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Effect of Organic Sources of Nutrients on Productivity and Economics of Rainfed Cotton in Vertisols under Semi-arid Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

A field study was conducted to evaluate the effect of various organic sources of nutrients on productivity and economics of rainfed cotton in Vertisols. The experiment was initiated during 2019-20 and the present study was conducted during kharif 2022-23 and 2023-24 at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The various organic sources of nutrients used were gliricidia green leaves, FYM and vermicompost. The nine treatments, which included three replications and different combinations of organic nutrient sources were evaluated in randomized block design. The findings after 5th cycle revealed that the integrated application of 50% N through FYM/ vermicompost + 50% N through gliricidia resulted in significantly higher increase in seed cotton and stalk yield. Higher monetary returns were observed with 100% RDF, however conjunctive use of FYM / vermicompost + gliricidia resulted in comparable monetary returns thereby signifying their application in economics of cotton cultivation. These studies suggest that it is beneficial to use conjoint application of FYM/ vermicompost and gliricidia green manure as it improves cotton yield with higher economic returns under semi-arid rainfed conditions.

Keywords: Economics; organic sources; productivity; rainfed cotton; semi-arid; Vertisols.

1. INTRODUCTION

“Cotton is said to be king of cash crops, and is considered as “king of fiber” and “white gold” because of it’s enormous significance in global economy. It plays a vital role in economy of the country because it provides fiber, a raw material for textile industry. In recent years, cotton apparels are being preferred to the synthetic ones due to increasing health consciousness among the people. Cotton provides livelihood to more than 60 million people in India by the way of agriculture, processing and use of cotton in textile. India is the world's largest cotton growing country and occupies 41% of the world's cotton area and around 26% of global cotton production, with a productivity of 441 kg lint ha^{-1}. In India cotton production was 316.57 lakh bales from 123.42 lakh hectares in 2023-2024. The leading cotton-growing states in India during 2023-2024 were Gujarat (89.65 lakh bales), Maharashtra (82.43 lakh bales), Telangana (48.12 lakh bales), Rajasthan (27.43 lakh bales) and Karnataka (16.93 lakh bales). Maharashtra ranks first in cotton area (42.34 lakh ha) followed by Gujarat, Telangana, Rajasthan and others with production of 82.43 lakh bales and average productivity of 331 kg lint ha^{-1}” (Anonymous, 2024). “India is the second largest consumers of cotton *i.e.* about 23 per cent which is 5.8 million MT and world cotton consumption is 25.63 million MT” (Anonymous, 2021).

“Organic carbon in soil performs crucial role in numerous soil processes, nutrient dynamics, water relations and in maintaining biological and physical health of soil. Thus, it determines the extent of soil productivity. Most of the dryland soils in dry regions of the country are low in organic carbon due to rapid oxidation process” (Srinivasarao *et al.,* 2014). The challenge facing agriculture in the coming decades will be to maintain, if not increase, soil fertility and productivity while meeting the steadily rising demands for food, fiber and energy (Bhavsar *et al.,* 2025). Decreasing soil fertility, inappropriate management of plant nutrients and deteriorating soil physical condition have made this task more difficult.

“Organic manures play an important role as a substitute for mineral nutrients; on the other hand indiscriminate use of chemical fertilizers affects soil health. A good management strategy for increasing yields and maintaining soil fertility is the use of organic manures, such as FYM, vermicompost, and gliricidia, for supplying nutrients to a cropping system as a whole” (Nanjappa *et al.,* 2001).

Main goals of organic farming are conservation and efficient utilization of natural resources for

appropriate profitability under the guiding factor of sustainability of the agriculture. Expensive (high cost) chemical fertilizers are causing economic problems to the small and marginal farmers. Cotton is cultivated abundantly in the rainfed region of central India, but productivity is limited because of the uneven distribution of rainfall, the eroded undulating terrain of the lands, and the low resources investment by farmers. These soils need low-cost, low-external-input farming systems to reduce fertiliser and pesticide costs and provide stability in production. Cultivation of cotton crop with organic resources can help farmers in increasing sustainable productivity.

2. MATERIALS AND METHODS

2.1 Site Description

An experiment was started in 2019-20 on the research field of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) Dr Panjabrao Deshmukh Krishi Vidyapeeth (Dr. PDKV), Akola, Maharashtra. The study was carried out under rainfed conditions over two years (2022-23 and 2023-24). The experimental site is located at an elevation of 325 meters above mean sea level (MSL), in a hot, semi-arid ecoregion at 20° 32' N latitudes and 77° 7' E longitudes. Rainfall during kharif 2023 (June - September) amounted to 694.9 mm. Most of the rainfall was received from the southwest monsoon. The highest recorded summer temperature was approximately 40.4°C, while the lowest recorded winter temperature was 10.9°C. Experimental soil belongs to the Vertisols order (classified as Typic Haplusterts) with clay texture as well as calcareous and lime concretions at varying depths.

The initial soil sample analysis data (2019-20) indicate that the soil was moderately alkaline (pH 8.2), electrical conductivity (EC) 0.30 dS/m, organic carbon (OC) 5.1 g kg^{-1}, Available nitrogen (AN) 184.5 kg ha^{-1}, Available phosphorus (AP) 14.2 kg ha^{-1}, and Available potassium (AK) 322 kg ha^{-1}

2.2 Experimental Details

The experiment was conducted with nine treatments comprising T_1 :100% RDF (60:30:30 NPK kg ha^{-1}),T_2:FYM 12 t $ha^{-1}$$T_3$:Gliricidia 8 t ha^{-1},T_4:Vermicompost 3.0 t ha^{-1},T_5:50% N through FYM + 50% N through Gliricidia,T_6:50% N through FYM + 50% N through Vermicompost,T_7:50% N through Vermicompost + 50% N through Gliricidia,T_8:25% N through FYM + 25% N through Vermicompost + 50% N through Gliricidia,T_9:25% N through Gliricidia + 25% N through Vermicompost + 50% N through Gliricidia. The phosphorus dose was compensated through phosphocompost from treatments T_5 to T_9: 50 % N as basal and remaining 50 % N as topdressing at 30 DAS. The various organic sources of nutrients used for the present study were *viz.*, FYM, vermicompost and gliricidia green leaf manure and phosphocompost (PROM) was used for compensation of phosphorus.

The nutrient content of various organic sources used during the study period was determined and presented in Table 1.

Table 1. Nutrient content in organic sources

Sr No	Organic material	N (%)	P (%)	K (%)
1.	FYM	0.51	0.18	0.42
2.	Gliricidia (green basis)	0.75	0.08	0.50
3.	Vermicompost	2.01	0.38	0.73
4.	Phosphocompost (PROM)	-	10.4	-

3. RESULTS AND DISCUSSION

3.1 Yield of Cotton

The seed cotton and cotton stalk yield ranged from 644.8 to 846.4, 1104.1 to 1450.1 and 639.5 to 1008.8 and 1110.6 to 1664.9 kg ha^{-1}, during 2022-23 and 2023-24 respectively (Table 2). The effect of conjoint use of FYM/ vermicompost and gliricidia green manure treatments on seed cotton yield were significant in both years (2022-23 & 2023-24).

The pooled yield data (Table 2) revealed that with application of 50% N through FYM + 50% N through gliricidia(T_5) showed higher seed cotton yield (927.6kg ha^{-1}) and had about 7.2 % higher seed cotton yield over 100% RDF (T_1). The corresponding increase in cotton stalk yield was 4.42 %. Similar finding were also observed by (Sonune *et al*., 2012; Rana & Badiyala, 2014; Kumar *et al*., 2019; Satpute *et al.,* 2019; Charjan *et al.,* 2024). Sapkal *et al.* (2019) also reported that use of bulky organic manure like FYM or vermicompost) led to an increase in seed cotton yield due to enough availability of nutrients (both macro and micro) in the balanced form with good soil environment. The increase in cotton yield recorded with conjunctive application of

FYM/vermicompost and gliricidia green leaf manure may be due to mineralization and slow release of nutrients from FYM/ gliricidia /vermicompost to cotton crop throughout the crop growth period and favouring more utilization of nutrient. Ramakrishna *et al.,* (2007) reported that farmyard manure provided the necessary minerals and acted as a catalyst for the effective usage of nutrient applications to boost yields by plant and enhanced the translocation of photosynthates towards sink and increase cotton yield.

The current research justifies the farmer's preference for N fertilization of cotton in semi-arid Vertisols, but suggests the need for use of balanced organic sources of nutrients for obtaining sustainable yields.

3.2 Economics of Cotton Cultivation

The data on economics of cotton cultivation (Table 3) indicated that the conjoint use of FYM/ vermicompost and gliricidia green manure resulted in higher monetary returns from cotton grown in Vertisol. The pooled data on effect of long-term organic sources of nutrients on economics of cotton indicate that the highest gross monetary returns (GMR) of 65525/- Rs ha^{-1} was obtained with application of 50% N through FYM + 50% N through gliricidia (T_5), which was found to be on par with application of 50% N through vermicompost + 50% N through gliricidia (T_7) with GMR 63864/- Rs ha^{-1}, also treatments T_1 and T_8 were on par to T_5. However, the highest net monetary returns (NMR) of 31689/- Rs ha^{-1} was obtained with 100% RDF (T_1), which was found to be on par with application of 50% N through vermicompost + 50% N through gliricidia (T_7) with NMR 28501/- Rs ha^{-1}, and application of 50% N through FYM + 50% N through gliricidia (T_5).

The higher GMR recorded with application of FYM/ vermicompost and gliricidia might be due to higher seed cotton yield compared to other treatments. The parallel results are in line with Raut *et al*. (2009) & Sankar *et al*. (2014). Sangshetty & Babalad (2010) also recorded significantly higher net returns, by application of FYM 100% (equivalent to 45 kg nitrogen) + gliricidia 100% (equivalent to 45 kg nitrogen) when compared to treatments treated with vermicompost and neem cake.

The B:C ratio was found to be maximum (2.08) with application of 100% RDF (T_1), followed by 1.80 with the application of 50% N through vermicompost + 50% N through gliricidia (T_7).

Table 2. Effect of organic sources of nutrients on cotton yield

Treatments	Cotton yield (kg ha^{-1})					
	Seed cotton			Cotton stalk		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_1 100% RDF (60:30:30 NPK kg ha^{-1})	831.3	900.0	865.6	1424.0	1559.0	1491.5
T_2 FYM 12 t ha^{-1}	656.5	813.0	734.8	1125.8	1408.9	1267.3
T_3 Gliricidia 8 t ha^{-1}	644.8	784.0	714.4	1104.1	1358.3	1231.2
T_4 Vermicompost 3.0 t ha^{-1}	678.4	891.0	784.7	1161.7	1546.5	1354.1
T_5 50% N through FYM + 50% N through Gliricidia	846.4	1008.8	927.6	1450.1	1664.9	1557.5
T_6 50% N through FYM + 50% N through Vermicompost	708.3	765.8	737.0	1208.1	1335.0	1271.6
T_7 50% N through Vermicompost + 50% N through Gliricidia	838.8	969.2	904.0	1437.6	1649.5	1543.6
T_8 25% N through FYM + 25% N through Vermicompost + 50% N through Gliricidia	790.2	927.9	859.0	1353.9	1548.1	1451.0
T_9 25% N through Gliricidia + 25% N through Vermicompost + 50% N through Gliricidia	709.2	639.5	674.3	1217.0	1110.6	1163.8
SE (m) ±	44.8	52.5	34.5	74.4	82.7	55.6
CD at 5%	134.3	157.4	99.9	223.1	248.0	161.0

Table 3. Effect of organic sources of nutrients on economics of cotton

Treatments		GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C Ratio
T_1	100% RDF (60:30:30 NPK kg ha^{-1})	61091	31689	2.08
T_2	FYM 12 t ha^{-1}	52014	8538	1.19
T_3	Gliricidia 8 t ha^{-1}	50550	18521	1.58
T_4	Vermicompost 3.0 t ha^{-1}	55622	18474	1.49
T_5	50% N through FYM + 50% N through Gliricidia	65525	26526	1.68
T_6	50% N through FYM + 50% N through Vermicompost	52019	11591	1.29
T_7	50% N through Vermicompost + 50% N through Gliricidia	63864	28501	1.80
T_8	25% N through FYM + 25% N through Vermicompost + 50% N through Gliricidia	60677	23780	1.64
T_9	25% N through Gliricidia + 25% N through Vermicompost + 50% N through Gliricidia	47398	14146	1.43
SE (m) ±		2114	2114	-
CD at 5%		6338	6338	-

Among the various organic sources used, higher B:C ratio in T_7 may be due to less quantity of vermicompost used compared to FYM which lowered cost of cultivation as compared FYM + gliricidia treatment(T_5). Similar finding was reported by Chavda & Rajawat (2015); Chandel *et al.* (2017).

4. CONCLUSION

The results after 5th cropping cycle indicate that it is advantageous to use FYM or vermicompost in conjunction with gliricidia green leaf manuring which recorded higher cotton yields with maximum monetary returns. Hence, it is concluded that to fulfil the nutrient requirement of rainfed cotton, application of 50% N through FYM (6 t ha^{-1}) or vermicompost (1.5 t ha^{-1}) + 50 % N through gliricidia (4 t ha^{-1}) resulted in sustaining cotton productivity in Vertisols under rainfed condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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