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Influence of NPK, vermicompost and poultry manure on physico-chemical properties of soil and yield of radish (*Raphanus sativus* L. var MOJAR 310)

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Abstract
A field experiment was conducted on" Influence of NPK, Vermicompost and Poultry Manure on Physio-Chemical Properties of Soil and Yield of Radish (*Raphanus sativus* L.) var MAJOR 310" at research farm of Department of soil science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, The experiment was laid out in factorial randomized block design with three levels of NPK fertilizer (0%, 50%, 100%), three levels of vermicompost (0%, 50%, 100%) and three levels of poultry manure (0%, 50%, 100%) . The results shows that maximum bulk density 2.49 Mg m^{-3} at 0-15 cm and 2.54 Mg m^{-3} at 15-30 cm, particle density 47.49 Mg m^{-3} at 0-15 cm and 46.59 Mg m^{-3} at 15-30 cm , water holding capacity 47.83 (%) at 0-15 cm and 46.16 (%) at 15-30 cm , pore space 46.50 (%) at 0-15 cm and 45.49 (%) at 15-30 cm, soil pH 7.25 at 0-15 cm and 7.27 pH at 15-30 cm, EC 0.29 dsm^{-1} at 0-15 cm and 0.27 dsm^{-1} at 15-30 cm, Application of NPK , vermicompost and poultry manure increase growth , enhance radish yield and improved physical and chemical properties of soil.

Keywords: Nitrogen, poultry manure, radish, vermicompost, yield attributes

Introduction

Soil is a natural resource that plays a critical role in supporting life on Earth and is a complex mixture of minerals, organic matter, water, air and a diverse array of microorganisms (Brady and Weil, 2016) [5]. It is the product of biochemical weathering of the parent materials. The formation of soil is influenced by factors like climate, organisms, parent materials, source and time (Belwal and Mehta, 2014) [4]. It is also considered as a non-renewable dynamic resource, comprising of unconsolidated minerals and organic matter including water and air within the uppermost layers of the earth's surface, and plays a crucial role in maintaining the terrestrial ecosystem on which life depends (Andrew *et al*., 2020) [1]. Radish (*Raphanus sativus* L.) is a member of the Brassicaceae family is native to Europe or Asia. It is a most popular root crop grown all over the world. It is grown for its young fleshy tuberous roots which are eaten raw or as a salad or cooked. Radish is a cool season crop and broadly divided into two groups: European or temperate and Asiatic or tropical. The Asiatic varieties although are higher yielders yet poor in quality attributes, whereas, European varieties are small in size, early in maturity and rich in quality parameters (Tripathi *et al.,* 2017) [20]. The radish leaves are rich in minerals and vitamin A (5IU) and vitamin C (14.8 mg per 100 g of edible portion. It supplies a variety of minerals like calcium, potassium, and phosphorus. It has high medicinal value and is prescribed for patients suffering from piles, liver troubles and jaundice (Brar *et al.,* 1972) [6]. Poultry manure has a high amount of nitrogen, phosphorus, and potassium than manure of other animals (Duncan, 2005). Poultry manure also helps to improve the water holding capacity, aeration and fertility status of soil (Khatri *et al.,* 2019) [7-8]. Organic agriculture practices rely upon recycling of crop residues, animal manure, farm organic residues and wastes etc. In view of higher cost of synthetic fertilizers and its contribution to poor health of soil and water it becomes imperative to go for alternative and cheaper source like organic manures (Kumar *et al.,* 2014) [21]. Applying vermicompost increased soil nitrogen and potassium levels by 33%, 40%, and 67%, respectively.

Intensive farming and imbalanced nutrient addition have led to soil shortage in critical nutrients. To boost production, balanced plant nutrition is crucial, and using organic sources of nutrition can be beneficial (Todawat *et al.,* 2017) [14].

Materials and Methods

The hottest temperature at the location occasionally descends below 40 °C or 50 °C and can reach 46 °C to 48 °C. The relative humidity ranged from 20-94%. On average, this region receives approximately 1100.00 mm of precipitation each year. The experimental site is 98 meters above sea level, at 25^0 57'N latitude and 81^0 59'E longitude. The experimental region's soil is classed as Inceptisol, with a sandy loam texture (sand content: 61.34%; silt content: 25.06%; clay content: 13.60%). The experiment was carried out using a factorial randomized block design (FRBD), with twenty-seven treatments and three dosages of NPK (0, 50, and 100%), Vermicopmost (0, 50, and 100%), Poultry manure (0,50 and 100). Three replications of the treatment were conducted. There were 81 plots in all. During the Rabi season, Radish is sown in 2 × 2 m patches spaced 30 x 10 cm apart. Soil samples were collected from each plot before and after the experiment at depths ranging from 0-15 to 15-30 cm using a soil auger. The soil samples were air-dried, passed through a 2 mm screen, and their various soil properties were analysed. Bulk density, Particle density, Pore space and Water holding capacity. M.L. Jackson tested soil pH using a pH meter, and Wilcox measured electrical conductivity (EC) with a conductivity meter.

Bulk density

The effect of NPK on bulk density of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 1.24 and 1.26 Mg m^{-3} was found 100% NPK and Maximum 1.28 and 1.30 Mg m-3 was recorded in 0%NPK.The effect of vermicompost on bulk density of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 1.24 and 1.26 Mg m-3 was found 100% vermicompost and Maximum 1.28 and 1.29 Mg m^{-3} was recorded in 0% vermicompost. Similarly, the effect of poultry manure on bulk density of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 1.24 and 1.26 Mg m-3 was found 100% poultry manure and Maximum 1.28 and 1.29 Mg m^{-3} was recorded in 0% poultry manure. The combination effect of NPK and Vermicompost, Vermicompost and poultry manure, NPK and poultry manure on bulk density Mg m-3 Soil was found non-significant the interaction effect of NPK, Vermicompost and Poultry Manure on bulk density of at 0-15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. It was observed the bulk density of soil was gradually decrease with an increase in dose of different levels of NPK, Vermicompost and Poultry Manure. Vermicompost and poultry manure is also had positive effects on soil physical characteristics, increased aggregate stability and decreased bulk density of the soils. Similar result has been recorded by Bajshya *et al.,* 2013; and Gangwar *et al.,* 2009 [3].

Table 1: Influence of NPK, vermicompost and poultry manure on bulk density of at 0-15 and 15-30 cm depth after crop harvest.

Influence of NPK	Bulk density (Mg m-3)		Influence of Vermicompost	Bulk density (Mg m-3)		Influence of Poultry manures	Bulk density (Mg m-3)	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0.0%	1.28	1.3	Vermicompost 0%	1.28	1.29	Poultry manure 0%	1.27	1.29
NPK 50%	1.25	1.27	Vermicompost 50%	1.24	1.27	Poultry manure 50%	1.25	1.27
NPM 100%	1.24	1.26	Vermicompost 100%	1.24	1.26	Poultry manure100%	1.24	1.26
F-Test	S	S	F-Test	S	S	F-Test	S	S
S. Ed. (±)	0.009	0.008	S. Ed. (±)	0.009	0.008	S. Ed. (±)	0.009	0.008
C.D@ 5%	0.018	0.015	C.D@ 5%	0.018	0.015	CD @5%	0.018	0.015

Table 2: Influence of NPK, Vermicompost and poultry manure on bulk density of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction (NPK + VC)	Bulk density (Mg m-3)		Influence of Interaction (VC + PM)	Bulk density (Mg m-3)		Influence of Interaction (NPK + PM)	Bulk density (Mg m-3)	
	0-15 cm	15.30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	1.29	1.31	VC 0% + PM 0%	1.29	1.31	NPK0.0% + PM0%	1.30	1.31
NPK0.0% + VC 50%	1.27	1.29	VC 0% + PM50%	1.28	1.30	NPK0.0% + PM50%	1.27	1.29
NPK0.0% + VC 100%	1.27	1.29	VC 0% + PM100%	1.26	1.28	NPK0.0% + PM100%	1.26	1.28
NPK 50% + VC 0%	1.27	1.29	VC 50% + PM0%	1.27	1.29	NPK 50% + PM 0%	1.26	1.28
NPK 50% + VC 50%	1.25	1.27	VC 50% + PM50%	1.24	1.27	NPK 50% + PM 50%	1.24	1.26
NPK 50% + VC 100%	1.22	1.28	VC 50% + PM100%	1.23	1.26	NPK 50% + PM 100%	1.24	1.26
NPK 100% + VC 0%	1.27	1.25	VC 100% + PM 0%	1.25	1.27	NPK 100% + PM 0%	1.26	1.28
NPK 100% + VC 50%	1.23	1.25	VC 100% + PM50%	1.24	1.26	NPK 100% + PM 50%	1.24	1.26
NPK 100% + VC 100%	1.23	1.25	VC 100% + PM100%	1.23	1.25	NPK 100% + PM100%	1.23	1.25
F-Test	NS	NS	F-Test	NS	NS	F-Test	NS	NS
S. Ed. (±)			S. Ed. (±)			S. Ed. (±)		
C.D@ 5%			C.D@ 5%			C.D@ 5%		

Table 3: Influence of NPK, Vermicompost and poultry manure on bulk density of at 0- 15 and 15-30 cm depth after crop harvest.

Treatment Combination		Bulk density (Mg m-3)	
Influence of Interaction NPK + VC + PM		0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	1.31	1.33
T_2	NPK0% + VC 0% + PM50%	1.3	1.31
T_3	NPK0% + VC 0% + PM100%	1.28	1.3
T_4	NPK0% + VC 50% + PM0%	1.3	1.32
T_5	NPK0% + VC 50% + PM50%	1.27	1.29
T_6	NPK0% + VC 50% + PM50%	1.26	1.28
T_7	NPK0% + VC 100% + PM0%	1.29	1.31
T_8	NPK0% + VC 100% + PM50%	1.27	1.29
T_9	NPK0% + VC 100% + PM100%	1.26	1.28
T_{10}	NPK 50% + VC 0% + PM0%	1.29	1.31
T_{11}	NPK 50% + VC 05 + PM50%	1.28	1.3
T_{12}	NPK 50% + VC 0% + PM100%	1.26	1.28
T_{13}	NPK 50% + VC 50% + PM0%	1.29	1.31
T_{14}	NPK 50% + VC 50% + PM50%	1.24	1.26
T_{15}	NPK 50% + VC 50% + PM100%	1.23	1.25
T_{16}	NPK 50% + VC 100% + PM0%	1.22	1.24
T_{17}	NPK 50% + VC 100% + PM50%	1.22	1.24
T_{18}	NPK 50% + VC 100% + PM100%	1.24	1.26
T_{19}	NPK 100% + VC 0% + PM0%	1.28	1.3
T_{20}	NPK 100% + VC 0% + PM50%	1.27	1.29
T_{21}	NPK 100% + VC 0% + PM100%	1.26	1.28
T_{22}	NPK 100% + VC 50% + PM0%	1.25	1.27
T_{23}	NPK 100% + VC 50% + PM50%	1.23	1.26
T_{24}	NPK 100% + VC 50% + PM100%	1.23	1.25
T_{25}	NPK 100% + VC 100% + PM0%	1.26	1.28
T_{26}	NPK 100% + VC 100% + PM50%	1.23	1.25
T_{27}	NPK 100% + VC 100% + PM100%	1.21	1.23
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		

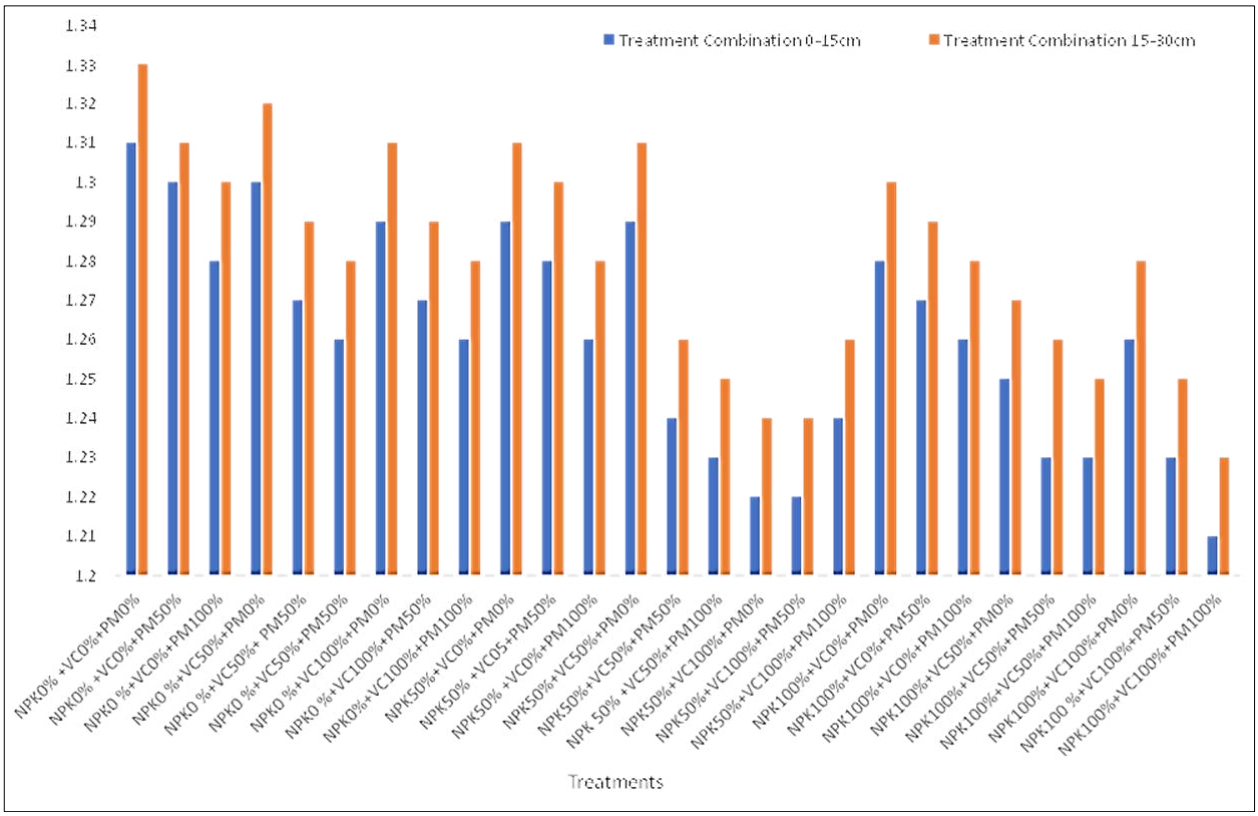


Fig 1: Influence of NPK, Vermicompost and poultry manure on bulk density of at 0-15 and 15-30 cm depth after crop harvest

Particle density (Mg m^{-3})

The effect of NPK on Particle density of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. The effect of vermicompost on bulk density of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minimum 2.53 and 2.53 Mg m-3 was found 100% vermicompost and Maximum 2.56 and 2.57 Mg m^{-3} was recorded in 0% vermicompost. Similarly, the effect of poultry manure on bulk density of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. The combination effect of NPK and Vermicompost, Vermicompost and poultry manure, NPK and poultry manure on Particle density Mg m^{-3} Soil was found non-significant the interaction effect of NPK, Vermicompost and Poultry Manure on Particle density of at 0- 15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. It was observed the particle density of soil was gradually increased with an increase in dose of different levels of NPK, Vermicompost and poultry manure. Vermicompost and poultry manure stimulates to influence the microbial activity of soil, increases the availability of oxygen, maintains normal soil temperature, increases soil porosity and infiltration of water, improves nutrient content. Similar result has been recorded by Bajshya *et al.,* 2013; and Gangwar *et al.,* 2009 [3].

Pore space (%)

The effect of NPK on Pore space of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. The effect of vermicompost on pore space of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 41.35 and 40.91 (%) was found 0% vermicompost and Maximum 45.06 and 43.94% was recorded in 100% vermicompost.

Similarly, the effect of poultry manure on Pore space of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 41.45 and 41.15 (%) was found 0% vermicompost and Maximum 45.59 and 44.29% was recorded in 100% vermicompost. The combination effect of NPK and Vermicompost on Pore space of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. The combination effect of NPK and Vermicompost on pore space of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. Similarly, the effect of Vermicompost and poultry manure on Pore space of soil at 0-15 and 15- 30 cm depth was found significant after crop harvest. The 40.32 and 40.19 (%) was found 0% vermicompost and Maximum 44.93 and 45.75% was recorded in 100% vermicompost the interaction effect of NPK Vermicompost and Poultry Manure on Particle density of at 0- 15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. The maximum pore space of soil for Influence of NPK + VC + PM was recorded 47.493 and 46.591 at 0-15 and 15-30 cm depth and the minimum value was 39.897 and 40.100 at 0-15 cm and 15-30 cm depth respectively. The presence of vermicompost and poultry manure in soil may act as a soil conditioner by supplying nutrients to plants, lowering C to N ratio, improving the soil texture, increasing soil porosity and water holding capacity, thereby requiring less tillage and irrigation. It was also observed the pore space of soil was gradually increased with an increase in dose of different levels of NPK, Vermicompost Poultry manure. Similar result has been recorded by Khatri *et al*., 2019 and Lakra *et al*., 2017. [7, 8, 9].

Table 4: Influence of NPK, Vermicompost and poultry manure on particle density of at 0-15 and 15-30 cm depth after crop harvest.

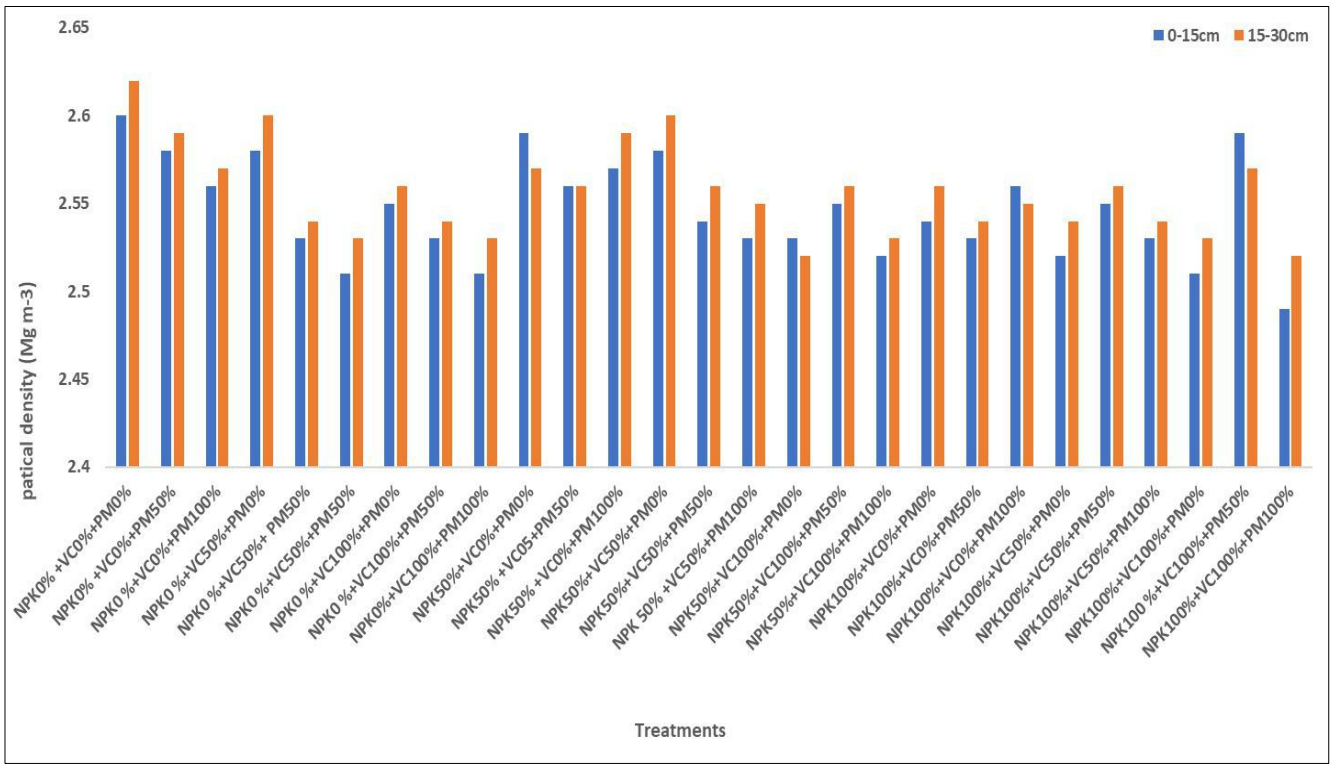
Influence of NPK	Particle density (Mg m-3)		Influence of Vermicompost	Particle density (Mg m^{-3})		Influence of Poultry manures	Particle density (Mg m-3)	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0.00%	2.55	2.56	Vermicompost 0%	2.56	2.57	Poultry manure 0%	2.56	2.57
NPK 50%	2.55	2.55	Vermicompost 50%	2.54	2.55	Poultry manure 50%	2.56	2.55
NPK 100%	2.54	2.54	Vermicompost 100%	2.53	2.53	Poultry manure 100%	2.53	2.53
F-Test	NS	NS	F-Test	S	S	F-Test	S	S
S. Ed. (±)			S. Ed. (±)	0.011	0.011	S. Ed. (±)	0.011	0.011
C.D@ 5%			C.D@ 5%	0.022	0.022	CD @5%	0.022	0.022

Table 5: Influence of NPK, Vermicompost and poultry manure on particle density of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction (NPK + VC)	Particle density (Mg m-3)		Influence of Interaction (VC + PM)	Particle density (Mg m-3)		Influence of Interaction (NPK + PM)	Particle density (Mg m-3)	
	0-15 cm	15.30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	2.57	2.59	VC 0% + PM 0%	2.58	2.59	NPK0.0% + PM0%	2.57	2.58
NPK0.0% + VC 50%	2.54	2.55	VC 0% + PM50%	2.54	2.55	NPK0.0% + PM50%	2.55	2.56
NPK0.0% + VC 100%	2.52	2.54	VC 0% + PM100%	2.53	2.54	NPK0.0% + PM100%	2.56	2.56
NPK 50% + VC 0%	2.56	2.56	VC 50% + PM0%	2.57	2.57	NPK 50% + PM 0%	2.56	2.57
NPK 50% + VC 50%	2.55	2.55	VC 50% + PM50%	2.55	2.56	NPK 50% + PM 50%	2.54	2.55
NPK 50% + VC 100%	2.53	2.55	VC 50% + PM100%	2.53	2.57	NPK 50% + PM 100%	2.52	2.54
NPK 100% + VC 0%	2.52	2.55	VC 100% + PM 0%	2.4	2.55	NPK 100% + PM 0%	2.53	2.53
NPK 100% + VC 50%	2.55	2.55	VC 100% + PM50%	2.53	2.54	NPK 100% + PM 50%	2.55	2.55
NPK 100% + VC 100%	2.52	2.53	VC 100% + PM100%	2.52	2.53	NPK 100% + PM100%	2.5	2.52
F-Test	NS	NS	F-Test	NS	NS	F-Test	NS	NS
S. Ed. (±)			S. Ed. (±)			S. Ed. (±)		
C.D@ 5%			C.D @ 5%			C.D@ 5%		

Table 6: Influence of NPK, vermicompost and poultry manure on particle density of at 0-15 and 15-30 cm depth after crop harvest,

Treatment Combination		Particle density (Mg m^{-3})	
Influence of Interaction NPK + VC + PM		0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	2.6	2.62
T_2	NPK0% + VC 0% + PM50%	2.58	2.59
T_3	NPK0% + VC 0% + PM100%	2.56	2.57
T_4	NPK0% + VC 50% + PM0%	2.58	2.6
T_5	NPK0% + VC 50% + PM50%	2.53	2.54
T_6	NPK0% + VC 50% + PM50%	2.51	2.53
T_7	NPK0% + VC 100% + PM0%	2.55	2.56
T_8	NPK0% + VC 100% + PM50%	2.53	2.54
T_9	NPK0% + VC 100% + PM100%	2.51	2.53
T_{10}	NPK 50% + VC 0% + PM0%	2.59	2.57
T_{11}	NPK 50% + VC 05 + PM50%	2.56	2.56
T_{12}	NPK 50% + VC 0% + PM100%	2.57	2.59
T_{13}	NPK 50% + VC 50% + PM0%	2.58	2.6
T_{14}	NPK 50% + VC 50% + PM50%	2.54	2.56
T_{15}	NPK 50% + VC 50% + PM100%	2.53	2.55
T_{16}	NPK 50% + VC 100% + PM0%	2.53	2.52
T_{17}	NPK 50% + VC 100% + PM50%	2.55	2.56
T_{18}	NPK 50% + VC 100% + PM100%	2.52	2.53
T_{19}	NPK 100% + VC 0% + PM0%	2.54	2.56
T_{20}	NPK 100% + VC 0% + PM50%	2.53	2.54
T_{21}	NPK 100% + VC 0% + PM100%	2.56	2.55
T_{22}	NPK 100% + VC 50% + PM0%	2.52	2.54
T_{23}	NPK 100% + VC 50% + PM50%	2.55	2.56
T_{24}	NPK 100% + VC 50% + PM100%	2.53	2.54
T_{25}	NPK 100% + VC 100% + PM0%	2.51	2.53
T_{26}	NPK 100% + VC 100% + PM50%	2.59	2.57
T_{27}	NPK 100% + VC 100% + PM100%	2.49	2.52
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		



Fig\ 2: Influence of NPK, vermicompost and poultry manure on particle density of at 0-15 and 15-30 cm depth after crop harvest

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Table 7: Influence of NPK, vermicompost and poultry manure on pore space (%) of at 0-15 and 15-30 cm depth after crop harvest.

Influence of NPK	Pore space (%)		Influence of Vermicompost	Pore space (%)		Influence of Poultry manures	Pore space (%)	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0.00%	43.14	42.38	Vermicompost 0%	41.35	40.91	Poultry manures 0%	41.45	41.15
NPK 50%	43.81	42.9	Vermicompost 50%	44.08	43.21	Poultry manures 50%	43.44	42.63
NPK 100%	43.54	42.79	Vermicompost 100%	45.06	43.94	Poultry manures 100%	45.59	44.29
F-Test	NS	NS	F-Test	S	S	F-Test	S	S
S. Ed. (±)			S. Ed. (±)	0.277	0.293	S. Ed. (±)	0.277	0.293
C.D@ 5%			C.D@ 5%	0.556	0.587	CD @5%	0.556	0.587

Table 8: Influence of NPK, vermicompost and poultry manure on pore space of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction (NPK + VC)	Pore space (%)		Influence of Interaction (VC + PM)	Pore space (%)		Influence of Interaction (NPK + PM)	Pore space (%)	
	0-15	15.30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	40.86	4063	VC 0% + PM 0%	40.86	40.63	NPK0.0% + PM0%	40.32	40.19
NPK0.0% + VC 50%	43.85	42.85	VC 0% + PM50%	43.12	42.85	NPK0.0% + PM50%	41.03	40.47
NPK0.0% + VC 100%	44.69	43.66	VC 0% + PM100%	45.42	43.66	NPK0.0% + PM100%	42.82	41.95
NPK 50% + VC 0%	41.6	41.18	VC 50% + PM0%	42.24	41.18	NPK 50% + PM 0%	41.26	40.91
NPK 50% + VC 50%	44.51	43.63	VC 50% + PM50%	43.39	43.63	NPK 50% + PM 50%	44.36	43.53
NPK 50% + VC 100%	45.31	43.88	VC 50% + PM100%	45.79	43.88	NPK 50% + PM 100%	46.6	45.19
NPK 100% + VC 0%	41.59	40.92	VC 100% + PM 0%	41.25	40.92	NPK 100% + PM 0%	42.9	42.21
NPK 100% + VC 50%	43.87	43.17	VC 100% + PM50%	43.82	43.17	NPK 100% + PM 50%	44.93	43.88
NPK 100% + VC 100%	45.17	44.29	VC 100% + PM100%	45.56	44.29	NPK 100% + PM100%	47.34	45.75
F-Test	NS	NS	F-Test	NS	NS	F-Test	S	S
S. Ed. (±)			S. Ed. (±)			S. Ed. (±)	4.8	4.8
C.D@ 5%			C.D@ 5%			C.D@ 5%	0.507	0.507

Table 9: Influence of NPK, vermicompost and poultry manure on pore space of at 0- 15 and 15-30 cm depth after crop harvest.

Treatment Combination		Pore space (%)	
	Influence of Interaction NPK + VC + PM	0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	39.9	40.1
T_2	NPK0% + VC 0% + PM50%	40.29	40.2
T_3	NPK0% + VC 0% + PM100%	42.41	41.59
T_4	NPK0% + VC 50% + PM0%	40.62	40.41
T_5	NPK0% + VC 50% + PM50%	44.46	43.54
T_6	NPK0% + VC 50% + PM50%	46.49	44.61
T_7	NPK0% + VC 100% + PM0%	42.08	41.5
T_8	NPK0% + VC 100% + PM50%	44.64	43.41
T_9	NPK0% + VC 100% + PM100%	47.38	46.09
T_{10}	NPK 50% + VC 0% + PM0%	40.11	40.43
T_{11}	NPK 50% + VC 05 + PM50%	41.33	40.5
T_{12}	NPK 50% + VC 0% + PM100%	43.38	42.63
T_{13}	NPK 50% + VC 50% + PM0%	42.57	41.92
T_{14}	NPK 50% + VC 50% + PM50%	44.13	43.47
T_{15}	NPK 50% + VC 50% + PM100%	46.84	45.5
T_{16}	NPK 50% + VC 100% + PM0%	44.06	43.46
T_{17}	NPK 50% + VC 100% + PM50%	44.71	43.61
T_{18}	NPK 50% + VC 100% + PM100%	47.17	44.57
T_{19}	NPK 100% + VC 0% + PM0%	40.59	40.44
T_{20}	NPK 100% + VC 0% + PM50%	41.49	40.72
T_{21}	NPK 100% + VC 0% + PM100%	42.69	41.62
T_{22}	NPK 100% + VC 50% + PM0%	40.6	40.43
T_{23}	NPK 100% + VC 50% + PM50%	44.52	43.6
T_{24}	NPK 100% + VC 50% + PM100%	46.5	45.49
T_{25}	NPK 100% + VC 100% + PM0%	42.57	41.68
T_{26}	NPK 100% + VC 100% + PM50%	45.46	44.62
T_{27}	NPK 100% + VC 100% + PM100%	47.49	46.59
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		

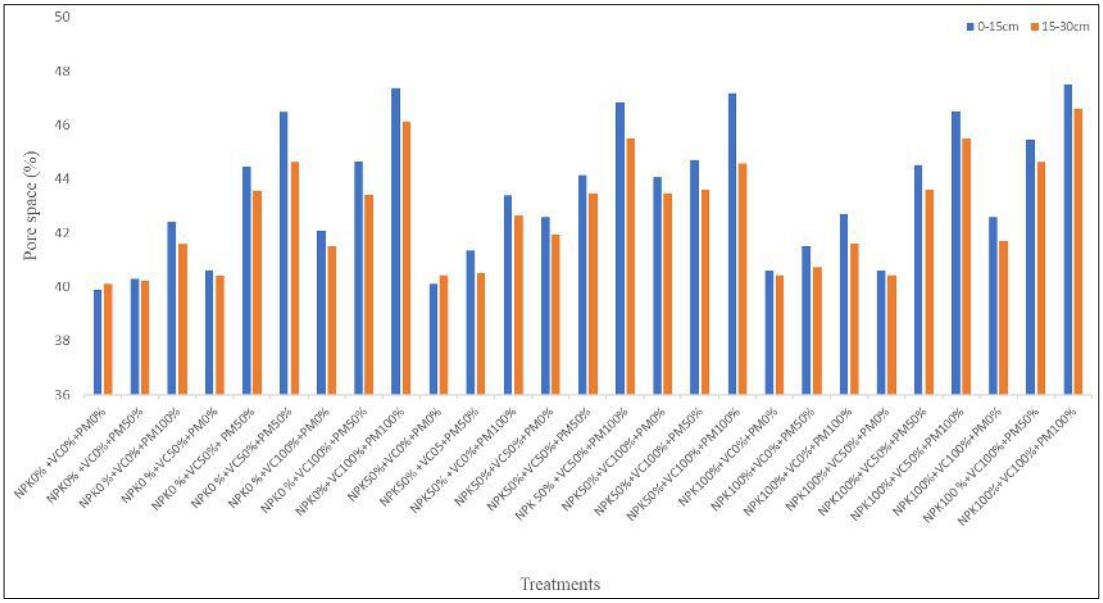

Fig 3: Influence of NPK, vermicompost and poultry manure on pore space of at 0-15 and 15-30 cm depth after crop harvest

Water Holding Capacity (%)

The effect of NPK on water holding capacity of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. The effect of vermicompost on water holding capacity of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 41.38 and 40.81 (%) was found 0% vermicompost and Maximum 43.87 and 40.00% was recorded in 100% vermicompost. Similarly, the effect of poultry manure on Pore water holding capacity of soil at 0-15 and 15- 30 cm depth was found significant after crop harvest. The Minium 41.33 and 40.93 (%) was found 0% vermicompost and Maximum 44.44 and 43.25% was recorded in 100% vermicompost. The combination effect of NPK and Vermicompost, Vermicompost and poultry manure, NPK and poultry manure on water holding capacity (%) Soil was found non-significant the interaction effect of NPK Vermicompost and Poultry Manure on Particle density of at 0- 15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. The addition of Vermicompost and poultry manure to the soil increases water-holding capacity and by maintaining evaporation losses to minimum as good adsorbent of atmospheric moisture eventually helps in maintaining the ecology of hydrologic cycle. It was observed the water holding capacity of soil was gradually increased with an increase in dose of NPK, Vermicompost poultry manure. Similar result has been recorded by Khatri *et al*., 2019 and Lakra *et al*., 2017 [7, 8, 9]

Table 10 Influence of NPK, vermicompost and poultry manure on water holding capacity of at 0-15 and 15-30 cm depth after crop harvest.

Influence of NPK	Water holding capacity (%)		Influence of Vermicompost	Water holding capacity (%)		Influence of Poultry manures	Water holding capacity (%)	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0.00%	42.2	41.42	Vermicompost 0%	41.38	40.81	Poultry manures 0%	41.33	4.93
NPK 50%	42.88	42.2	Vermicompost 50%	43.15	42.13	Poultry manures 50%	42.63	41.76
NPK 100%	43.31	42.32	Vermicompost 100%	43.87	43	Poultry manures 100%	44.44	43.25
F-Test	NS	NS	F-Test	S	S	F-Test	S	S
S. Ed. (±)			S. Ed. (±)	0.277	0.293	S. Ed. (±)	0.277	0.293
C.D@ 5%			C.D@ 5%	0.556	0.587	CD @5%	0.556	0.587

Table 11: Influence of NPK, vermicompost and poultry manure on water holding capacity of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction	Water holding capacity (%)		Influence of Interaction	Water holding capacity (%)		Influence of Interaction (NPK + PM)	Water holding capacity (%)	
(NPK + VC)	0-15 cm	15.30 cm	(VC + PM)	0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	40.72	40.33	VC 0% + PM 0%	40.73	40.63	NPK0.0% + PM0%	41.31	40.87
NPK0.0% + VC 50%	41.14	40.65	VC 0% + PM50%	42.24	42.85	NPK0.0% + PM50%	42.28	41.16
NPK0.0% + VC 100%	42.27	41.44	VC 0% + PM100%	43.64	43.66	NPK0.0% + PM100%	43.03	42.21
NPK 50% + VC 0%	41.36	41.02	VC 50% + PM0%	42.02	41.18	NPK 50% + PM 0%	41.38	4.92
NPK 50% + VC 50%	43.14	42.15	VC 50% + PM50%	42.28	43.63	NPK 50% + PM 50%	43.4	42.41
NPK 50% + VC 100%	44.94	43.21	VC 50% + PM100%	44.35	43.88	NPK 50% + PM 100%	43.87	43.27
NPK 100% + VC 0%	41.9	41.44	VC 100% + PM 0%	41.23	40.92	NPK 100% + PM 0%	41.45	40.93
NPK 100% + VC 50%	43.6	42.48	VC 100% + PM50%	43.37	43.17	NPK 100% + PM 50%	43.76	42.81
NPK 100% + VC 100%	46.12	45.08	VC 100% + PM100%	45.33	44.29	NPK 100% + PM100%	44.72	43.52
F-Test	NS	NS	F-Test	NS	NS	F-Test	NS	NS
S. Ed. (±)			S. Ed. (±)			S. Ed (±)		
C.D@ 5%			C.D@ 5%			C.D@ 5%		

Table 12: Influence of NPK, vermicompost and poultry manure on water holding capacity of at 0-15 and 15-30 cm depth after crop harvest.

Treatment Combination		Water holding capacity (%)	
Influence of Interaction NPK + VC + PM		0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	40.23	40.08
T_2	NPK0% + VC 0% + PM50%	41.29	40.81
T_3	NPK0% + VC 0% + PM100%	42.41	41.74
T_4	NPK0% + VC 50% + PM0%	40.9	40.37
T_5	NPK0% + VC 50% + PM50%	42.46	41.48
T_6	NPK0% + VC 50% + PM50%	43.49	41.65
T_7	NPK0% + VC 100% + PM0%	41.08	40.66
T_8	NPK0% + VC 100% + PM50%	42.97	41.62
T_9	NPK0% + VC 100% + PM100%	45.05	44.38
T_{10}	NPK 50% + VC 0% + PM0%	41.11	40.53
T_{11}	NPK 50% + VC 05 + PM50%	41	40.66
T_{12}	NPK 50% + VC 0% + PM100%	42.04	41.58
T_{13}	NPK 50% + VC 50% + PM0%	41.9	41.6
T_{14}	NPK 50% + VC 50% + PM50%	42.8	41.8
T_{15}	NPK 50% + VC 50% + PM100%	45.51	43.84
T_{16}	NPK 50% + VC 100% + PM0%	43.06	42.39
T_{17}	NPK 50% + VC 100% + PM50%	43.05	42.71
T_{18}	NPK 50% + VC 100% + PM100%	45.5	44.71
T_{19}	NPK 100% + VC 0% + PM0%	40.85	40.38
T_{20}	NPK 100% + VC 0% + PM50%	41.15	40.49
T_{21}	NPK 100% + VC 0% + PM100%	42.36	41.03
T_{22}	NPK 100% + VC 50% + PM0%	41.29	41.1
T_{23}	NPK 100% + VC 50% + PM50%	44.18	43.18
T_{24}	NPK 100% + VC 50% + PM100%	45.83	44.16
T_{25}	NPK 100% + VC 100% + PM0%	41.57	41.28
T_{26}	NPK 100% + VC 100% + PM50%	44.79	43.13
T_{27}	NPK 100% + VC 100% + PM100%	47.83	46.16
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		

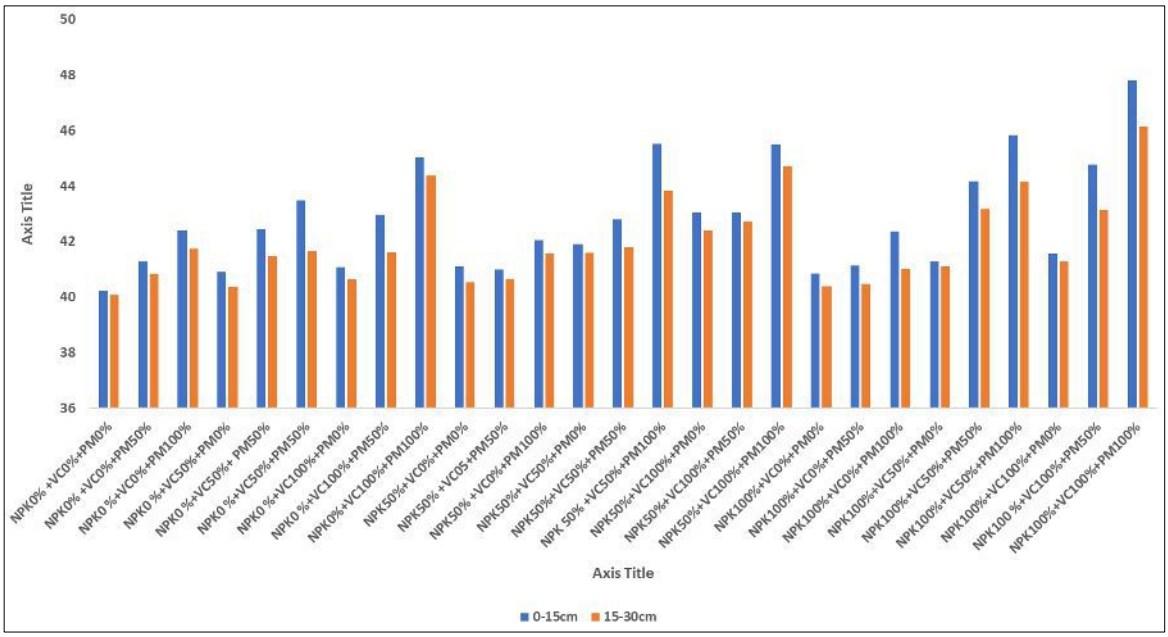

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Fig 4: Influence of Interaction (NPK + VC + PM) on water holding capacity of at 0-15 and 15-30 cm depth after harvest

Soil pH (1:2) w/v

The effect of NPK on Soil pH of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 7.12 and 7.14 pH was found 100% NPK and Maximum 7.19 and 7.21pH was recorded in 0% NPK. The effect of vermicompost on Soil pH of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minimum7.12 and 7.14 pH (%) was found 100% vermicompost and Maximum 7.21 and 7.23pH was recorded in 0% vermicompost. Similarly, the effect of poultry manure on Soil pH of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minimum 7.14 and 7.16 pH was found 100% vermicompost and Maximum 7.19 and 7.23pH was recorded in 0% vermicompost. The combination effect of NPK and Vermicompost, Vermicompost and poultry manure, NPK and poultry manure on Soil (pH) Soil was found non-significant. the interaction effect of NPK Vermicompost and Poultry

Manure on Soil pH of at 0- 15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. Increasing the rate of organic Manure increases the soil organic carbon these organic carbon releases organic acid and organic acid decrease the soil pH. When increases soil depth soil pH decrease due to decrease in alkanity and this result were confirmed by Singh *et al*. (2007).

Table 12: Influence of NPK, vermicompost and poultry manure on soil pH of at 0-15 and 15-30 cm depth after crop harvest

Influence of NPK	pH		Influence of Vermicompost	pH		Influence of Poultry manures	pH	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0%	7.19	7.21	Vermicompost 0%	7.21	7.23	Poultry manures 0%	7.19	7.21
NPK 50%	7.18	7.21	Vermicompost 50%	7.17	7.19	Poultry manures 50%	7.16	7.19
NPK 100%	7.12	7.14	Vermicompost 100%	7.12	7.14	Poultry manures 100%	7.14	7.16
F-Test	S	S	F-Test	S	S	F-Test	S	S
S. Ed. (±)	0.011	0.01	S. Ed. (±)	0.11	0.01	S. Ed. (±)	0.011	0.01
C.D@ 5%	0.022	0.02	C.D@ 5%	0.022	0.02	CD @5%	0.022	0.02

Table 13: Influence of NPK, vermicompost and poultry manure on soil pH of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction (NPK + VC)	pH		Influence of Interaction (VC + PM)	pH		Influence of Interaction (NPK + PM)	pH	
	0-15 Cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	7.22	7.25	VC 0% + PM 0%	7.21	7.24	NPK0.0% + PM0%	7.23	7.25
NPK0.0% + VC 50%	7.19	7.21	VC 0% + PM50%	7.19	7.21	NPK0.0% + PM50%	7.21	7.24
NPK0.0% + VC 100%	7.16	7.18	VC 0% + PM100%	7.17	7.19	NPK0.0% + PM100%	7.18	7.12
NPK 50% + VC 0%	7.22	7.24	VC 50% + PM0%	7.21	7.23	NPK 50% + PM 0%	7.19	7.22
NPK 50% + VC 50%	7.19	7.22	VC 50% + PM50%	7.18	7.21	NPK 50% + PM 50%	7.16	7.19
NPK 50% + VC 100%	7.13	7.16	VC 50% + PM100%	7.16	7.18	NPK 50% + PM 100%	7.14	7.16
NPK 100% + VC 0%	7.18	7.2	VC 100% + PM 0%	7.15	7.16	NPK 100% + PM 0%	7.15	7.17
NPK 100% + VC 50%	7.12	7.14	VC 100% + PM50%	7.12	7.15	NPK 100% + PM 50%	7.12	7.14
NPK 100% + VC 100%	7.07	7.09	VC 100% + PM100%	7.1	7.12	NPK 100% + PM100%	7.1	7.12
F-Test	NS	NS	F-Test	NS	NS	F-Test	NS	NS
S. Ed. (±)			S. Ed. (±)			S. Ed. (±)		
C.D@ 5%			C.D@ 5%			C.D@ 5%		

Table 14: Influence of NPK, vermicompost and poultry manure on soil pH of at 0-15 and 15-30 cm depth after crop harvest.

Treatment Combination		pH	
	Influence of Interaction NPK + VC + PM	0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	7.25	7.27
T_2	NPK0% + VC 0% + PM50%	7.22	7.24
T_3	NPK0% + VC 0% + PM100%	7.2	7.22
T_4	NPK0% + VC 50% + PM0%	7.2	7.24
T_5	NPK0% + VC 50% + PM50%	7.19	7.21
T_6	NPK0% + VC 50% + PM50%	7.17	7.19
T_7	NPK0% + VC 100% + PM0%	7.2	7.21
T_8	NPK0% + VC 100% + PM50%	7.16	7.13
T_9	NPK0% + VC 100% + PM100%	7.14	7.16
T_{10}	NPK 50% + VC 0% + PM0%	7.23	7.26
T_{11}	NPK 50% + VC 05 + PM50%	7.23	7.24
T_{12}	NPK 50% + VC 0% + PM100%	7.2	7.24
T_{13}	NPK 50% + VC 50% + PM0%	7.23	7.24
T_{14}	NPK 50% + VC 50% + PM50%	7.18	7.22
T_{15}	NPK 50% + VC 50% + PM100%	7.16	7.19
T_{16}	NPK 50% + VC 100% + PM0%	7.17	7.2
T_{17}	NPK 50% + VC 100% + PM50%	7.12	7.16
T_{18}	NPK 50% + VC 100% + PM100%	7.11	7.12
T_{19}	NPK 100% + VC 0% + PM0%	7.21	7.21
T_{20}	NPK 100% + VC 0% + PM50%	7.19	7.22
T_{21}	NPK 100% + VC 0% + PM100%	7.14	7.17
T_{22}	NPK 100% + VC 50% + PM0%	7.16	7.18
T_{23}	NPK 100% + VC 50% + PM50%	7.12	7.14
T_{24}	NPK 100% + VC 50% + PM100%	7.1	7.12
T_{25}	NPK 100% + VC 100% + PM0%	7.09	7.11
T_{26}	NPK 100% + VC 100% + PM50%	7.07	7.09
T_{27}	NPK 100% + VC 100% + PM100%	7.05	7.07
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		

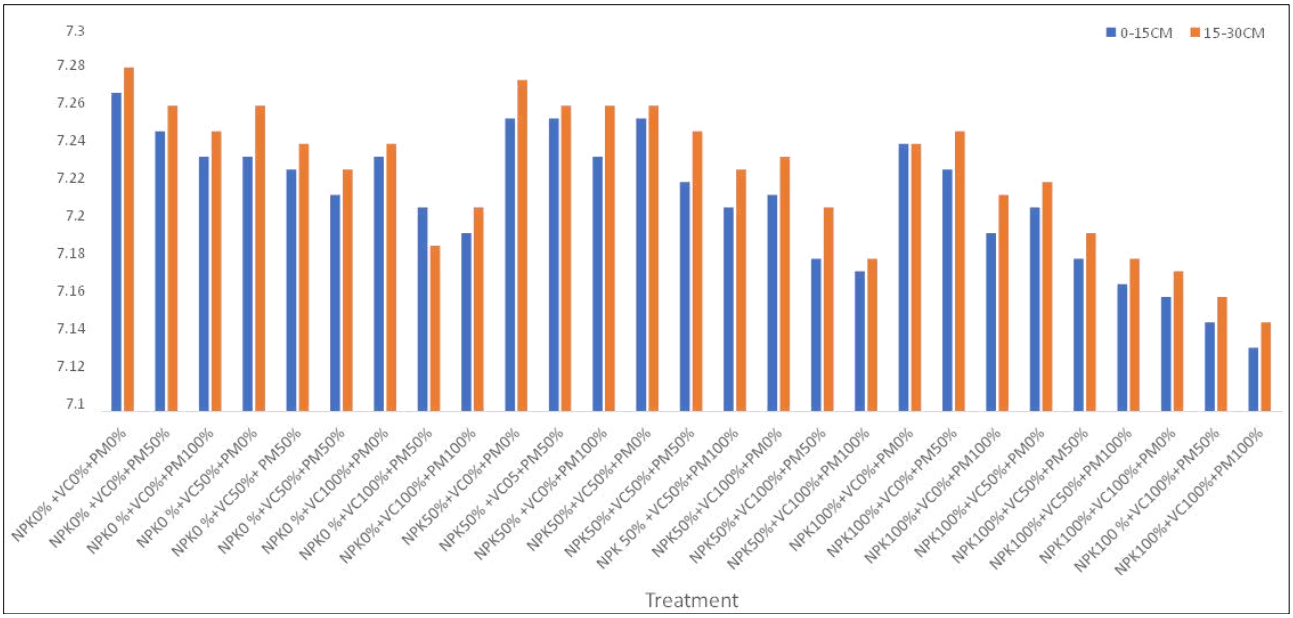

Fig 5: Influence of Interaction (NPK + VC + PM) on soil pH of at 0-15 and 15-30 cm depth after harvest

Electrical Conductivity (dSm^{-1})

The effect of NPK on Soil EC of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minium 0.201 and 0.199 EC was found 0% NPK and Maximum 0.247 and0.226 EC was recorded in 100% NPK. The effect of vermicompost on Soil EC of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The Minimum 0.213 and 0.212 EC was found 0% vermicompost and Maximum 0.222 and 0.206 EC was recorded in 100% vermicompost. Similarly, the effect of poultry manure on Soil EC of soil at 0-15 and 15-30 cm depth was found non-significant after crop harvest. The combination effect of NPK and Vermicompost on Soil EC of soil at 0-15 and 15-30 cm depth was found significant after crop harvest. The 0.178 and 0.167 EC was found 0% NPK and vermicompost and Maximum 0.256 and 0.238 EC was recorded in 100% NPK and vermicompost. The combination effect of NPK and Vermicompost on Soil EC of soil at 0-15 and 15-30 cm depth was found non- significant after crop harvest. Similarly, the effect of Vermicompost and poultry manure on Soil EC of soil at 0-15 and 15- 30 cm depth was found significant after crop harvest. The 0.194 and 0.206 EC was found 0% vermicompost and poultry manure and Maximum 0.247 and 0.224 EC was recorded in 100% vermicompost and poultry manure. The interaction effect of NPK Vermicompost and Poultry Manure on Electrical Conductivity of at 0- 15 and 15-30 cm depth after harvest was also found non-significant at 5% Critical difference. It might due to increase rate of Vermicompost and Poultry manure into soil build up soil organic carbon and soil organic carbon increases soluble salt in soil and when increase in soil depth decreases electrical conductivity. It might due to decrease in soluble salt in sub soil. similar results were recorded by Kansotia *et al.,* (2015).

Table 15: Influence of NPK, vermicompost and poultry manure on electrical conductivity (dSm-1) of at 0-15 and 15-30 cm depth after crop harvest.

Influence of NPK	Electrical Conductivity (dSm-1)		Influence of Vermicompost	Electrical Conductivity (dSm-1)		Influence of Poultry manures	Electrical Conductivity (dSm^{-1})	
	0-15 cm	15-30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK 0.00%	0.201	0.199	Vermicompost 0%	0.213	0.212	Poultry manures 0%	0.201	0.193
NPK 50%	0.206	0.199	Vermicompost 50%	0.219	0.206	Poultry manures 50%	0.223	0.209
NPK 100%	0.247	0.226	Vermicompost 100%	0.222	0.206	Poultry manures 100%	0.23	0.206
F-Test	S	S	F-Test	S	S	F-Test	NS	NS
S. Ed. (±)	0.009	0.008	S. Ed. (±)	0.009	0.008	S. Ed. (±)		
C.D@ 5%	0.019	0.016	C.D@ 5%	0.019	0.016	CD @5%		

Table 16: Influence of NPK, vermicompost and poultry manure on electrical conductivity (dSm-1) of at 0-15 and 15-30 cm depth after crop harvest.

Influence of Interaction (NPK + VC)	Electrical Conductivity (dSm^{-1})		Influence of Interaction (VC + PM)	Electrical Conductivity (dSm^{-1})		Influence of Interaction (NPK + PM)	Electrical Conductivity (dSm^{-1})	
	0-15	15.30 cm		0-15 cm	15-30 cm		0-15 cm	15-30 cm
NPK0.0% + VC 0%	0.178	0.167	VC 0% + PM 0%	0.194	0.192	NPK0.0% + PM0%	0.194	0.206
NPK0.0% + VC 50%	0.203	0.197	VC 0% + PM50%	0.21	0.198	NPK0.0% + PM50%	0.209	0.193
NPK0.0% + VC 100%	0.222	0.234	VC 0% + PM100%	0.199	0.19	NPK0.0% + PM100%	0.2	0.199
NPK 50% + VC 0%	0.192	0.203	VC 50% + PM0%	0.237	0.23	NPK 50% + PM 0%	0.198	0.203
NPK 50% + VC 50%	0.213	0.199	VC 50% + PM50%	0.202	0.19	NPK 50% + PM 50%	0.2	0.199
NPK 50% + VC 100%	0.212	0.193	VC 50% + PM100%	0.23	0.206	NPK 50% + PM 100%	0.22	0.193
NPK 100% + VC 0%	0.233	0.21	VC 100% + PM 0%	0.208	0.213	NPK 100% + PM 0%	0.247	0.227
NPK 100% + VC 50%	0.252	0.23	VC 100% + PM50%	0.244	0.231	NPK 100% + PM 50%	0.248	0.227
NPK 100% + VC 100%	0.256	0.238	VC 100% + PM100%	0.238	0.221	NPK 100% + PM100%	0.247	0.224
F-Test	NS	S	F-Test	NS	NS	F-Test	S	NS
S. Ed. (±)	0.014		S. Ed. (±)			S. Ed. (±)	0.016	
C.D@ 5%	0.028		C.D@ 5%			C.D@ 5%	0.032	

Table 17: Influence of NPK, vermicompost and poultry manure on electrical conductivity (dSm-1) of at 0-15 and 15-30 cm depth after crop harvest

Treatment Combination		Electrical Conductivity (dSm-1)	
Influence of Interaction NPK + VC + PM		0-15 cm	15-30 cm
T_1	NPK0% + VC 0% + PM0%	0.15	0.15
T_2	NPK0% + VC 0% + PM50%	0.2	0.18
T_3	NPK0% + VC 0% + PM100%	0.18	0.17
T_4	NPK0% + VC 50% + PM0%	0.22	0.22
T_5	NPK0% + VC 50% + PM50%	0.17	0.15
T_6	NPK0% + VC 50% + PM50%	0.22	0.22
T_7	NPK0% + VC 100% + PM0%	0.21	0.24
T_8	NPK0% + VC 100% + PM50%	0.26	0.25
T_9	NPK0% + VC 100% + PM100%	0.2	0.21
T_{10}	NPK 50% + VC 0% + PM0%	0.18	0.19
T_{11}	NPK 50% + VC 05 + PM50%	0.19	0.2
T_{12}	NPK 50% + VC 0% + PM100%	0.21	0.21
T_{13}	NPK 50% + VC 50% + PM0%	0.23	0.22
T_{14}	NPK 50% + VC 50% + PM50%	0.19	0.19
T_{15}	NPK 50% + VC 50% + PM100%	0.23	0.18
T_{16}	NPK 50% + VC 100% + PM0%	0.19	0.19
T_{17}	NPK 50% + VC 100% + PM50%	0.22	0.2
T_{18}	NPK 50% + VC 100% + PM100%	0.23	0.19
T_{19}	NPK 100% + VC 0% + PM0%	0.25	0.23
T_{20}	NPK 100% + VC 0% + PM50%	0.24	0.21
T_{21}	NPK 100% + VC 0% + PM100%	0.21	0.19
T_{22}	NPK 100% + VC 50% + PM0%	0.26	0.24
T_{23}	NPK 100% + VC 50% + PM50%	0.25	0.23
T_{24}	NPK 100% + VC 50% + PM100%	0.24	0.22
T_{25}	NPK 100% + VC 100% + PM0%	0.22	0.21
T_{26}	NPK 100% + VC 100% + PM50%	0.25	0.24
T_{27}	NPK 100% + VC 100% + PM100%	0.29	0.27
	F-Test	NS	NS
	S. Ed. (±)		
	C.D@ 5%		

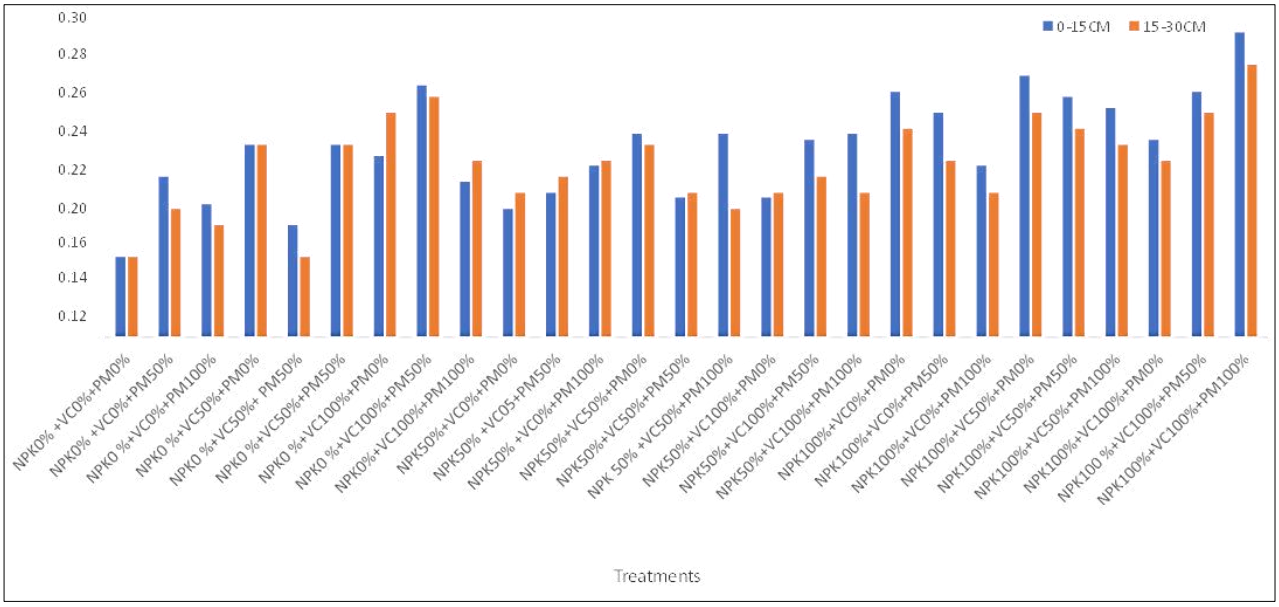

Fig 6: Influence of Interaction (NPK + VC + PM) on electrical conductivity (dSm-1) of at 0-15 and 15-30 cm depth after harvest

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Conclusion

According to the trial, the fertilizers [Urea (46% N), + DAP (46% P_2O_5), + MOP (60% K_2O), + Vermicompost + poultry manure] used at different levels of NPK, Vermicompost and Poultry manure different sources produced the best results in treatment T_{27} (NPK @ 100% + Vermicompost @ 100% + Poultry manure @100), which was followed by treatment T_{26}. In T_{27}, the soil health parameters retained the appropriate soil properties. Therefore, for increased farm revenue and sustainable agriculture, it might be advised that farmers receive the finest combination treatment (T_{27}).

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