Influence of NPK and FYM on Physical and Chemical properties of Soil under Spinach in an Inceptisol of Prayagraj, Uttar Pradesh, India

ABSTRACT

The field experiment was conducted to assess the “Influence of NPK and FYM on Physical and Chemical properties of Soil under Spinach in an Inceptisol of Prayagraj, Uttar Pradesh, India” to observe the combined effects of NPK fertilizer and FYM on soil health and yield. The results showed that the application of NPK and FYM had a significant and non-significant effect on soil physico-chemical properties. The maximum bulk density (1.28 Mg m^{-3} and 1.33 Mg m^{-3}), particle density (2.60 Mg m^{-3} and 2.62 Mg m^{-3}) and pH (7.21 and 7.26) was recorded in T_1 (Absolute control) at 0-15 and 15-30 cm depth. Similarly, the maximum percentage pore space (49.07 and 46.08%), water holding capacity (48.05 and 44.28%), EC (0.38 and 0.36 dS m^{-1}), percentage organic carbon (0.53 and 0.46%), available nitrogen (262.85 and 232.03 kg ha^{-1}), phosphorus (41.73 and 32.48 kg ha^{-1}) and potassium (241.62 and 220.52 kg ha^{-1}) was recorded in T_9 (RDF @100% + FYM @ 100%).

Key words: Soil health, Spinach, FYM, soil properties.

1. INTRODUCTION

Spinach is commonly grown in all soil types and is one of the most popular leafy vegetables with high calorific values. It is a cheap and rich source of vitamin A, which helps improve eyesight. It is also a good source of vitamin C and mineral elements like iron, zinc, calcium, magnesium, and phosphorus, and the cheapest source of antioxidants and dietary fibres. Green leafy vegetables have a unique place in our daily diet because of their colour, flavour, and healthy benefits. They are rich in minerals and hence can be called "mines of minerals" Singh *et al.* [1].

“Spinach (*Beta vulgaris* L.) 2n = 2x = 18, commonly known as "Indian spinach" in English and "Palak" in Hindi, originated in the Indo-Chinese region and belongs to the genus Beta, specie vulgaris, and family Chenopodiaceae” Jabeen *et al.* [2].

In India, leafy vegetables grow on nearly 10.29 million ha, with an annual production of 18.80 metric tonnes. In India, spinach will be grown on a total area of 53.3 thousand hectares during 2021. Total production will be 463.9 thousand metric tonnes, with a productivity of 8.5 metric tonnes per hectare Anonymous, 2021.

“The combination of organic and inorganic fertilizers can increase plant production. Organic composts increase the content of nutrients in soil and their availability for plants Boldrin *et al*. [3] and may contribute towards reducing inorganic nitrogen fertilization, which has negative environmental impacts” Graham *et al.* [4].

FYM provides food for soil microorganisms; this increases the activity of microbes, which in turn help to convert unavailable plant nutrients into available forms, and being rich in organic matter is required for supplementing the nutrients to the plants. Soil organic matter indirectly affects some of the plant and soil aspects important to plant growth, like soil bulk density, particle density, soil moisture content, and crop water use efficiency.

Essentially, the presence of organic matter in soils is responsible for improving the physical and chemical properties of the soil through mineralization and gelation of soil particles. According to some studies, applying FYM along with N fertilizers can increase the plant height, leaf number, leaf length, leaf width, fresh weight, and yield of spinach compared to applying N alone. In spinach, nitrogen is essential for vegetative growth, chlorophyll synthesis, nitrate reductase activity, and protein formation.

Nitrogen is also a component of all proteins and enzymes, and it is engaged in some energy-transformation metabolic activities Lal *et al*. [5].

In spinach, phosphorus is an essential component of photosynthetic processes that are involved in the synthesis of sugars, oils, and starches, as well as the conversion of solar energy to chemical energy, plant development, and stress resistance. It enhances crop maturity and encourages early root growth, leaf size, tillering, flowering, grain output, and Deep roots also benefit the plant by keeping it rooted in the soil and preventing water loss due to lodging Oladipo *et al.* [6].

Potassium is a plant nutrient that has a high association with crop quality. It's vital for optimal crop quality, plant health, stress tolerance, seed quality, regulating water balance, stomatal movement, enzyme activation, and carbohydrate translocation, as well as for healthy growth Roy *et al.* [7].

2. MATERIALS AND METHODS

2.1 Experimental Site and Location

the investigative site of the crop research farm which falls under Geographical Co-ordinates of Prayagraj District which is located at 25^0 58’ N latitude and 81^0 52' E longitude with an altitude of 98 meter above mean sea level and is situated 5 km away on the right bank of

Yamuna-river. Representative the Agro-Ecological Sub Region [North Alluvial plain zone (0-1% slope)] and Agro-Climatic Zone (Upper Gangetic Plain Region).

2.2 Climate Condition

The fieldwork was done in the Prayagraj district, which is part of the subtropical belt and has semi-arid climatic conditions with both winter and summer temperature extremes. "The maximum temperature of the location reaches up to 46˚-48˚C and seldom falls as 4˚-5˚C. The relative humidity ranges between 20% to 94%. The average annual rainfall in prayagraj is around 900-1100 mm annually. The minimum temperature during the crop season was to be 5.9˚C and the maximum is to be 29.04˚C. The maximum humidity was to be 42.72% and maximum was to be 93.28%" (Singh *et al.* [8].

Table 1. Details of Treatment Combination

Treatment	Treatment combination	Symbols
T_1	RDF @ 0% + FYM @ 0%	R_0F_1
T_2	RDF @ 0% + FYM @ 50%	R_0F2
T_3	RDF @ 0% + FYM @ 100%	R_0F3
T_4	RDF @ 50% + FYM @ 0%	R_1F_1
T_5	RDF @ 50% + FYM @ 50%	R_1F_2
T_6	RDF @ 50% + FYM @ 100%	R_1F_3
T_7	RDF @ 100% + FYM @ 0%	R_2F_1
T_8	RDF @ 100% + FYM @ 50%	R_2F_2
T_9	RDF @ 100% + FYM @ 100%	R_2F_3

Note:

Recommended Dose of Fertilizer: - 90:50:50 (NPK)

Farm Yard Manure: 20 t ha^{-1}

2.3 Experimental Design

The present research investigation was setup in a randomised block design (RBD) with nine treatment combinations, which are replicated three times and randomly allocated in each replication, dividing the research site into twenty-seven plots. In this study, inorganic fertilisers like nitrogen, phosphorus, and potassium were used as RDF, and organic manure

like FYM was applied in three different doses. Sowing of the spinach crop was carried out on the 2nd of December, 2021, respectively, by hand. The seed variety Harit Shobha was sown at a rate of 25 kg ha^{-1} and at a row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm.

2.4 Fertilizer Application

The recommended doses of NPK 90:50:50 (100%) was applied to the spinach: N(196 kg ha^{-1}), P_2O_5 (312 kg ha^{-1}), and K_2O (83 kg ha^{-1}). The 100 percent application of N, P, and K was used as the basal dose at the time of sowing. In addition to these applications, FYM was used as a basal dose at 0, 10, and 20 t ha^{-1} for the treatment. The sources of NPK fertilisers were nitrogen through urea (46% N_2O). Phosphorus through single superphosphate (16% P_2O_5) and potassium through muriate of potassium (60% K_2O) were applied earlier to sowing in regards to treatments just before the seed sowing. Nitrogen and urea (46% N) were applied in two different doses.

2.5 Soils Analysis

The soils from each plot were separately collected, air-dried, ground, and passed through a 2-mm-size sieve for laboratory analysis. Soil samples were analysed for bulk density, particle density, Percentage pore space, and water holding capacity (Muthuvel *et al*., 1992) [9], pH [10], EC (Wilcox, 1950) [11], Percentage Organic Carbon (Walkley and Black, 1934) [12], Available Nitrogen (Subbiah and Asiija, 1956) [13], Available Phosphorus (Olsen *et al*., 1954) [14] and Available Potassium (Toth and Prince, 1949) [15] before sowing and after harvest of the crop.

2.6 Statistical Analysis

The statistical analysis of the data was carried out using STATISTICA (7.0) software [16].

3. RESULTS AND DISCUSSION

3.1 Effect of Nutrient Management on Physical Properties of Soil after Harvest of Spinach

The ressult observed in treatment T_1 non-significantly higher Bulk density (1.28 Mg m^{-3} and 1.33 Mg m^{-3}), Particle density (2.60 Mg m^{-3} and 2.62 Mg m^{-3}) and significantly higher Percentage pore space (49.07% and 46.18%), Water holding capacity (48.05% and 44.28%)

of soil were observed in treatment T_9 at 0-15 and 15-30 cm depth, respectively (Table 2 and fig. 1). This corroborates with the findings of [17, 18].

3.2 Effect of Nutrient Management on Chemical Properties of Soil after Harvest of Spinach

The result observed in treatment T_1 non-significantly higher soil pH (7.21 and 7.26) at 0-15 cm and 15- 30 cm depth, respectively (Table 2 and fig.1). There was significantly higher Electrical Conductivity (0.38 and 0.36 dS m^{-1}), Percentage Organic Carbon (0.53% and 0.46%), Available N (262.85 and 232.03 kg ha^{-1}), Available P (41.73 kg ha^{-1} and 32.48 kg ha^{-1}) and Available K (241.62 kg ha^{-1} and 220.52 kg ha^{-1}) were observed in treatment T_9 at 0-15 and at 15- 30 cm depth, respectively (Table 3 and fig.2, 3). This corroborates with the findings of [17, 18].

Table No. :2 Effect of Organic and Inorganic source of Nutrient on Bulk density, Particle density, Pore space, Water holding capacity and pH.

Treatments		Bulk Density ($Mg\ m^{-3}$)		Particle Density ($Mg\ m^{-3}$)		Percentage Pore space (%)		Water holding capacity (%)		pH	
		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
T_1	Absolute control	1.28	1.33	2.60	2.62	46.18	41.07	43.18	40.02	7.21	7.26
T_2	RDF @ 0% + FYM @ 50%	1.25	1.30	2.57	2.59	47.50	42.95	45.50	41.82	7.16	7.23
T_3	RDF @ 0% + FYM @ 100%	1.22	1.27	2.54	2.57	48.17	44.35	46.80	43.03	7.10	7.14
T_4	RDF @ 50% + FYM @ 0%	1.27	1.32	2.58	2.60	46.58	41.97	44.58	40.95	7.19	7.24
T_5	RDF @ 50% + FYM @ 50%	1.24	1.29	2.55	2.57	47.50	43.15	45.75	42.05	7.13	7.18
T_6	RDF @ 50% + FYM @ 100%	1.21	1.26	2.52	2.54	48.57	44.65	47.10	43.35	7.05	7.11
T_7	RDF @ 100% + FYM @ 0%	1.26	1.31	2.56	2.58	47.09	42.85	44.90	41.25	7.17	7.21
T_8	RDF @ 100% + FYM @ 50%	1.23	1.28	2.53	2.55	47.90	44.02	45.80	42.55	7.09	7.14
T_9	RDF @ 100% + FYM @100%	1.19	1.24	2.50	2.52	49.07	46.08	48.05	44.28	6.96	7.01
F-test		NS	NS	NS	NS	S	S	S	S	NS	NS
S.Em (±)		0.0223	0.0278	0.039	0.0485	0.5731	0.409	0.7881	0.6982	0.04948	0.09762
CD (P=0.05)		-	-	-	-	1.7181	1.226	2.3628	2.0933	-	-

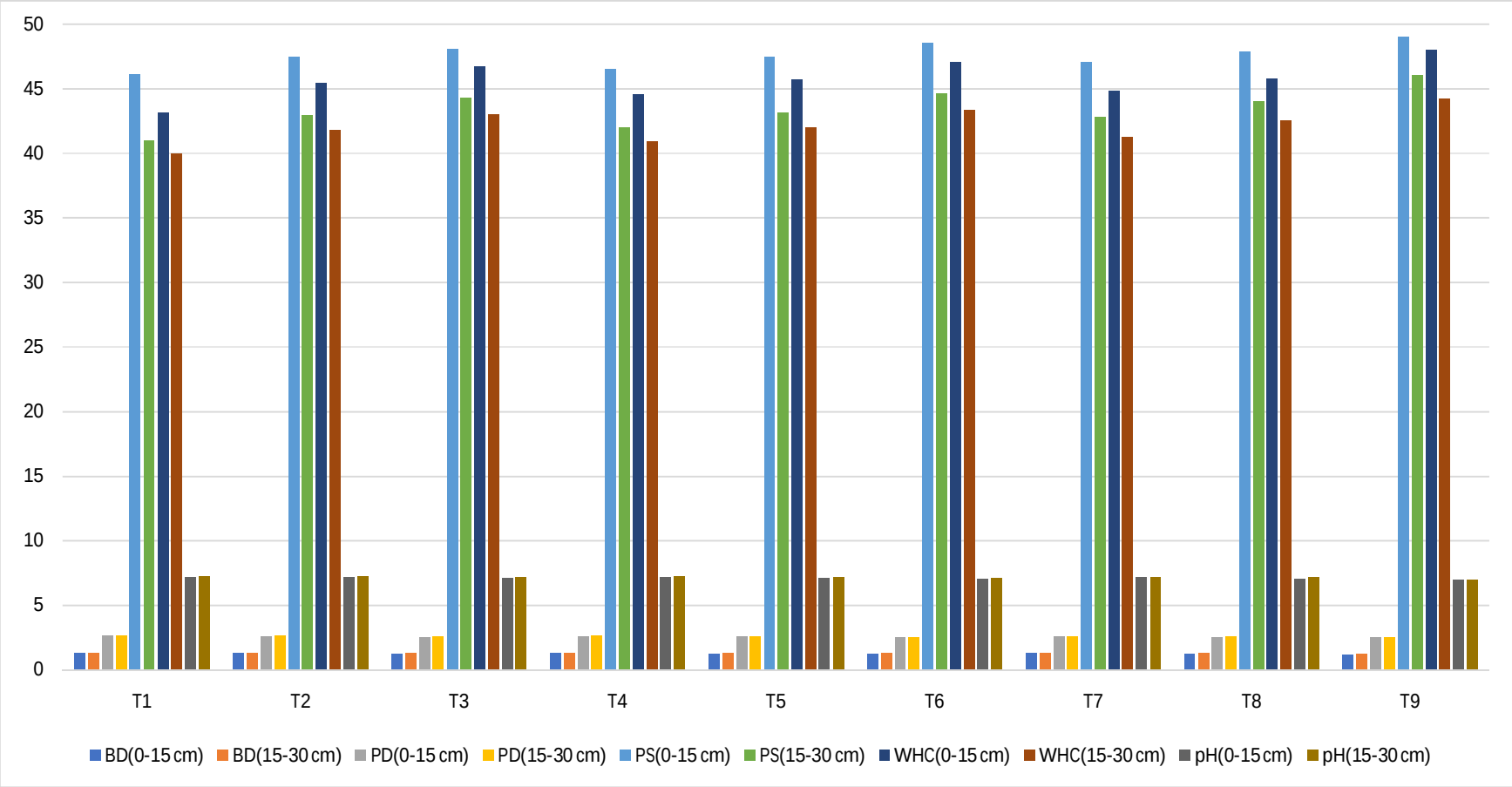

Fig. No.: 1 Effect of Organic and Inorganic source of Nutrient on Bulk density, Particle density, Percentage Pore space, Water holding capacity and pH.

Table No. :3 Effect of Organic and Inorganic source of Nutrient on Electrical conductivity, Organic Carbon, Available Nitrogen, Available phosphorus and Available Potassium.

Treatments		Electrical conductivity (dS m^{-1})		Percentage Organic Carbon (%)		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	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	Absolute control	0.23	0.21	0.35	0.32	235.23	204.52	21.45	19.53	199.32	168.67
T_2	RDF @ 0% + FYM @ 50%	0.26	0.23	0.42	0.37	241.70	209.35	25.69	22.25	207.55	188.17
T_3	RDF @ 0% + FYM @ 100%	0.29	0.29	0.46	0.42	249.59	213.45	29.34	25.88	215.75	200.02
T_4	RDF @ 50% + FYM @ 0%	0.25	0.23	0.38	0.34	245.20	211.63	27.53	23.35	214.45	198.97
T_5	RDF @ 50% + FYM @ 50%	0.27	0.26	0.43	0.39	251.32	219.54	31.75	26.45	223.85	207.25
T_6	RDF @ 50% + FYM @ 100%	0.33	0.31	0.49	0.43	257.73	224.82	36.85	29.95	233.98	213.78
T_7	RDF @ 100% + FYM @ 0%	0.32	0.30	0.39	0.36	253.38	221.38	34.25	27.09	230.90	210.33
T_8	RDF @ 100% + FYM @ 50%	0.34	0.33	0.45	0.40	259.43	228.10	38.33	30.08	237.15	215.55
T_9	RDF @ 100% + FYM @100%	0.38	0.36	0.53	0.46	262.85	232.03	41.73	32.48	241.62	220.52
F-test		S	S	S	S	S	S	S	S	S	S
S.Em. (±)		0.0131	0.01176	0.0112	0.01042	1.14799	1.0715	1.07603	1.05409	1.02439	0.968644
CD (P=0.05)		0.03927	0.03525	0.0336	0.03125	3.44169	3.212406	3.2259	3.16016	3.07113	2.903994

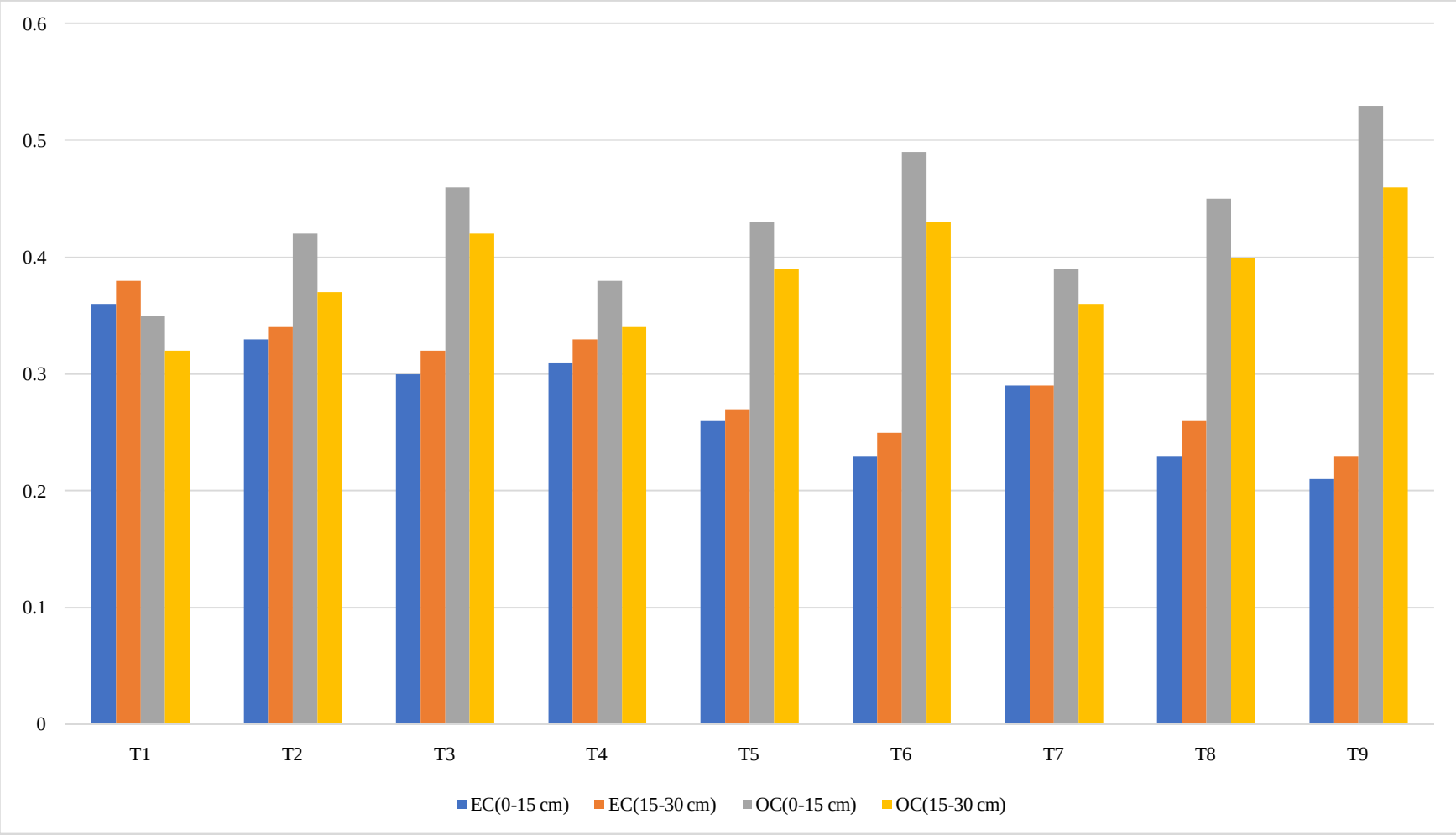

Fig. No.: 2 Effect of Organic and Inorganic source of Nutrient on Electrical Conductivity and Percentage Organic Carbon.

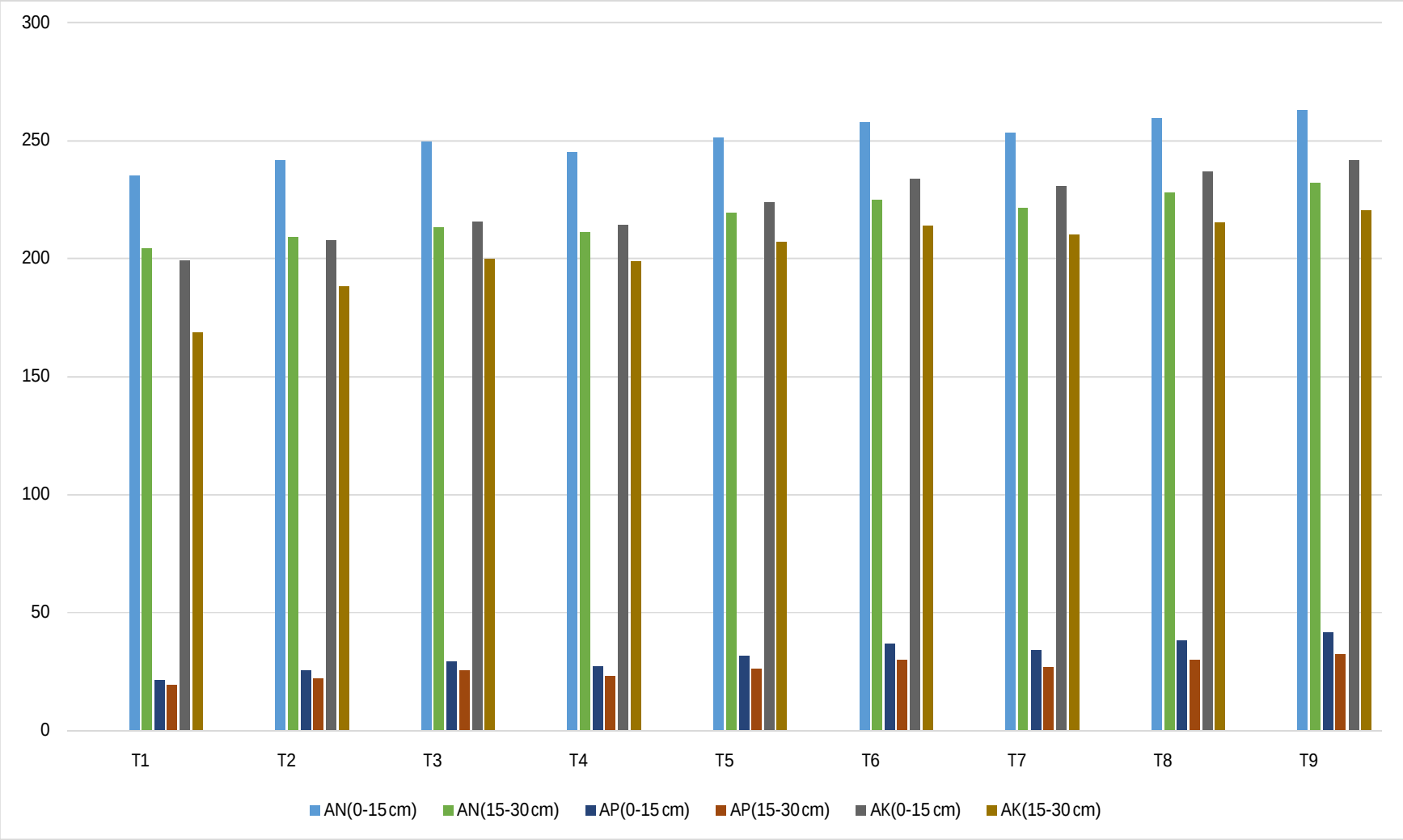

Fig. No.: 3 Effect of Organic and Inorganic source of Nutrient on Available Nitrogen, Available phosphorus and Available Potassium.

4. CONCLUSION

Conclusion Based on the results, the application of organic manure and inorganic fertilizer was found to improve the soil's health in references to spinach. Application of T_9 [RDF (90:50:50 NPK kg ha^{-1}) + FYM (20 t ha^{-1})] was found optimal for improving Soil Properties like Pore space, Water holding capacity, Electrical conductivity, Organic Carbon and Available Nitrogen, Phosphorus, Potassium.

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