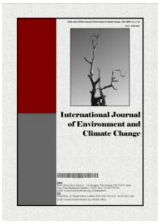

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Effect of Vermicomposting and Composting of Municipal Solid Waste (MSW) on Growth, Yield and Quality of Chickpea

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Authors' contributions

This work was carried out in collaboration among all authors. Author CC conduct the research trial, soil and plant analysis and report writing. Author PHV designed & Guided for doing the research work as a research guide and author PZ managed the literature searches and analysis. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was undertaken with an objective to understand the effect of municipal solid waste (MSW) vermicompost and compost on growth, yield and quality of chickpea. The experiment was laid in randomized block design with three replications and seven treatments *viz,* T_1 - RDF, T_2 - RDF + vermicompost of MSW @ 2.5 t ha^{-1}, T_3 - RDF + vermicompost of MSW @ 5 t ha^{-1}, T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1}, T_5 - RDF + compost of MSW @ 2.5 t ha^{-1}, T_6 - compost of MSW @ 5 t ha^{-1}, T_7 -compost of MSW @ 7.5 t ha^{-1}. The field experiment was conducted at College of Agriculture, Latur farm during the Rabi season 2016-2017. The recommended dose of fertilizer (25:50:00 N: P: K) and MSW vermicompost and compost was applied at the time of sowing. The results of field experiment revealed that the maximum availability of macro and micronutrients in soil, growth attributes viz. plant height and number of branches in all growth stages of chickpea were found at application of 7.5 tones of MSW vermicompost ha^{-1} along with 100% RDF (25:50:00 NPK) followed by application of 7.5 tones MSW compost ha^{-1} along with

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100% RDF and which was significantly increased with increased levels of MSW vermicompost and compost. Similar trend was observed in case of yield and quality parameters *viz.,* protein content of chickpea.

Keywords: Vermicomposting; composting municipal solid waste; growth and quality of chickpea.

1. INTRODUCTION

Rapid increase in population and change in the lifestyle in India have resulted in a remarkable increase in municipal solid waste (MSW). MSW includes both domestic and commercial waste and it refers to the materials discarded in the urban areas for which municipalities are usually held responsible for collection, transport and final disposal. The accumulation of large amount of MSW creates several problems in city and nowadays the management has become a biggest challenge in front of Municipal Corporation of many cities in India. According to Hoornweg [1], in India, MSW generation has been estimated as 0.46 kg/day per capita in 1995 and the study also forecasted the increase of MSW generation would be 0.7 kg/ day per capita in 2025. The chemical composition of MSW compost was alkaline in nature (pH 7.75), carbon content was 174 g kg^{-1}, NPK was 17.9, 0.38 and 9.54 g kg^{-1} respectively, where as macronutrients Ca Mg and S content were 3.01, 0.73 and 5.81 g kg^{-1} respectively and micronutrients concentration viz. Fe, Zn, Mn, Cu and B were 0.20, 14.28, 24.04, 11.69 and 27.68 g kg^{-1} respectively [2]. The composting of MSW was which having 45 per cent organic matter, 36 per cent moisture content and acceptable amount of plant nutrients NPK and carbon contents is 0.05, 0.002, 0.35 and 35 per cent respectively [3]. The recycling of MSW in agriculture which helps to supply of nutrients to plants. The MSW vermicompost and compost used in soil application found helpful in maintaining soil fertility and improve moisture holding capacity of soil and helps to increase the production. Chickpea grain yields are known to improve with the application of nitrogen [4]. Phosphorus plays an important role in nodulation, nitrogen fixation, growth and yield of chickpea [5]. Vermicompost enriches soil in most natural organic manner and also increases the soil fertility, soil micro-organisms and organic fertilizer is completely harmless and provide macro and micronutrients that is best to crop growth. MSW vermicomposting and composting is being encouraged in many countries of the world and researchers have experienced the benefits of rising MSW in the field. Onwudiwe et al. [6] and Elayarajan et al. [7] reported that maximum nutrient, yield and quality of maize were observed through integrated application of 100% NPK along with MSW vermicompost and FYM.

2. MATERIALS AND METHODS

Municipal solid waste was collected from the Latur city. The collected MSW was air dried separately spreading over a polythene sheet for 48 hours. The air dried samples were partial decomposed for three weeks before putting into vermicomposting process. A convenient pit of a size 2×1×1 m was constructed with a concrete base. The pit was filled with partial decomposed MSW in layers 15 to 20 cm thick and cow dung slurry was added in the ratio of 3:1 and released about 1000 earthworms (*Eisenia Foetida*) and maintained the humidity around 65 to 75 per cent by watering and also inoculated cow dung which served as attractive feeding resource for earthworms. The processes of vermicomposting and was carried out for a period of 60 days and vermicompost was ready after 70 days for application. Compost preparation was conducted in dug out pits 2×1×1m by adopting aerobic decomposition process. MSW waste was filled in layers 15 to 20 cm thick and cow-dung slurry was added in the ratio of 3:1. To improve the aeration, contents in the pits were turned once in fifteen days. After seven days, efficient cultures of *Trichoderma harizanum* were added to the pit to enhance the rate of decomposition. The compost was ready after 90 days for application. The chemical composition of MSW compost was alkaline in nature (pH 7.90) and electrical conductivity was 1.60 dSm^{-1}. Organic carbon content was 17.16 per cent, total N, P, K were 0.60, 0.25, 0.38 per cent respectively. The micronutrients and heavy metals in the MSW compost were estimated and observed their concentration Cu - 42.11 mg kg^{-1}, Mn - 250.67 mg kg^{-1}, Zn - 62 mg kg^{-1}, Fe - 1224 mg kg^{-1}, Pb - 22.9 mg kg^{-1}, Cr - 15.05 mg kg^{-1} and Ni - 15.43 mg kg^{-1}. Cadmium was found below detectable level. The vermicompost was alkaline in nature (pH 7.45) and electrical conductivity was 1.85 dSm^{-1}. Organic carbon content was 20.17 per cent, total N, P, K were 0.72, 0.33, 0.45 per cent respectively. The micronutrients and heavy

metals in the MSW vermicompost were estimated and observed their concentration Cu - 60.72 mg kg^{-1}, Mn - 343.17 mg kg^{-1}, Zn - 72 mg kg^{-1}, Fe - 1287 mg kg^{-1}, Pb - 21.05 mg kg^{-1}, Cr - 12.53 mg kg^{-1} and Ni - 12.75 mg kg^{-1}. Cadmium was found below detectable level in MSW vermicompost.

The experiment was conducted during *Rabi* season of 2016-17 at farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Latur in Marathwadha region Maharastra. This experiment was laid out in randomized block design with three replications and seven treatments *viz,*T_1- RDF, T_2 - RDF + vermicompost of MSW @ 2.5 t ha^{-1}, T_3 - RDF + vermicompost of MSW @ 5 t ha^{-1}, T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1}, T_5 - RDF + compost of MSW @ 2.5 t ha^{-1}, T_6 -compost of MSW @ 5 t ha^{-1}, T_7 -compost of MSW @ 7.5 t ha^{-1}. Total numbers of plots were 21, size 3.6 x 3 sq. m with spacing 30 x 10 cm with local variety Aakash (BDNG 797). MSW vermicompost and compost was applied at the time of planting and recommended dose of fertilizer (25:50:00 N: P: K) was applied in the same time. The random selection of five plants per plots for recorded the growth and yield attribute viz. plant height, no of pods, total biomass and grain yield and quality parameters like protein content was determined by standard procedure AOAC, 1975, The chemical analysis of soil was carried out as per standard procedure [8]. Statistical analysis was carried out with [9].

3. RESULTS AND DISCUSSION

3.1 Chemical Properties of Soil

The result regarding chemical properties (Table 1 and Figs. 1, 2 & 3) of soil viz. pH, EC and $CaCO_3$ did not affected significantly however organic carbon showed significant treatments result under MSW compost and vermicompost. The soil pH (7.47), EC (0.31 dsm^{-1}) and calcium carbonate (7.83%) were recorded lowest due to application of MSW vermicompost with combination of inorganic fertilizers i.e. RDF + vermicompost of MSW @ 7.5 t ha^{-1}. The higher $CaCO_3$ was recorded due to treatment with T_1 – control (9.50%). Further data revealed that there was decrease in $CaCO_3$ content in the post harvest soil samples over the initial (9%) soil samples. This clearly indicated that the application of organic manure reduced the $CaCO_3$ content in soil might be due to addition of sufficient organic matter in the soil [10]. However, organic carbon (7.77 g kg^{-1}) significantly increases due to the application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} followed by the RDF + compost of MSW @ 7.5 t ha^{-1} which was significantly superior over the control. The increase in organic carbon might be due to addition of organic matter in soil through vermicompost and compost. Similar results were also observed by Walter et al. (2006) composted municipal solid waste (MSW) applied at the rate of 0, 40, 80 or 120 Mg ha^{-1} significantly increased soil organic carbon levels after application. Available nutrients *viz*. N,P and K in soil were significantly affected with a application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} (T_4) recorded significantly higher available N (235.20 kg ha^{-1}), P (24.17 kg ha^{-1}) and K (619.07 kg ha^{-1}) in soil after harvest of chickpea followed by treatment RDF + compost of MSW @ 7.5 t ha^{-1} (T_7). Thakur [11] reported that application of phosphorus and potassium increases the NPK of the soil with increases in the concentration of the nutrients which increases the metabolic activities in plant. Increasing the doses of compost increased the levels of nutrients in soil [12]. The status of DTPA extractable micronutrients was found maximum *viz*. Fe (2.13 mg ka^{-1}), Mn (4.70 mg kg^{-1}), Zn (0.88 mg kg^{-1}), Cu (4.08 mg kg^{-1}) with the application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} (T_4) followed by application of RDF + compost of MSW @ 7.5 t ha^{-1} (T_7) and which significant over control. The results were in agreement with the findings of Ananda et al. [13], who reported that organic nutrient sources increased the micronutrient status of soil against control.

3.2 Plant Growth Attributes

The plant height were recorded at vegetative, flowering, pod formation and maturity stage of crop (Table 2) and plant height depicted in Fig. 4. It was evident from the results that the plant height was significantly affected due to MSW vermicompost and compost at different stages of the crop and it was increased with advanced stage. The treatment T_4 -RDF + vermicompost of MSW @ 7.5 t ha^{-1}recorded significantly higher plant height at flowering (39.33 cm), pod formation (45.87 cm) and maturity (51.07 cm) over rest of the treatments. Whereas the minimum height of plant was observed with treatment controlatflowering, pod formation and maturity stages of chickpea. However, the resultant treatment T_4 showed at

par result with the treatment T_7 - RDF + compost of MSW @ 7.5 t ha^{-1}at flowering, pod formation and maturity stage. Treatments at vegetative stage were found non-significant. This increase of plant height might be due to application of vermicompost and compost of MSW which helped in acceleration of various metabolic processes in plants resulting greater apical growth Sanu et al. [14]. The data regarding number of pods recorded at maturity stage was presented in Table 3. It was evident from the results that, the number of pods $plant^{-1}$ were significantly affected due to application of vermicompost and compost of MSW. The maximum number of pods $plant^{-1}$ were observed with the treatment T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1}at maturity stage of chickpea (50.27) which was significantly superior over rest of the treatments. The minimum number of pods was observed with treatment T_1 - control (36.47) of chickpea. The reason for increasing the number of pods might be due to availability of nutrients through application of vermicompost and compost of MSW to the chickpea crop which increased number of pods $plant^{-1}$. The reason for increasing the number of pods might be due to availability of nutrients through application of vermicompost and compost of MSW to the chickpea crop which increased number of pods $plant^{-1}$. Similar results were also reported by Singh et al. [15] application of 5 t vermicompost ha^{-1} improved chickpea grain yield by 14.89 % and observed maximum no of pods $plant^{-1}$ (60.4). The data regarding total biomass production (Table 3) recorded significantly increase in total biomass of chickpea. The accumulation of biomass was relatively more at the later part of the crop. This may be attributed to the productive phases of chickpea. The maximum and significant increase of biomass was recorded with treatment T_4 i.e. application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} (4997.33 kg ha^{-1}) which was at par with T_7 - RDF + compost MSW @ 7.5 t ha^{-1} (4750.00 kg ha^{-1}), T_3 - RDF + vermicompost of MSW @ 5 t ha^{-1} (4590.00 kg ha^{-1}) and T_6 - RDF +compost of MSW @ 5 t ha^{-1} (4566.67 kg ha^{-1}) at harvesting stage. This may be due to the effect of both vermicompost and compost of MSW application at the rate of 7.5 t ha^{-1}. Potassium plays a major role in growth as it is involved in assimilation, transport, and storage tissue development. Similar results were found by Bhanu Prakash et al. [16]. Highest biomass yield of (45082 kg ha^{-1}) was recorded with the 50 per cent RDF along with compost made from urban waste, cow dung, rock phosphate, green leaves and micronutrients.

3.3 Grain Yield Attribute and Yield of Chickpea

The data pertaining to the number of pods $plant^{-1}$ are presented in Table 3 and depicted in Fig 5. It was evident from the results that, the number of pods $plant^{-1}$ and total biomasswere significantly affected due to application of vermicompost and compost of MSW. The maximum number of pods $plant^{-1}$ and total biomasswere observed with the treatment T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1}at maturity stage of chickpea which was significantly superior over rest of the treatments. The data pertaining to grain yield depicted in Fig 3. It was observed from the results that the treatment T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1} recorded significantly higher grain yield (20.20 q ha^{-1}) over the rest of treatments and it was at par with the treatment T_7 - RDF + compost of MSW @ 7.5 t ha^{-1}(18.87 q ha^{-1}). The lowest grain yield was recorded by treatment T_1 - control (15.17 q ha^{-1}). The increased seed yield in chickpea might be due to effect application of MSW vermicompost and compost.Similar results also found by Sedigheh et al. [17] showed maximum soybean grain yield (4426 kg ha^{-1}) on application of enriched MSW compost which increased grain yield (23%) compared to non-enriched MSW compost. Jat and Ahlawat [5] found that the Application of vermicompost increased the grain yield (2.44 t ha^{-1}) of chickpea by (18.4%) and (19.1%) over no vermicompost.

3.4 Quality of Chickpea

The data pertaining to protein content in seed and protein yield are presented in Table 4 and Figs. 6 and 7. It was evident from the results that, the protein content in seed and protein yield were significantly affected due to different doses of MSW vermicompost and compost. Significantly higher protein content (23.70%) was observed in treatment T_4 - RDF + vermicompost of MSW @ 7.5 t $ha^{-1}$and it was at par with the treatment T_7 - RDF + compost of MSW @ 7.5 t ha^{-1} (22.85%). The lower protein content (19.31%) in seed was observed with treatment T_1 (control). The higher protein yield (474.18 kg ha^{-1}) was observed with treatment T_4 - RDF + vermicompost of MSW @ 7.5 t ha^{-1} which was significantly superior than the rest of treatments except treatment T_7 at par with the treatment T_7 - RDF + compost of MSW @ 7.5 t ha^{-1} (418.69 kg ha^{-1}). The lower protein yield (300.73 kg ha^{-1}) was observed in treatment T_1 (control). Similar results were found by Kasthuri et al. (2011) reported that the application of MSWC up to 500 g/pot was found

significant. The percentage of protein was increased significantly up to 250 g/pot for green gram and 500 g/pot for fenugreek in compost treated plots compared to control. Pezeshkpour et al. [18] reported that the application of vermicompost @ 12 t ha^{-1} to chickpea improved the protein content and protein yield (18.3% and 438.7 kg ha^{-1} respectively). This might be due to nitrogen which plays an important role in the synthesis of amino acids, carbohydrates etc. Which influence the synthesis of phytohormones such as auxins, gibberellins, cytokinins and ethylene resulting in increased protein content in brinjal [19].

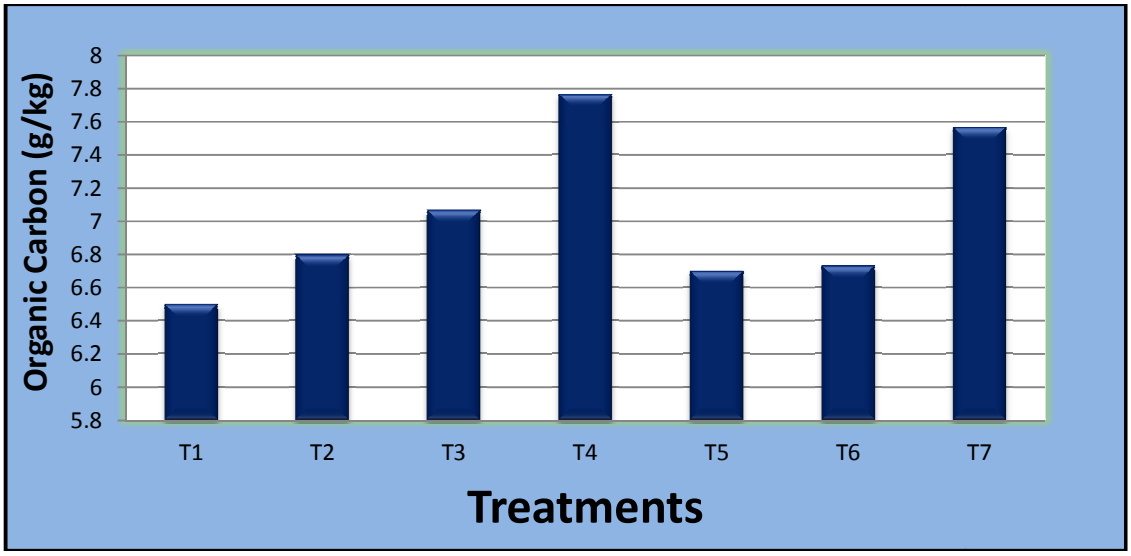

Fig. 1. Effect of MSW vermicompost and compost on soil organic carbon (g/kg)

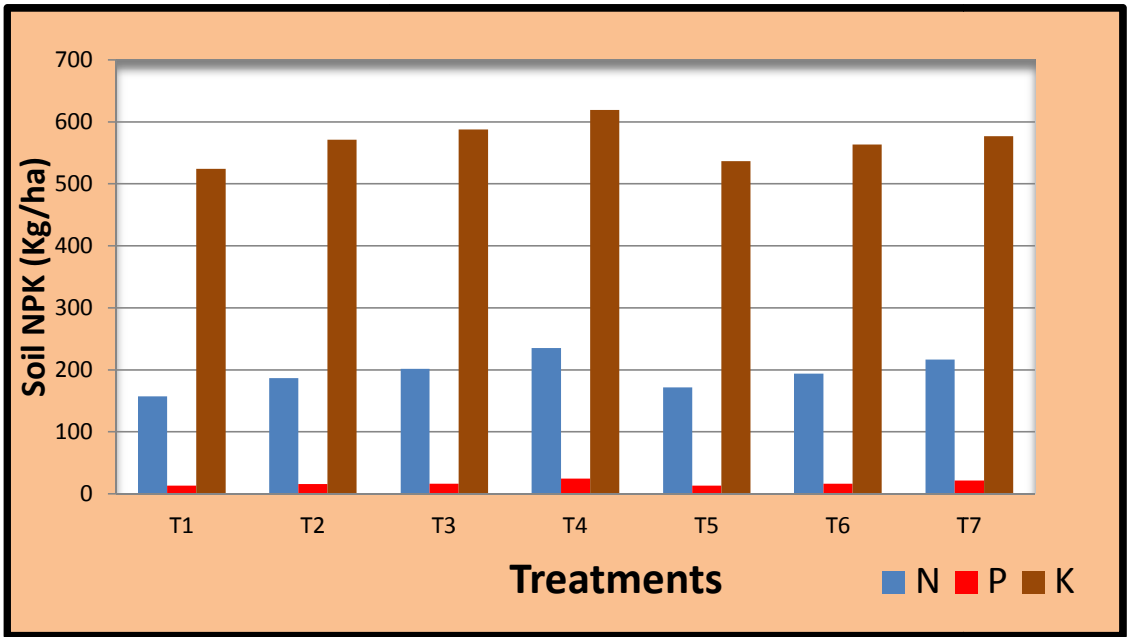

Fig. 2. Effect of MSW vermicompost and compost on soil available NPK (Kg/ha)

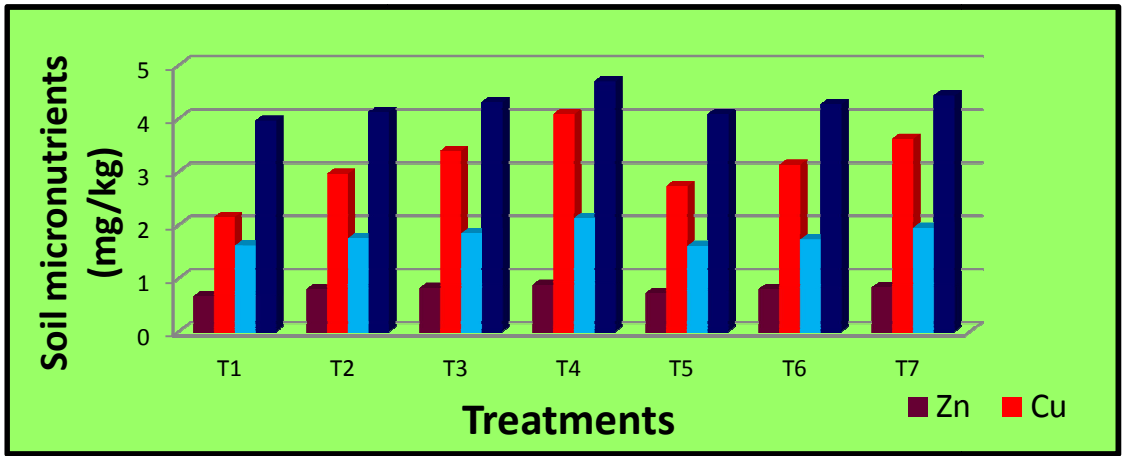

Fig. 3. Effect of MSW vermicompost and compost on soil micronutrients (mg/kg)

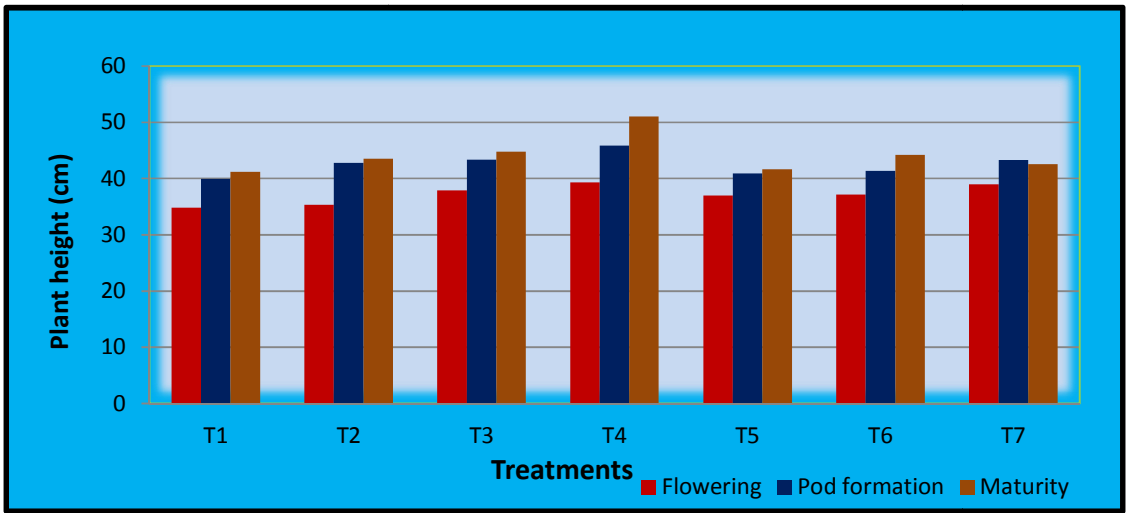

Fig. 4. Effect of MSW vermicompost and compost on plant height

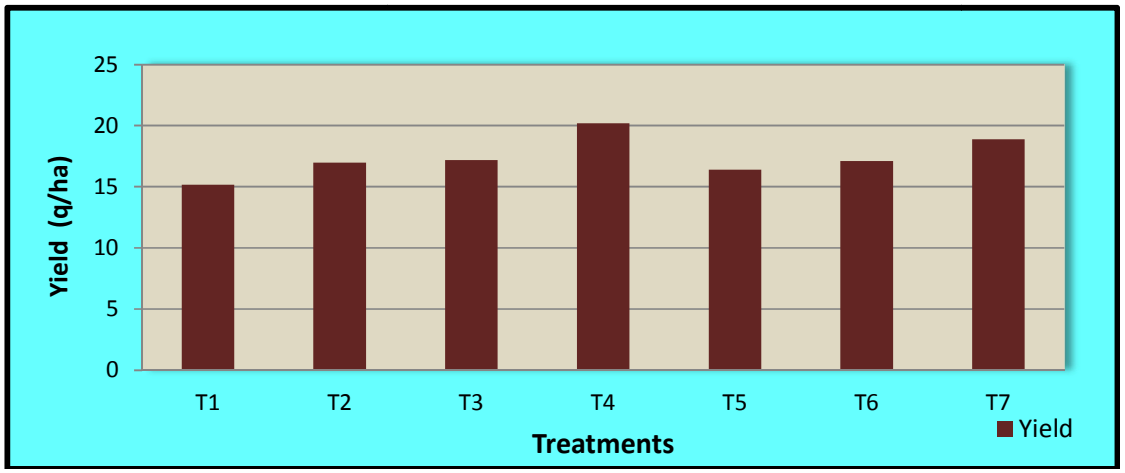

Fig. 5. Effect of MSW vermicompost and compost on yield of chickpea

Table 1. Effect of MSW vermicompost and compost on chemical properties of soil and available nutrients status in soil after harvest of chickpea

Treatments	Chemical properties of Soil				Available macronutrients (kg ha^{-1})			Soil DTPA extractable micro nutrients (mg kg^{-1})			
	Soil pH (1: 2.5)	EC(dSm^{-1}) (1: 2.5)	OC (g kg^{-1})	$CaCO_3$ (%)	N	P_2O_5	K_2O	Zn	Cu	Fe	Mn
T_1: RDF	7.55	0.41	6.50	9.50	156.8	13.1	523.9	0.66	2.15	1.62	3.96
T_2: RDF + vermicompost of MSW @ 2.5 t ha^{-1}	7.52	0.35	6.80	9.23	186.6	15.5	570.9	0.80	2.96	1.75	4.12
T_3: RDF + vermicompost of MSW @ 5 t ha^{-1}	7.53	0.36	7.07	8.40	201.6	16.2	587.6	0.82	3.39	1.84	4.31
T_4: RDF + vermicompost of MSW @ 7.5 t ha^{-1}	7.47	0.31	7.77	7.83	235.2	24.1	619.0	0.88	4.08	2.13	4.70
T_5: RDF + compost of MSW @ 2.5 t ha^{-1}	7.47	0.39	6.70	9.33	171.7	13.3	536.7	0.72	2.73	1.61	4.08
T_6: RDF + compost of MSW @ 5 t ha^{-1}	7.48	0.36	6.73	8.83	194.1	16.1	563.2	0.80	3.13	1.73	4.27
T_7: RDF + compost of MSW @ 7.5 t ha^{-1}	7.48	0.36	7.57	8.33	216.5	21.5	577.1	0.83	3.62	1.95	4.43
S.Em±	0.050	0.032	0.257	0.369	6.466	0.873	14.807	0.018	0.271	0.056	0.053
CD at 5%	NS	NS	0.792	NS	19.923	2.689	45.622	0.054	0.834	0.171	0.164
Initial status of soil	7.6	0.46	7.45	9.0	190.4	14.75	559.58	0.63	2.20	1.62	3.85

Table 2. Effect of vermicompost and compost of MSW on plant height (cm) of chickpea

Treatments	Mean plant height (cm)			
	Vegetative	Flowering	Pod formation	Maturity
T_1: RDF	26.00	34.80	39.93	41.20
T_2: RDF + vermicompost of MSW @ 2.5 t ha^{-1}	24.25	35.33	42.81	43.47
T_3: RDF + vermicompost of MSW @ 5 t ha^{-1}	25.87	37.87	43.33	44.80
T_4: RDF + vermicompost of MSW @ 7.5 t ha^{-1}	27.13	39.33	45.87	51.07
T_5: RDF + compost of MSW @ 2.5 t ha^{-1}	27.53	36.93	40.93	41.60
T_6: RDF + compost of MSW @ 5 t ha^{-1}	27.47	37.13	41.33	44.20
T_7: RDF + compost of MSW @ 7.5 t ha^{-1}	28.20	39.00	43.27	42.53
S.Em ±	1.466	1.000	0.985	1.782
CD at 5%	NS	3.082	3.036	5.490

Table 3. Effect of application of MSW vermicompost and compost on number of pods plant^{-1}, total biomass and grain yield of chickpea (kg ha^{-1})

Treatments	Mean number of pods plant^{-1} at maturity	Total Biomass (kg ha^{-1})	Grain yield (Q ha^{-1})
T_1: RDF	36.47	3611.00	15.17
T_2: RDF + vermicompost of MSW @ 2.5 t ha^{-1}	44.27	3910.00	16.97
T_3: RDF + vermicompost of MSW @ 5 t ha^{-1}	44.60	4590.00	17.17
T_4: RDF + vermicompost of MSW @ 7.5 t ha^{-1}	50.27	4997.00	20.20
T_5: RDF + compost of MSW @ 2.5 t ha^{-1}	39.47	3900.00	16.40
T_6: RDF + compost of MSW @ 5 t ha^{-1}	41.47	4566.67	17.10
T_7: RDF + compost of MSW @ 7.5 t ha^{-1}	43.73	4750.00	18.87
S.Em±	1.632	179.289	0.715
CD at 5%	5.027	552.407	2.203

Table 4. Effect of MSW vermicompost and compost on quality attributes of chickpea

Treatments	Protein content (%)	Protein yield (kg ha^{-1})
T_1: RDF	19.31	300.73
T_2: RDF + vermicompost of MSW @ 2.5 t ha^{-1}	20.31	311.36
T_3: RDF + vermicompost of MSW @ 5 t ha^{-1}	21.50	383.43
T_4: RDF + vermicompost of MSW @ 7.5 t ha^{-1}	23.70	474.18
T_5: RDF + compost of MSW @ 2.5 t ha^{-1}	19.75	351.08
T_6: RDF + compost of MSW @ 5 t ha^{-1}	20.80	356.80
T_7: RDF + compost of MSW @ 7.5 t ha^{-1}	22.85	418.69
S.Em±	0.296	18.392
CD at 5%	0.912	56.669

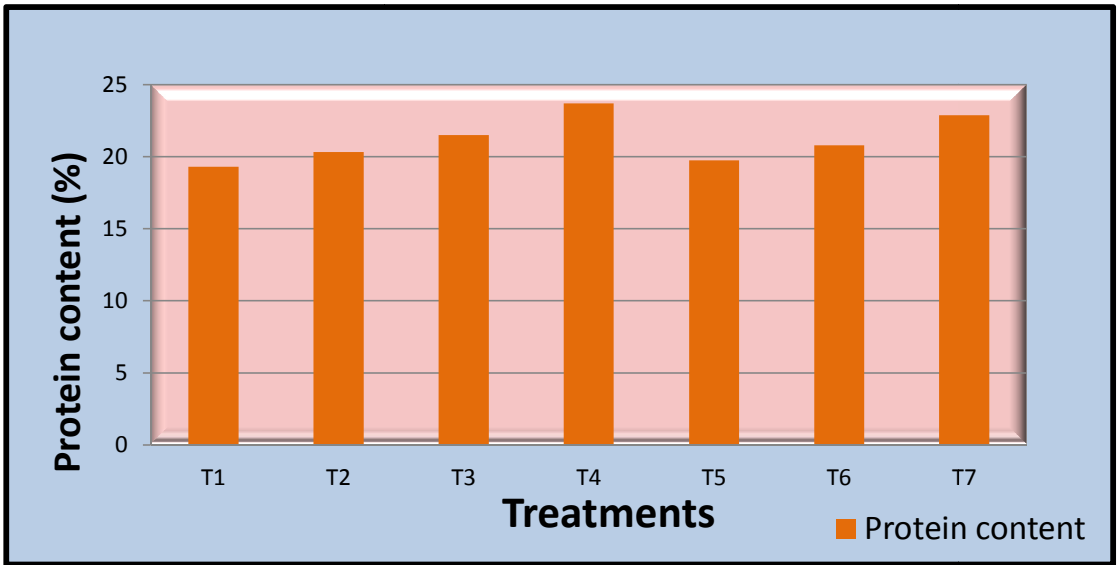

Fig. 6. Effect of MSW vermicompost and compost on seed protein content (%)

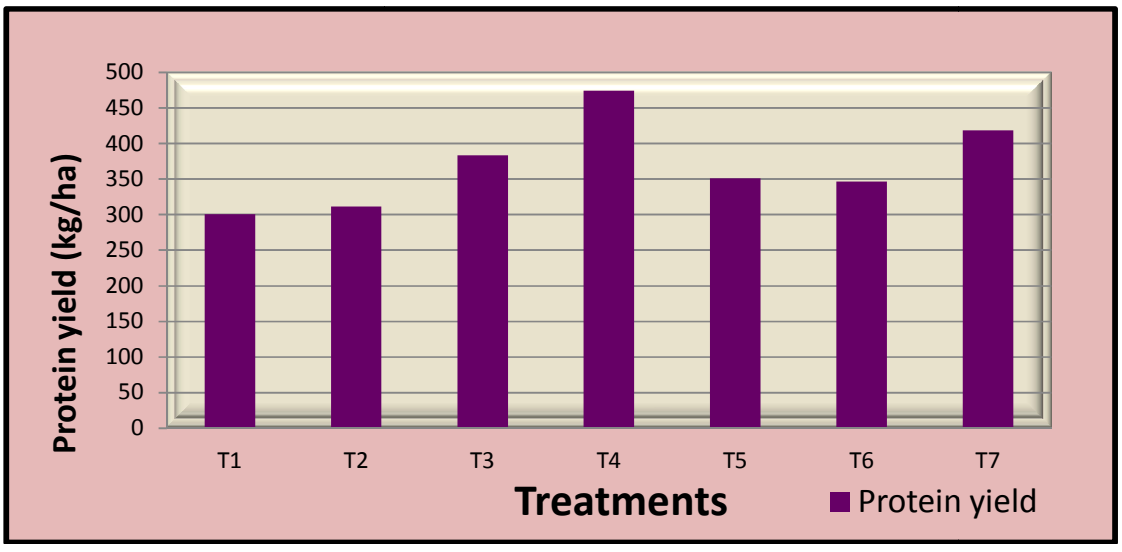

Fig. 7. Effect of MSW vermicompost and compost on protein yield (kg/ha)

4. CONCLUSION

All growth parameters, yield and quality of chickpea and nutrients status in soil was improved with application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} which was superior over the control. Maximum yield (20.20 q/ha) and protein content (23.70%) in chickpea was recorded with application of RDF + vermicompost of MSW @ 7.5 t ha^{-1} followed by RDF + compost of MSW @ 7.5 t ha^{-1}. However, concluded that MSW vermicompost and compost will be used for application in agricultural field along with inorganic fertilizer, which improves growth, yield and quality of crop. The composting and vermicomposting of municipal solid waste (MSW) will be a solution for management of MSW in urban area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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