

## Effect of Soil Amendments on Dry Matter Production, Nutrient Uptake and Yield in Maize (*Zea mays* L.)

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**Abstract** A field experiment was carried out to evaluate the efficacy of different soil amendments on plant growth characteristics in maize crop. Application of all the amendments improved dry biomass and was significantly more than that of control and RDF 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 (3547 kg ha<sup>-1</sup>). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of nitrogen (78.97, 66.94, 64.62 and 55.23 kg ha<sup>-1</sup>) than RDF and control plots in stover at harvest. At harvest in stover, application of amendments tanksilt, vermicompost and biochar resulted in significant increase in uptake of P (9.30, 7.53 and 6.90 kg ha<sup>-1</sup>) than RDF but the application of FYM resulted in increase in uptake of phosphorus (4.97 kg ha<sup>-1</sup>) which was on par with RDF. Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of

potassium (127.5, 107, 101.6, 90.9 and 70.99 kg ha<sup>-1</sup>) than RDF and control plots in stover at harvest.

**Keywords** Maize, Dry matter production, Nutrient uptake, Yield, Tanksilt.

### Introduction

Maize (*Zea mays* L.) is the “Queen of cereals” and third most important cereal crop in the world after wheat and rice with respect to area and productivity. It has a great significance as human food, animal feed and diversified uses for large number of industrial products. The productivity of maize mainly depends on its nutrient management. Subha and Giri [1] application of vermicompost alone or in combination with half RDF recorded significantly more dry matter in maize over half RDF alone. Higher grain yield of 4194 kg ha<sup>-1</sup> was produced by plots where biochar was applied in combination with chemical fertilizer which was on par with application of sole mineral N application (3974 kg ha<sup>-1</sup>) followed by incorporation of biochar in combination with FYM. Saranya et al. [2] application of biochar along with *Azospirillum* recorded an increase in the available N, P, and K content by 104.3, 238.8 and 187.5% over control at 120 days of plant growth. An improvement in the uptake of NPK by maize grown on the clay soil of Junagadh was also reported by the integrated supply of nutrients through 1.5 t ha<sup>-1</sup> vermicompost and 120 kg N ha<sup>-1</sup> through the fertilizer [3]. Increase in grain yield in biochar amended plots include the effect of biochar on soil

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**Table 1.** Soil amendments impact on dry matter production (kg ha<sup>-1</sup>) at knee high stage, tasselling stage and at harvest of maize.

Treatments	Knee high stage	Dry matter (kg ha <sup>-1</sup> )	
		Tasselling stage	Harvest
T <sub>1</sub> : Vermicompost	1308.72	8637.82	16779.32
T <sub>2</sub> : FYM	1082.33	7841.16	15000.65
T <sub>3</sub> : Tanksilt	1367.05	9227.49	18148.78
T <sub>4</sub> : Biochar	1158.92	8033.49	15577.25
T <sub>5</sub> : Control	943.64	5408.16	9484.66
T <sub>6</sub> : RDF	1006.16	6222.66	12247.65
CD ( <i>p</i> = 0.05)	115.62	749.21	1517.3
SEm±	38.36	248.6	503.47

properties like water holding capacity, increased cation exchange capacity and providing a medium for adsorption of plant nutrients and improved conditions for soil microorganisms [4]. The grain yield of maize was significantly higher when vermicompost was applied @ 2 t ha<sup>-1</sup> and was on par with FYM @ 10 t ha<sup>-1</sup> [5].

### Materials and Methods

Maize variety 900-M-GOLD was cultivated during *rabi* 2014-15 in randomized block design (RBD) with 6 treatments replicated four times at the College farm, College of agriculture, Rajendranagar. Treatments consist of T<sub>1</sub>-vermicompost @ 5 t ha<sup>-1</sup>, T<sub>2</sub>-FYM @ 10 t ha<sup>-1</sup>, T<sub>3</sub>-tanksilt @ 50 t ha<sup>-1</sup>, T<sub>4</sub>-biochar @ 10 t ha<sup>-1</sup>, T<sub>5</sub>-control (without any fertilizer), T<sub>6</sub>- RDF (NPK-200, 60, 50 kg ha<sup>-1</sup>). Recommended Dose of Fertilizers was commonly applied from treatment T<sub>1</sub> to T<sub>4</sub>. Dry matter production was estimated by uprooting five plants from the destructive sampling area from each plot at knee high, tasselling and harvesting stage. These are cleaned and dried in hot air oven at 60°C till constant weight was obtained. Their weights were recorded and expressed in kg ha<sup>-1</sup>. Grain yield was estimated by harvesting the matured cobs from net plot area and dried. After drying, shelling was done by maize sheller and again the grain was dried and weights were recorded as per the treatments and expressed in q ha<sup>-1</sup>. The plant samples were digested with H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>O<sub>2</sub> and distilled by microkjeldhal distillation method to estimate the nitrogen content in plant sample [6]. Phosphorus content in the diluted diacid digest was determined by vanadomolybdo phosphoric acid yellow color

method on spectrophotometer at 420 nm [6]. Potassium content in the diluted diacid digest was determined by flame emission spectroscopy using flame photometer [7]. The uptake of N, P and K by the crop was computed and expressed in kg ha<sup>-1</sup> as follows.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Dry matter (kg ha}^{-1}\text{)}}{100}$$

### Results and Discussion

#### Dry matter production

Dry matter production was recorded at knee high, tasselling stage and at harvest were presented in Table 1. The dry matter production at different crop growth stages was significantly influenced by application of different amendments tanksilt, vermicompost, biochar and FYM.

The perusal of data of the dry matter production at knee high stage indicates that highest dry matter production was produced with the application of tanksilt @ 50 t ha<sup>-1</sup> (1367.1 kg ha<sup>-1</sup>) followed by vermicompost application (1308.72 kg ha<sup>-1</sup>) which was statistically on par with tanksilt applied plots. Application of all the amendments improved dry biomass and was significantly more than that of control and RDF plots. However, the dry biomass in control and RDF was at par at knee high stage.

Similar trend in dry biomass was sustained till

**Table 2.** Soil amendments impact on nitrogen, phosphorus and potassium uptake ( $\text{kg ha}^{-1}$ ) at knee high stage and at harvest of maize.

Treatments	N uptake ( $\text{kg ha}^{-1}$ )			P uptake ( $\text{kg ha}^{-1}$ )			K uptake ( $\text{kg ha}^{-1}$ )		
	Harvest			Harvest			Harvest		
	Knee high stage	Sto-ver	Grain	Knee high stage	Sto-ver	Grain	Knee high stage	Sto-ver	Grain
T <sub>1</sub> : Vermicompost	31.67	66.94	114.23	2.72	7.53	18.87	56.49	107.02	62.51
T <sub>2</sub> : FYM	20.45	55.23	67.52	1.8	4.97	10.37	44.4	91	46.75
T <sub>3</sub> : Tanksilt	34.17	78.97	153.39	3.38	9.3	28.43	60.36	127.55	83.64
T <sub>4</sub> : Biochar	23.52	64.62	76.04	1.84	6.9	16.38	49.02	101.67	50.42
T <sub>5</sub> : Control	16.6	23.94	26.55	0.84	2.93	5.09	33.8	49.64	14.08
T <sub>6</sub> : RDF	19.11	38.82	60.38	1.14	4.21	9.15	38.86	71	28.99
CD ( $p = 0.05$ )	2.45	6.04	9.93	0.23	0.955	1.88	4.58	10.05	8.11
SEm±	0.81	2	3.29	0.07	0.31	0.62	1.52	3.33	2.7

harvest of the crop except that the dry matter production of RDF applied plots was significantly more than control both at tasselling and at harvest. The increase in dry matter production due to application of amendments may be attributed to the favorable soil physical and chemical environment. Interactive effect of FYM and fertilizer provided congenial soil environment for better plant growth resulting into increased dry matter production of the crop [8].

#### Nutrient uptake

##### Nitrogen uptake

The nitrogen uptake was calculated from nitrogen content and dry biomass at knee high stage and at harvest were presented in Table 2.

*At knee high stage* : The nitrogen uptake at knee high stage ranged from  $16.60 \text{ kg ha}^{-1}$  (control) to  $34.17 \text{ kg ha}^{-1}$  (tanksilt). The nitrogen uptake in RDF ( $19.11 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $16.60 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of nitrogen ( $34.17, 31.67, 23.52$  and  $20.45 \text{ kg ha}^{-1}$ ) than RDF and control plots. The improvement in nitrogen uptake was due to multiplication effect of higher nutrient absorption i.e., nitrogen as well as high biomass production. Applied composts worked as a slow release fertilizers therefore organically supplied plants have

more opportunity to uptake nutrients continuously for longer time [9].

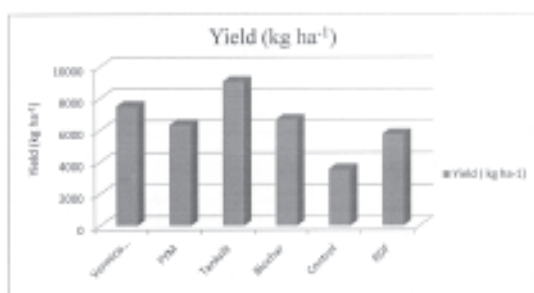
*At harvest* : The nitrogen uptake in stover at harvest ranged from  $23.94 \text{ kg ha}^{-1}$  (control) to  $78.97 \text{ kg ha}^{-1}$  (tanksilt). The nitrogen uptake in RDF ( $38.82 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $23.94 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of nitrogen ( $78.97, 66.94, 64.62$  and  $55.23 \text{ kg ha}^{-1}$ ) than RDF and control plots.

The nitrogen uptake in grain at harvest was ranged from  $26.55 \text{ kg ha}^{-1}$  (control) to  $153.39 \text{ kg ha}^{-1}$  (tanksilt). The nitrogen uptake in RDF ( $60.38 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $26.55 \text{ kg ha}^{-1}$ ). Application of amendments tanksilt, vermicompost and biochar resulted in significant increase in uptake of nitrogen ( $153.39, 114.23$  and  $76.04 \text{ kg ha}^{-1}$ ) than RDF but the application of FYM resulted in increase in uptake of phosphorus ( $67.52 \text{ kg ha}^{-1}$ ) which was on par with RDF.

The application of tanksilk significantly increased the nitrogen uptake compared to vermicompost, FYM and biochar application.

##### Phosphorus uptake

The phosphorus uptake was calculated from phosphorus content and dry biomass at knee high stage and at harvest were presented in Table 2.



**Fig. 1.** Soil amendments impact on grain yield ( $\text{kg ha}^{-1}$ ) of maize.

*At knee high stage :* The phosphorus uptake at knee high stage ranged from  $0.84 \text{ kg ha}^{-1}$  (control) to  $3.38 \text{ kg ha}^{-1}$  (tanksilt). The phosphorus uptake in RDF ( $1.14 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $0.84 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of P ( $3.38, 2.72, 1.84$  and  $1.80 \text{ kg ha}^{-1}$ ) than RDF and control plots.

*At harvest :* The phosphorus uptake in stover at harvest was ranged from  $2.93 \text{ kg ha}^{-1}$  (control) to  $9.30 \text{ kg ha}^{-1}$  (tanksilt). The phosphorus uptake in RDF ( $4.21 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $0.84 \text{ kg ha}^{-1}$ ). Application of amendments tanksilt, vermicompost and biochar resulted in significant increase in uptake of P ( $9.30, 7.53$  and  $6.90 \text{ kg ha}^{-1}$ ) than RDF but the application of FYM resulted in increase in uptake of phosphorus ( $4.97 \text{ kg ha}^{-1}$ ) which was on par with RDF. Biochar application had positive effects on the soil and the resulting increased nutrient uptake due to great availability of nutrients from the soil [10]. The application of tanksilt significantly increased the phosphorus uptake compared to vermicompost, FYM and biochar application.

The phosphorus uptake in grain at harvest was ranged from  $2.93 \text{ kg ha}^{-1}$  (control) to  $9.30 \text{ kg ha}^{-1}$  (tanksilt). The phosphorus uptake in RDF ( $9.15 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $5.09 \text{ kg ha}^{-1}$ ). Application of amendments tanksilt, vermicompost and biochar resulted in significant increase in uptake of phosphorus ( $28.43, 18.87$  and  $16.38$

$\text{kg ha}^{-1}$ ) than RDF but the application of FYM resulted in increase in uptake of phosphorus ( $10.37 \text{ kg ha}^{-1}$ ) which was on par with RDF. The application of tanksilt significantly increased the phosphorus uptake compared to vermicompost, FYM and biochar application.

#### Potassium uptake

The potassium uptake was calculated from potassium content and dry biomass at knee high stage and at harvest were presented in Table 2.

*At knee high stage :* The potassium uptake at knee high stage ranged from  $33.80 \text{ kg ha}^{-1}$  (control) to  $60.36 \text{ kg ha}^{-1}$  (tanksilt). The potassium uptake in RDF ( $38.86 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $33.8 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of potassium ( $60.36, 56.49, 49.02, 44.40$  and  $38.86 \text{ kg ha}^{-1}$ ) than RDF and control plots. The application of FYM along with fertilizers increased the uptake of nutrients in sandy loam soil [11]. The application of tanksilt significantly increased the potassium uptake compared to FYM and biochar application, but it was on par with application of vermicompost.

*At harvest :* The potassium uptake in stover at harvest was ranged from  $49.64 \text{ kg ha}^{-1}$  (control) to  $127.55 \text{ kg ha}^{-1}$  (tanksilt). The potassium uptake in RDF ( $71.00 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $49.64 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase uptake of potassium ( $127.5, 107, 101.6, 90.9$  and  $70.99 \text{ kg ha}^{-1}$ ) than RDF and control plots.

The potassium uptake in grain at harvest was ranged from  $14.08 \text{ kg ha}^{-1}$  (control) to  $83.64 \text{ kg ha}^{-1}$  (tanksilt). The potassium uptake in RDF ( $28.99 \text{ kg ha}^{-1}$ ) was significantly more than that of control ( $14.08 \text{ kg ha}^{-1}$ ). Application of all the amendments tanksilt, vermicompost, biochar and FYM resulted in significant increase in uptake of potassium ( $83.64, 62.51, 50.42$  and  $46.7 \text{ kg ha}^{-1}$ ) than RDF and control plots.

## Yield

The application of different amendments resulted in significantly more grain yield than RDF applied plots and control (Fig. 1). The grain yield of maize ranged from 3547 kg ha<sup>-1</sup> (control) to 9054 kg ha<sup>-1</sup> (tanksilt). The lowest yield was produced from control plot where fertilizer was not applied. In RDF applied plots 5750 kg ha<sup>-1</sup> of maize grain yield was recorded. Among the various amendment, 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 (57.50 kg ha<sup>-1</sup>). 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.

An increase in grain yield in biochar amendments plots include the effect of biochar on soil physiochemical 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 [12]. The better growth in terms of leaf area index, dry matter accumulation and more cobs/plant could be the reason for increased grain yield [8].

## Conclusion

Application of amendments like tanksilt, vermicompost, FYM and biochar increased the nutrient uptake, dry matter production and yield. All the amendment application resulted in significant increase in grain yield over the RDF applied plots but the appli-

cation of FYM was on par with the RDF applied plots. The increase in yield of maize by the application of amendments was due to good soil physical conditions and more uptake of nutrients.

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