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Impact of different composts on physical and chemical properties of vertisols under rainfed *Bt.* cotton

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Abstract
The experiment was initiated from 2023-24 to study the "Impact of composts on physical and chemical properties of vertisols under rainfed *Bt.* cotton" at Research Field of Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola, Maharashtra. There were eight treatments viz. T_1-Absolute control, T_2-10 t ha^{-1} FYM (University Recommended Dose), T_3-75% RDN through VNIT compost, T_4-75% RDN through Vermicompost, T_5-75% RDN through PDKV phospho-compost, T_6-100% RDN through VNIT compost, T_7-100% RDN through Vermicompost and T_8-100% RDN through phospho-compost replicated three times in Randomized Block Design. The results after 1st year of organic *Bt.* cotton experimentation, application of 100% RDN through phosphocompost revealed significant improvement in physical properties viz., BD, HC and MWD of the Vertisols, whereas in case of physic-chemical properties improvement in pH, EC and organic carbon content of the soil was non-significant. However, the significant improvement in residual available N, P and K content in soils was observed under 10 tha^{-1} FYM application treatment. The available S content was significantly highest in PDKV phosphocompost treatment.

Keywords: FYM, phosphocompost, vermicompost, soil physical, chemical properties, *Bt.* rainfed cotton, vertisol

Introduction

Cotton (*Gossypium hirsutum* L.) is a natural fiber crop that is derived from the Arabic word "quotn". The Gossypium genus, was also derived from the Arabic word "goz", meaning a soft substance. Cotton is an unique natural fiber crop in the world. Apart from its fiber, cotton is an important source of vegetable oil used for the preparation of soup, medicine, cosmetics, and animal feed. The cottonseed is rich in both oil (18-24%) and protein (20-40%), and thus leftover cake is often used as concentrate feed for cattle.

India accounts for around 25% of the total global cotton production and is one of the most important commercial crops cultivated in the country and it plays an important role in the textile industry. Due to its economic importance in India, it is also referred to as "White-Gold". It is a means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing, and other allied industries.

Nine significant cotton-growing states in India make up the majority of the country's cotton production which includes Gujarat, Maharashtra, Madhya Pradesh, Telangana, Andhra Pradesh, and Karnataka.

The soil moisture and fertility of soils is very important under cultivation of rainfed crop, like cotton. It was observed that organic sources such as FYM, vermincompost, phosphocompost etc. improve the physical and chemical properties of soils. Organic sources are also very much important in increasing the microbial activity in the soil, improving soil health as well as the productivity of crop and also help to increase the nutrient content of soil.

Farmyard manure provides essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favourable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes (Ismail *et al.*, 1998) [12]. Farm Yard Manure (FYM) increases organic carbon content in the soil and improves soil physical properties (Manchala *et al.*, 2017) [26]. Similarly, vermicompost is an excellent source of nutrients for crops and helps to convert organic waste into rich humus.

Vermicompost is a rich source of micro and macronutrient. The nutrients present in it are readily water soluble for the uptake of micro flora. Vermicompost, which is produced by earthworms, is a rich source of both micro and macro nutrients, vitamins, growth hormones and enzymes (Bhavalkar, 1991) [2].

Phospho-compost or N-enriched phospho-compost technology has, thus, been developed using phosphate solubilizing microorganisms, namely, *Aspergillus awamori*, *Pseudomonas straita* and *Bacillus megaterium*, phosphate rock, pyrite and bio-solids to increase the manurial value as compared to ordinary FYM. VNIT compost could offer a solution to replenish soil nutrients and improve soil health, leading to increased agricultural productivity and sustainability.

Materials and Methods

A field experiment was conducted at the Research Farm Department of Soil Science, Dr. PDKV, Akola during *kharif* season of 2023-24. There were eight treatments replicated three times in Randomized Block Design viz. [T_1- Absolute control, T_2-10 t ha^{-1} FYM (University Recommended Dose of FYM), T_3-75% RDN through VNIT compost (@4.5 t ha^{-1}), T_4-75% RDN through Vermicompost (@7.5 t ha^{-1}), T_5-75% RDN through PDKV phospho-compost (@5.6 t ha^{-1}), T_6-100% RDN through VNIT compost (@6 t ha^{-1}), T_7-100% RDN through Vermicompost (@10 t ha^{-1}) and T_8-100% RDN through phospho-compost (@7.5 t ha^{-1}). The recommended dose of fertilizers to *Bt.* Cotton is 90:45:45 N:P:K kg ha^{-1} and the doses of organic compost was given on the basis of nitrogen equivalent. All the composts samples utilized for the experiment were analysed by using standard methods and their nutritional content is presented in table 1.

Table 1: Nutrient content (%) in organic sources used for the experimentation

Sr. No.	Name of organic source	Nutrient content (%)		
		N	P	K
1.	FYM	0.51	0.17	0.47
2.	Phosphocompost	1.20	1.85	0.65
3.	VNIT Compost	1.50	0.90	0.70
4.	Vermicompost	0.90	1.49	0.60

Treatment wise soil samples were collected at 0-20 cm depth at harvesting of cotton crop. The air dried samples were carefully and gently ground with the wooden pestle to break soil lumps (clods) and were passed through sieve of 2 mm diameter. The sieved samples were mixed thoroughly and stored in polythene bags, properly labelled and preserved for subsequent analysis. For mean weight diameter, 8 mm size aggregates were retained on the sieve and used. For analysis of organic carbon, the soil samples were passed thorough 0.5 mm sieve.

Bulk Density was determined by clod coating method (Jackson, 1973) [13]. Hydraulic conductivity was determined by constant head method (Klute and Dirksen, 1986). Mean wet diameter was determined by aggregate stability method by Yoder (1936) [35]. The hydrogen ion activity expressed as pH was measured with pH meter using 1:2.5 soil water suspensions (Jackson, 1973) [13]. The clear supernatant extract obtained from suspension used for pH was taken for EC measurements (Jackson, 1973) [13]. To determine the organic carbon content of soil, the wet oxidation method as given by Nelson and Sommers (1982) [29] was followed.

The data was subjected to Analysis of Variance (ANOVA) in Randomized Block Design with 8 treatments and 3 replications as per standard statistical method and standard error was used to calculate Critical Difference to know the significant different among treatments and mean were separated by using F test (Panse and Sukhatme, 1985) [31].

Results and Discussion

Influence of organic nutrient sources to rainfed *Bt.* cotton on physical properties of Vertisols.

Bulk Density of soils

The data regarding the bulk density of soils is presented in a table 2 and depicted in Figure 1 under different organic treatments. The bulk density of soil under organic treatments ranged from 1.54 to 1.42 Mg m^{-3}. A significant influence on the bulk density of soils was observed under different organic sources over the control. As the doses of well-decomposed organic increases, there was a reduction in the bulk density of the soil. The treatment receiving 100% RDN through Phospho-compost recorded the lowest bulk density of 1.42 Mg m^{-3}, which was statistically at par to all other organic treatments. The highest bulk density of 1.54 Mg m^{-3} of Vertisols was observed in the absolute control treatment. Similar findings were also observed by Marathe and Bharambe (2005) [27], Katkar *et al*., (2007) [16] and Khan et al., (2010) [18].

Hydraulic Conductivity of soils

Data regarding the saturated hydraulic conductivity of experimental soils after the cotton crop harvest is presented in Table 2. The hydraulic conductivity of the soil showed significant differences under various organic treatments compared to the control. The data shows that after the crop harvest, the hydraulic conductivity of the surface soil ranged from 0.85 to 1.27 cm hr^{-1}. The treatment which received 100% RDN through Phospho-compost showed the highest hydraulic conductivity (1.27 cm hr^{-1}) followed by 10 t ha^{-1} FYM and 75% RDN through PDKV Phospho-compost (1.26 cm hr^{-1}), while the absolute control had the lowest hydraulic conductivity (0.85 cm hr^{-1}). All organic treatments were at par with each other record of improvement in H.C. Similar findings were reported by Khan *et al*., (2010) [18] and Khuspure et al., (2018) [19].

Mean Weight Diameter of soils

The data presented in the table 2 and depicted in the fig. 2 show a significant influence of various organic sources on the mean weight diameter (MWD) after the harvest of cotton crop. The MWD of surface soils varied from 0.72 to 0.76 mm. The incorporation of FYM @ 10 t ha^{-1}, 75% RDN through Vermicompost compost and 100% RDN through phosphocompost showed significantly highest MWD of vertisols over the VNIT compost and control treatment. The lowest MWD of 0.72 mm was observed in the absolute control treatment. Similar findings were reported by Brar *et al.*, (2015) [4], Khuspure *et al.*, (2018) [19] and Sapkal *et al.*, (2019) [33].

Table 2: Influence of different compost treatments on physical properties of soil after harvest of rainfed *Bt.* cotton crop

Treatments	BD (Mg m^{-3})	HC (cm hr^{-1})	MWD (mm)
T_1- Absolute Control	1.54	0.85	0.72
T_2-10t ha^{-1} FYM (Recommended Dose of FYM)	1.42	1.26	0.76
T_3- 75% RDN through VNIT compost	1.45	1.22	0.73
T_4- 75% RDN through Vermicompost	1.44	1.25	0.76
T_5- 75% RDN through PDKV Phosphocompost	1.44	1.26	0.75
T_6- 100% RDN through VNIT compost	1.44	1.25	0.73
T_7-100% RDN through Vermicompost compost	1.43	1.25	0.75
T_8-100% RDN through Phospho-compost	1.42	1.27	0.76
SE(m)$\pm$	0.026	0.02	0.007
CD at 5%	0.081	0.064	0.017

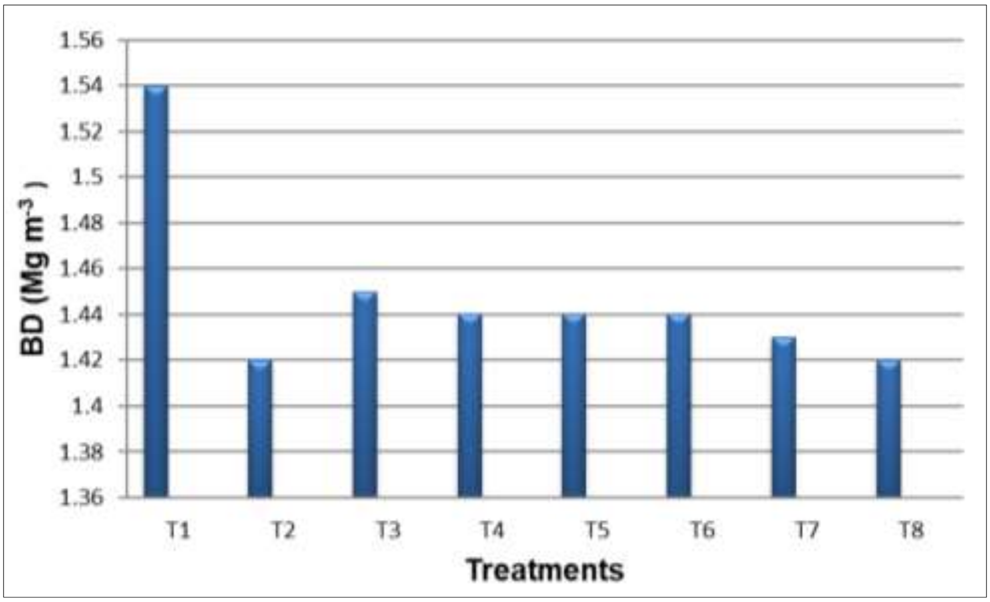

Fig 1: Bulk Density of soil as influence by various organic sources

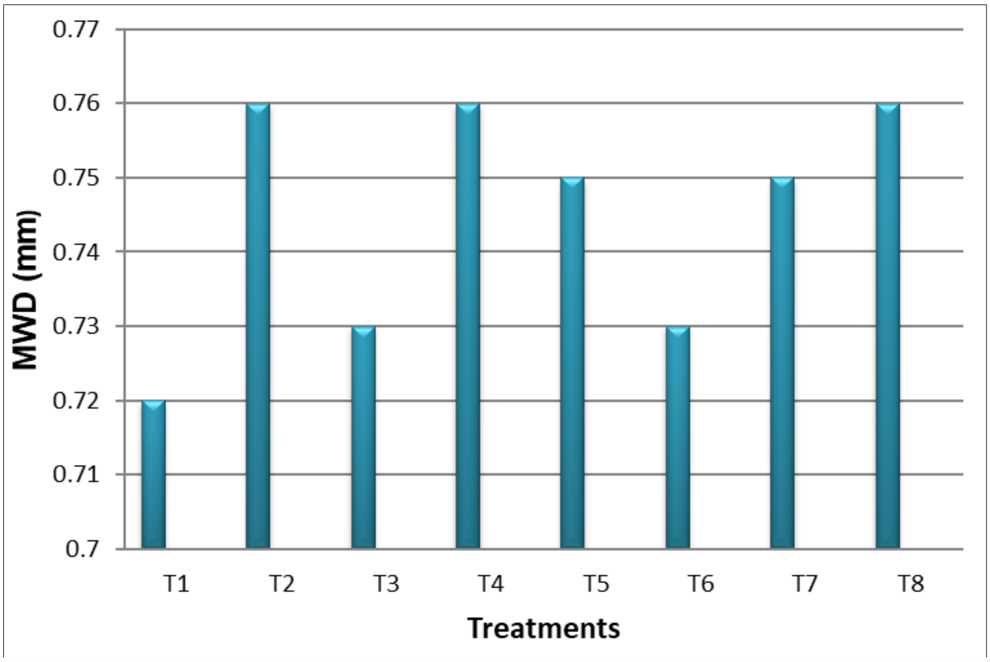

Fig 2: MWD of soil as influence by different compost sources

Influence of organic nutrient sources to rainfed *Bt.* cotton on chemical properties in Vertisols

Organic manures after their addition to soil undergo decomposition, during such biological degradation, organic acids are formed which held to lower down the soil pH and EC and organics like composts and FYM add the carbon source to soil hence increases the organic carbon levels in soils.

The pH, electrical conductivity, and organic carbon status of the soils were analyzed after the harvest *Bt.* cotton. The data is presented in the table 3. The influence of organic sources on the pH, electrical conductivity, and organic carbon content in Vertisols was non-significant.

Soil pH and Electrical Conductivity

The pH of the experimental soil was ranged from 8.10 to 8.17, and EC was ranged from 0.17 to 0.20 dSm^{-1}. The highest pH and EC values were observed in the absolute control treatment i.e. no addition of any organic matter and were found to decreases as the doses of organic nutrient sources increases. A slight change in pH was noted with the application of organic sources might be due to first year of organic experimentation. The lowest values of pH and EC were observed in the treatment that received well-decomposed FYM @ 10 t ha^{-1}, which were pH 8.10 and EC 0.17 dSm^{-1}, respectively. These findings are consistent with the results obtained by Dsouza A. *et al.*, (2018) [6] and Ojha *et al.*, (2014) [30] reported a decrease in pH due to different organic sources and doses, including FYM. Similar results were also reported by Khuspure et al., (2018) [19]. Higher value of EC was also for the FYM @ 10 t ha^{-1} treatment, furthermore Halemani *et al.*, (2004) [10] observed that the application of 50% compost showed the lowest EC compared to other treatments. Furthermore, Dsouza A. *et al.*, (2018) [6] reported that there were non-significant changes in EC of the soils due to organic ammendments. Also Khuspure *et al*., (2019) [14] reported that the highest pH and EC values were found in the absolute control and it was decrease as the doses of organic nutrient sources increases.

Soil organic carbon content

After first year of organic cotton experimentation the effect of different organic sources on organic carbon was also non-significant. However, numerically hightest (5.8 g kg^{-1}) organic carbon content in soil was observed in treatment 10 t ha^{-1} FYM and 100% RDN through Phospho-compost application treatments. The lowest organic carbon value 5.4 g kg^{-1} was observed in the absolute control treatment. These findings are in line with those of Ingle *et al.*, (2019) [11].

Table 3: Influence of different compost treatments on pH, EC and OC content of soil after harvest of *Bt.* cotton

Treatments	pH (1: 2.5)	EC (dSm^{-1})	OC (g kg^{-1})
T_1- Absolute Control	8.17	0.20	5.4
T_2-10t ha^{-1} FYM (Recommended Dose of FYM)	8.10	0.17	5.8
T_3- 75% RDN through VNIT compost	8.14	0.18	5.5
T_4- 75% RDN through Vermicompost	8.15	0.18	5.6
T_5- 75% RDN through PDKV Phosphocompost	8.13	0.18	5.7
T_6- 100% RDN through VNIT compost	8.13	0.18	5.6
T_7-100% RDN through Vermicompost compost	8.13	0.17	5.7
T_8-100% RDN through Phospho-compost	8.12	0.17	5.8
SE(m)$\pm$	0.042	0.013	0.016
CD at 5 %	NS	NS	NS

Influence of organic nutrient sources to rainfed *Bt.* cotton on fertility status of Vertisols

The addition of different organic sources increases the availability of major nutrients in the soils and improves the fertility status. The impact of organic sources on available nitrogen, available phosphorus, available potassium and available sulphur was studied and presented in table 4 below.

Available Nitrogen

Figure 3 shows the Significantly impact of different organic sources viz. FYM, vermicompost, VNIT compost, and phospho-compost on the available nitrogen in the soil after harvesting the rainfed *Bt.* cotton crop in Vertisols. The available nitrogen contain in soil was ranged from 185.80 to 217.08 kg ha^{-1}.

The study found that, the amount of nitrogen in the soil increased as the doses of well-decomposed organic manure increases. The data revealed that, 10 t ha^{-1} application of FYM reported significantly highest available nitrogen content at 217.08 kg ha^{-1} in soil after harvest of *Bt.* cotton crop which is followed by 100% RDN through Vermicompost, 75% RDN through VNIT compost and 100% RDN through phosphocompost. The lowest nitrogen content, 185.80 kg ha^{-1}, was observed in the absolute control.

The results are similar with the findings of Das *et al.*, (2003) [5], reported that, soil available nitrogen increased from 167 kg ha^{-1} to 240.7 kg ha^{-1} with the application of FYM compared to the control. Halemani *et al.*, (2004) [10] also observed that applying FYM @ of 10 t ha^{-1} to cotton resulted in increased carbon content and soil available nitrogen (254.36 kg ha^{-1}) compared to the control. Similar results were also reported by Liu *et al.*, (2010) [24], and Shankar et al., (2012) [36]. Additionally, the findings of Karangami *et al.*, (2017) [14], Gaddi *et al.*, (2020) [8], Karikatti *et al.*, (2020) [15], Reddy *et al.*, (2019) [32], Kumar *et al.*, (2020) [22], and Bose *et al.*, (2021) [3] are consistent with the findings of our study.

Available phosphorus

The data about the soil available phosphorus is despite in the Figure 3. The data indicates that organic sources such as FYM, vermicompost, VNIT compost, and Phospho-compost have a significant impact on the available phosphorus content in the soil after harvest of *Bt.* cotton crop.

The available P after the *Bt.* cotton harvest was significantly affected by various treatments. The results showed that the available phosphorus ranged from 12.43 to 17.71 kg ha^{-1}. It was observed that the available P status of the soil increased with higher doses of well-decomposed organic manures. The treatment that received 100% recommended dose of nitrogen (RDN) through Phospho-compost recorded the highest available P at 17.71 kg ha^{-1}. The treatment 75% RDN through PDKV phosphocompost and 10 t ha^{-1} FYM were at par with 100% RDN through phosphocompost. These results are consistent with the findings of Mali D.V. *et al.*, (2020) [25], reported that the highest available P (16.14 kg ha^{-1}) was observed with the application of recommended dose of fertilizers (RDF) through farmyard manure (FYM) along with the remaining P through phosphocompost. Similar results were also reported by Halemani *et al.*, (2004) [10], Liu *et al.*, (2010) [24], and Shankar et al. (2012) [36].

Table 4: Influence of different compost treatments on nutrient status of soil after harvest of *Bt.* cotton crop

Treatments	Available Nutrient			
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})
T_1- Absolute Control	185.80	12.43	317.62	9.42
T_2-10t ha^{-1} FYM (Recommended Dose of FYM)	217.08	17.49	344.59	11.62
T_3- 75% RDN through VNIT compost	195.63	12.63	325.51	11.86
T_4- 75% RDN through Vermicompost compost	206.33	14.95	318.86	11.96
T_5- 75% RDN through PDKV Phosphocompost	195.50	17.60	330.09	12.10
T_6- 100% RDN through VNIT compost	197.27	14.71	327.87	12.12
T_7-100% RDN through Vermicompost	210.27	16.73	323.20	12.17
T_8-100% RDN through Phospho-compost	203.40	17.71	330.77	12.25
SE(m)±	1.86	0.16	13.86	0.01
CD at 5 %	5.70	0.49	NS	0.03

Available Potassium

The data for soil potassium contain in soil is presented in Table 4 and in Fig. 3 showed the non-significant impact of various organic sources, viz. FYM, vermicompost, VNIT compost, and phospho-compost, on available potassium contain in soil after harvesting *Bt.* cotton.

The available potassium content in the soil ranged from 317.86 to 330.77 kg ha^{-1}. Notably, the highest potassium content after harvesting of *Bt.* Cotton was observed in 100% RDN through phospho-compost (330.77 kg ha^{-1}). The lowest potassium content was observed in absolute control treatment (317.62 kg ha^{-1}).

The similar result was also observed by Ingle *et al.*, (2019) [11], the highest amount of available potassium in soil recorded in treatment 100% N-FYM +Compensation of P Phospho-compost 373.10 Kg ha^{-1} which was significant superior with followed by rest of all treatments. Similar results were also reported by Aladankatti *et al.*, (2012) [1], Shankar *et al.*, (2012) [36], and *Liu et al.*, (2010) [24] and Halemani *et al.*, (2004) [10].

Available Sulphur

The significant improvement in available sulphur content is illustrated in the figure 3. After the harvest of cotton, the available sulphur content in the soil ranges from 9.42 to 12.25 mg kg^{-1}. The significantly highest available sulphur contain (12.25 mg kg^{-1}) was observed in 100% RDN through Phospho-compost which was followed by treatment 100% RDN through Vermicompost compost (12.17 mg kg^{-1}). The lowest sulphur content (9.42 mg kg^{-1}) was observed in Absolute Control. This increase may be attributed to the high sulphur content in the enriched compost. The addition of organic matter in the form of Phospho-compost, vermicompost, VNIT compost, and FYM likely contributed to the rise in sulphur content in various treatments. A similar increase in available sulphur after crop harvest was reported by Singh and Pramod (2011).

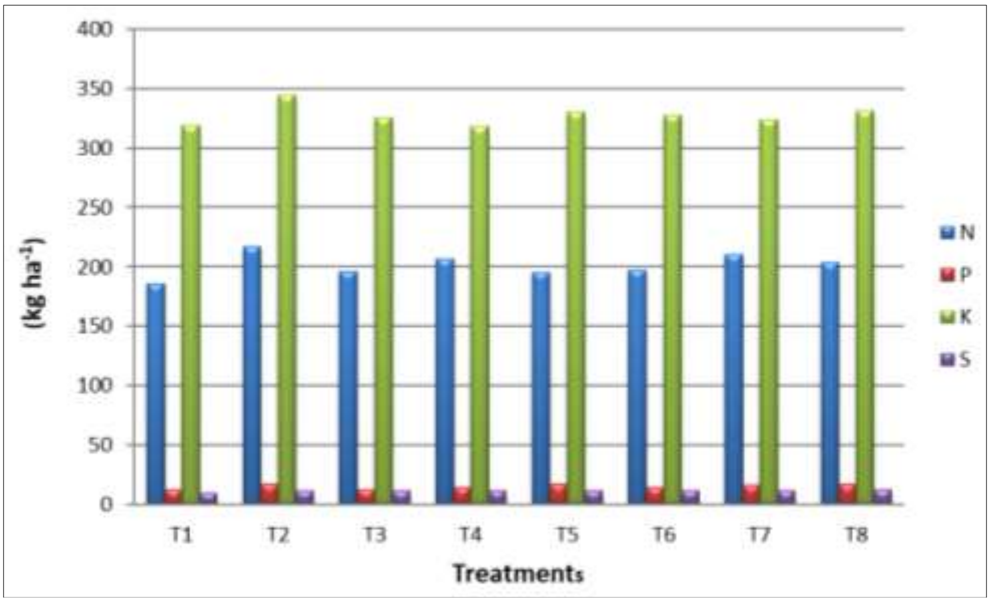

Fig 3: Effect of different compost sources of nutrients on available nutrients in soil

Conclusion

After the first cycle of rainfed organic *Bt.* cotton experimentation, it can be concluded that the application of 100% RDN through phosphocompost (@7.5 t ha^{-1}) showed significant improvement on soil physical properties viz., BD, HC and MWD of the vertisol whereas improvement was non-significant as regards of soil pH, EC and OC content of the soils and available S content was significantly highest in phosphocompost treatment. . Whereas, residual content of available N, P and K in Vertisols was observed under the 10 tha^{-1} FYM application.

References

1. Aladankatti YR, Hallikarni SS, Nandagavi RA. Long term effect of organic and inorganic nutrients sources on soil organic carbon and major nutrients in Vertisols. Geographical Research. 2012;14:11-23.
2. Bhavalakar U. Vermiculture biotechnology for LEISA - seminar on low external input sustainable agriculture. Amsterdam, Netherlands; 1991. p. 16.
3. Bose P, Roy M, Patra PK. Evaluation of long term different nutrient management practices on crop productivity and soil quality in rice (*Oryza sativa*) - potato (*Solanum tuberosum*) - groundnut (*Arachis hypogaea*) cropping system in new alluvial soil zone of West Bengal, India. Plant Archives. 2021;21(1):2383-2392.
4. Brar BS, Singh J, Singh G, Kaur G. Effect of long-term application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize wheat rotation. International Journal of Research in Agronomy. 2015;3(5):220-238.
5. Das A, Prasad M, Shivay YS, Subha KM. Productivity and sustainability of cotton (*Gossypium hirsutum*) - wheat (*Triticum aestivum*) cropping system as influenced by FYM and Azotobacter. Journal of Agronomy and Crop Science. 2003;190:298-304.
6. Dsouza A, Deshmukh PW, Bhoyar SM. Influence of organic composts on soil physical and chemical properties under soybean crop in Vertisols. International Journal of Chemical Studies. 2018;6(1):2139-2142.
7. Dsouza A, Deshmukh PW, Bhoyar SM. Effect of enriched composts on rhizosphere soil enzymatic activity of soybean in Vertisols. International Journal of Current Microbiology and Applied Sciences. 2017;6(10):105-111.
8. Gaddi AK, Basavanneppa MA, Tevari P. Effects of long term use of organic and inorganic fertilizers on soil fertility and productivity under paddy-sesame cropping system. Bangladesh Journal of Botany. 2020;49(3):585-591.
9. Jat G, Sharma KK, Jat NK. Effect of FYM and mineral nutrient on physico-chemical properties of soil under mustard in western arid zone of India. Annals of Plant and Soil Research. 2012;14(2):167-166.
10. Halemani HL, Hallikeri SS, Nooli SS, Nandagavi RA, Harish Kumar HS. Effect of organics on cotton productivity and physico-chemical properties of soil. In: Proceedings of the International Symposium on "Strategies for Sustainable Cotton Production - A Global Vision." VAS, Dharwad; 2004. p. 174-180.
11. Ingle SR, Singh H, Alam MDS, Kharche VK, Wankhade SG. Effect of different resource conservation practices on soil chemical properties under cotton cultivation. Journal of Pharmacognosy and Phytochemistry. 2019;9(1):1140-1143.
12. Ismail S, Malewar GU, Rege VS, Yelvikar NV. Influence of FYM and gypsum on soil properties and yield of groundnut grown in Vertisols. Agropedology. 1998;8:73-75.
13. Jackson ML. Soil Chemical Analysis. New Delhi, India: Prentice Hall Publication Pvt. Ltd.; 1973.
14. Karangami LD, Bhoyar SM, Manchala SK, Deshmukh PW, Dhurve N. Effect of rainfed organic cotton on chemical properties in Vertisol. Agriculture Update. 2017;12(4):912-916.
15. Karikatti P, Bhat SN, Balanagoudar SR, Mastanareddy BG, Veeresh H, Rao S. Long term effect of organics, integrated and inorganic nutrient management practices on soil properties in Vertisols. International Journal of Current Microbiology and Applied Sciences. 2020;9(1):2317-2326.
16. Katkar RN, Bhalerao PD, Ghatol PU, Patil BR. Influence of organics and inorganics on soil fertility, seed cotton yield and fibre quality in Vertisol. PKV Research Journal. 2007;31(2):216-222.
17. Katkar RN, Sonune B, Kadu PR. Long-term effect of fertilization on soil chemical and biological characteristics and productivity under sorghum (*Sorghum bicolor*) - wheat (*Triticum aestivum*) system in Vertisols. Indian Journal of Agricultural Sciences. 2011;81(8):734-739.
18. Khan NI, Malik AU, Umer F, Bodla MI. Effect of tillage and farm yard manure on physical properties of soil. International Research Journal of Plant Science. 2010;1(4):75-82.
19. Khuspure JA, Bhoyar SM, Deshmukh PW. Influence of organic manure on physical properties of Vertisol under cotton cultivation. Journal of Soil and Water Conservation. 2018;17(3):294-298.
20. Khuspure JA, Bhoyar SM, Deshmukh PW. Influence of manure application on soil chemical properties and crop yield under cotton cultivation. International Journal of Chemical Studies. 2019;7(6):159-163.
21. Khuspure J, Kware D, Bhoyar SM. Impact of different organic manures application on soil microbial population and soil fertility under rainfed organic cotton production. Trends in Bioscience. 2014;7(6):1547-1549.
22. Kumar V, Goyal V, Dey P. Impact of STCR based long term integrated management practices on soil chemical properties and yield attributing parameters of wheat and pearl millet in semi-arid North-West India. International Journal of Chemical Studies. 2020;8(4):1320-1328.
23. Kumari SRP, Subbaravamma R, Reddy AN. Response of cotton to farm yard manure in deep black cotton soils under rainfed conditions. Journal of Cotton Research and Development. 2005;19(2):220-223.
24. Liu E, Yan C, Mei X, He W, Bing SH, Ding L, Liu Q, Liu S, Fan T. Long term effect of chemical fertilizer, straw and manure on soil chemical and biological properties in north-west China. Geoderma. 2010;158:173-180.
25. Mali DV, Padghan AY, Ingle SN, Bhoyar SM, Deshmukh DP, Jadhao SM, Jadhao SD, Raut NW. Soil nutrient status as influenced by resource consequence practices under cotton-soybean rotation in Vertisols. Journal of Pharmacognosy and Phytochemistry. 2020;9(5):2072-2076.
26. Manchala SK, Bhoyar SM, Deshmukh PW. Influence of organic manures on soil physical properties in cotton under rainfed conditions. International Journal of Chemical Studies. 2017;5(5):832-835.
27. Marathe RA, Bharambe PR. Physical characteristics of Vertisols as influenced by INM system under sweet orange. Journal of Indian Society of Soil Science. 2005;41(1):52-57.

28. Nagar RK, Goud VV, Kumar R, Kumar R. Effect of organic manures and crop residue management on physical, chemical and biological properties of soil under pigeonpea based intercropping system. International Journal of Farm Science. 2016;6(1):101-113.
29. Nelson DW, Sommers LE. Methods of Soil Analysis, Part 2. Agronomy Monograph No. 9. American Society of Agronomy; 1982. p. 539-579.
30. Ojha RB, Shah SC, Pande KR, Dhakal DD. Residual effects of farm yard manure on soil properties in spring season, Chitwan, Nepal. International Journal of Science Research in Agriculture Science. 2014;1(8):165-171.
31. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: ICAR; 1985.
32. Reddy GK, Sharma SHK, Chandra Shaker K, Ravi P, Singh M, Ravi W. Long term effect (17 years) of different nutrient management practices on crop yield trends, soil productivity and sustainability in rice-rice cropping system under semi-arid tropical climatic condition in an Inceptisol of India. International Research Journal of Pure and Applied Chemistry. 2019;20(3):1-14.
33. Sapkal KA, Bhoyar SM, Rathod PH. Effect of organic sources on physico-chemical properties of soil and uptake of nutrient in cotton under rainfed conditions. Journal of Pharmacognosy and Phytochemistry. 2019;8(5):1492-1496.
34. Golada SL, Sharma GL, Verma A, Jain HK. Effect of FYM, nitrogen and Azospirillum on yield, economics and soil nutrient status of forage pearl millet. Madras Agriculture Journal. 2012;99(4-6):308-310.
35. Yoder RE. A direct method of aggregate analysis of soil and study of the physical nature of erosion losses. Agronomy Journal. 1936;28:337-351.