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Effect of organic and inorganic fertilizers on physico-chemical properties of soil of lentil (*Lens Culinaris*)

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Abstract

A field experiment was conducted under rainfed conditions at the farm of the department of soil science at Prof. Rajendra Singh (Rajju Bhaiya) university Prayagraj, Uttar Pradesh, India, to assess the effects of nutrient management on the physiochemical characteristics of soil and lentil crop. It consists Nine treatment combination including various mixtures of inorganic and organic fertilizers. Farmyard manure (FYM), vermicompost (VC) and NPK were used in the study with Randomized Block Design (RBD). This treatment combination used T₁ (Control), T₂ (FYM @ 2.5 t ha⁻¹), T₃ (FYM @ 5 t ha⁻¹), T₄ (VC @ 1 t ha⁻¹), T₅ (VC @ 2 t ha⁻¹), T₆ (50 % NPK), T₇ (100 % NPK), T₈ (FYM @ 2.5 t ha⁻¹ VC @ 1 t ha⁻¹ + 50 % NPK), T₉ (FYM @ 5 t ha⁻¹ + VC @ 2 t ha⁻¹ + 100 % NPK). The result shows that application of different levels combination of farmyard manure, vermicompost and NPK improved soil health increased growth and yield of Lentil crop. It was observed that among the application of all treatment combinations T₉ shows the superiority in Pore Space (47.3%), Water holding capacity (46.5%) and Organic Carbon level of 0.44%. In terms of post-harvest nutrient availability, treatment T₉ recorded the maximum levels of Available Nitrogen (321.6 kg ha⁻¹), Available Phosphorus (24.43 kg ha⁻¹) and Available Potassium (214.5 kg ha⁻¹). Thus, concluded that integrated application of farmyard manure (FYM), vermicompost (VC) and NPK (T₉) ensure optimal yield while maintaining and improving soil health, promoting environmental sustainability. In almost all the aspect in compare to T₁ (control).

Keywords: Lentil, organic, FYM, VC, NPK, INM

Introduction

The English word “lentil” originates from the Latin word “lens”, which also gives us the word for optical “lenses” due to their similar shape. Lentil is self-pollinated crop. Family of lentil is Fabaceae. And its chromosome no. is 2n= 14. Raw lentils are much higher in protein by weight - about 24-26% (24-26 g per 100 g), because cooking adds water weight. Lentil seeds contained a total fat of about 1.4 g/100 g, distributed unevenly over the fatty fractions as follows: saturated fatty acids (SFA), 16.7 %; monounsaturated fatty acids (MUFA), 23.7 % and polyunsaturated fatty acids (PUFA), 58.8 % (FAOSTAT., 2022). Lentils are a significant dietary source of a plethora of vitamins including folate, thiamin (B1) and riboflavin (B2). Other water-soluble vitamins have also been reported in lentils as follows: niacin; pantothenic acid and pyridoxine. In addition, vitamin E (a, b and c tocopherols) was measured in lentils by (Faris *et al.* 2012)^[6]. Approximately 6.5-7 million tonnes of lentils are produced worldwide each year, with Canada, India, and Australia accounting for more than 70% of the total. India is the biggest user and second-largest producer, while Canada is the leading producer and exporter, accounting for more over one-third of the world's supply. India produced 1.28 million tons of lentils in 2023 at a productivity of 904 kg ha⁻¹ on an average of 1.42 million hectares. The market for lentil protein is anticipated to grow at a compound annual growth rate (CAGR) of 5.1% and reach a valuation of US\$208.3 million by 2033 (Shaikh *et al.*, 2024)^[17].

One of the earliest and most popular organic amendments in Indian agriculture is farmyard manure (FYM), which is created from decomposed animal dung, urine, and crop residues.

FYM is a dependable input for maintaining soil fertility under a variety of agroclimatic situations because it offers a steady and balanced supply of nutrients, enhances soil structure and water-holding capacity, and promotes microbial activity Rajan *et al.* (2023)^[14].

In order to create a healthy lentil stand, vermicompost increases soil porosity and water-holding capacity, decreases soil compaction, enhances air and water penetration, and helps retain moisture. Vermicompost has a significant potential as a partial substitute for chemical nitrogen in lentil production, as evidenced by a 50.4% increase in lentil yield over the control when 50% of the recommended dose of nitrogen (RDN) was supplied through vermicompost at 1 t ha⁻¹ as a basal application in the semi-arid region of northern India (Rehman *et al.* 2023)^[16].

The NPK fertilizers are used in conjunction with FYM and vermicompost, pulse crops yield better results than when any one ingredient is applied alone. The beneficial effects of applying vermicompost, organic manure, and inorganic fertilizers together were primarily linked to improved nutrient availability and favorable effects on the physical and chemical characteristics of the soil, which led to improved yield attributes and eventually higher yields in legume crops. In a study on lentil nutrient management, (Kumar *et al.* 2024)^[10].

Materials and Methods

The course of present investigation entitled “Effect of Organic and Inorganic Fertilizers on Physico-Chemical Properties of Soil of Lentil (*Lens Culinaris*)” comprise of a field experiment which was carried out at the Soil Science Research Farm, Prof. Rajendra Singh (Rajju Bhaiya) University Naini, Prayagraj during Rabi season 2025-26. The maximum temperature of the location ranges between 46°C - 48°C and minimum falls below 40°C-50°C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100 mm annually. Soil samples were taken from 0-15 and 15-30 cm soil depth randomly prior to tillage operations, air dried and passed through 2mm sieve. Then the composite soil sample was taken for mechanical and chemical analysis. Bouyoucos Hydrometer method (1927)^[5] was used for the mechanical analysis of soil to determine sand, silt and clay fraction in the sample. The experiment was laid out in a Randomized Block Design with nine treatments replicated thrice. T₁(Control), T₂(FYM @ 2.5 t ha⁻¹), T₃(FYM @ 5 t ha⁻¹), T₄(VC @ 1 t ha⁻¹), T₅(VC @ 2 t ha⁻¹), T₆(50 % NPK), T₇(100 % NPK), T₈(FYM @ 2.5 t ha⁻¹ VC @ 1 t ha⁻¹ + 50 % NPK), T₉(FYM @ 5 t ha⁻¹ VC @ 2 t ha⁻¹ 100 % NPK). Bulk density, Particle density, Pore space and Water holding capacity analyzed by measuring cylinder method given by Muthuvel *et al.*, 1992^[11], Soil pH analyzed by Digital pH meter given by M. L. Jackson, 1958. Electrical conductivity analyzed by Digital conductivity meter given by Wilcox, 1950^[20], Organic carbon analyzed by Wet oxidation method given by Walkley and Black, 1947, Available Nitrogen analyzed by Modified alkaline permanganate oxidation method given by Subbiah and Asija, 1956, Available Phosphorus Analyzed by Olsen’s extraction followed by Spectrophotometric method given by Olsen *et al.*, 1954^[12], Available Potassium analyzed by Neutral normal ammonium acetate extraction followed by Flame photometric method given by Toth and Prince, 1949^[19].

Result and Discussion: Bulk density (Mg m-3)

The data depicted in table 1 and fig. 1 shows the Bulk density (Mg

m-3) of soil influenced by organic and inorganic fertilizers. The maximum Bulk density of soil was recorded 1.37 Mg m-3 at 0-15 cm and 1.33 Mg m-3 at 15-30 cm in treatment T₇ (NPK @ 100%) followed by 1.34 Mg m-3 at 0-15 cm and 1.31 Mg m-3 at 15-30 cm in treatment T₆ (NPK @ 50%) and minimum Bulk density of soil was recorded 1.22 Mg m-3 at 0-15 cm and 1.20 Mg m-3 at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) respectively.

The mean value of Bulk density of soil (Mg m-3) was found non-significant. Organic amendments add fine, low-density organic particles and stimulate root and microbial activity, which loosens compacted soil aggregates and increases macropore formation - lowering overall soil mass per unit volume. Inorganic fertilizers alone, lacking this aggregating organic matter, leave the soil comparatively denser. Similar result has been recorded by (Agegnehu *et al.*, 2017)^[1].

Particle density (Mg m-3)

The data depicted in table 1 and fig. 1 shows the particle density (Mg m-3) of soil influenced by organic and inorganic fertilizers. The maximum particle density of soil was recorded 2.57 Mg m-3 at 0-15 cm and 2.58 Mg m-3 at 15-30 cm in treatment T₇ (NPK @ 100 %) followed by 2.55 Mg m-3 at 0-15 cm and 2.56 Mg m-3 at 15-30 cm in treatment T₁ (Control) and minimum particle density of soil was recorded 2.51 Mg m-3 at 0-15 cm and 2.52 Mg m-3 at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) respectively.

The mean value of particle density of soil (Mg m-3) was found non-significant.

Because Fertilizer type doesn’t alter the mineralogy of sand, silt, and clay particles, so treatments had negligible effect. Similar result has been recorded by (Khan *et al.* 2017)^[9]

Pore space (%):

The data depicted in table 1 and fig. 1 shows the Pore space (%) of soil influenced by organic and inorganic fertilizers. The response of pore space of soil was found significant. The maximum pore space of soil was recorded 47.3 % at 0-15 cm and 43.7 % at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) followed by 44.8 % at 0-15 cm and 42.7 % at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum pore space of soil was recorded 40.3 % at 0-15 cm and 38.6 % at 15-30 cm in treatment T₁ (Control) respectively.

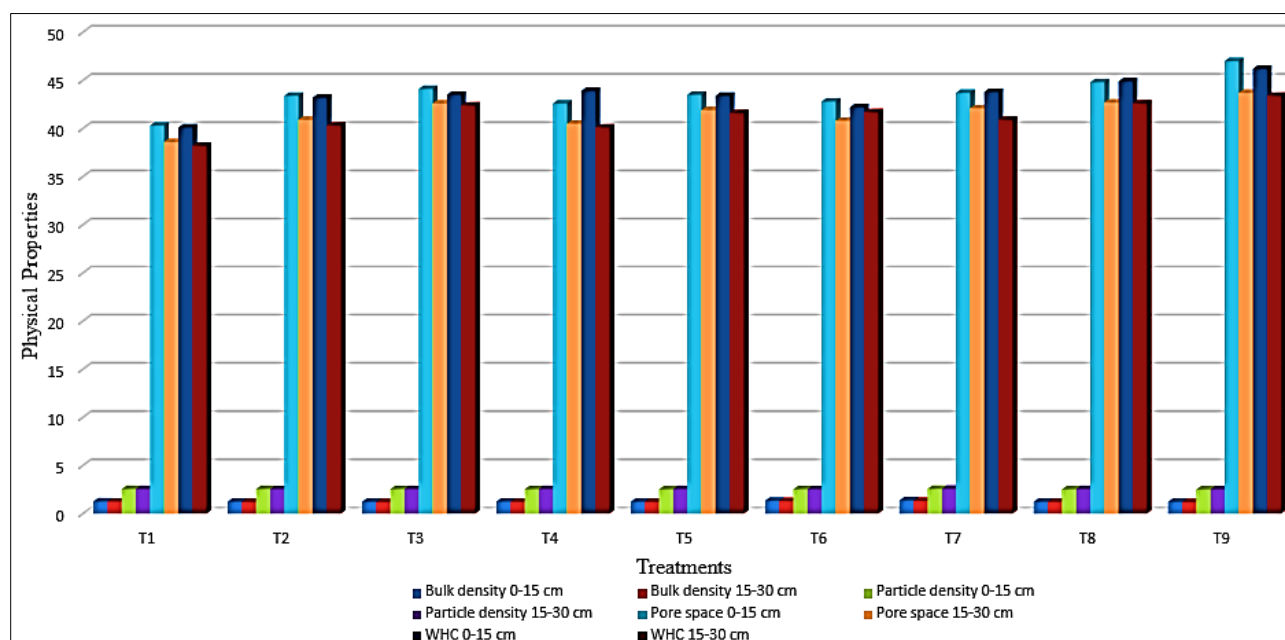
Parthasarathi *et al.*, 2008^[13] showed in his experiment that use of vermicompost with the combination of NPK significantly increases the pore space and other physical property. Water holding capacity (%):

The data depicted in table 1 and fig. 1 shows the water holding capacity (%) of soil influenced by organic and inorganic fertilizers. The maximum water holding capacity of soil was recorded 46.5 % at 0-15 cm and 43.4 % at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) followed by 44.9 % at 0-15 cm and 42.6 % at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum water holding capacity of soil was recorded 40.1 % at 0-15 cm and 38.2 % at 15-30 cm in treatment T₁ (NPK @ 100%) respectively.

The mean value of water holding capacity (%) of soil was found significant. Since pore space and water retention are structurally linked, increased porosity directly translates into greater capacity to hold water. Similar result has been recorded by (Rani *et al.*, 2017)^[15].

Table 1: Effect of organic and inorganic fertilizers on Bulk density (Mg m⁻³), Particle density (Mg m⁻³), Pore space (%) and Water holding capacity (%) of soil.

Treatments		Bulk density (Mg m ⁻³)		Particle density (Mg m ⁻³)		Pore space (%)		Water holding capacity (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control	1.27	1.26	2.55	2.56	40.3	38.6	40.1	38.2
T ₂	FYM @ 50 %	1.24	1.22	2.55	2.54	43.4	40.9	43.2	40.3
T ₃	FYM @ 100 %	1.23	1.21	2.54	2.55	44.1	42.6	43.5	42.4
T ₄	VC @ 50 %	1.25	1.23	2.53	2.56	42.6	40.5	43.9	40.1
T ₅	VC @ 100 %	1.23	1.22	2.52	2.56	43.5	41.9	43.4	41.6
T ₆	NPK @ 50 %	1.34	1.31	2.53	2.53	42.8	40.8	42.2	41.7
T ₇	NPK @ 100 %	1.37	1.33	2.57	2.58	43.7	42.1	43.8	40.9
T ₈	NPK @ 50% + VC @ 50 % + FYM @ 50%	1.23	1.22	2.52	2.56	44.8	42.7	44.9	42.6
T ₉	NPK @ 100% + VC @ 100% + FYM @ 100%	1.22	1.20	2.51	2.52	47.3	43.7	46.5	43.4
F-Test		NS	NS	NS	NS	S	S	S	S
S. Ed. (±)		-	-	-	-	0.834	0.973	0.011	0.012
C.D. at 5%		-	-	-	-	1.776	2.071	0.023	0.027

**Fig 1:** Effect of organic and inorganic fertilizers on Bulk density (Mg m⁻³), Particle density (Mg m⁻³), Pore space (%) and Water holding capacity (%) of soil.**Soil pH (1:2.5) w/v**

The data depicted in table 2 and fig. 2 shows the pH of soil as influenced by organic and inorganic fertilizers. The maximum pH of soil was recorded 7.47 at 0-15 cm and 7.55 at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100 %) followed 7.4 at 0-15 cm and 7.39 at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum pH of soil was recorded 6.7 at 0-15 cm and 6.75 at 15-30 cm in treatment T₁ (NPK @ 100%) respectively.

The mean value of pH of soil was found non-significant. Organic matter decomposition releases organic acids and various basic cations (Ca²⁺, Mg²⁺, K⁺) that buffer soil acidity, while also improving the soil's cation exchange and buffering capacity - nudging pH toward neutral. Similar result has been recorded by (Yadav *et al.*, 2019) [21].

Soil EC (dSm-1)

The data depicted in table 2 and fig. 2 shows the soil EC of soil as influenced by organic and inorganic fertilizers. The maximum EC of soil was recorded 0.46 dSm-1 at 0-15 cm and 0.43 dSm-1 at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM

@ 100%) followed by 0.44 dSm-1 at 0-15 cm and 0.412 dSm-1 at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum EC of soil was recorded 0.26 dSm-1 at 0-15 cm and 0.23 dSm-1 at 15-30 cm in treatment T₁ (Control) respectively.

The mean value of EC (dSm-1) of soil was found non-significant. EC increased with higher doses of NPK, VC, and FYM because decomposition of organic matter releases soluble salts and ions into the soil solution, and mineral fertilizers directly add soluble salt ions - both raising conductivity. Similar result has been recorded by (Bharti *et al.*, 2016) [3].

Organic carbon (%)

The data depicted in table 2 and fig. 2 shows the organic carbon of soil as influenced by organic and inorganic fertilizers. The maximum organic carbon of soil was recorded 0.44 % at 0-15 cm and 0.43 % at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) followed by 0.42 % at 0-15 cm and 0.41 % at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum organic carbon of soil was recorded 0.32% at 0-15 cm and 0.31 % at 15-30 cm in treatment T₁

(Control) respectively.

The mean value of organic carbon (%) of soil was found significant since these materials are themselves carbon-rich; their

decomposition directly adds humus and organic carbon to the soil, unlike inorganic fertilizer which supplies no carbon. Similar result has been recorded by (Bhattacharyya *et al.*, 2008) [4].

Table 2: Effect of organic and inorganic fertilizers on pH, EC (dSm-1), and Organic carbon (%) of soil.

		pH		EC (dSm-1)		Organic carbon (%)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control	7.21	7.30	0.26	0.23	0.32	0.31
T ₂	FYM @ 50 %	7.33	7.35	0.33	0.40	0.36	0.35
T ₃	FYM @ 100 %	7.34	7.38	0.37	0.33	0.41	0.39
T ₄	VC @ 50 %	7.25	7.33	0.43	0.41	0.37	0.36
T ₅	VC @ 100 %	7.28	7.34	0.42	0.38	0.39	0.37
T ₆	NPK @ 50 %	6.9	6.79	0.33	0.32	0.35	0.34
T ₇	NPK @ 100 %	6.7	6.75	0.34	0.32	0.34	0.33
T ₈	NPK @ 50% + VC @ 50 % + FYM @ 50%	7.4	7.39	0.44	0.412	0.42	0.41
T ₉	NPK @ 100% + VC @ 100% + FYM @ 100%	7.47	7.55	0.46	0.43	0.44	0.43
	F-Test	NS	NS	NS	NS	S	S
	S.Ed. (±)	-	-	-	-	0.027	0.019
	C.D. at 5%	-	-	-	-	0.058	0.042

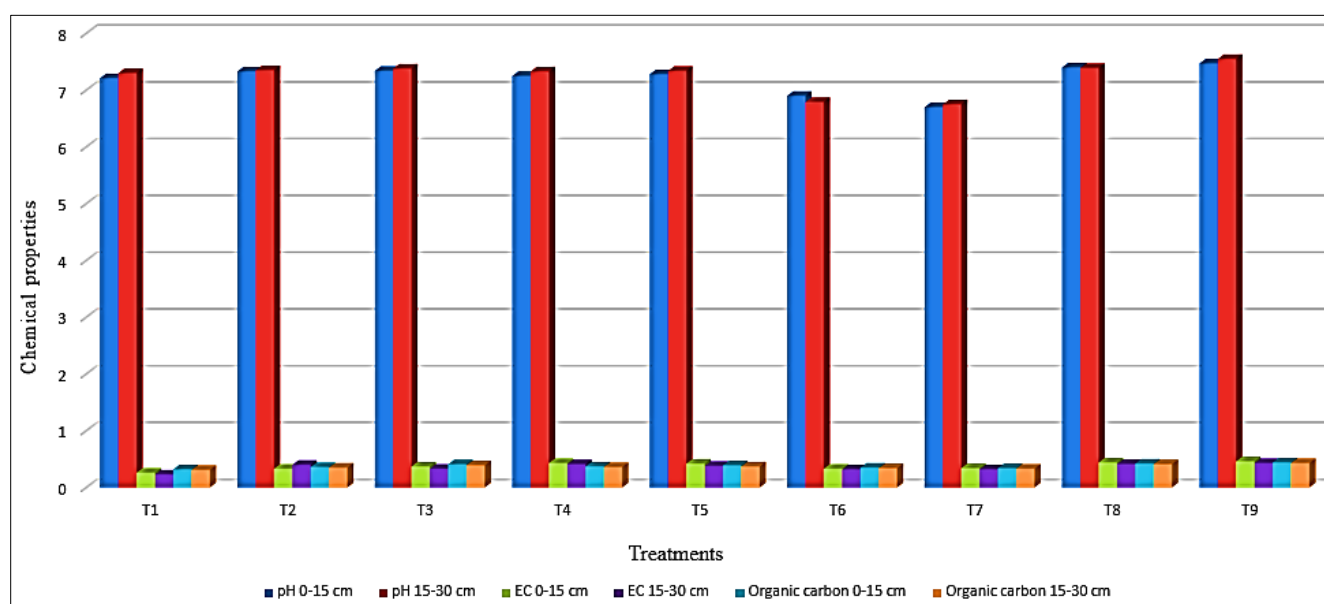


Fig 2: Effect of organic and inorganic fertilizers on pH, EC (dSm⁻¹), and Organic carbon (%) of soil.

Available nitrogen (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available nitrogen (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available nitrogen of soil was recorded 321.6 kg ha⁻¹ at 0-15 cm and 311.6 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) followed by 318.01 kg ha⁻¹ at 0-15 cm and 307.01 kg ha⁻¹ at 15-30 cm in treatment T₇ (NPK @ 100%) and minimum available nitrogen of soil was recorded 281.3 kg ha⁻¹ at 0-15 cm and 279.3 kg ha⁻¹ at 15-30 cm in treatment T₁ (Control) respectively.

The mean value of available nitrogen (kg ha⁻¹) of soil was found significant. Organic fertilizers and chemical fertilizers release nitrogen into the field and lentil also fixes environmental nitrogen in field that results a good amount of available nitrogen. Similar result has been recorded by (Zhang *et al.*, 2012) [23].

Available phosphorus (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available phosphorus (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available phosphorus of soil was recorded 24.43 kg ha⁻¹ at 0-15 cm and 24.16 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @

100%) followed by 23.82 kg ha⁻¹ at 0-15 cm and 23.64 kg ha⁻¹ at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum available phosphorus of soil was recorded 16.51 kg ha⁻¹ at 0-15 cm and 14.74 kg ha⁻¹ at 15-30 cm in treatment T₁ (Control) respectively.

The mean value of available phosphorus (kg ha⁻¹) of soil was found significant. This synergy (NPK + VC and FYM) releases adequate amount of phosphorus into the soil that's why the integrated treatment consistently outperformed either input used alone. Similar result has been recorded by (Bera *et al.*, 2016) [2].

Available potassium (kg ha⁻¹)

The data depicted in table 3 and fig. 3 clearly shows the available potassium (kg ha⁻¹) of soil as influenced by organic and inorganic fertilizers. The maximum available potassium of soil was recorded 214.5 kg ha⁻¹ at 0-15 cm and 212.4 kg ha⁻¹ at 15-30 cm in treatment T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) followed by 209.3 kg ha⁻¹ at 0-15 cm and 206.6 kg ha⁻¹ at 15-30 cm in treatment T₈ (NPK @ 50% + VC @ 50 % + FYM @ 50%) and minimum available potassium of soil was recorded 175.7 kg ha⁻¹ at 0-15 cm and 165.1 kg ha⁻¹ at 15-30 cm in treatment T₁ (Control) respectively.

The mean value of available potassium (kg ha⁻¹) of soil found significant. Organic manures mineralize slowly, releasing nutrients gradually while also improving microbial activity that

enhances nutrient cycling - complementing the readily available nutrients from inorganic NPK. Similar result has been recorded by (Zorb *et al.*, 2014)^[22].

Table 3: Effect of organic and inorganic fertilizers on Available nitrogen (kg ha⁻¹), Available phosphorus (kg ha⁻¹), and Available potassium (kg ha⁻¹) of soil.

Treatments		Available nitrogen (kg ha ⁻¹)		Available phosphorus (kg ha ⁻¹)		Available potassium (kg ha ⁻¹)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁	Control	281.3	279.3	16.51	14.7433	175.7	165.1
T ₂	FYM @ 50 %	284.6	280.9	18.30	16.1833	179.1	166.7
T ₃	FYM @ 100 %	289.5	283.8	20.78	19.9733	182.6	169.3
T ₄	VC @ 50 %	287.9	281.2	19.26	16.4767	180.4	169.07
T ₅	VC @ 100 %	292.0	285.3	21.64	18.7533	184.4	173.1
T ₆	NPK @ 50 %	308.6	296.6	22.48	21.23	197.9	186.6
T ₇	NPK @ 100 %	318.01	307.01	22.96	22.18	207.3	205.7
T ₈	NPK @ 50% + VC @ 50 % + FYM @ 50%	309.5	305.9	23.82	23.64	209.3	206.6
T ₉	NPK @ 100% + VC @ 100% + FYM @ 100%	321.6	311.6	24.43	24.1633	214.5	212.4
F-Test		S	S	S	S	S	S
S.Ed. (±)		5.951	5.805	0.589	1.291	2.646	2.984
C.D. at 5%		12.66	12.35	1.254	2.748	5.632	6.352

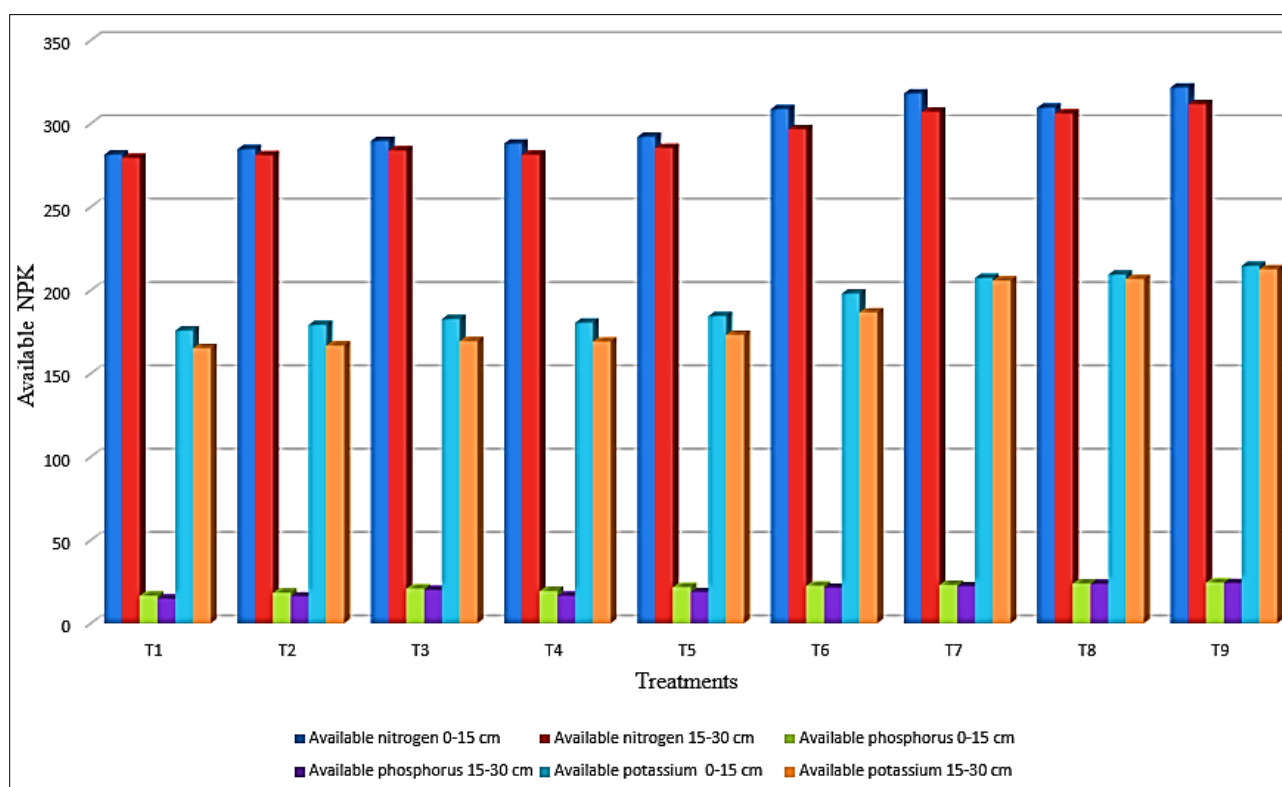


Fig 3: Effect of Organic and inorganic fertilizers on Available nitrogen (kg ha⁻¹), Available phosphorus (kg ha⁻¹), and Available potassium (kg ha⁻¹) of soil.

Conclusion

On the basis of experimental study, it was concluded that integrated use of NPK fertilizers in combination with vermicompost and FYM found better in respect to growth, yield and soil characters of Lentil crop. However, the treatment receiving chemical fertilizers with vermicompost and FYM T₉ (NPK @ 100% + VC @ 100% + FYM @ 100%) proved better in respect to, physical and chemical health of Lentil. The integrated use of chemical fertilizers with FYM and vermicompost enhanced the soil fertility status in respect of Bulk density, Particle density, Pore space and Water holding capacity in the soil. The maximum improvement in soil health was noticed where FYM, vermicompost was applied with chemical fertilizers. Therefore,

the T₉ treatment proved better for production of Lentil crop and may be recommended to the farmers for better production and sustainable agriculture.

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