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Effect of Organic Sources on Biological Properties of Vertisols in Cotton

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Authors' contributions

This work was carried out in collaboration among all authors. Author MSK designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SMB and LDK managed the analyses of the study. Author GRK managed the literature searches and assisted in analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the farm of Cotton Research Unit, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* season 2015-16 to study the effect of organic cotton on biological properties of vertisols. The experiment was laid out in randomized block design with 3 replications and 10 treatments comprising organic sources viz. (T_1 – Farm yard manure (FYM) @ 5 t ha^{-1}, T_2 - vermicompost @ 2.5 t ha^{-1}, T_3 - FYM @10 t ha^{-1}, T_4 - vermicompost @ 5 t ha^{-1}, T_5 - *In-situ* green manuring with sunhemp, T_6 - Castor cake @ 500 kg ha^{-1}, T_7 - FYM (source of 15 kg P_2O_5) + green manuring with sunhemp, T_7 - FYM (source of 15 kg P_2O_5) + green manuring with sunhemp, T_8 - Neem cake @ 500 kg ha^{-1}, T_9 - FYM 5 t ha^{-1} + Neem cake @ 500 kg ha^{-1} and T_{10} - Absolute Control). Results revealed that application of FYM @ 10 t ha^{-1} recorded significantly highest bacterial, fungal population during flowering and boll bursting stages of cotton. However, highest actinomycetes population was recorded by the application of vermicompost @ 5 t ha^{-1} at flowering stage and FYM @ 10 t ha^{-1} at boll bursting stage of cotton. Significantly highest seed cotton yield was obtained with the concentrated organic manure i.e. Neem cake @ 500 kg ha^{-1} and remained at par with Castor cake @ 500 kg ha^{-1}, FYM 5 t ha^{-1} + Neem cake @ 500 kg ha^{-1}.

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1. INTRODUCTION

Chemical fertilizers have a huge impact on now a day's food production which is crucial for surviving the increasing world's population. According to FAO, chemical fertilizers increase the world's agricultural production more than 50% and nitrogenous fertilizers are the most utilized fertilizers for nutritional purpose [1]. But more than 50% of applied N fertilizers are lost into the environment [2]. Due to the environmental concerns there is an urgent need to reduce the chemical fertilizers utilization at the same time need to increase the new production technologies with the combination of organic resources (Farm yard manure (FYM), compost, green manure etc.) which are sustainable in both economically and naturally.

As per Cotton advisory board (CAB) in India, cotton is cultivated on 125.84 lakh ha with production of 360.00 lakh bales and productivity of 486 kg ha-^{1}. In Maharashtra, it occupied 43.64 lakh ha with production of 82 lakh bales giving an average yield of 319 kg lint ha-^{1} during 2019-20. Cotton is the most capital-intensive cash crop grown predominantly in Maharashtra. It covers about 34 % of total cotton area and contributes 17 per cent of the production. About 97 per cent of the cotton crop is cultivated under rainfed condition. In Vidarbha region, area under cultivation of cotton is 12.37 lakh ha with production of about 35 lakh bales and gives average yield of 312 kg lint ha^{-1}.

Organic cotton production systems involves utilization of organic manures (FYM, vermicompost, green manures, cakes etc.) and agronomic practices (crop rotation, bio-pesticides, botanicals etc.) Organic production systems enhances the soil fertility and crop productivity in sustainable manner.

Unlike chemical fertilizers, most of the organic fertilizers provide a balanced nutrition to the crops which improves the crop quality because they contain traces of micro nutrients and also provide food for soil microorganisms while they mineralize the complex compounds into simpler forms (plant available forms). Vermicompost which is produced by earthworms contains all nutrients with nitrogen fixers and plant growth promoters [3],[4].

The soil rich in organic matter consists of more population of micro flora and fauna viz., bacteria, fungi, actinomycetes, algae etc. Agricultural practices may modify organic substrate level, nutrient status, pH, aeration, moisture availability and temperature which influenced the growth of microorganism. Despite the targeted achievements, agricultural sector is confronted with serious challenges due to rapid growth, depletion of land fertility and shrinking of non-renewable energy sources. Sole and indiscriminate utilization of chemical fertilizers in intensive cropping systems leads to decline in soil fertility and unfavorable physical condition and biological system. It can be rectified by organic fertilizers which improves soil health, ultimately helpful to achieve sustainable crop production.

1.1 Objective of the Study

To evaluate the effect of rainfed organic cotton on rhizospheral activity.

2. MATERIALS AND METHODS

An experiment was conducted at Cotton Research Unit, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season of 2015-16 in a randomized block design (RBD) with 3 replications comprised of 10 organic sources. The treatments comprised application of FYM, vermicompost, castor cake and *in-situ* green leaf manuring of sunhemp. The soils of the experimental area were medium deep black, clay loam texture with typical swell-shrink, deep cracks, high water holding capacity, dominant in Montmorillonite clay mineral and slickensides characteristics classified under order vertisol. Serial dilute plate technique (Dhingra and Sinclair, 1993) was used for estimate soil microbial count. Nutrient Agar (NA), Potato Dextrose Agar (PDA) and Kenknight Agar Medias are used for bacterial, fungi and actinomycetes population respectively. Treatments details are presented in Table 1.

2.1 Application of Organic Manures

Five organic sources of nutrients were used for the "Organic cotton experimentation" out of which two viz., FYM and vermicompost were well decomposed bulky organic manures and castor cake and neem cake were concentrated organic manures and sunhemp was used for *in-situ* green manuring. The sunhemp crop was raised between the rows of cotton crop which was buried *in-situ* 45 DAS as a green manuring treatment. All the required cultural and plant protection measures were adopted.

Table 1. Treatments details

Sr. No.	Treatment
1	T_1 - FYM @ 5 t ha^{-1}
2	T_2 - Vermicompost @ 2.5 t ha^{-1}
3	T_3 - FYM @10 t ha^{-1}
4	T_4 - Vermicompost @ 5 t ha^{-1}
5	T_5 - *In-situ* green manuring with sunhemp
6	T_6 - Castor cake @ 500 kg ha^{-1}
7	T_7 - FYM (source of 15 kg P_2O_5) + green manuring with sunhemp
8	T_8 - Neem cake @ 500 kg ha^{-1}
9	T_9 - FYM 5 t ha^{-1} + Neem cake @ 500 kg ha^{-1}
10	T_{10} - Absolute Control

The data obtained for various parameters were analyzed in RBD statistical procedure [5]. The appropriate standard error of mean (S.E. m ±) and the critical difference (C.D.) were calculated at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Effect of Organic Sources on Microbial Population in Soil at Grand Growth Stages of Cotton

Effect of organic sources on microbial population in soil at grand growth stages of cotton viz. Bacteria, Fungi, Actinomycetes of soil was studied and discussed under the following heads.

3.1.1 Bacterial population

The data on effect of various treatments on bacterial population in soil at cotton grand growth stages was significant. The results showed that, the highest bacterial population observed at the flowering stage as compared to boll bursting stage (Table 2). Bacterial population at flowering and boll bursting stages ranged from 33.11 x 10^{-6} cfu g^{-1} soil to 82.83 x 10^{-6} cfu g^{-1} soil and 17.77 x 10^{-6} cfu g^{-1} soil to 52.67 x 10^{-6} cfu g^{-1} soil respectively.

Significantly highest bacterial population at flowering stage was recorded with treatment FYM @ 10 t ha^{-1} (T_3) which was at par with T_7, T_4, T_9 treatments at flowering (82.83 x 10^{-6} cfu g^{-1} soil) and boll bursting stages (52.67 x 10^{-6} cfu g^{-1} soil). The lowest bacterial population was recorded in Absolute control (T_{10}). Higher rate of bacterial population associated with FYM treatments which might be due to FYM comprises ready source of carbon, act as substrate for stimulation of bacterial multiplication. The increment in the bacterial population at both the critical stages of cotton under study was registered with increase in the doses of vermicompost and FYM. Chandramohan [6] observed that, the population of microorganisms (fungi, actinomycetes and bacteria) were higher during vegetative and flowering stage as compared to harvest stage, significantly highest microbial population was recorded in sunhemp + vermicompost followed by sunhemp + poultry treatment. The superiority of FYM. The highest population of bacteria and fungi recorded in FYM treated plots followed by crop residues incorporation. Lowest population of microorganism was recorded in plots treated with sole application of chemical fertilizers [7].

3.1.2 Fungal population

Data regarding the fungal population of soil at grand growth stages of cotton crop is given in Table 2. The fungal population of soil at flowering and boll bursting stages was significant under different organic treatments. Fungal population ranged from (22.83 x10^{-4} cfu g^{-1} soil to 52.33 x 10^{-4} cfu g^{-1} soil) and (13.83 x 10^{-4} cfu g^{-1} soil to 36.18 x 10^{-4} cfu g^{-1} soil) at flowering and boll bursting stages respectively.

At flowering stage significantly highest fungal population was recorded in treatment (T_3) receiving well decomposed FYM @ 10 t ha^{-1} (52.33 x 10^{-4} cfu g^{-1} soil) and remained on par with treatment T_9- FYM 5 t ha^{-1} + Neem cake @ 500 kg ha^{-1} (48.67 x 10^{-4} cfu g^{-1} soil). The lowest fungal population was observed in absolute control (22.83 x 10^{-4} cfu g^{-1} soil).

Table 2. Effect of organic sources on bacterial, fungal and actinomycetes population at grand growth stages of cotton

Treatment	Bacterial population (cfu × 10^{-6} g^{-1} soil)		Fungal population (cfu ×10^{-4} g^{-1} soil)		Actinomycetes population (cfu ×10^{-4} g^{-1} soil)	
	At flowering stage	At boll bursting stage	At flowering stage	At boll bursting stage	At flowering stage	At boll bursting stage
T_1- FYM @ 5 t ha^{-1}	75.11	40.09	43.33	29.66	84.80	56.16
T_2- Vermicompost @ 2.5 t ha^{-1}	68.61	41.00	40.99	28.17	82.36	56.79
T_3- FYM @ 10 t ha^{-1}	82.83	52.67	52.33	36.18	87.66	66.49
T_4- Vermicompost @ 5 t ha^{-1}	79.70	48.50	42.16	33.83	91.16	62.99
T_5- In-situ green manuring with sunhemp	74.61	40.48	38.66	29.16	89.83	55.67
T_6- Castor cake @ 500 kg ha^{-1}	61.00	41.67	35.33	30.16	83.97	50.78
T_7- FYM (Source of 15 kg P_2O_5) + green manuring with sunhemp	82.50	50.45	41.33	34.83	87.55	60.49
T_8 - Neem cake @ 500 kg ha^{-1}	67.55	46.96	37.21	33.58	75.16	56.40
T_9 - FYM 5 t ha^{-1} + Neem cake @ 500 kg ha^{-1}	75.15	41.19	48.67	33.86	81.65	61.36
T_{10}- Absolute control	33.11	17.77	22.83	13.83	30.49	20.44
SE(m) ±	2.81	2.41	1.70	1.07	2.18	1.90
CD at 5%	8.25	7.07	4.98	3.15	6.39	5.58

Significantly highest (36.18 x 10^{-4} cfu g^{-1} soil) fungal population at boll bursting stage was recorded in treatment (T_3) with the application FYM @ 10 t ha^{-1} and which was at par with T_7, T_9, T_4 treatments. However, lowest fungal population (13.83 x 10^{-4} cfu g^{-1} soil) was recorded in the absolute control which might be addition of organic matter into the soil. The fungi rapidly grew and were almost double in their population as compared to control while at boll bursting stage their population decline to some extent. Halemani et al. [8] reported that, significantly highest bacterial (76.66 x 10^{-6} cfu g^{-1} soil) fungi (40.22 x 10^{-4} cfu g^{-1} soil) and actinomycetes (54.77 x 10^{-4} cfu g^{-1} soil) with FYM application alone @ 10 ton ha^{-1} followed by FYM @ 5 ton + cotton stalk residues 2.5 ton ha^{-1} and @ 5 ton + vermicompost. Similar results were also reported by Badole and More [9].

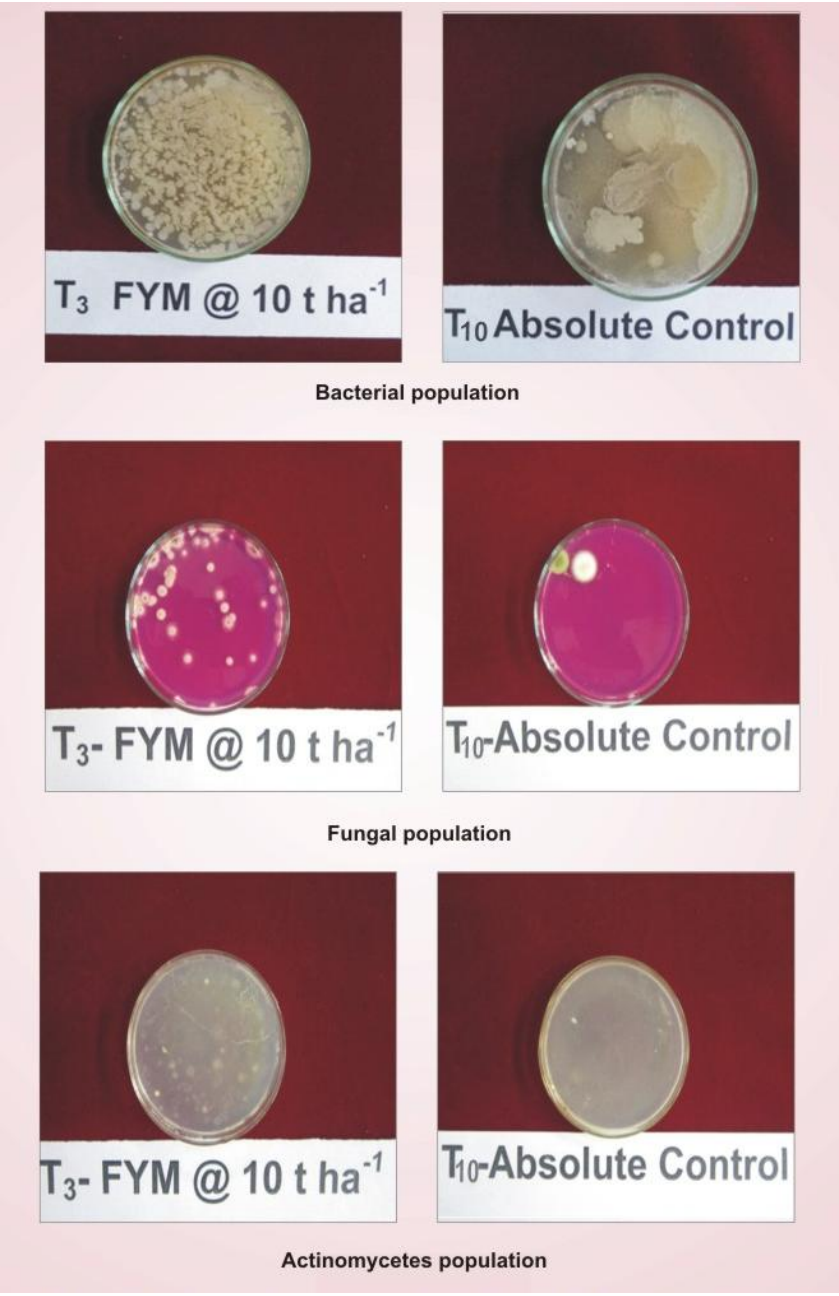

Fig. 1. Effect of organic sources on microbial population in soil

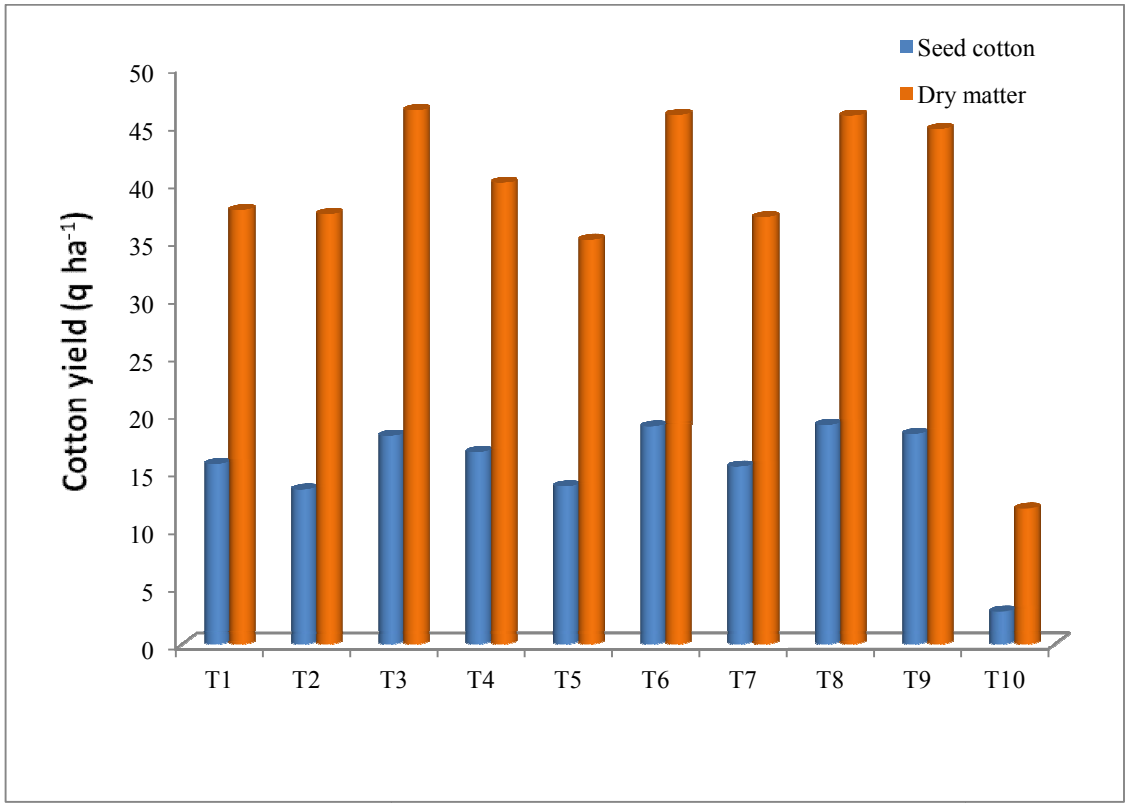

Fig. 2. Yield performance of cotton as influenced by various organic treatments

3.1.3 Actinomycetes population

The data on effect of organic sources on actinomycetes population in soil were recorded at flowering and boll bursting stages. The effect was significant under different organic treatments. The results indicated in general the highest actinomycetes population was recorded during flowering stage and declined at boll bursting stage Table 2.

It was noted that, significantly highest actinomycetes population at flowering stage (91.16 x 10^{-4} cfu g^{-1} soil) was recorded in treatment (T_4) with the vermicompost application @ 5 t ha^{-1} and it was on par with treatment (T_5) in- situ green manuring with sunhemp, (T_3) FYM @ 10 t ha^{-1} (T_7) FYM (source of 15 kg P_2O_5) + green manuring with sunhemp, (T_1) FYM @ 5 t ha^{-1}. The lowest actinomycetes population was recorded in absolute control (30.49 x 10^{-4} cfu g^{-1} soil).

Significantly highest actinomycetes populace at boll bursting stage (66.49 x 10^{-4} cfu g^{-1} soil) was recorded in treatment (T_3) with the FYM application @ 10 t ha^{-1} and it was on par with treatment (T_4) Vermicompost @ 5 t ha^{-1}, (T_7) FYM (source of 15 kg P_2O_5) + green manuring with sunhemp. Absolute control was recorded with lowest actinomycetes population (20.44 x 10^{-4} cfu g^{-1} soil). The superiority of FYM and vermicompost in registering higher population of soil bacteria, fungi and actinomycetes in comparison to RDF alone was reported by Sangshetty and Babalad [10].

3.2 Seed Cotton Yield

The results pertaining to seed cotton yield in relation to various organic sources are depicted in Fig. 2. The difference in seed cotton yield and dry matter among different organic sources was obtained to be significant. Highest seed cotton yield (19.00 q ha^{-1}) was recorded in the treatment of T_8-Neem cake 500 kg ha^{-1} which was at par to the T_6-castor cake @ 500 kg ha^{-1} and T_9-FYM (5 t ha^{-1}) + Neem cake @ 500 kg $ha^{-1}$and T_3-FYM @ 10 t $ha^{-1}$and T_4-vermicompost @ 5 t ha^{-1}. Minimum seed cotton yield was obtained

with absolute control treatment (2.8 q ha^{-1}) which was significantly lower than different organic sources treated. Hanumanthappa and Shivaraj [11] described that, neem cake application @ 750 kg per ha^{-1} recorded the highest seed (558 kg ha^{-1}) and stalk yield (2100 kg ha^{-1}) as compared to control. Similar results were also reported by Wankhade et al. [12].

The data pertaining to dry matter production are depicted in Fig. 2. The maximum dry matter production was documented in the treatment of bulky organic manure i.e. FYM @ 10 t ha^{-1} (46.31 q ha^{-1}) which was at par with castor cake @ 500 kg ha^{-1} (45.91 q ha^{-1}), neem cake @ 500 kg ha^{-1} (45.84 q ha^{-1}), FYM 5 t ha^{-1}+ neem cake @ 500 kg ha^{-1} (44.68 q ha^{-1}). However, application of lower doses of organic material i.e. FYM @ 5 t ha^{-1} (37.65 q ha^{-1}), Vermicompost @ 2.5 t ha^{-1} (37.28 q ha^{-1}) showed lower dry matter yield as compared to other manure treatments. The significantly lowest performance of cotton crop in respect of dry matter yield of cotton (11.72 q ha^{-1}) was observed in the absolute control treatment. Nawlakhe et al. [13] reported that, yield attributes and seed cotton yield were significantly superior by vermicompost application @ 2 t ha^{-1} over others except FYM @ 5 t ha^{-1} which was at par with it. Similar results were reported by Katkar et al. [14].

4. CONCLUSION

Based on findings of long term experimentation (6 year) of organic cotton, it can be concluded that the application of either neem cake @ 500 kg ha^{-1} or castor cake @ 500 kg ha^{-1} or FYM @ 5 t ha^{-1} + neem cake @ 500 kg ha^{-1}, significantly increased seed cotton, and dry matter yield. However, the application of FYM @10 t ha^{-1} exhibited superiority in improving the soil rhizospheral activity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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