with the findings of Jayaprakash et al. [23].

3.6 Economics

Data pertaining to economics of maize analyzed statistically and was significantly differed due to application of different type of organic amendments and shown in Table 2. Highest cost of cultivation was observed in the application of vermicompost (INR 49250 ha^{-1}) and lowest cost of cultivation in control (INR 26650 ha^{-1}). Maximum gross returns (INR 131283 ha^{-1}), net returns (INR 85533 ha^{-1}) and BC ratio (2.87) were recorded with the application of tanksilt and minimum gross returns (INR 51431 ha^{-1}), net returns (INR 24781 ha^{-1}) and BC ratio (1.93) were recorded in the control. Application of all the treatments increased net returns compared to control. Application of soil amendments with chemical fertilizer shown the increased grain yield and ultimately resulted in high BC ratio. Results were in line with the findings of Tetarwal et al. [24] and Lone et al. [25].

Table 2. Economics (₹ ha^{-1}) of maize as influenced by different treatments

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
T_1 : Vermicompost @ 5 t ha^{-1}	49250	108706	59456	2.21
T_2 : FYM @ 10 t ha^{-1}	45750	91712	45962	2.00
T_3 : Tanksilt @ 50 t ha^{-1}	45750	131283	85533	2.87
T_4 : Biochar @ 10 t ha^{-1}	44570	96671	52101	2.17
T_5 : Control	26650	51431	24781	1.93
T_6 : RDF (NPK-200, 60, 50 kg ha^{-1})	33760	83375	49615	2.47
SEm±	--	3340.82	3340.82	---
CD (P = 0.05)	--	10070.33	10070.33	--

Note: Price of each inputs: Vermicompost- 3000 ₹ t^{-1}, FYM- 1200 ₹ t^{-1}, Tanksilt-240 ₹ t^{-1}, Biochar- 1100 ₹ t^{-1}, Urea-6 ₹ kg^{-1}, DAP- 23 ₹ kg^{-1}, MOP- 22 ₹ kg^{-1}.

4. CONCLUSION

Application of tanksilt produced taller plants at all stages. The growth parameter viz., leaf area, leaf area index recorded significantly higher with tanksilt application which is on par with the application of vermicompost, biochar, FYM. Growth parameters *viz.*, plant population, plant height, leaf area, LAI were not significantly influenced by application of soil amendments at 30 days after sowing. Among the various amendments, the grain yield of maize followed the order of tanksilt > vermicompost > biochar > FYM. Application of all the treatments increased net returns compared to control.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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