

EFFECT OF DIFFERENT TILLAGE AND ORGANIC INPUTS ON SOIL PROPERTIES AND YIELD OF COTTON IN VERTISOLS

ABSTRACT

The present investigation was conducted during *Kharif* 2023-24 to study the effect of different tillage and organic inputs on soil properties and yield of cotton in Vertisols. The experiment was conducted at Research Farm, Department of Soil Science, Dr. PDKV, Akola. The experiment was laid out in factorial randomized block design with two factors, four tillage treatments as factor A and four source of manure treatments as factor B. Each treatment was replicated three times. The treatments were composed of factor A consisting of four tillage operations [conventional tillage (T₁), reduced tillage (T₂), minimum tillage (T₃) and zero tillage (T₄)] and factor B consisting of organic manures such as farmyard manure (10 t ha⁻¹) (M₁), vermicompost (5 t ha⁻¹) (M₂), phosphocompost (5 t ha⁻¹) (M₃) and no manure (M₄). The results showed that conventional tillage resulted in the highest seed cotton yield (14.10 ha⁻¹), stalk yield (27.78 ha⁻¹), total uptake of N (46.46 ha⁻¹), P (7.86 ha⁻¹), and K (38.31 ha⁻¹) compared to other tillage practices. Among the organic manure treatments the highest seed cotton yield (11.21 ha⁻¹), stalk yield (21.95 ha⁻¹), total N (37.27 ha⁻¹), P (6.57 ha⁻¹) and K (32.44 ha⁻¹) uptake by cotton was observed with phosphocompost application. Based on the observations noted, the available N, P and K of the soil were significantly influenced due to tillage and organic manures. Among the tillage practices, the highest content of available N (182.14 kg ha⁻¹), P (17.14 kg ha⁻¹) and K (312.95 kg ha⁻¹) were recorded under reduced tillage. The use of vermicompost resulted in the highest available N (185.93 kg ha⁻¹) and K (316.68 kg ha⁻¹), while the highest available P (18.22 kg ha⁻¹) was observed in the treatment with phosphocompost.

Keywords: Cotton; Vertisols; tillage; organic manures.

INTRODUCTION

Cotton (*Gossypium spp.*) is one of the most important crops in India's semi-arid areas. Cotton, commonly referred as "white gold," is a very valuable commodity that is crucial to the economics of many nations and is regarded as the king of all fibre crops. It is an important source of fibre, oil and animal feed (Dai and Dong, 2014). Cotton is a tropical crop that significantly contributes to economic development worldwide. The main goal of cotton cultivation for farmers is to obtain cotton fibre, the elongated and thickened single cell of the seed epidermis. The Indian Textile Industry consumes a diverse range of fibres and yarns and the ratio of use of cotton to non-cotton fibres in India is around 60:40 whereas it is 30:70 in the rest of the world. (Anonymous, 2024).

India got 1st place in the world in cotton acreage with 124.69 lakh hectares area under cotton cultivation. In terms of productivity, India is on 33rd rank with a yield of 441 kg ha⁻¹. India is having 2nd place in the world with an estimated production of 323.11 lakh bales (5.50 million metric tonnes) during the cotton season 2023-24. India is also the 2nd largest consumer of cotton in the world with an estimated consumption of 317 lakh bales (5.39 million metric tonnes) (Anonymous, 2024). Maharashtra is the leading state in terms of the area (42.22 lakh hectares) under cotton cultivation. Still, it ranks second in production (82 lakh bales) next to Gujarat (89.65 lakh bales) (Anonymous, 2024).

Tillage is the oldest art associated with the development of agriculture and involves operations to modify the physical characteristics of soil. It is the most difficult and time-consuming work in crop production, accounting for about 30 percent of the total expenditure. However, there is potential to reduce this cost by understanding the objectives of tillage and carrying out the operations at the right time with proper implementation. "Conservation tillage is a type of tillage that aims to reduce soil and water loss. It typically involves keeping at least 30% of crop residue or mulch on the soil surface year-round. This practice helps to prevent soil erosion, preserves water in the root zone and enhances soil fertility and productivity." (Derpsch, 2005). Conservation tillage eliminates power-intensive soil tillage, thus reducing the drudgery and labour required for crop production by more than 50% of the small-scale farmers.

Reduced tillage practices, also known as conservation tillage, are one of the best alternatives to conventional tillage and they have increased globally over the last two decades (Hofmeijer *et al.*, 2019).

Organic sources like FYM, vermicompost and phosphocompost are well-known for improving soil quality and productivity. These sources contain most of the nutrients required by crops, which can help to improve physical properties like soil structure, maximum water holding capacity, hydraulic conductivity and create a more favourable environment for root growth. The proliferation of microbial activity in soil leads to the conversion of unavailable nutrients to available forms, which increases crop yields in the long term by improving soil's physical, chemical and biological properties. Application of FYM significantly increases soil organic carbon levels, infiltration rate, water retention capacity, soil aggregation and aggregate stability in water. (Benbi *et al.*, 1998). Vermicompost, which is produced by earthworms, is an incredibly nutrient-rich organic supplement that contains both micro and macronutrients, vitamins, growth hormones and enzymes (Orozco *et al.*, 1996). Phosphocompost has been reported to improve soil pH, organic matter, total nitrogen and available phosphorus. (Hellal *et al.*, 2013).

Vertisols are a type of soil that undergoes swelling and shrinking due to changes in moisture levels. They have high water retention capacity but low infiltration rate and high cation exchange capacity. To sustain reasonable levels of organic cotton production, it is essential to improve and maintain the organic matter in these soils. This can increase water infiltration, reduce erosion and improve soil structure and aggregate stability. Moreover, it can enhance the supply of nutrients, particularly nitrogen, phosphorus and sulphur. Thus, a good organic matter management program is necessary for fertility management under organic production systems.

In this context, the present investigation was planned to study the effect of different tillage and organic inputs on soil properties and yield of cotton in Vertisols.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the Kharif season of 2023-24. Soil of the experimental field was classified as Vertisols, particularly

montmorillonitic, hyperthermic a family of Typic Haplustert. It has smectite clay minerals with swell-shrink properties, soils are moderately alkaline in reaction with pH of 8.03, low in available N ($175.30 \text{ kg ha}^{-1}$) and P (13.40 kg ha^{-1}) and sufficient in available potash content (306 kg ha^{-1}). The experiment was laid out in a factorial randomized block design with two factors. Factor A consists of four tillage treatments [conventional tillage(T_1), reduced tillage(T_2), minimum tillage(T_3) and zero tillage(T_4)] and factor B consists of organic manures such as farmyard manure (10 t ha^{-1}) (M_1), vermicompost (5 t ha^{-1}) (M_2), phosphocompost (5 t ha^{-1}) (M_3) and no manure (M_4). All the treatments were replicated three times.

The initial soil samples (0-20 cm) were collected from each plot in all three replications. Available N was determined by the alkaline permanganate method using an automatic distillation system (Subbiah and Asija, 1956). Available P was measured by Olsen's method with a UV double-beam spectrophotometer (Watanabe and Olsen, 1965). Potassium was assessed using the neutral normal ammonium acetate method with a flame photometer (Hanway and Heidal, 1952). The plant samples have been collected randomly from every plot at the harvest of the crop. After cleansing and drying the plant samples have been saved in polythene bags with the right labelling for chemical analysis. Total nitrogen was determined by micro-Kjeldhal's distillation method (piper, 1966). Total phosphorous was estimated by using spectrophotometer (Jackson, 1973) and total potassium by using a flame photometer (piper, 1966). Cotton was picked from net plots in all the replications and yield per hectare was calculated. The data was subjected to statistical analysis as per Gomez and Gomez (1984).

RESULT AND DISCUSSION

1. Yield of Cotton

1.1 Effect of tillage:

The data in respect of seed cotton and stalk yield of cotton as influenced by different tillage and organic manures is placed in Table 1 and depicted in Fig. 1. The seed cotton yield (14.10 q ha^{-1}) and stalk yield (27.78 q ha^{-1}) were noticed significantly higher in conventional tillage followed by reduced tillage, which noted a seed cotton yield of (10.22 q ha^{-1}) and stalk yield of (19.70 q ha^{-1}), while the lowest seed cotton yield (4.87 q ha^{-1}) and stalk yield (9.13 q ha^{-1}) were observed in zero tillage among all tillage practices. The lower trend of crop yield is most, likely due to the hardness of black

cotton soil, poor hydraulic conductivity and poor soil aeration under conservation agriculture practices. Similar results were achieved by Saleem *et al.*, (2022), who reported that the conventional tillage showed the highest plant height (121 cm), total bolls per plant (22.9 bolls), boll weight (2.74 g) and seed yield (2031 kg ha⁻¹) of the cotton crop, as compared to zero tillage.

1.2 Effect of organic manures:

Based on an assessment of data, it was noticed that the seed yield and stalk yield of cotton were superior with the application of phosphocompost and found the lowest in the absence of organic manures. The significantly highest seed cotton yield (11.21 q ha⁻¹) and stalk yield (21.95 q ha⁻¹) were noticed higher in treatment with phosphocompost (M₃) followed by seed cotton yield (10.60 q ha⁻¹) and stalk yield (20.76 q ha⁻¹) in treatment with vermicompost (M₂), both the treatments were on par with each other. The lowest seed cotton yield (7.33 q ha⁻¹) and stalk yield (14.02 q ha⁻¹) were observed in the no manured plot (M₄). It may infer that the increase in seed cotton yield may be due to more availability and efficient use of nutrients. As phosphocompost improves phosphorus availability in the soil. Phosphorus plays a crucial role in root growth and the development of reproductive parts (such as flowers and seeds). This leads to better plant establishment and higher cotton yield. The results obtained during experimentation corresponded to the findings of Solunke *et al.*, (2011) who stated that FYM @ 10 t ha⁻¹ and vermicompost @ 2 t ha⁻¹ recorded significantly higher seed cotton yield. Results are in line with the findings of Nawlakhe *et al.*, (2010) who reported that seed cotton yield and stalk yield were significantly superior with an application of vermicompost @ 2 t ha⁻¹ over others, except FYM @ 5 t ha⁻¹ which was at par with the findings with an application of vermicompost. Similar results were reported by Rannavare *et al.*, (2006) who stated that the application of vermicompost (2 t ha⁻¹) and application of FYM (5 t ha⁻¹) registered significant maximum seed cotton yield and stalk yield over sunhemp in-situ green manuring (5 t ha⁻¹).

1.3 Interaction effect:

Data with respect to the interaction of tillage and organic manures on seed cotton yield and stalk yield of cotton was found significant.

Table No. 1: Effect of tillage and organic inputs on seed cotton yield (q ha⁻¹) and stalk yield of cotton (q ha⁻¹).

Treatments	Yield (q ha ⁻¹)	
	Seed cotton yield (q ha ⁻¹)	Stalk yield (q ha ⁻¹)
a) Tillage practices		
T ₁ - Conventional tillage	14.10	27.78
T ₂ - Reduced tillage	10.22	19.70
T ₃ - Minimum tillage	9.47	18.04
T ₄ - Zero tillage	4.87	9.13
SE (m)±	0.456	0.44
CD @ 5%	1.317	1.26
b) Organic manures		
M ₁ - FYM	9.22	17.90
M ₂ - Vermicompost	10.60	20.76
M ₃ - Phosphocompost	11.21	21.95
M ₄ - No Manure	7.64	14.02
SE (m)±	0.456	0.44
CD @ 5%	1.317	1.26
Interaction of tillage and organic manures (a X b)		
SE (m)±	0.912	0.87
CD @ 5%	2.634	2.52

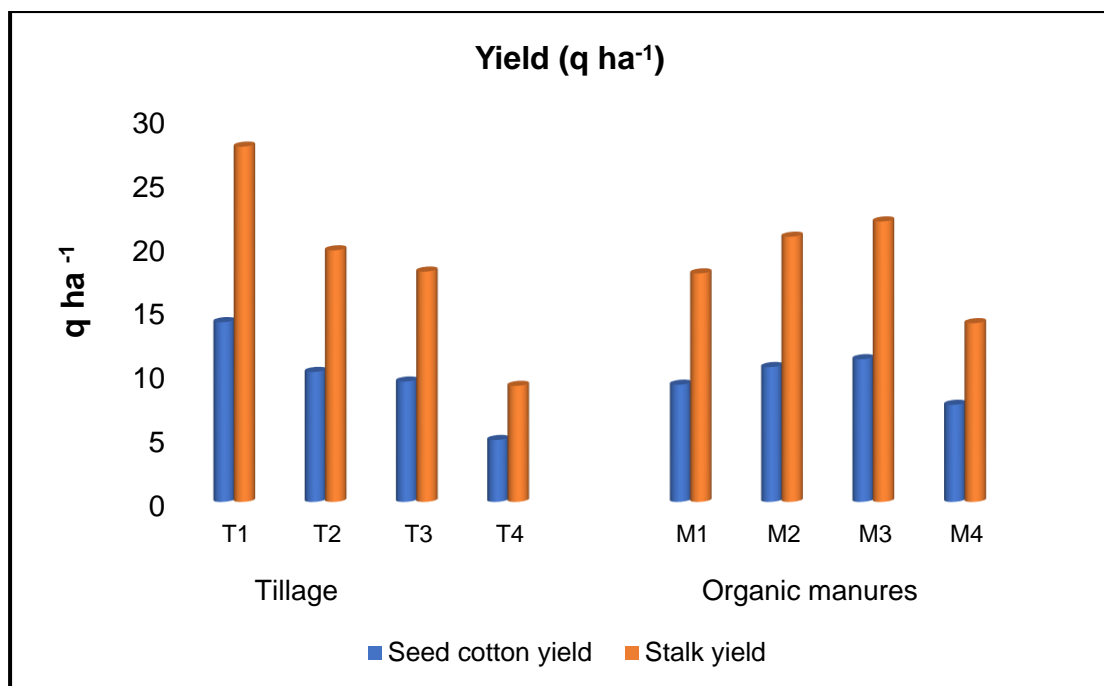


Fig. 1. Seed cotton yield and stalk yield of cotton as influenced by different tillage and organic manures.

2. Total uptake of nitrogen, phosphorous and potassium

2.1 Effect of tillage:

Significantly higher N, P and K uptake were recorded in conventional tillage over other tillage practices at the harvest stage (Table 2 and Fig. 2). The higher uptake of N (46.46 kg ha⁻¹), P (7.86 kg ha⁻¹) and K (38.31 kg ha⁻¹) was recorded under conventional tillage, followed by reduced tillage with nitrogen uptake of 32.61 kg ha⁻¹, phosphorous uptake of 5.54 kg ha⁻¹ and potassium uptake of 29.44 kg ha⁻¹. The lowest uptake of N (15.36 kg ha⁻¹), P (2.38 kg ha⁻¹), and K (13.83 kg ha⁻¹) was observed under zero tillage. Conventional tillage results in higher nutrient uptake (N, P, K) because it loosens the soil, improves aeration, enhances water infiltration and promotes root growth, allowing plants to access more nutrients. Overall, the total uptake of N, P and K showed an increasing trend in the order of zero tillage < minimum tillage < reduced tillage < conventional tillage. Similar observations for uptake of nitrogen & phosphorous were noted by Deibert *et al.* (1989). The results corroborate with the findings of Ishaq *et al.*, (2001) who stated that the uptake of nitrogen, phosphorous and potassium by cotton was higher under conventional tillage than minimum tillage and deep tillage treatments.

2.2 Effect of organic manures:

Based on the data assessment, it was noticed that the effect of organic manures on uptake of N, P and K was found to be significant. The highest uptake of N (37.27 kg ha^{-1}), P (6.57 kg ha^{-1}) and K (32.44 kg ha^{-1}) was noted with an application of phosphocompost followed by the application of vermicompost with nitrogen uptake of 34.41 kg ha^{-1} , phosphorous uptake of 5.74 kg ha^{-1} and potassium uptake of 29.82 kg ha^{-1} . Phosphocompost improve root growth and increase plants ability to absorb water and nutrients, that improve nutrient uptake for better growth and yield. However, the lowest uptake of nitrogen (23.76 kg ha^{-1}), phosphorous (3.53 kg ha^{-1}) and potassium (20.85 kg ha^{-1}) was identified in treatment with no organic manures. The results confirm with the findings of Age *et al.* (2019) who reported that a significantly higher uptake of N, P and K by cotton was recorded with the application of 100 % P through phosphocompost over other treatments and revealed that the increase in total potassium uptake was due to the incorporation of decomposed material like FYM, phosphocompost, vermicompost and glyricidia green leaf manuring along with inorganic fertilizers.

2.3 Interaction effect:

Data with respect to the interaction of tillage and organic inputs on total uptake of nitrogen, phosphorous and potassium was found significant.

Table No. 2: Effect of tillage and organic inputs on total uptake of N, P and K by cotton.

Treatments	Nitrogen uptake (kg ha^{-1})	Phosphorous uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
a) Tillage practices			
T ₁ (Conventional tillage)	46.46	7.86	38.31
T ₂ (Reduced tillage)	32.61	5.54	29.44
T ₃ (Minimum tillage)	30.61	4.79	27.44
T ₄ (Zero tillage)	15.36	2.38	13.83
SE (m)±	0.03	0.08	0.03
CD @ 5%	0.08	0.22	0.07

b) Organic manures			
M ₁ (FYM)	29.58	4.74	25.92
M ₂ (Vermicompost)	34.41	5.74	29.82
M ₃ (Phosphocompost)	37.27	6.57	32.44
M ₄ (No Manure)	23.76	3.53	20.85
SE (m)±	0.03	0.08	0.03
CD @ 5%	0.08	0.22	0.07
Interaction of tillage and organic manures (a X b)			
SE (m)±	0.05	0.15	0.05
CD @ 5%	0.15	0.44	0.15

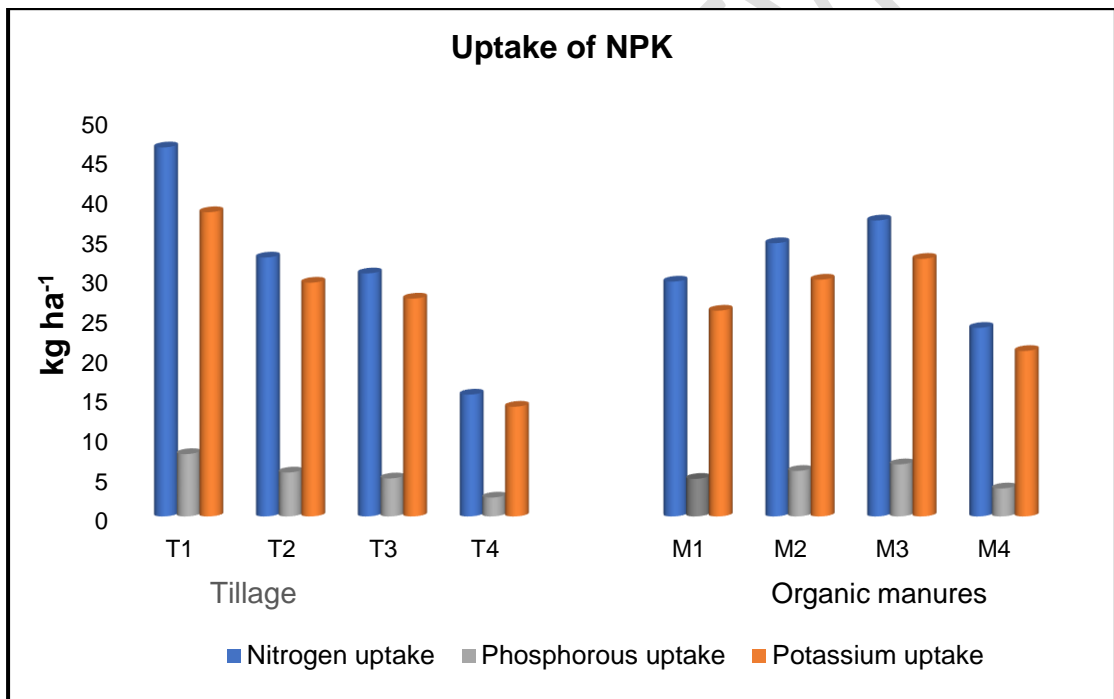


Fig. 2. Total uptake of NPK as influenced by different tillage and organic manures.

3. Soil available NPK

3.1 Effect of tillage:

Data pertaining to available N, P and K as influenced by different tillage and organic inputs is presented in table 3 and graphically presented in Fig. 3 The available soil

nutrients were influenced and mostly observed higher under reduced tillage and minimum tillage. Among the treatments with organic manures, the nutrients were commonly more, where vermicompost and phosphocompost were applied. In respect of residual soil fertility, available N, P and K were influenced significantly by reduced tillage. The significantly highest content of available nitrogen ($182.14 \text{ kg ha}^{-1}$), phosphorus (17.14 kg ha^{-1}) and potassium ($312.95 \text{ kg ha}^{-1}$) was recorded under reduced tillage. Reduced mechanical disturbance of the soil under conservation tillage resulted in the highest nutrient levels as compared to conventional tillage. The corresponding observations were also noticed by Jadhao *et al.*, (2021) who reported that significantly higher levels of available N, P and K were observed under minimum tillage as compared to conventional tillage. Jat *et al.*, (2017) also revealed that conservation agriculture-based cropping systems improved soil properties and availability of phosphorous and potassium in the surface soil layer compared to conventional farmer's practice. The results corroborate with the findings reported by Bharambe *et al.*, (2002) and Halemani *et al.*, (2004).

3.2 Effect of organic manures:

The treatments with organic manures have also influenced the availability of N, P and K significantly. The significant enhancement in available N ($185.93 \text{ kg ha}^{-1}$) and K ($316.68 \text{ kg ha}^{-1}$) were noted where vermicompost was applied, whereas the significantly highest available P (18.22 kg ha^{-1}) was noted where phosphocompost was given. However, the lowest values of available N ($170.29 \text{ kg ha}^{-1}$), P (12.72 kg ha^{-1}) and K ($297.25 \text{ kg ha}^{-1}$) were recorded in treatment with no organic manures. The enhanced nutrient availability in treatments with vermicompost and phosphocompost is due to the faster decomposition of organic matter and the ability of these manures to release specific nutrients more efficiently than untreated soil. Similar findings were also reported by Halemani *et al.*, (2004), Liu *et al.*, (2010) and Shankar *et al.* (2012) who reported that available N, P and K status of soil at harvest of the crop were increased significantly with application of FYM 10 t ha^{-1} over no FYM. These results are in line with the findings of Das *et al.*, (2003) who, reported that soil available K was increased with the application of FYM over control.

3.3 Interaction effect:

Data with respect to the interaction of tillage and organic inputs on available nitrogen, phosphorous and potassium was found significant.

Table No. 3: Effect of different tillage and organic inputs on available NPK.

Treatments	Available N (kg ha⁻¹)	Available P (kg ha⁻¹)	Available K (kg ha⁻¹)
a) Tillage practices			
T ₁ - Conventional tillage	180.38	15.53	310.33
T ₂ - Reduced tillage	182.14	17.14	312.95
T ₃ - Minimum tillage	180.55	16.60	311.88
T ₄ - Zero tillage	178.00	15.49	305.93
SE (m)±	0.062	0.13	0.18
CD @ 5%	0.178	0.38	0.52
b) Organic manures			
M ₁ – FYM	181.70	17.59	312.88
M ₂ – Vermicompost	185.93	16.23	316.68
M ₃ – Phosphocompost	183.15	18.22	314.25
M ₄ - No manure	170.29	12.72	297.25
SE (m)±	0.062	0.13	0.18
CD @ 5%	0.178	0.38	0.52
Interaction of tillage and organic manures (a X b)			
SE (m)±	0.123	0.27	0.36
CD @ 5%	0.356	0.77	1.04

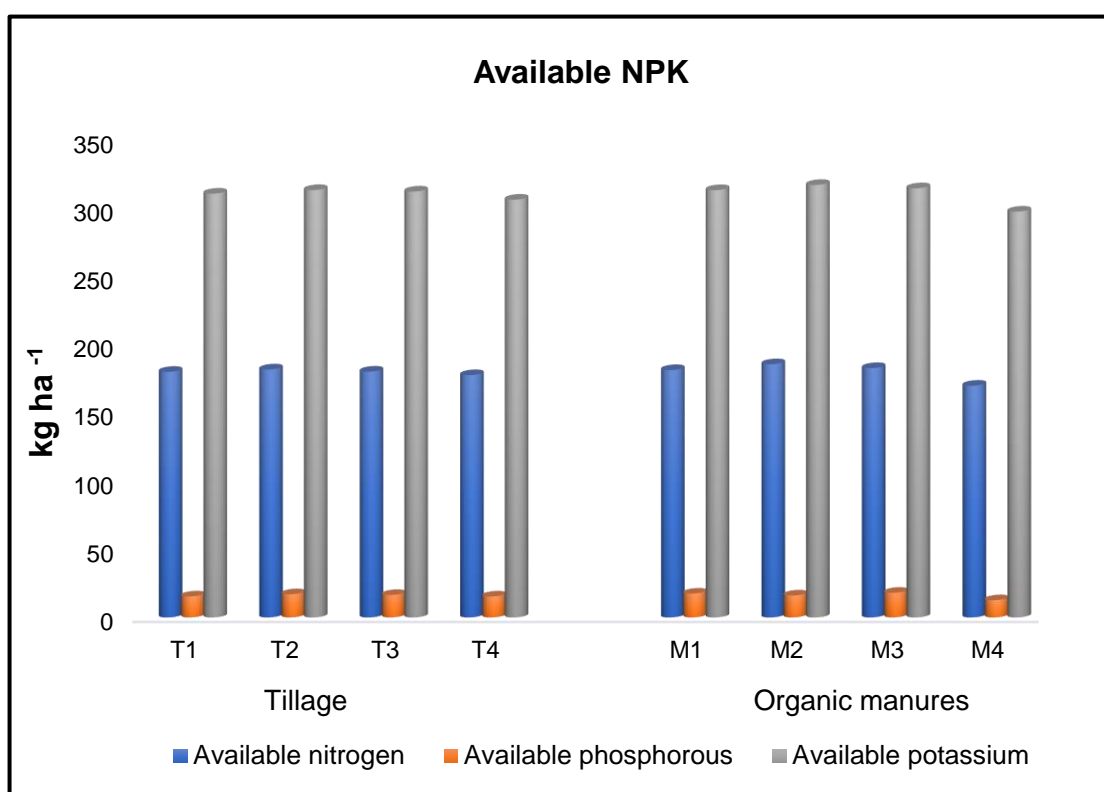


Fig. 3. Available NPK as influenced by different tillage and organic manures.

CONCLUSION

Based on the investigation, it was concluded that conventional tillage combined with phosphocompost was most effective in improving the yield and nutrient uptake compared to zero tillage and no-manure treatments. The residual fertility of the soil with respect to available macronutrients (N, P and K) was enhanced under reduced tillage and with the application of vermicompost and phosphocompost. These practices improved soil nutrient content and fertility compared to zero tillage and no-manure treatments, which resulted in lower nutrient levels. Therefore, combining reduced tillage with organic inputs viz. FYM, vermicompost and phosphocompost proved to be beneficial for enhancing soil nutrient availability, higher yield and promoting sustainable soil health.

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