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Growth and yield response of cotton grown under organic inputs and tillage practices in Vertisols

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Abstract
A field experiment was conducted during the *Kharif*-2024 at the Research Farm, Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to evaluate the influence of different tillage practices and organic inputs on the growth and yield of cotton in Vertisol soils. The soil of the experimental site was montmorillonite, hyperthermic, high clay content having typical swell-shrink properties. The experiment was initiated in a factorial randomized block design with 16 treatment combinations involving four tillage practices—conventional, reduced, minimum, and zero tillage—and four organic inputs—FYM (10 t ha^{-1}), vermicompost (5 t ha^{-1}), phospho-compost (5 t ha^{-1}), and a no-manure control, replicated four times from the year 2023-24. The second cycle of organic cotton experiment results revealed that, interaction effect of conventional tillage with FYM @ 10 t ha^{-1} showed significantly highest plant height at 30, 60 and 90 DAS, and was also reported highest no. of sympodial branches over all other treatment combinations. However, interaction effect of conventional tillage practices in combination with phospho-compost @ 5 t ha^{-1} showed significant superiority in squares and bolls formation of cotton and which was reflected on significantly highest seed cotton yield (16.50 q ha^{-1}) as well as cotton stalk yield (35.49 q ha^{-1}), might be due to the fact that, major available nutrient content in phospho-compost is higher over all other organics used for experimentation and Vertisols, the soils have a poor workability due to high clay content and their typical swell-shrink properties and formation of deep wide cracks under moisture variations pose many challenges for agriculture, if not tilled properly. These findings indicating that adopting suitable tillage methods in conjunction with nutrient-rich organic inputs can play a crucial role in enhancing organic cotton productivity under rainfed conditions.

Keywords: Organic cotton, conventional tillage, phospho-compost, FYM, vermicompost, Vertisols

Introduction

Cotton (*Gossypium* spp.), derived from the Arabic word *Qutun*, is one of India's most important commercial crops, often referred to as the "White Gold of Black Soil" in Maharashtra. It is the world's leading natural textile fiber and a valuable oilseed crop, supporting the livelihoods of around 6 million Indian farmers and impacting 60-70 million people engaged in related activities. India ranks among the top cotton-producing countries, cultivating the crop on 127 lakh hectares—40% of the global area—with an output of 302.25 lakh bales and an average productivity of 447 kg/ha. Maharashtra leads in area under cotton (42.22 lakh ha) and ranks second in production, but Vidarbha regions lag with low productivity (300 kg/ha) due to challenges such as rainfed farming, erratic rainfall, heavy black cotton soils and poor-quality inputs etc. Tillage practices play a crucial role in crop management in black cotton soils and is typically classified as conventional (deep ploughing) or conservation (reduced or zero tillage). In organic farming, soil health is maintained by leveraging mineral and organic matter through microbial processes rather than synthetic fertilizers. Nutrient uptake, particularly of nitrogen, phosphorus, sulfur, zinc, and boron, is influenced by microbial activity, soil moisture, and root dynamics. Deficiencies are common in tropical cotton-growing soils but can often be addressed more effectively through biological stimulation and improved soil management rather than increased fertilizer use (FiBL). Organic amendments like farmyard manure (FYM), vermicompost, and phospho-compost significantly improve soil fertility.

FYM enhances organic carbon, water infiltration, and aggregate stability (Benbi *et al*., 1998) [3], while vermicompost supplies readily available nutrients (Orozco *et al*., 1996) [17]. Phospho-compost, enriched with rock phosphate-solubilizing microbes, improves nutrient balance and availability, particularly phosphorus and nitrogen. This is especially relevant in black cotton soils (Vertisols), which dominate regions like Vidarbha. Characterized by swelling and shrinking behaviour, high water-holding capacity, and low infiltration, these soils require organic matter inputs to improve physical structure and nutrient availability. The present study was undertaken to evaluate the impact of various tillage systems and organic inputs on crop growth and yield performance of cotton grown on heavy black soils.

Materials and Methods

A field experiment was conducted during the *Kharif*-2024 at the Research Farm, Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil was classified as Black Cotton Soils, Vertisols, specifically montmorillonitic and hyperthermic, characterized by smectite clay minerals with characterised swell-shrink properties and formation of deep wide cracks under moisture variations. The study employed a factorial randomized block design (FRBD) with two factors, Factor A (Tillage): T_1-Conventional tillage, T_2-Reduced tillage, T_3-Minimum tillage, T_4-Zero tillage and Factor B (Organic inputs): M1-FYM @ 10 t ha^{-1}, M2-Vermicompost @ 5 t ha^{-1}, M3-Phospho-compost @ 5 t ha^{-1}, M4-No manure (control), in all 16 treatments replicated four times. Plotwise seed cotton was picked and after harvesting dry matter yield was noted from net plot area in all the replications and yield per plot and yield per hectare was calculated.

Results and Discussion

Growth Parameters

Plant height was recorded from the soil surface to the terminal bud on five randomly selected plants in each plot at 30, 60, and 90 DAS. Data on sympodial branches, number of squares, and bolls per plant were also recorded at 60 and 90 DAS from same five representative plants.

Plant Height

Plant height, measured as the vertical distance from the soil surface to the top of the plant including all above-ground parts, is primarily influenced by the activity of the shoot apical meristem. The mean plant heights recorded at 30, 60, and 90 days after sowing (DAS) are summarized in Table 1 and interaction effect is illustrated in Figure 1, 2 & 3.

Cotton plant height showed significant differences across tillage treatments at 30, 60 and 90 DAS. Conventional tillage recorded the tallest plants, with mean heights of 20.26 cm, 69.66 cm, and 78.49 cm at 30, 60, and 90 DAS, respectively. The growth trend indicated rapid height increase during early stages, which slowed during later development. This was followed by reduced and minimum tillage, while the shortest plants were observed under zero tillage (12.98 cm, 24.43 cm, and 31.89 cm at the respective intervals). These results align with findings by Alkins *et al.* (2012), who reported maximum plant height in disc-harrowed plots and minimum in no-tillage treatments. Saleem *et al*. (2022) [20] also observed the highest plant height under conventional tillage (121 cm). Similarly, Ravali (2024) [19] found plant height to be significantly greater under conventional tillage compared to zero tillage, confirming the influence of soil disturbance on early crop vigor and growth.

Table 1: Effect of tillage and organic inputs on plant height

Treatments	Height (cm)		
	30 DAS	60 DAS	90 DAS
A. Tillage practices			
T_1-Conventional tillage	20.26	69.66	78.49
T_2-Reduced tillage	16.39	55.96	59.28
T_3-Minimum tillage	15.83	44.91	50.59
T_4-Zero tillage	12.98	24.43	31.89
SE (m)±	0.186	0.209	0.205
CD @ 5%	0.53	0.597	0.584
B. Organic manures			
M_1-FYM	18.60	53.53	59.39
M_2-Vermicompost	17.21	49.94	56.71
M_3-Phosphocompost	16.65	47.54	53.46
M_4-No manure	13.01	43.95	50.68
SE (m)±	0.186	0.209	0.205
CD @ 5%	0.53	0.597	0.584
Interaction of tillage and organic manures (A X B)			
SE (m)±	0.372	0.419	0.41
CD @ 5%	1.059	1.193	1.168

Influence of various organic inputs on cotton plant height was found to be statistically significant at all growth stages (30, 60, and 90 DAS). Among the treatments, the application of farmyard manure (FYM) resulted in the tallest plants, measuring 18.60 cm, 53.53 cm, and 59.39 cm at 30, 60, and 90 DAS, respectively. This was followed by vermicompost, which also contributed to improved plant growth. In contrast, the control treatment (no manures) recorded the shortest plant heights—13.01 cm, 43.95 cm, and 50.68 cm at the respective intervals. The enhanced growth under FYM treatment may be attributed to improved nutrient availability, soil structure, and microbial activity facilitated by organic matter. These observations are consistent with the findings of Jan *et al*. (2020), who reported significant increases in plant height with the application of FYM and compost across various *Bt*. cotton varieties. Similarly, Bhavsar *et al*. (2025) [4] noted that combined application of 50% nitrogen through FYM and 50% through Gliricidia significantly increased plant height compared to other organic nutrient management practices.

The data on the interaction effects of tillage and organic inputs on plant height at 30, 60, and 90 DAS was significant and presented in Fig 1, 2, and 3, respectively. Among the treatment combinations, conventional tillage combined with FYM consistently resulted in the tallest plants across all intervals having plant hight at 30 (22.45 cm), 60 (77.10 cm) and 90 (83.56 cm) DAS.

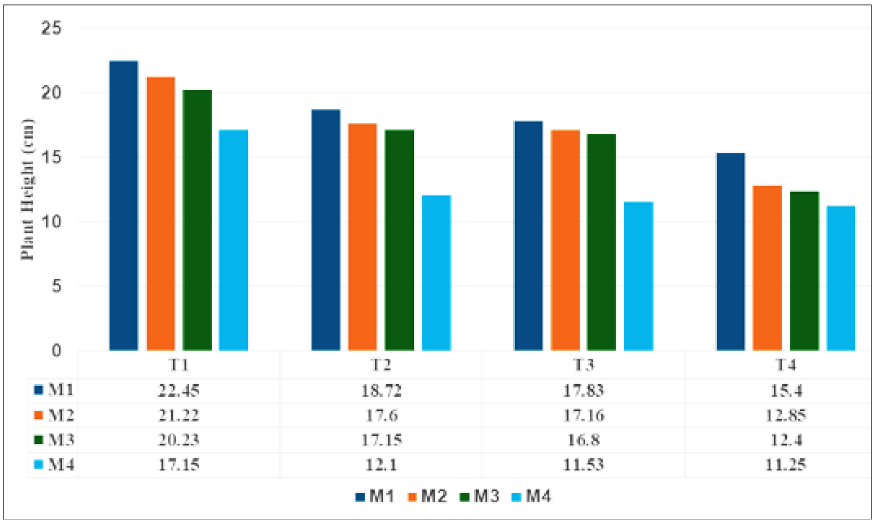


Fig 1: Effect of tillage and organic inputs on plant height (30 DAS)

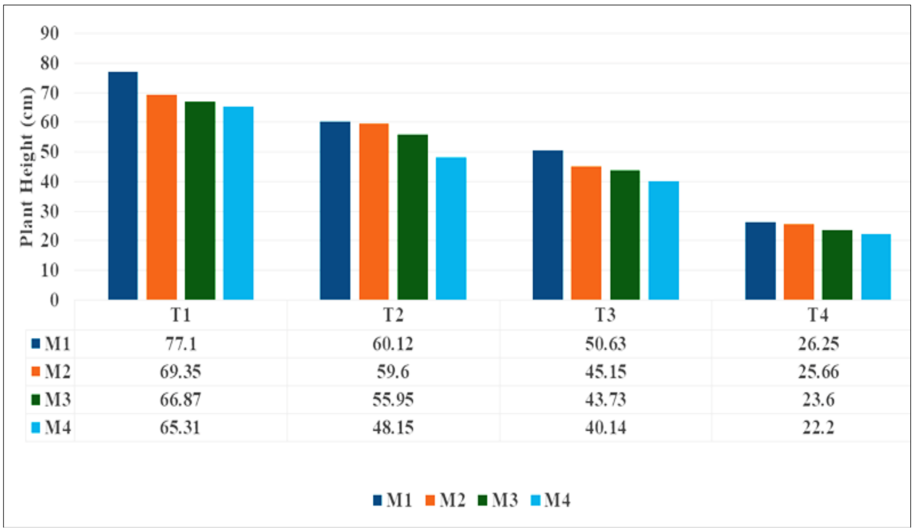


Fig 2: Effect of tillage and organic inputs on plant height (60 DAS)

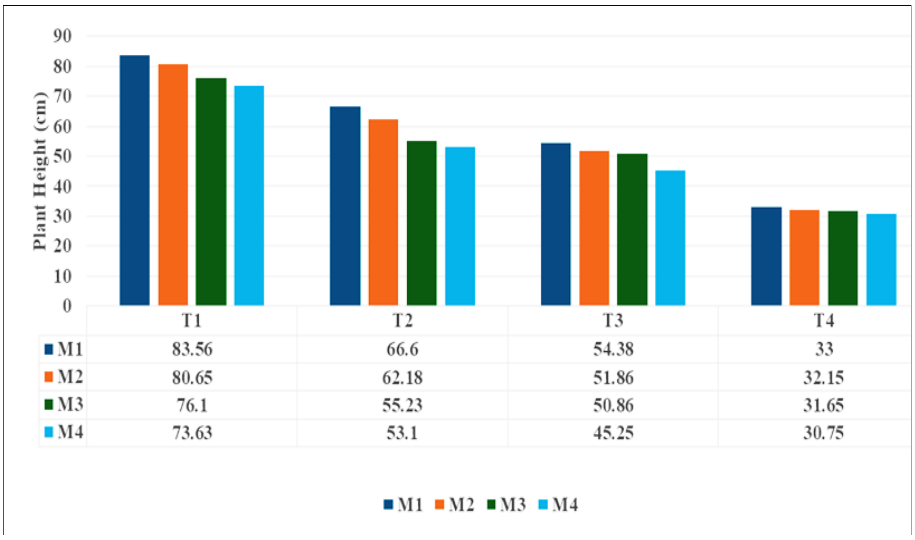


Fig 3: Effect of tillage and organic inputs on plant height (90 DAS)

Number of Sympodial Branches: Data on the number of sympodial branches per plant at 30, 60, and 90 DAS under different tillage and organic input treatments are presented in Table 2.

Table 2: Effect of tillage and organic inputs on number of sympodial branches

Treatments	No. of branches per plant		
	30 DAS	60 DAS	90 DAS
A. Tillage practices			
T_1-Conventional tillage	4.89	8.88	11.41
T_2-Reduced tillage	4.08	8.09	10.01
T_3-Minimum tillage	3.76	7.65	8.97
T_4-Zero tillage	2.49	5.09	6.86
SE (m)±	0.14	0.242	0.512
CD @ 5%	0.401	0.688	1.46
B. Organic manures			
M_1-FYM	4.01	7.76	9.42
M_2-Vermicompost	3.85	7.03	9.46
M_3-Phosphocompost	4.24	8.53	10.32
M_4-No manure	3.12	6.39	8.03
SE (m)±	0.141	0.242	0.512
CD @ 5%	0.401	0.688	1.46
Interaction of tillage and organic manures (A X B)			
SE (m)±	0.281	0.483	1.025
CD @ 5%	NS	NS	NS

Tillage practices significantly influenced the number of sympodial branches at 30, 60, and 90 DAS. The highest number of branches was recorded under conventional tillage (4.89, 8.88, and 11.41, respectively), followed by reduced and minimum tillage. Zero tillage consistently produced the lowest branch count (2.49, 5.09, and 6.86, respectively). These results suggest that improved soil aeration and root development under conventional tillage promote vegetative growth. Similar findings were reported by Bhavsar *et al.* (2025) [4], who observed a higher number of branches with the application of 50% N through FYM and 50% through gliricidia, indicating the importance of balanced nutrient supply and soil conditions for enhanced branching.

Influence of different organic inputs on the number of sympodial branches in cotton plants was found to be significant across all growth stages (30, 60, and 90 DAS). At 30 and 90 DAS, the highest number of sympodial branches was recorded in soils treated with phospho-compost (4.24 and 10.32, respectively), which was statistically at par with the treatments involving FYM (4.01 and 9.42) and vermicompost (3.85 and 9.46). In contrast, the lowest number of branches was observed in the control treatment without any manure (3.12 and 8.03). At 60 DAS, the trend remained similar, with phospho-compost again leading to the highest number of branches (8.53), followed by FYM (7.76) and vermicompost (7.03), while the control plot showed the lowest value (6.39). These findings suggest that organic inputs, particularly phospho-compost significantly promote the formation of sympodial branches, likely due to improved nutrient availability and enhanced soil biological activity. These results are in agreement with Blaise *et al.* (2005) [5], who reported that the application of FYM increased the number of sympodial branches due to its partial phosphorus contribution. Jan *et al.* (2020) [13] also observed the highest sympodial branching in the Lala Zar cotton variety under combined application of FYM and compost. The interaction effect of tillage and organic manures on the number of branches was found to be non-significant.

Number of Squares

The number of squares per plant serves as a key indicator of the reproductive efficiency and health of the cotton crop. The effect of various tillage methods and organic manures on square formation is summarized in Table 3 and interaction effect is illustrated in Fig. 5 & 6.

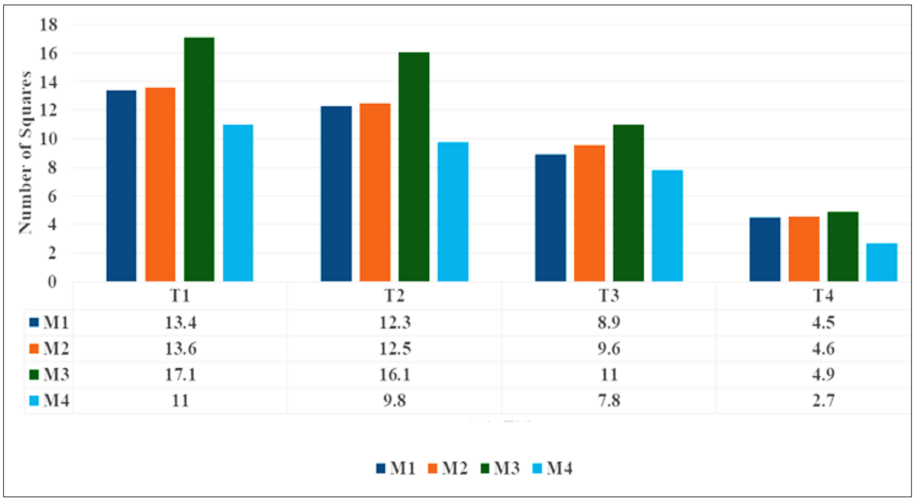
Table 3: Effect of tillage and organic inputs on number of squares per plant

Treatments	No. of squares per plant	
	60 DAS	90 DAS
A. Tillage practices		
T_1-Conventional tillage	15.37	11.44
T_2-Reduced tillage	13.98	10.14
T_3-Minimum tillage	10.27	8.29
T_4-Zero tillage	5.14	4.53
SE (m)±	0.239	0.137
CD @ 5%	0.681	0.39
B. Organic manures		
M_1-FYM	11.42	9.08
M_2-Vermicompost	10.84	8.36
M_3-Phosphocompost	13.74	9.85
M_4-No manure	8.76	7.11
SE (m)±	0.239	0.137
CD @ 5%	0.681	0.39
Interaction of tillage and organic manures (A X B)		
SE (m)±	0.478	0.274
CD @ 5%	1.362	0.781

Tillage practices significantly influenced the number of squares per plant. The highest squares were observed under conventional tillage (15.37 and 11.44 at 60 and 90 DAS, respectively), followed by reduced tillage (13.98 and 10.14). Zero tillage recorded the lowest number of squares (5.14 and 4.53 at 60 and 90 DAS, respectively). These results align with those of Saleem *et al*. (2022) [20], who reported superior square formation under conventional tillage compared to zero tillage in cotton.

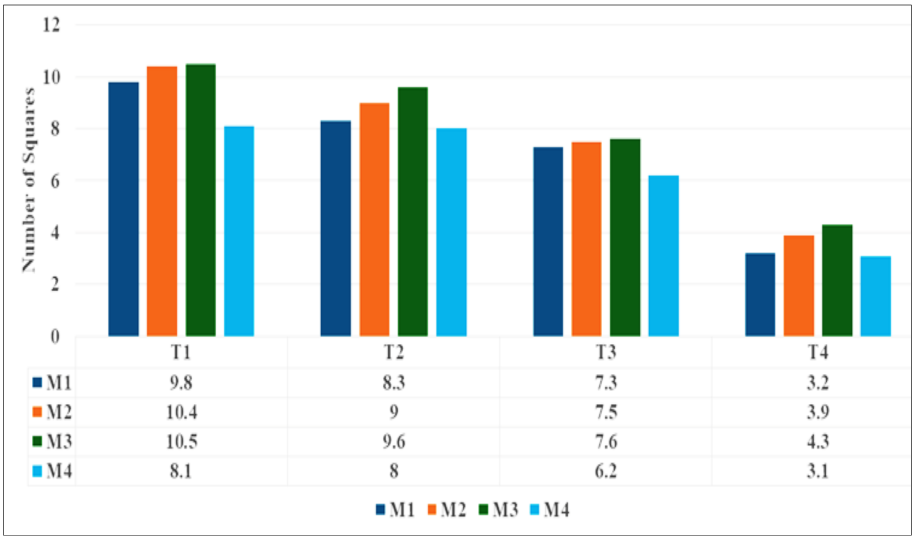
Influence of different organic inputs on the number of squares per plant was found to be significant at both 60 and 90 DAS. The highest number of squares was recorded in the phospho-compost treatment (13.74 and 9.85 at 60 and 90 DAS, respectively), followed by FYM. The lowest number was observed in the no-manure treatment (8.76 and 7.11 at 60 and 90 DAS, respectively). These findings are supported by Nawlakhe *et al*. (2010) [16], who reported a higher number of bolls per plant with vermicompost application, comparable to FYM, indicating the beneficial impact of organic amendments on cotton reproductive performance.

A statistically significant interaction was observed between tillage practices and organic manure application on the number of squares per plant at both 60 and 90 DAS, as shown in Fig 5 and 6. Significantly highest number of squares 17.10 per plant and 10.50 per plant at 60 and 90 DAS was recorded under the combination treatment of conventional tillage with phospho-compost @ 5 t ha^{-1}, highlighting the synergistic effect of favourable soil conditions and nutrient-rich organic input on reproductive development in cotton.



	T1	T2	T3	T4
M1	13.4	12.3	8.9	4.5
M2	13.6	12.5	9.6	4.6
M3	17.1	16.1	11	4.9
M4	11	9.8	7.8	2.7

Fig 4: Effect of tillage and organic inputs on number of squares (60 DAS)



	T1	T2	T3	T4
M1	9.8	8.3	7.3	3.2
M2	10.4	9	7.5	3.9
M3	10.5	9.6	7.6	4.3
M4	8.1	8	6.2	3.1

Fig 5: Effect of tillage and organic inputs on number of squares (90 DAS)

Number of Bolls

The data pertaining to number of bolls per plant as influenced by different tillage practices and organic manures is presented in Table 4 and interaction results is depicted in Fig 7 & 8.

Table 4: Effect of tillage and organic inputs on number of bolls per plant

Treatments	No. of bolls per plant	
	60 DAS	90 DAS
A. Tillage practices		
T_1-Conventional tillage	4.25	9.41
T_2-Reduced tillage	2.61	6.29
T_3-Minimum tillage	2.21	4.13
T_4-Zero tillage	1.52	2.78
SE (m)±	0.025	0.017
CD @ 5%	0.072	0.05
B. Organic manures		
M_1-FYM	2.85	6.06
M_2-Vermicompost	2.33	5.17
M_3-Phosphocompost	3.22	6.70
M_4-No manure	2.19	4.68
SE (m)±	0.025	0.017
CD @ 5%	0.072	0.05
Interaction of tillage and organic manures (A X B)		
SE (m)±	0.051	0.035
CD @ 5%	0.144	0.099

The number of bolls per plant was significantly influenced by different tillage practices at both 60 and 90 DAS. The highest boll count was recorded under conventional tillage (4.25 and 9.41 bolls per plant, respectively), followed by reduced tillage (2.69 and 6.29 bolls per plant). Zero tillage recorded the lowest number of bolls per plant (1.52 at 60 DAS and 2.78 at 90 DAS), indicating the adverse impact of minimal soil disturbance on boll formation. These results are in line with the findings of Irfan *et al*. (2020) [11], who reported that deep tillage promoted significantly more opened bolls per plant than conventional tillage. Similarly, Saleem *et al*. (2022) [20] also observed that conventional tillage practices resulted in higher boll production compared to zero tillage in cotton.

Organic inputs significantly influenced the number of bolls per plant at both 60 and 90 days after sowing (DAS). The highest number of bolls was recorded under phospho-compost treatment (3.22 at 60 DAS and 6.70 at 90 DAS), followed by vermicompost. The lowest values were observed in the no-manure treatment (2.19 and 4.68 at 60 and 90 DAS, respectively). These findings align with those of Kumari *et al*. (2005), who observed increased boll number and weight with FYM application. Similar results were reported by Iqbal *et al*. (2020) [10] and Jan *et al*. (2020) [13], highlighting the positive effect of organic inputs on boll development. Bhavsar *et al*. (2025) [4] also found that combined application of FYM and gliricidia resulted in a significantly higher number of bolls per plant, comparable to 100% RDF and other organic input combinations.

A statistically significant interaction between tillage practices and organic manure application was observed for the number of bolls per plant at both 60 and 90 DAS (Fig 7 and 8). The combination of conventional tillage and phospho-compost consistently resulted in the significantly highest number of bolls at 60 (4.92) and 90 (10.62) DAS, indicating a synergistic effect of improved soil aeration and nutrient availability on reproductive development.

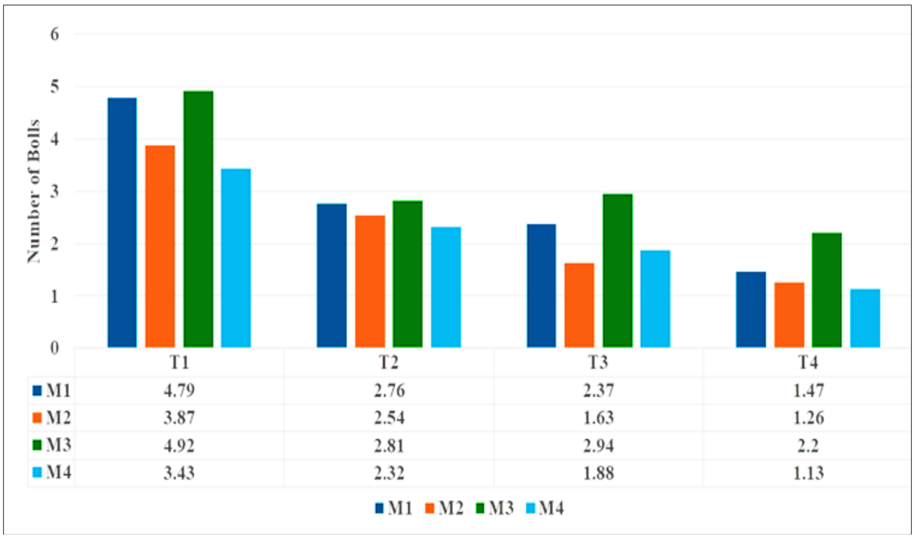


Fig 6: Effect of tillage and organic inputs on number of bolls (60 DAS)

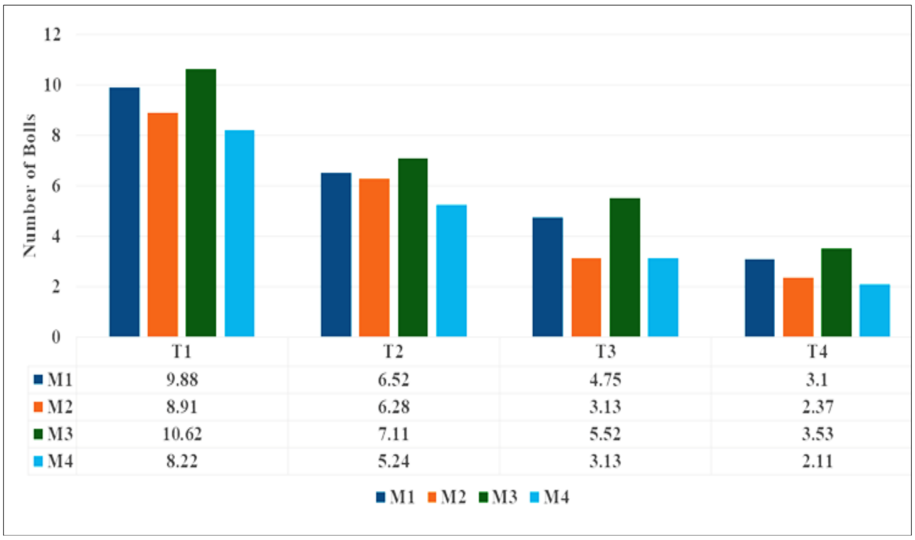


Fig 7: Effect of tillage and organic inputs on number of bolls (90 DAS)

Yield of Cotton

The data regarding effect of tillage practices and organic inputs on seed cotton yield and cotton stalk yield is presented in Table 5 and their interaction effect depicted in Fig 9 & 10.

Table 5: Effect of tillage and organic inputs on yield of cotton

Treatments	Yield (q ha^{-1})	
	Seed Cotton Yield	**Cotton Stalk Yield**
	A. Tillage practices	
T_1-Conventional tillage	13.90	28.97
T_2-Reduced tillage	10.78	22.10
T_3-Minimum tillage	10.05	19.98
T_4-Zero tillage	5.33	10.49
SE (m)±	0.225	0.532
CD @ 5%	0.641	1.515
	B. Organic manures	
M_1-FYM	9.95	20.55
M_2-Vermicompost	10.78	22.41
M_3-Phosphocompost	11.50	24.32
M_4-No manure	7.83	14.26
SE (m)±	0.225	0.532
CD @ 5%	0.641	1.515
	Interaction of tillage and organic manures (A X B)	
SE (m)±	0.45	1.063
CD @ 5%	1.283	3.03

Tillage practices had a significant effect on both seed cotton and stalk yield. The highest seed cotton yield was recorded under conventional tillage (13.90 q ha^{-1}), followed by reduced tillage (10.78 q ha^{-1}) and minimum tillage (10.05 q ha^{-1}). The lowest yield was observed under zero tillage (5.33 q ha^{-1}). A similar trend was observed for stalk yield, with conventional tillage producing the highest yield (28.97 q ha^{-1}), and zero tillage the lowest (10.49 q ha^{-1}). These results are in agreement with Blaise (2005) [5], who reported significant yield differences among tillage treatments. Likewise, Jalota *et al*. (2008) [12] and Irfan *et al*. (2020) [11] found superior seed cotton yields under deep or conventional tillage compared to reduced or zero tillage. Further support comes from Konde *et al*. (2020) and Ravali *et al*. (2024) [19], who also reported maximum seed and stalk yields under conventional tillage, with significant declines under zero tillage.

The effect of various organic inputs on seed cotton yield and stalk yield was found to be statistically significant. Among the treatments, phospho-compost recorded the highest seed cotton yield (11.50 q ha^{-1}), followed by vermicompost (10.78 q ha^{-1}) and FYM (9.95 q ha^{-1}). The lowest seed yield (7.83 q ha^{-1}) was recorded in the no manure treatment. Similarly, cotton stalk yield was significantly highest in the phospho-compost treated plots (24.32 q ha^{-1}), followed by vermicompost (22.51 q ha^{-1}) and FYM (20.55 q ha^{-1}). The lowest stalk yield (14.26 q ha^{-1}) was observed under the no manure treatment. These findings align with the results of Khuspure *et al*. (2018) [14], who reported that application of bulky organic manures, especially FYM at 10 t ha^{-1}, significantly increased seed cotton yield. Iqbal *et al*. (2020) [10] also observed higher seed cotton yield in soils treated with FYM compared to untreated controls. Furthermore, Jan *et al*. (2020) [13] noted that the combined application of organic sources produced the highest seed cotton yield in the Lala Zar variety, Ravali *et al*. (2024) [19] reported significantly higher seed and stalk yields under phospho-compost treatment, with yields on par with vermicompost. The lowest yields were again observed in plots with no manure. Overall, the application of organic inputs, especially well decomposed phospho-compost and vermicompost revealed a positive influence on both seed and stalk yield of cotton, likely due to improvements in soil fertility and nutrient availability.

The interactive effects of tillage practices and various organic inputs on the seed and stalk cotton yield was found to be significant. The data generated in this regard is presented in Fig 9 and 1, respectively. Interaction effect of conventional tillage along with phospho-compost showed significantly superiority over all other combinations with 16.50 q ha^{-1} seed cotton yield as well as 35.49 q ha^{-1} cotton stalk yield under rainfed conditions in black cotton soils.

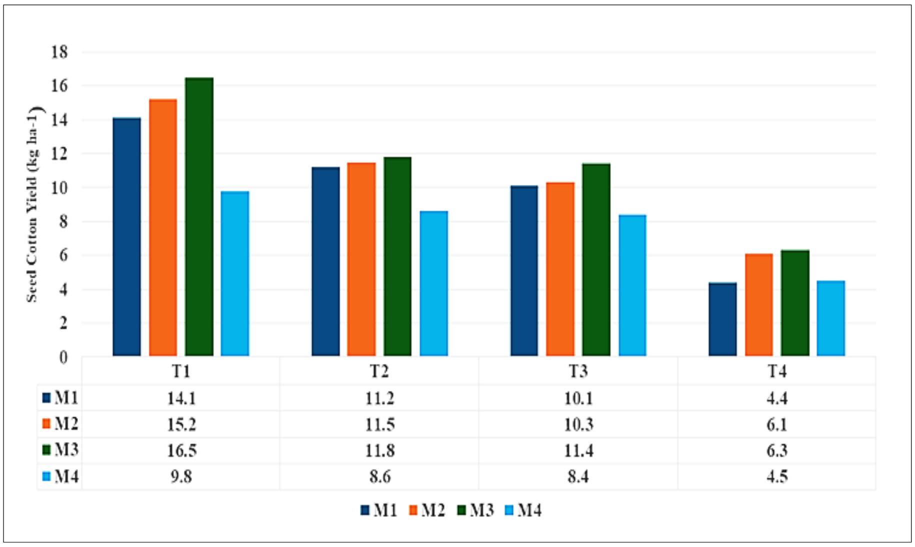


Fig 8: Effect of tillage and organic inputs on seed cotton yield

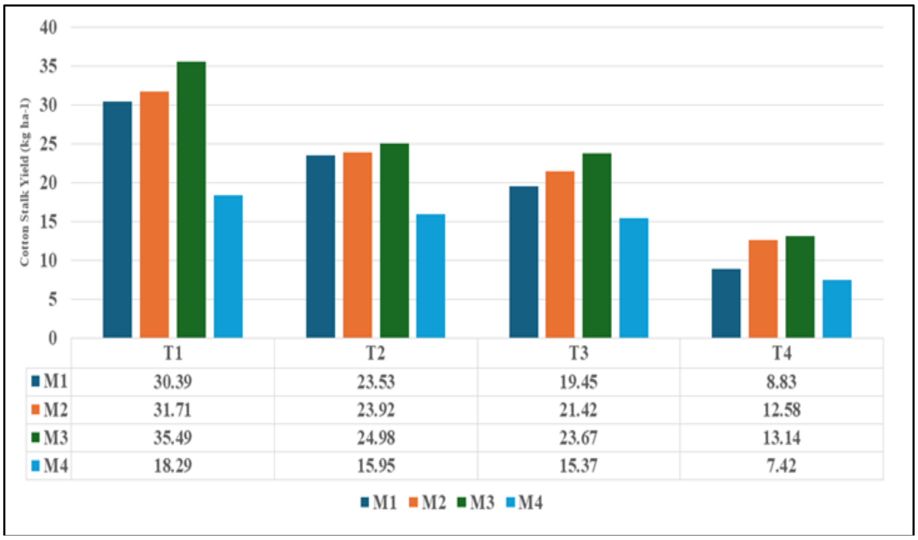


Fig 9: Effect of tillage and organic inputs on cotton stalk yield

Conclusion

The present study demonstrated that both tillage practices and organic inputs significantly influenced cotton growth and yield in black soils, Vertisols. Among the tillage treatments, conventional tillage consistently outperformed reduced, minimum, and zero tillage by recording the highest plant height, number of sympodial branches, squares, bolls, and ultimately, seed and stalk yield. Similarly, among the organic amendments, phospho-compost proved to be the most effective, significantly enhancing vegetative growth, followed closely by vermicompost. The combination of conventional tillage with phospho-compost emerged as the most productive interaction, indicating a synergistic effect on crop performance and soil nutrient availability. These findings underscore the importance of integrated soil management practices that combine suitable tillage methods with organic nutrient sources to optimize cotton productivity and sustain soil fertility under organic farming conditions in black cotton soils, having a poor workability due to high clay content and their typical swell-shrink properties and formation of deep wide cracks under moisture variations. These findings indicating that adopting suitable tillage methods in conjunction with nutrient-rich organic inputs can play a crucial role in enhancing organic cotton productivity under rainfed conditions.

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References

1. Adeli A, Brooks JP, Miles D, Misna T, Feng G, Jenkins JN. Combined effects of organic amendments and fertilization on cotton growth and yield. Agronomy Journal. 2022;114(6):3445-3456.

2. Agegnehu G, Nelson PN, Bird MI. Crop yield, plant nutrient uptake and soil physicochemical properties under organic soil amendments and nitrogen fertilization on Nitisols. Soil Tillage Res. 2016;160:1-13.
3. Benbi DK, Biswas CR. Nutrient budgeting and long-term sustainability under a rice-wheat system. Nutr Cycl Agroecosyst. 1998;52:253-262.
4. Bhavsar MS, Gabhane VV, Ganvir MM, Patode RS, Bhoyar SM, Jadhao SD. Effect of organic sources of nutrients on performance, nutrient uptake and yield of rainfed cotton in Vertisols under semi-arid condition. Plant Arch. 2025;25(1):893-898.
5. Blaise D, Singh JV, Bonde AN, Tekale KU, Mayee CD. Effects of farmyard manure and fertilizers on yield, fibre quality and nutrient balance of rainfed cotton (*Gossypium hirsutum*). Bioresour Technol. 2005;96(3):345-349.
6. FiBL (Research Institute of Organic Agriculture). Organic farming principles and nutrient management. Various publications. 2022.
7. Garcia JP, Wortmann CS, Mamo M, Drijber R, Tarkalson D. One-time tillage of no-till: Effects on nutrients, mycorrhizae, and phosphorus uptake. Agron J. 2007;99(4):1093-1103.
8. Geng Y, Cao G, Wang L, Wang S. Effects of equal chemical fertilizer substitutions with organic manure on yield, dry matter, and nitrogen uptake of spring maize and soil nitrogen distribution. PLoS One. 2019;14(7):e0219512.
9. Hofmeijer MA, Krauss M, Berner A, Peigné J, Mäder P, Armengot L. Effects of reduced tillage on weed pressure, nitrogen availability and winter wheat yields under organic management. Agronomy. 2019;9(4):180.
10. Iqbal S, Luqman M, Nasrullah HM, Ullah A, Akram HM. Response of cotton to application of organic and inorganic source of nutrients in semi-arid climate. Sarhad J Agric. 2020;36(3):929-938.
11. Irfan M, Ali H, Ahmad S, Sattar A, Areeb A, Hussain S, *et al*. Various tillage systems and sowing methods affect growth and yield related characters of cotton. J Arable Crops Mark. 2020;2(1):9-19.
12. Jalota SK, Buttar GS, Sood A, Chahal GBS, Ray SS, Panigrahy S. Effects of sowing date, tillage and residue management on productivity of cotton (*Gossypium hirsutum* L.)-wheat (*Triticum aestivum* L.) system in northwest India. Soil Tillage Res. 2008;99(1):76-83.
13. Jan M, Hussain S, Anwar-ul-Haq M, Iqbal J, Ahmad L, Aslam M, *et al*. Effect of farmyard manure and compost application on transgenic Bt cotton varieties.. 2020.
14. Khuspure JA, Bhoyar SM, Deshmukh PW. Influence of organic manure on physical properties of Vertisol under cotton cultivation. J Soil Water Conserv. 2018;17(3):294-298.
15. Mahmood YA, Ahmed FW, Juma SS, Al-Arazah AA. Effect of solid and liquid organic fertilizer and spray with humic acid and nutrient uptake of nitrogen, phosphorus and potassium on growth, yield of cauliflower. Plant Arch. 2019;19(2):1504-1509.
16. Nawlakhe SM, Mankar DD. Effect of integrated nutrient management on soil moisture content and soil physico-chemical properties under long term experimentation site in cotton + greengram intercropping.. 2009:287-294.
17. Orozco FH, Cegarra J, Trujillo LM, Roig A. Vermicomposting of coffee pulp using the earthworm *Eisenia fetida*: effects on C and N contents and the availability of nutrients. Biol Fertil Soils. 1996;22(1):162-166.
18. Ozpinar S, Isik A. Effects of tillage, ridging and row spacing on seedling emergence and yield of cotton. Soil Tillage Res. 2004;75(1):19-26.
19. Ravali E, Konde NM, Bhoyar SM, Kanase N, Singh A, Thite MD, *et al*. Effect of different tillage and organic inputs on soil properties and yield of cotton on Vertisols. Asian J Soil Sci Plant Nutr. 2024;10(4):164-175.
20. Saleem MF, Ghaffar A, Rahman MHU, Imran M, Iqbal R, Soufan W, *et al*. Effect of short-term zero tillage and legume intercrops on soil quality, agronomic and physiological aspects of cotton under arid climate. Land. 2022;11(2):289.
21. Wezel A, Casagrande M, Celette F, Vian JF, Ferrer A, Peigné J. Agroecological practices for sustainable agriculture. A review. Agron Sustain Dev. 2014;34(1):1-20.