__Original Research Article__

Influence of NPK Levels in Conjugation with FYM on Soil Health properties and Yield of Maize (*Zea mays* L.)

Abstract

This field experiment aimed to assess the "Influence of NPK levels in conjugation with FYM on soil health and yield of maize (*Zea mays* L.)" at the Crop Research Farm of the Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute (SHUATS), Prayagraj (U.P.) during the *Zaid* season 2022. The outcomes demonstrated a considerable impact of NPK and FYM application on the physico-chemical characteristics of the soil. At a depth of 0-15 cm and 15-30 cm, the maximum bulk density (1.26 and 1.37 Mg m^{-3}), particle density (2.65 and 2.71 Mg m^{-3}) and pH (7.36 and 7.44) was recorded in NPK_0FYM_0, while the minimum bulk density (1.16 and 1.25 Mg m^{-3}), particle density (2.60 and 2.65 Mg m^{-3}) and pH (7.16 and 7.24) was found in $NPK_{100}FYM_{100}$. Similarly, the maximum EC (0.29 and 0.42 dS m^{-1}), organic carbon (0.74 and 0.52%), percentage pore space (48.52 and 46.31%), water holding capacity (45.28 and 42.60%) and available nitrogen (252.03 and 184.03 kg ha^{-1}), phosphorus (32.65 and 25.83 kg ha^{-1}) and potassium (315.62 and 241.52 kg ha^{-1}) was recorded in $NPK_{100}FYM_{100}$, while the minimum EC (0.21 and 0.31 dS m^{-1}), organic carbon (0.44 and 0.34%), percentage pore space (44.76 and 40.79%), water holding capacity (39.41 and 36.47%) and available nitrogen (224.52 and 156.52 kg ha^{-1}), phosphorus (22.62 and18.46 kg ha^{-1}) and potassium (273.32 and 189.67 kg ha^{-1}) was recorded in NPK_0FYM_0. However, the maize yield and physico-chemical characteristics of the soil was significantly influenced by the application of NPK with FYM.

Keywords: FYM, NPK, Properties, Mazie, Health, Yield.

Introduction:

Soil is essential in maize production because it provides nutrients, water, and physical support for growth (Ncube *et al.*, 2011). Maize requires well-drained, healthy soil with enough water retention and aeration (Gbegbelegbe *et al.*, 2009). Organic and inorganic fertilizers can be used to improve soil fertility and increase maize output (Kanyanjua *et al*., 2007). Alkaline soil of Prayagraj can benefit from acidifying fertilizers or amendments to improve nutrient uptake by maize (Mandal *et al.*, 2015). Soil texture affects water-holding and nutrient retention. Maize grows best in loam soils, but alluvial soil in Prayagraj can be improved for maize cultivation by adding organic matter (Sharma and Shukla, 2017).

Maize (*Zea mays* L.) is an important cereal crop, widely grown for food, feed, and industrial purposes. It is the third most important cereal crop after wheat and rice. However, maize production is limited by various factors, including soil nutrient deficiencies. Therefore, the application of NPK fertilizers and FYM can enhance the soil properties and ultimately improve the growth and yield of maize (Ahmad *et al.*, 2019). However, maize production is often limited by poor soil health, particularly in regions where soil fertility is low (Kumar *et al.*, 2019). Therefore, there is a need to explore sustainable agricultural practices that can improve soil health and enhance maize productivity.

Materials and Methods:

The experiment was carried out during the *Zaid* season 2022 at the Crop Research Farm of the Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj (U.P.). The site, which is situated at latitudes 25^{0}47'69" N and 81^{0}85'74" E, has a humid subtropical climate with 900-1100 mm of annual rainfall on average. Three levels of FYM (0, 50 and 100%) and three levels of NPK fertilizer (0, 50 and 100%) were used in the experiment's Factorial Randomized Block Design (F-RBD). Treatments included NPK_0FYM_0 (absolute control), NPK_0FYM_{50} (0% NPK + 50% FYM), NPK_0FYM_{100} (0% NPK + 100% FYM), $NPK_{50}FYM_0$(50% NPK + 0% FYM), $NPK_{50}FYM_{50}$ (50% NPK + 50% FYM), $NPK_{50}FYM_{100}$ (50% NPK + 100% FYM), $NPK_{100}FYM_0$ (100% NPK + 0% FYM), $NPK_{100}FYM_{50}$ (100% NPK + 50% FYM) and $NPK_{100}FYM_{100}$ (100% NPK + 100% FYM). All the treatments were randomly replicated three times. Soil samples were taken from each plot at a depth of 0-15 and 15-30 cm before and after the experimental crop was sown. The soil samples were dried in the air, put through a 2 mm screen, and then had several soil properties measured. The following accepted methods were used to determine the soil's B.D., P.D. (Mg m^{-3}), %PS, WHC (%), pH, EC at 25^{o}C (dS m^{-1}), available nitrogen, phosphorus and potassium (kg ha^{-1}): Muthuvel *et al.* (1992), Jackson (1958), Wilcox (1950), Walkley and Black (1934), Subbiah and Asija (1956), Olsen *et al*. (1954), Toth and Prince (1949).

Results and Discussion:

The statistically analyzed data is presented in Table and Figure 1 and 2 show the impacts of NPK and FYM on soil health metrics.

Bulk density (Mg m^{-3})

The effect of FYM on bulk density of soil after crop harvest was found significant, with higher bulk density 1.28 and 1.45 Mg m^{-3} of soil was recorded at 0-15 and 15-30 cm depth in FYM_0 and lower bulk density 1.21 and 1.30 Mg m^{-3} was found in FYM_{100}. The effect of NPK on bulk density was found non-significant. However, the interaction of NPK and FYM had a significant impact on bulk density, with the maximum bulk density 1.30 and 1.47 Mg m^{-3} of soil was recorded at 0-15 and 15-30 cm depth in NPK_0FYM_0 and the minimum bulk density 1.19 and 1.24 Mg m^{-3} was found in $NPK_{100}FYM_{100}$.

Particle Density (Mg m^{-3})

Regarding particle density of soil after crop harvest, neither FYM, NPK, nor their interaction had a significant effect.

Pore space (%)

FYM significantly influenced percentage pore space of soil after crop harvest, with the maximum percentage pore space 47.90 and 45.89% of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100}, and the minimum percentage pore space 45.32 and 41.61% was found in FYM_0. The effect of NPK on percentage pore space was found non-significant. However, the interaction of NPK and FYM showed a significant effect, with maximum percentage pore space 48.52 and 46.31% of soil was recorded at 0-15 and 15-30 cm depth in $NPK_{100}FYM_{100}$ and the minimum percentage pore space 44.76 and 40.79% was found in NPK_0FYM_0.

Water Holding Capacity (%)

Similarly, FYM had a significant effect on water holding capacity of soil after crop harvest, with maximum water holding capacity 46.32 and 43.12% of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum water holding capacity 43.24 and 40.18% was found in FYM_0. The effect of NPK on water holding capacity was non-significant. The interaction of NPK and FYM had a significant impact, with the maximum water holding capacity 47.05 and 43.70% of soil was recorded at 0-15 and 15-30 cm depth in

$NPK_{100}FYM_{100}$ and the minimum water holding capacity 42.18 and 39.57% was found in NPK_0FYM_0.

Soil pH

FYM had a significant effect on soil pH after crop harvest, with the maximum pH 7.31 and 7.50 of soil was recorded at 0-15 and 15-30 cm depth in FYM_0 and the minimum pH 6.90 and 7.11 was found in FYM_{100}. NPK also had a significant effect on soil pH, with the maximum pH 7.25 and 7.49 of soil was recorded at 0-15 and 15-30 cm depth in NPK_0 and the minimum pH 6.99 and 7.10 was found in NPK_{100}. The interaction of NPK and FYM showed a significant effect, with the maximum pH 7.40 and 7.65 of soil was recorded at 0-15 and 15-30 cm depth in NPK_0FYM_0 and the minimum pH 6.74 and 6.89 was found in $NPK_{100}FYM_{100}$.

Electrical conductivity (dS m^{-1})

The effect of FYM on the EC of soil after crop harvest was found significant, with the maximum EC 0.39 and 0.27 dS m^{-1} of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum EC 0.32 and 0.22 dS m^{-1} was found in FYM_0. Similarly, the effect of NPK on soil EC was significant, with the maximum EC 0.37 and 0.27 dS m^{-1} of soil was recorded at 0-15 and 15-30 cm depth in NPK_{100} and the minimum EC 0.33 and 0.23 dS m^{-1} was found in NPK_0. The interaction of NPK and FYM had a significant impact on the EC of soil with the maximum EC 0.42 and 0.29 dS m^{-1} of soil was recorded at 0-15 and 15-30 cm depth in $NPK_{100}FYM_{100}$ and the minimum EC 0.31 and 0.21 dS m^{-1} was found in NPK_0FYM_0.

Organic carbon (%)

FYM significantly influenced the percentage of organic carbon in soil after crop harvest, with the maximum percentage organic carbon 0.48 and 0.45% of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum percentage organic carbon 0.36 and 0.35% was found in FYM_0. Similarly, NPK had a significant effect, with the maximum percentage organic carbon 0.45 and 0.42% of soil was recorded at 0-15 and 15-30 cm depth in NPK_{100} and the minimum percentage organic carbon 0.40 and 0.38% was found in NPK_0. The interaction of NPK and FYM showed a significant effect, with the maximum percentage organic carbon 0.52 and 0.47% of soil was recorded at 0-15 and 15-30 cm depth in

$NPK_{100}FYM_{100}$ and the minimum percentage organic carbon 0.34 and 0.33% was found in NPK_0FYM_0.

Nitrogen (kg ha^{-1})

The effect of FYM on available nitrogen in soil after crop harvest was significant, with maximum available nitrogen 276.72 and 243.43 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum available nitrogen 264.60 and 232.51 kg ha^{-1} was found in FYM_0. Similarly, NPK had a significant effect, with the maximum available nitrogen 278.55 and 247.17 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in NPK_{100} and the minimum available nitrogen 262.17 and 229.11 kg ha^{-1} was found in NPK_0. The interaction of NPK and FYM had a significant impact, with the maximum available nitrogen 282.85 and 252.03 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in $NPK_{100}FYM_{100}$ and the minimum available nitrogen 255.23 and 224.52 kg ha^{-1} was found in NPK_0FYM_0.

Phosphorus (kg ha^{-1})

FYM significantly influenced the available phosphorus in soil after crop harvest, with the maximum available phosphorus 29.71 and 26.03 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum available phosphorus 25.05 and 23.02 kg ha^{-1} was found in FYM_0. Similarly, NPK had a significant effect, with the maximum available phosphorus 31.08 and 26.52 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in NPK_{100} and the minimum available phosphorus 23.81 and 22.42 kg ha^{-1} was found in NPK_0. The interaction of NPK and FYM showed a significant effect, with the maximum available phosphorus 32.65 and 27.83 kg ha^{-1} of soil was at 0-15 and 15-30 cm depth in $NPK_{100}FYM_{100}$ and the minimum available phosphorus 22.62 and 20.46 kg ha^{-1} was found in NPK_0FYM_0.

Potassium (kg ha^{-1})

The effect of FYM on the available potassium of soil after crop harvest was found significant, with the maximum available potassium 231.45 and 212.44 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in FYM_{100} and the minimum available potassium 215.89 and 193.66 kg ha^{-1} was found in FYM_0. Similarly, NPK had a significant effect, with the maximum available potassium 237.56 and 217.13 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in NPK_{100} and the minimum available potassium 208.54 and 186.62 kg ha^{-1} was found in NPK_0. The interaction of NPK and FYM had a significant impact, with the maximum available potassium 242.62 and 221.52 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depth in $NPK_{100}FYM_{100}$ and the minimum available potassium 200.32 and 169.67 kg ha^{-1} was found in NPK_0FYM_0.

Table 1: Effect of NPK and FYM on Bulk Density, Particle Density, Pore Space and Water Holding Capacity.

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
Levels of NPK								
NPK_0	1.22	1.33	2.63	2.68	46.18	42.92	40.73	38.02
NPK_{50}	1.20	1.31	2.62	2.67	46.61	43.94	41.49	38.58
NPK_{100}	1.19	1.27	2.61	2.66	47.14	44.28	41.95	39.14
S.Em. (±)	-	-	-	-	-	-	-	-
C.D. at 5%	-	-	-	-	-	-	-	-
Levels of FYM								
FYM_0	1.23	1.35	2.64	2.69	45.32	41.61	40.14	37.08
FYM_{50}	1.20	1.31	2.62	2.67	46.72	43.65	41.36	38.64
FYM_{100}	1.17	1.27	2.60	2.65	47.90	45.89	42.66	40.02
S.Em. (±)	0.01	0.01	-	-	0.39	0.48	0.34	0.26
C.D. at 5%	0.03	0.04	-	-	1.17	1.44	1.01	0.79
NPK x FYM interaction								
NPK_0FYM_0	1.26	1.37	2.65	2.71	44.76	40.79	39.41	36.47
NPK_0FYM_{50}	1.21	1.33	2.63	2.68	46.46	42.69	40.73	38.13
NPK_0FYM_{100}	1.18	1.29	2.61	2.66	47.33	45.29	42.03	39.45
$NPK_{50}FYM_0$	1.23	1.35	2.64	2.69	45.28	41.79	40.15	37.14
$NPK_{50}FYM_{50}$	1.20	1.31	2.62	2.67	46.71	43.97	41.65	38.61
$NPK_{50}FYM_{100}$	1.18	1.27	2.60	2.65	47.85	46.06	42.67	40.00
$NPK_{100}FYM_0$	1.22	1.32	2.63	2.68	45.92	42.24	40.86	37.63
$NPK_{100}FYM_{50}$	1.19	1.28	2.61	2.66	46.97	44.29	41.70	39.19
$NPK_{100}FYM_{100}$	1.16	1.25	2.60	2.65	48.52	46.31	43.28	40.60
S.Em. (±)	0.02	0.02	-	-	0.67	0.83	0.58	0.46
C.D. at 5%	0.05	0.06	-	-	2.02	2.50	1.75	1.36

Table 2: Effect of NPK and FYM on pH, EC, OC, Nitrogen, Phosphorus and Potassium.

Treatments	**pH (w/v)**		**EC (dS m^{-1})**		**OC (%)**		**Nitrogen (kg ha^{-1})**		**Phosphorus (kg ha^{-1})**		**Potassium (kg ha^{-1})**	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Levels of NPK												
NPK$_0$	7.30	7.38	0.23	0.33	0.55	0.40	229.11	161.11	23.81	20.42	281.54	206.62
NPK$_{50}$	7.28	7.36	0.25	0.35	0.58	0.42	238.66	170.66	26.97	23.22	298.09	227.00
NPK$_{100}$	7.24	7.32	0.27	0.37	0.62	0.45	247.18	179.17	31.08	24.52	310.56	237.13
S.Em. (±)	-	-	0.002	0.004	0.006	0.003	1.65	1.58	0.27	0.10	2.74	2.24
C.D. at 5%	-	-	0.007	0.011	0.019	0.008	4.95	4.74	0.81	0.30	8.21	6.71
Levels of FYM												
FYM$_0$	7.34	7.42	0.22	0.32	0.48	0.36	232.51	164.51	25.05	21.02	288.89	213.66
FYM$_{50}$	7.28	7.36	0.24	0.35	0.58	0.42	239.01	171.00	27.10	23.10	296.85	224.66
FYM$_{100}$	7.20	7.28	0.27	0.39	0.69	0.48	243.43	175.43	29.71	24.03	304.45	232.44
S.Em. (±)	-	-	0.002	0.004	0.006	0.003	1.65	1.58	0.27	0.10	2.74	2.24
C.D. at 5%	-	-	0.007	0.011	0.019	0.008	4.95	4.74	0.81	0.30	8.21	6.71
NPK x FYM interaction												
NPK$_0$FYM$_0$	7.36	7.44	0.21	0.31	0.44	0.34	224.52	156.52	22.62	18.46	273.32	189.67
NPK$_0$FYM$_{50}$	7.31	7.39	0.22	0.33	0.56	0.41	229.35	161.35	23.18	20.68	281.55	209.17
NPK$_0$FYM$_{100}$	7.23	7.31	0.25	0.36	0.64	0.45	233.45	165.45	25.62	22.12	289.75	221.02
NPK$_{50}$FYM$_0$	7.34	7.42	0.22	0.32	0.49	0.37	231.63	163.63	23.86	21.66	288.45	219.97
NPK$_{50}$FYM$_{50}$	7.29	7.37	0.24	0.35	0.58	0.42	239.54	171.54	26.21	23.85	297.85	226.25
NPK$_{50}$FYM$_{100}$	7.21	7.29	0.28	0.38	0.68	0.48	244.82	176.82	30.85	24.14	307.98	234.78
NPK$_{100}$FYM$_0$	7.31	7.39	0.24	0.33	0.51	0.38	241.38	173.38	28.68	22.95	304.90	231.33
NPK$_{100}$FYM$_{50}$	7.24	7.32	0.27	0.37	0.61	0.44	248.14	180.10	31.91	24.78	311.15	238.55
NPK$_{100}$FYM$_{100}$	7.16	7.24	0.29	0.42	0.74	0.52	252.03	184.03	32.65	25.83	315.62	241.52
S.Em. (±)	-	-	0.004	0.01	0.01	0.004	2.86	2.74	0.47	0.18	4.74	3.88
C.D. at 5%	-	-	0.012	0.02	0.03	0.014	8.57	8.21	1.40	0.53	14.22	11.63

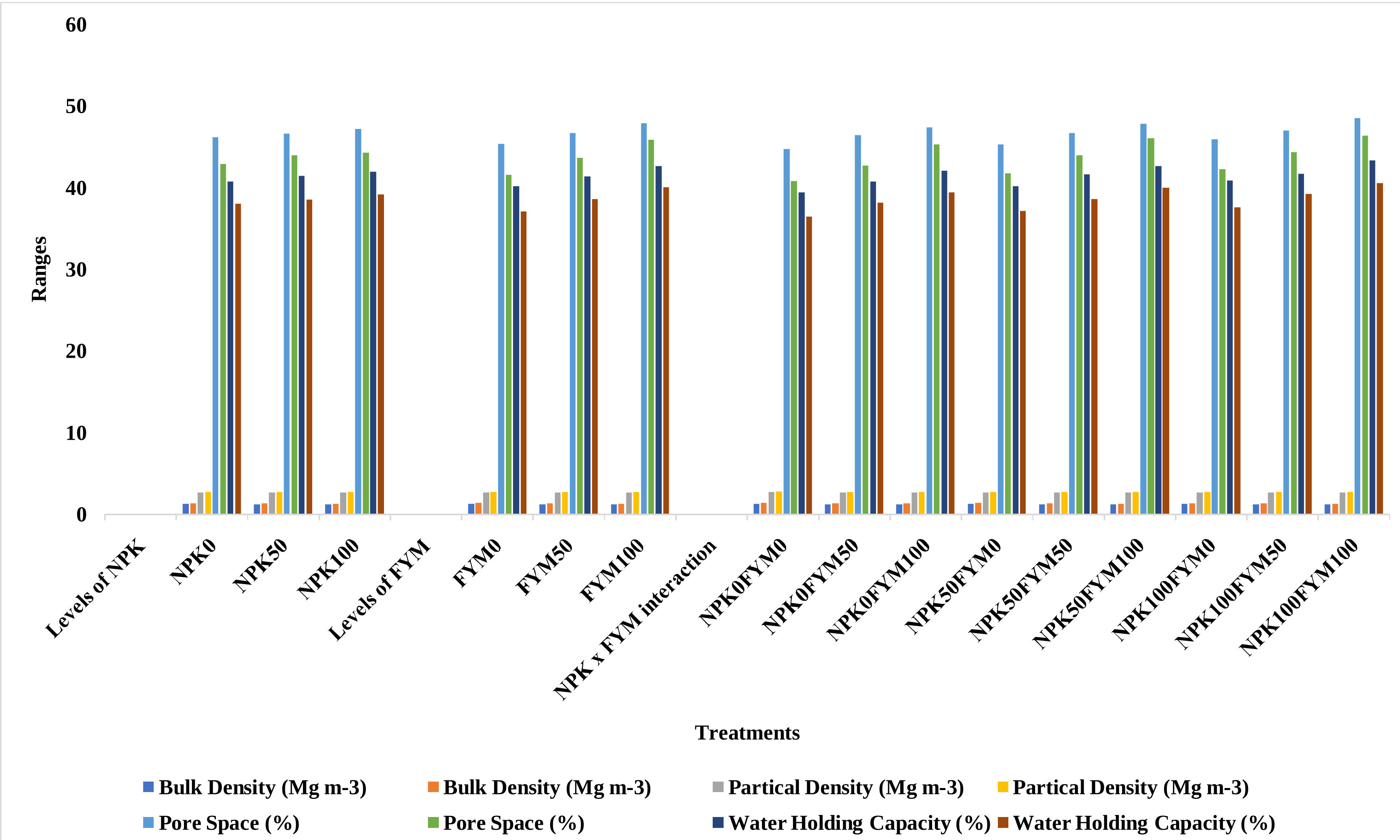

Fig. 1: Effect of NPK and FYM on Bulk Density, Particle Density, Pore Space and Water Holding Capacity.

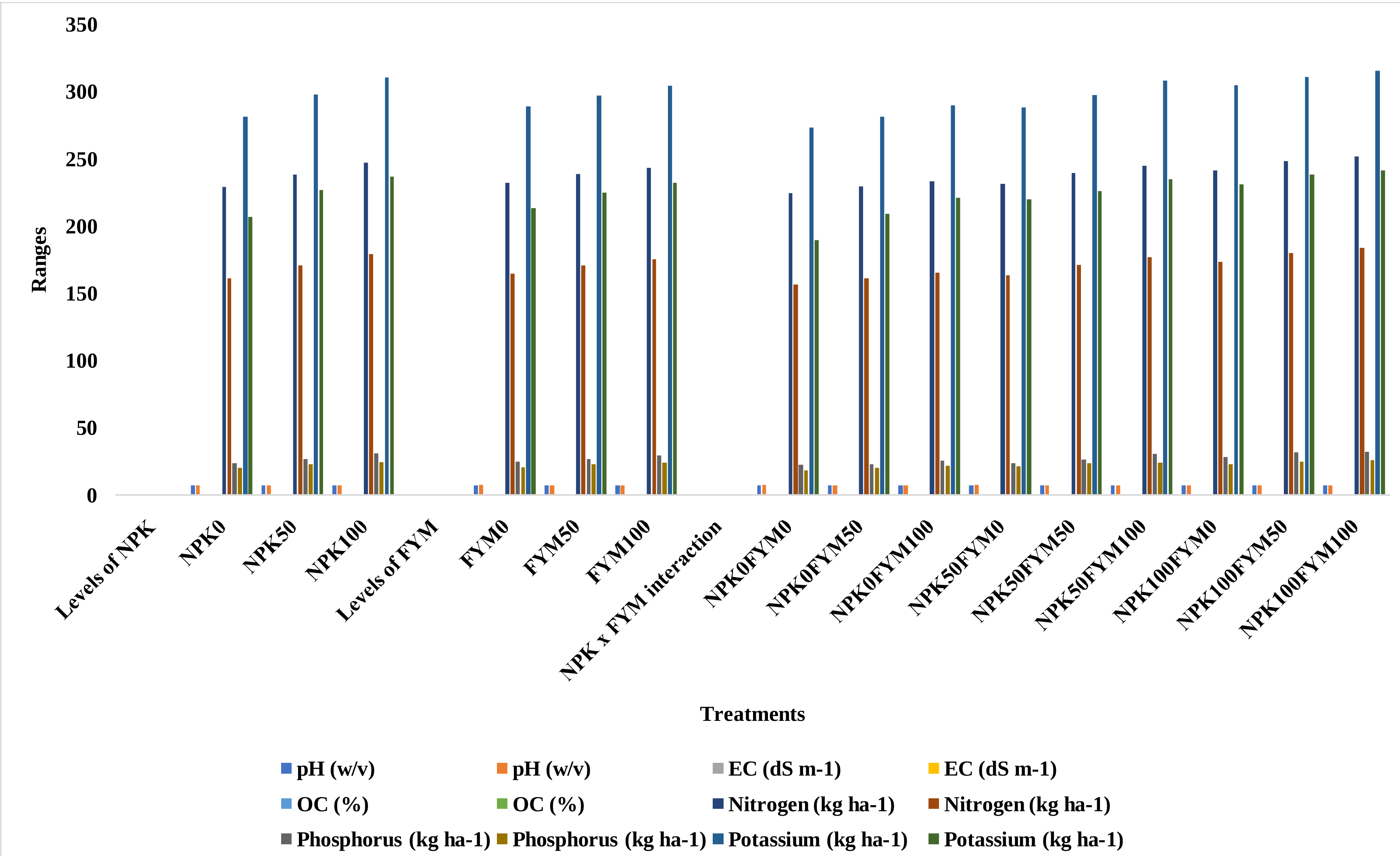

Fig. 2: Effect of NPK and FYM on pH, EC, OC, Nitrogen, Phosphorus and Potassium.

Conclusion:

The findings of this study show that using NPK with FYM can improve soil health indices and maize output. The highest maize yield was obtained when 120-60-40 kg ha^{-1} NPK was used in conjunction with 10 t ha^{-1} FYM in treatment $NPK_{100}FYM_{100}$. The findings of this study emphasize the significance of controlling the use of chemical fertilizers and organic amendments in order to promote soil health and crop productivity. More research is needed to investigate the long-term impact of NPK and FYM treatment on soil health and crop productivity.

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