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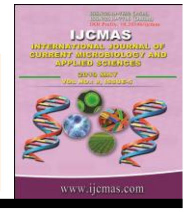

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Performance of Tomato (*Solanum lycopersicum* L.) in Acid Soil under Integrated Nutrient Management with Biochar as a Component

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A B S T R A C T

Majority of the soils in the North Eastern Hill (NEH) region of India are acid in reaction causing low crop yields. The region produces huge quantity of crop residue/weed biomass which can be converted into biochar for managing soil acidity. To evaluate the performance of tomato (cv. Megha tomato-2) in acid soil of Meghalaya under integrated nutrient management having biochar as a component, an experiment was conducted during *rabi* season of 2017-18 at Research Farm of School of Natural Resource Management, CPGSAS, Umiam, Meghalaya and the following sixteen treatments were tested under RBD with three replications: T_1 - Control, T_2 - B @ 2 t/ha, T_3 - B @ 3 t/ha, T_4 - B @ 4 t/ha, T_5 - 75% RDF + B @ 2 t/ha, T_6 - 75% RDF + B @ 3 t/ha, T_7 - 75% RDF + B @ 4 t/ha, T_8 - 75% RDF + B @ 2 t/ha + VC @ 2.5 t/ha, T_9 - 75% RDF + B @ 3 t/ha + VC @ 2.5 t/ha, T_{10} -75% RDF + B @ 4 t/ha + VC @ 2.5 t/ha, T_{11} - 100% RDF + B @ 2 t/ha, T_{12} - 100% RDF + B @ 3 t/ha, T_{13} - 100% RDF + B @ 4 t/ha, T_{14} - 100% RDF + B @ 2 t/ha + VC @ 2.5 t/ha, T_{15} - 100% RDF + B @ 3 t/ha + VC @ 2.5 t/ha, T_{16} - 100% RDF + B @ 4 t/ha+ VC @ 2.5 t/ha. The experimental results revealed that the highest plant height (cm) and number of fruits/plant was recorded in the treatment T_{16} - 100% RDF + B @ 4 t/ha + VC @ 2.5 t/ha with 150 and 127 percent increase over control, respectively. Average fruit weight (66.12 g), fruit yield (38.85 t/ha), fruit dry matter (5.22 t/ha) and haulm dry matter (3.19 t/ha) was recorded highest in the treatment T_{16} - 100% RDF + B @ 4 t/ha + VC @ 2.5 t/ha which were significantly higher over all other treatments indicating that the application of biochar @ 4 t/ha in combination with vermicompost @ 2.5 t/ha and 100% RDF was most effective in increasing tomato yield in acid soil than sole application of biochar or biochar in combination with recommended doses of chemical fertilizers.

Introduction

Soil is the basic foundation for sustainable crop production and the soil quality effects crop production. Out of 142 million ha of cultivable area in India, 49 million ha of area is acidic, of which 26 million ha of area having soil pH<5.5 and the rest 23 million ha of area having soil pH range 5.6 to 6.5. Approximately, 84 per cent of the soils in the North Eastern Hill (NEH) region of India are acidic in reaction, having low available phosphorus (P) and zinc whereas toxicity of iron and aluminium (Lyngdoh and Sanjay-Swami, 2018). In acid soils, P adsorption is generally attributed to hydrous oxides of iron and aluminium. There is great possibility that some natural phosphates of aluminium or iron (such as variscite and strengite) may formed in these soils making P the most limiting nutrient for crop production (Sanjay-Swami and Maurya, 2018; Sanjay-Swami *et al.*, 2019). In Meghalaya, the acid soils are found under different acidic ranges like moderately acidic soils (1.19 million ha), and slightly acidic soils (1.05 million ha) (Maji *et al.*, 2012). The soils of Meghalaya are high in organic carbon, which is a measure of supplying potential of soil nitrogen, deficient in available phosphorous, medium to low in available potassium, calcium, magnesium and toxic in Al and Fe. To overcome the problem of soil acidity, farmers adopt variety of soil amendments like manures, lime and composts to make soil nutrients available to crops as well as to protect them from the toxic elements. Among soil amendments, liming is good practice to overcome the acidity problem; however, it may not be economical in the regions where it is expensive. Biochar is an alternative, good and cheap organic source to overcome the soil acidity problem (Chan *et al.*, 2008, Yadav and Sanjay-Swami, 2018).

Biochar is a carbonaceous solid material obtained from thermally degrading biomass in the absence of oxygen or presence of little oxygen. It is commonly defined as charred organic matter, produced with the intention to apply in the soils to sequester carbon and improve soil physical and chemical properties (Lehmann and Joseph, 2009). It is produced by processes called pyrolysis, the direct thermal decomposition of biomass in the absence of oxygen which produces a mixture of solids (biochar), gas (syngas) and liquid (bio oil). Yield and quality of biochar depends on maintaining of specific temperature (Demirbas, 2004; Sanjay-Swami *et. al.*, 2018). Temperature of 400-500^0 C produces more quantity of biochar, while temperatures above 700^0 C favour the yield of liquid and gas fuel components. The major resource required for the production of the biochar is organic residue. The NEH region produces huge quantity of crop residue/weed biomass which can be converted into biochar for managing soil acidity (Yadav and Sanjay-Swami, 2018). Soil health management in the fragile ecosystems of the NEH region should be based on recycling of available plant residues, agro-forestry, and integrated nutrient management (Sanjay-Swami, 2019). Biochar has numerous beneficial effects to soils used for agricultural purposes. The application of charcoal to the soil for improving its physical condition is an old practice (Renner, 2007). There are reports in the literature that biochar in combination with inorganic fertilizers had shown significant increase in yield of cowpea, maize and peanut (Yamato *et al.,* 2006), paddy (Zhang *et al.,* 2012), spring barley, winter wheat, carrots, spinach, oilseed rape, peas and beetroot (Hammond *et al.*, 2013). However, meager information is available on integrating biochar with organic manures and chemical fertilizers. Therefore, the present investigation was carried out to evaluate the performance of tomato (cv. Megha tomato-2) in acid soil of Meghalaya under integrated nutrient management having biochar as a major component.

Materials and Methods

A field experiment was conducted during *rabi* season of 2017-18 at Research Farm of School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences (CPGSAS), Umiam, Ri-bhoi district, Meghalaya which is located at 91018’ to 92018’ E longitude and 25040’ to 26020’ N latitude with an altitude of 950 m above the mean sea level. The experimental area falls under subtropical humid climate with high rainfall and cold winter. Tomato cv. Megha tomato-2 was used as test crop with three doses of biochar (B) @ 2, 3 and 4 t/ha, vermicompost (VC) @ 2.5 t/ha and two graded recommended doses of NPK fertilizers (RDF) @ 75 and 100%. The trial was replicated three times adopting Randomized Block Design (RBD) with 16 treatment combinations namely, T_1 - Control, T_2 - B @ 2 t/ha, T_3 - B @ 3 t/ha, T_4 - B @ 4 t/ha, T_5 - 75% RDF + B @ 2 t/ha, T_6 - 75% RDF + B @ 3 t/ha, T_7 - 75% RDF + B @ 4 t/ha, T_8 - 75% RDF + B @ 2 t/ha + VC @ 2.5 t/ha, T_9 - 75% RDF + B @ 3 t/ha + VC @ 2.5 t/ha, T_{10} - 75% RDF + B @ 4 t/ha + VC @ 2.5 t/ha, T_{11} - 100% RDF + B @ 2 t/ha, T_{12} - 100% RDF + B @ 3 t/ha, T_{13} - 100% RDF + B @ 4 t/ha, T_{14} - 100% RDF + B @ 2 t/ha + VC @ 2.5 t/ha, T_{15} - 100% RDF + B @ 3 t/ha + VC @ 2.5 t/ha, T_{16} - 100% RDF + B @ 4 t/ha+ VC @ 2.5 t/ha. The experimental soil was acidic in reaction having pH 5.1 and medium in available phosphorus (18.70 kg/ha). The detailed analysis of experimental soil is presented in Table 1.

The biochar utilized in this study was prepared through pyrolysis by using waste from the plywood industry as a feedstock source at ICAR Research Complex for NEH Region, Umiam whereas vermicompost was procured from Rural Resource and Training Centre, Umran. The characteristics of biochar and vermicompost along with the method of analysis are provided in Table 2.

The biochar and vermicompost at required rate were applied 15 days before transplanting of tomato seedlings and mixed well in the surface soil. The growth and yield parameters of tomato were recorded at maturity. The data recorded for various parameters were analysed statistically by following procedure of Gomez and Gomez (1984).

Results and Discussion

Plant height (cm)

Plant height is the observable parameter which helps to assess the effectiveness of various treatments. The plant height of tomato recorded under different treatments is presented in Table 3. The highest plant height (56.2 cm) was recorded with the application of 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}), whereas the lowest plant height (37.4 cm) was observed under control plots (T_1). The sole application of biochar @ 2 t/ha slightly increased plant height over control plots (T_1). Further, successive increase in biochar doses i.e. 3 and 4 t/ha also increased plant hight over each lower doses of biochar. Biochar has been reported to modify soil quality characteristics. As it was alkaline in nature (pH 8.6), probably the pH of acidic soil under study (5.1) improved, thereby increasing crop growth and yields. The similar findings were also reported by Novak *et al.,* (2013).

The combined application of 75% RDF and biochar markedly increased the plant height over sole application of biochar at respective graded doses, whereas the combination of 75% RDF + biochar + vermicompost @ 2.5 t/ha significantly increased the plant height over sole application of biochar at respective graded doses. A close scrutiny of data also revealed that the combined application of 100% RDF and biochar significantly increased the plant height over sole application of biochar at respective graded doses, however, the addition of vermicompost @ 2.5 t/ha with 100% RDF and biochar further increased the plant height over 100% RDF and biochar at respective graded doses. The research findings with respect to plant height are also in concurrence with the findings of Mohideen (2018) who observed better growth of chilli with the application of

Gliciridia biochar + 100% urea over sole applications. The probable reason for further improvement in plant height with the addition of vermicompost along with 100% RDF and biochar is the additional supply of plant nutrients as well as improvement in physical and biological properties of soil by vermicompost (Sanjay-Swami and Bazaya, 2010; Konyak and Sanjay-Swami, 2018; Gupta *et al.,* 2019).

Number of fruits/plant

Number of fruits/plant was recorded least (7.40) in control plots which slightly increased with each successive higher doses of biochar (Table 3). The combined application of 100% RDF and biochar significantly increased the number of fruits/plant over sole application of biochar at respective graded doses and it was at par with the combined application of 75% RDF + biochar + vermicompost @ 2.5 t/ha at respective graded doses of biochar. The number of fruits/plant further increased with the addition of vermicompost @ 2.5 t/ha with 100% RDF and biochar at respective doses of biochar and the maximum number of fruits/plant was recorded in the treatment receiving 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}).

The increased number of fruits/plants observed under study may be due to the fact that number of fruits are dependent on canopy size and vigour of plants which is observed higher under T_{16} with 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha. These results corroborate the findings of Antonious (2018) who reported that addition of biochar (1% w/w) to sewage sludge (SS) and yard waste (YW) treatments significantly increased number of fruits/plant in tomato indicating a positive effect of biochar on the growth at University of Kentucky, Lexington, Kentucky.

Average fruit weight (g)

The sole application of biochar @ 2 t/ha markedly and significantly increased average fruit weight (g) of tomato over control plots (T_1), however, further successive increase in biochar doses i.e. 3 and 4 t/ha slightly increased average fruit weight over each lower doses of biochar (Table 3). The combined application of 75% RDF and biochar significantly increased the average fruit weight over sole application of biochar at respective graded doses. Similarly, the inclusion of vermicompost @ 2.5 t/ha with 75% RDF + biochar significantly increased the plant height over 75% RDF and biochar at respective graded doses. However, non-significant increase in average fruit weight was observed with further increase in RDF to 100% in combination with biochar over 75% RDF and biochar at respective graded doses. The examination of data further revealed that the combined application of 75% RDF + biochar + vermicompost @ 2.5 t/ha was superior over 100% RDF and biochar at respective graded doses with more average fruit weight. However, the addition of vermicompost @ 2.5 t/ha with 100% RDF + biochar further increased the average fruit weight over 100% RDF and biochar at respective graded doses and the maximum average fruit weight (66.12 g) was observed with the application of 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}).

The higher average fruit weight recorded with the application of biochar over control is possibly due to improvement in soil properties and increased nutrient availability (Lehmann *et al.,* 2003; Oguntunde *et al.,* 2004; Lehmann *et al.,* 2006; Deluca *et al.,* 2009). However, the addition of biochar with RDF significantly increased the nutrient availability due to increased nutrients supply maintained by chemical fertilizers. These results are in agreement with the findings of

Mohideen (2018) who also reported improvement in average fruit weight of chilli with the application of *Gliciridia* biochar + 100% urea over sole applications. Further, inclusion of vermicompost @ 2.5 t/ha with 100% RDF + biochar further improved average fruit weight of tomato due to combined beneficial effect. The beneficial effect of vermicompost on average fruit weight might be due to additional supply of plant nutrients as well as improvement in physical and biological properties of soil (Sanjay-Swami and Bazaya, 2010; Konyak and Sanjay-Swami, 2018; Gupta *et al.,* 2019). The highest average fruit weight (66.12 g) observed under T_{16} corroborates the findings of CRIDA (2016).

Fresh fruit yield (t/ha)

The fresh fruit yield of tomato under different treatment varied from 8.32 to 38.86 t/ha (Table 4). The data indicated that the sole application of biochar at different graded doses i.e. 2, 3 and 4 t/ha significantly increased the fruit yield over control plots (T_1) which recorded lowest fruit yield (8.32 t/ha). However, successive increase in biochar doses from lowest level of 2 t/ha to 3 and 4 t/ha slightly increased fruit yield over lower doses. The combined application of 75% RDF and biochar significantly increased the fruit yield over sole application of biochar at respective graded doses as well as over control plots. Further, significant increase in fruit yield was observed with subsequent increase in RDF to 100% in combination with biochar over 75% RDF and biochar at respective graded doses. Similarly, the inclusion of vermicompost @ 2.5 t/ha with 75% RDF + biochar significantly increased the fruit yield over 75% RDF and biochar at respective graded doses. The fruit yield obtained with 75% RDF + biochar + vermicompost @ 2.5 t/ha was observed to be superior over 100% RDF and biochar at respective graded doses. However, the addition of vermicompost @ 2.5 t/ha with 100% RDF + biochar further increased the fruit yield over 100% RDF and biochar at respective graded doses and the maximum fruit yield (38.86 t/ha) was recorded with the application of 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}).

Application of biochar significantly increased fresh fruit yield of tomato over control. Lehmann *et al.,* (2003) also observed the immediate beneficial effects of biochar addition to soil due to higher P availability, because it may contribute as a source of available and exchangeable P, ameliorator of P complexing metals (Ca^{2+}, Al^{3+} and $Fe^{3+, 2+}$), as a promoter of microbial activity and P mineralization (Deluca *et al.,* 2009). The results obtained under present investigation also confirmed the findings of Oguntunde *et al.,* (2004) who compared maize yields between disused charcoal production sites and adjacent fields, Kotokosu watershed, Ghana and observed 91 per cent higher grain yield and 44 per cent higher biomass yield on charcoal site than control. Lehmann *et al.,* (2006) again advocated that biochar application boosts up the soil fertility and improves soil quality by raising soil pH, increasing moisture holding capacity, attracting more beneficial fungi and microbes, improving cation exchange capacity and retaining nutrients in soil, thereby increasing crop yields.

The addition of biochar with RDF also significantly increased the nutrient availability due to increased nutrient supply through chemical fertilizers. Yamato *et al.,* (2006) also reported that *Acacia* bark charcoal plus fertilizer increased maize and peanut yields in area of low soil fertility. Inclusion of vermicompost @ 2.5 t/ha with 100% RDF + biochar further improved average fruit weight of tomato that might be due to combined beneficial effect biochar and vermicompost in maintaining additional supply of plant nutrients as well as improvement in physical and biological properties of soil (Sanjay-Swami and Bazaya, 2010; Konyak and Sanjay-Swami, 2018; Gupta *et al.*, 2019). The maximum fruit yield (38.86 t/ha) recorded with the application of 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}) is in agreement with the findings of CRIDA (2016) wherein eight treatments *viz.* T_1 - Control, T_2 - RDF (120-60-60), T_3 - Biochar (2 t/ha), T_4 - Biochar (4 t/ha), T_5 - RDF + Biochar (2 t/ha), T_6 - RDF + Biochar (4 t/ha), T_7 - RDF + Biochar (2 t/ha) + FYM (5 t/ha), T_8 - RDF + Biochar (4 t/ha) + FYM (5 t/ha) were tested in a rainfed Alfisol (Typic Haplustalf) to evaluate maize (DHM 117) performance and observed maximum yield with RDF + Biochar (4 t/ha) + FYM (5 t/ha).

Fruit and haulm dry matter (t/ha)

The highest fruit and haulm dry matter yield of tomato was recorded as 5.22 and 3.19 t/ha with the application of 100% RDF + biochar @ 4 t/ha + vermicompost @ 2.5 t/ha (T_{16}) which was approximately 6 and 7 fold more over control plots (Table 4). The fruit and haulm dry matter of tomato significantly increased with the sole application of biochar at different graded doses i.e. 2, 3 and 4 t/ha over control plots (T_1) which recorded lowest fruit and haulm dry matter (0.86 and 0.46 t/ha).

Table.1 Physico-chemical properties of experimental soil along with methods followed for analysis

Parameters	Value	Methods	References
pH	5.10	Potentiometry	Jackson (1973)
EC(dS/m)	0.45	Conductometry	Jackson (1973)
Bulk density (g/cm^3)	1.43	Clod method	Campbell and Henshall (2001)
Available N (kg/ha)	261.00	Alkaline potassium permanganate method	Subbiah and Asija (1956)
Available P_2O_5 (kg/ha)	18.70	Brays No. 1	Jackson (1973)
Available K_2O (kg/ha))	235.15	Flame photometer method	Jackson (1973)
DTPA extractable micronutrients (ppm)			
Iron	6.18	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
Zinc	36.48		
Manganese	48.43		
Copper	16.78		
Soil acidity indices (cmol(p+)/kg)			
Exchangeable acidity	3.02	Titrimetric determination	Jackson (1973)
Exchangeable aluminium	2.25	Titrimetric determination	Jackson (1973)
Exchangeable Ca & Mg	1.33	Complexometric titration method	Jackson (1973)
Cation exchange capacity	7.33	Ammonium acetate saturation method	Jackson (1973)

Table.2 Characteristics of biochar and vermicompost used in the study along with methods followed for analysis

Parameters	Biochar	Vermicompost	Methods	References
pH	8.60	7.30	Potentiometry	Jackson (1973)
EC (dS/m)	1.77	-	Conductometry	Jackson (1973)
Nitrogen (%)	0.61	2.11	Kjeldahl digestion and distillation method	Jackson (1973)
Phosphorus (%)	0.22	1.23	Vanadomolybdate method	Jackson (1973)
Potassium (%)	1.01	1.53	Flame photometer method	Jackson (1973)
DTPA extractable micronutrients (ppm)				
Iron	0.06	250.20	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
Zinc	1.72	1095.00		
Manganese	0.04	53.00		
Copper	0.12	248.60		

Table.3 Growth and yield attributing characters of tomato (*Solanum lycopersicum* L.) in acid soil under integrated nutrient management with biochar as a component

Treatments	Plant height (cm)	Number of fruits/plant	Average fruit weight (g)
T_1 - Control	37.4	7.40	17.94
T_2 - Biochar @ 2 t/ha	38.1	7.52	25.74
T_3 - Biochar @ 3 t/ha	39.0	7.68	30.72
T_4 - Biochar @ 4 t/ha	39.5	7.92	33.73
T_5 - 75% RDF + Biochar @ 2 t/ha	44.4	8.40	35.14
T_6 - 75% RDF + Biochar @ 3 t/ha	45.8	8.60	39.44
T_7 - 75% RDF + Biochar @ 4 t/ha	47.8	8.72	42.75
T_8 - 75% RDF + Biochar @ 2 t/ha + Vermicompost @ 2.5 t/ha	47.2	8.68	41.47
T_9 - 75% RDF + Biochar @ 3 t/ha + Vermicompost @ 2.5 t/ha	53.6	9.12	49.73
T_{10} - 75% RDF + Biochar @ 4 t/ha + Vermicompost @ 2.5 t/ha	55.1	9.32	56.08
T_{11} - 100% RDF + Biochar @ 2 t/ha	46.7	8.64	41.39
T_{12} - 100% RDF + Biochar @ 3 t/ha	49.8	8.92	45.15
T_{13} - 100% RDF + Biochar @ 4 t/ha	51.4	8.96	48.83
T_{14} - 100% RDF + Biochar @ 2 t/ha + Vermicompost @ 2.5 t/ha	48.7	8.84	45.20
T_{15} - 100% RDF + Biochar @ 3 t/ha + Vermicompost @ 2.5 t/ha	54.0	9.24	55.52
T_{16} - 100% RDF + Biochar @ 4 t/ha + Vermicompost @ 2.5 t/ha	56.2	9.40	66.12
SE(m)±	2.51	0.44	2.15
CD($p \leq 0.05$)	7.26	1.28	6.27

Table.4 Fresh fruit yield, fruit and haulm dry matter yield of tomato (*Solanum lycopersicum* L.) in acid soil under integrated nutrient management with biochar as a component

Treatments	Fresh fruit yield (t/ha)	Fruit dry matter (t/ha)	Haulm dry matter (t/ha)
T_1 - Control	8.32	0.86	0.46
T_2 - Biochar @ 2 t/ha	12.10	1.02	0.55
T_3 - Biochar @ 3 t/ha	14.75	1.13	0.62
T_4 - Biochar @ 4 t/ha	16.70	1.31	0.73
T_5 - 75% RDF + Biochar @ 2 t/ha	18.47	1.60	0.90
T_6 - 75% RDF + Biochar @ 3 t/ha	21.22	1.78	1.00
T_7 - 75% RDF + Biochar @ 4 t/ha	23.32	2.06	1.18
T_8 - 75% RDF + Biochar @ 2 t/ha + Vermicompost @ 2.5 t/ha	22.47	2.01	1.15
T_9 - 75% RDF + Biochar @ 3 t/ha + Vermicompost @ 2.5 t/ha	28.35	3.76	2.23
T_{10} - 75% RDF + Biochar @ 4 t/ha + Vermicompost @ 2.5 t/ha	32.62	4.33	2.58
T_{11} - 100% RDF + Biochar @ 2 t/ha	22.32	1.86	1.06
T_{12} - 100% RDF + Biochar @ 3 t/ha	25.22	2.95	1.74
T_{13} - 100% RDF + Biochar @ 4 t/ha	27.37	3.34	1.97
T_{14} - 100% RDF + Biochar @ 2 t/ha + Vermicompost @ 2.5 t/ha	24.97	2.26	1.29
T_{15} - 100% RDF + Biochar @ 3 t/ha + Vermicompost @ 2.5 t/ha	32.12	4.29	2.56
T_{16} - 100% RDF + Biochar @ 4 t/ha + Vermicompost @ 2.5 t/ha	38.85	5.22	3.19
SE(m)±	1.27	0.14	0.08
CD(p≤0.05)	3.67	0.40	0.23

However, successive increase in biochar doses from lowest level of 2 t/ha to 3 and 4 t/ha slightly increased fruit and haulm dry matter over lower doses. The combined application of 75% RDF and biochar significantly increased the fruit and haulm dry matter over sole application of biochar at respective graded doses as well as over control plots. Further, significant increase in fruit and haulm dry matter was also observed with subsequent increase in RDF to 100% in combination with biochar over 75% RDF and biochar at respective graded doses. Similarly, the inclusion of vermicompost @ 2.5 t/ha with 75% RDF + biochar significantly increased the fruit and haulm dry matter over 75% RDF and biochar at respective graded doses. The fruit and haulm dry matter obtained with 75% RDF + biochar + vermicompost @ 2.5 t/ha was observed to be superior over 100% RDF and biochar at respective graded doses. However, the addition of vermicompost @ 2.5 t/ha with 100% RDF + biochar further increased the fruit and haulm dry matter over 100% RDF and biochar at respective graded doses. The trend observed for fruit and haulm dry matter yield under different treatments followed the same trend of fresh fruit yield, possibly due to the same reasons as already discussed.

In conclusion, the combined application of biochar @ 4 t/ha with vermicompost @ 2.5 t/ha and 100% RDF was found to be most effective in increasing tomato yield in acid soil than sole application of biochar or biochar in combination with recommended doses of chemical fertilizers.

Abbreviations

RDF (Recommended doses of NPK fertilizers), B (Biochar), VC (Vermicompost)

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