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Response of Integrated Nutrients on Soil Health and Yield Attributes of Cluster bean (*Cyamopsis tetragonoloba* L.) *cv.* Neelam

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted during *Zaid* season 2022 to study "Response of integrated nutrients on soil health and yield attributes of Cluster bean (*Cyamopsis tetragonoloba* L.) *cv.* Neelam" on central Research farm Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj. The design applied was randomized block design consisted nine treatment three @ NPK, Vermicompost and Zinc @ 0, 50 and 100%, respectively. The best treatment was T_9 (@ 100% RDF + @ 100% $ZnSO_4$ + Vermicompost @ 10 t ha^{-1}) has effect on physical and chemical property of soil and yield of cluster bean. The data observed in post-harvest soil were significantly increased maximum values of percentage pore space (46.533%), water holding capacity (41.103%), organic

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carbon (0.56%), Nitrogen (328.32 kg ha^{-1}), Phosphorus (20.270 kg ha^{-1}) and Potassium (234.893 kg ha^{-1}). Plant height at different days 30, 60 and 90 DAS was (23.03, 54.22 and 121.86 cm), No. of leaves per plant at different days 30, 60 and 90 DAS was (29.11, 47.74 and 82.60) Pod length (14.11), number of cluster $plant^{-1}$ (6.47), number of pods $cluster^{-1}$ (7.47), number of pods per plant (48.35), number of seed pods (9.76), pod weight (2.35 g). The combination of T_9 (@ 100% RDF + @ 100% $ZnSO_4$ + Vermicompost @ 10 t ha^{-1}) showed slight decrease in pH (7.250), bulk density (1.172 Mg m^{-3}) and particle density (2.228 Mg m^{-3}) The maximum cost benefit ratio (C: B) 1:2.67, maximum gross return 750900.00, Rs ha^{-1} maximum net profit 469604.00 Rs ha^{-1}, and highest yield with 25.03 q ha^{-1} in T_9 (@ 100% RDF+ @ 100% $ZnSO_4$ + Vermicompost @ 10 t ha^{-1}).

Keywords: Soil nutrients; yield attributes; vermicompost; NPK; Zn; cluster bean.

1. INTRODUCTION

“The agricultural soil supports the crop growth better, if the suitable fertilizers are supplied for the growth of all vegetable crops” (Chavan *et al*. 2014). 'Cyamopsis tetragonoloba or cluster bean (Guar) belongs to the family Fabaceae (Leguminosae). It is commercially grown for its seeds as a source of natural polysaccharide (galactomannan), commercially known as guar gum. Guar gum has several uses in food” (Khalil. 2001). “Use of inorganic fertilizers alone though increases the production at a faster rate but it may not sustain the productivity in long run and affects soil health. Moreover, inorganic fertilizers are costly and their imbalanced use deteriorate soil physio-chemical environment. On the other hand, organic sources of nutrients are cheaper, ecofriendly, improve soil properties and can substitute nutrient requirement of crops partially. Hence, integrated use of inorganic fertilizers, organic manures, and low-cost nutrient sources such as bio fertilizers is the better option for sustainable production and maintenance of soil health” [1]. “The application of vermicompost helps to improves and conserves the fertility of soil. Vermicompost imparts a dark color of the soil and thereby help to maintain the temperature of soil. Vermicompost is one of the manures used by the farmer in growing crops because of early availability and presence of almost all the nutrients required by plants. The composition of vermicompost is 0.6-1.2% N, 0.13-0.22% P and 0.40-0.75%” (K Pawar. 2007) and (Kumar et al. 2018). “For soils low in available P, the nutrient must be applied in either organic or inorganic P sources to obtain optimal crop yield. However, excessive use of applied P sources can cause eutrophication in water bodies from surface runoff of sediments carrying P or leaching of P in sandy soils” [2]. “Vermicomposting is a process in which vermicompost is produced by earthworms and is proving to be an extremely nourishing organic fertilizer and more omnipotent growth promoter over the traditional compost. It has a protective function against the pestilential chemical fertilizers which destroy the soil richness and affect natural soil fertility adversely. Vermicompost is rich in NPK, micronutrients, crude proteins, beneficial soil microbes, and growth-promoting plant hormones and enzymes” [3]. “Vermicompost can withhold nutrients for a longer period, while the traditional compost fails to provide the essential amount of macro and micronutrients to plants in a shorter time, the vermicompost does. Vermicompost works as a ‘slow-release organic fertilizer’ whereas the chemical fertilizers release their nutrients more rapidly in soil and soon get depleted. Nitrogen and phosphorus are not completely available to the roots of the plant in the first year, because nitrogen and phosphorus compost are higher in ‘ammonium content’ while the vermicompost contains a higher content of ‘nitrates’ which is an extensively available form of nitrogen to plants. Vermicompost acts as an efficient ‘soil conditioner’ and its prolonged application over the years lead to the up gradation of soil quality and soil fertility. Vermicompost possesses high-water holding capacity, aeration, and drainage. The soil treated with vermicompost over the years is characterized by near-neutral pH and more electrical conductivity. The high levels of beneficial microbial population in vermicompost paves a way for inhibition of plant pathogens by out-competing plant pathogens for available food resources. Vermicompost improves the physiochemical and biological properties of the soil and contributes to organic enrichment” [4] and [5]. “Zn deficient soil can lead to Zn deficiency in human and livestock as well. Such nation communities, having maize as their staple food are prone to the Zn deficiency induced health challenges” [6]. “In order to reverse this trend, method of zinc application is a critical concern. Many researchers found soil application of Zn to be a better alternative of Zn nutrition whereas, some reported foliar application to be beneficial and more zinc fertilizer efficient. It was recently documented that zinc foliar application is a simple way for making quick correction of plant nutritional status, as reported for wheat" [7] and maize [8].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at research Farm of Soil Science at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, the area is situated on the south of Prayagraj on the right bank of the river Yamuna on the South of Rewa Road at about 6 km from Prayagraj city. It is situated at $25^0 57''$ N latitude, $81^0 59''$ E longitude and at the altitude of 98 meter above the sea level.

2.2 Climatic Condition

The area of Prayagraj district comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and cold Winter. The maximum temperature of the location reaches up to 46^0C – 48^0C and seldom falls as low as 4^0C – 5^0C. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually.

2.3 Collection of Soil Sample for Analysis

The soil sample were randomly collected from twenty-seven different sites in the experiment plot prior to tillage operation from a depth of 0-15 and 15-30cm.soil sample was air dried and passed through a 2mm sieve for Physical and Chemical Analysis.

2.3.1 Physical analysis

The Physical Analysis were bulk density, particle density, pore space, and water holding capacity done using a Graduated measuring cylinder (Muthuvel et al. 1992).

2.3.2 Chemical analysis

The chemical analysis was pH, Ec (Wilcox, 1950), organic carbon [9], available nitrogen [10], available phosphorous [11], available potassium [12] and zinc (Shaw and dean, 1952 and Holmes 1945).

2.4 Statistical Analysis

The data recorded during the investigation will be subjected to statistical analysis by RBD, as per the method "Analysis of Variance (ANOVA) technique". Experiment will be laid out in RBD and the treatment will be replicated three times. The significant and non-significant.

Effect was judged with the help of F table. The significant difference between the means was tested against the critical difference of 5%level. Fisher (1950).

3. RESULTS AND DISCUSSION

3.1 Effect of Integrated Nutrients on Physical Properties of Soil after Harvest

The data showed that the minimum bulk density (1.172 and 1.462 Mg m^{-3}), Particle density (2.228 and 2.503 Mg m^{-3}) at 0-15 and 15-30 cm of soil depth was found in treatment T_9 (@ 100% RDF + @100% ZnSO4 + Vermicompost @ 10t ha^{-1}) and maximum bulk density (1.194 and 1.580 Mg m^{-3}), particle density (2.377 and 2.600 Mg m^{-3}) which was found in T_1 (control).The pore space (46.533 and 44.404%), Water holding capacity (44.84 and 42.82%) are maximum in T_9 (@ 100% RDF + @ 100% $ZnSO_4$ + Vermicompost @ 10 t ha^{-1}). However minimum values were detected in the treatment T_1 (control) at 0-15 and 15-30 cm of soil depth respectively (Table 2 and Fig. 1) [13-15].

3.2 Effect of Integrated Nutrients on Chemical Properties of Soil after Harvest

The data showed that minimum pH, (7.250 and 7.567), Ec (0.260 and 0.257) at 0-15 and 15-30 cm of soil depth was found in T_9 (@ 100% RDF + @100% $ZnSO_4$ + Vermicompost @ 10 t ha^{-1}) and the maximum pH, (7.657 and 7.810) and Ec (0.353 and 0.326 dS m^{-1}) which was found in T_1 (control) respectively. The organic carbon (0.56 and 0.53%), Nitrogen (328.32 and 310.80 kg ha^{-1}), phosphorus (33.063 and 29.867 kg ha^{-1}), potassium (234.893 and 197.617 kg ha^{-1}) and Zinc (0.95 and 0.82 Mg ha^{-1}) are maximum in T_9 (100% RDF + 100% $ZnSO_4$ + Vermicompost @10 t ha^{-1}.However minimum values were detected in the treatment T_1 (control) at 0-15 and 15-30 cm of soil depth respectively (Table 3 and Figs. 2, 3).

Table 1. Treatment combinations of Cluster bean

S. No.	Treatments No.	Treatment combinations
1.	T_1	Control
2.	T_2	RDF @ 0% + $ZnSO_4$ @ 0%+ Vermicompost @ 5 t ha^{-1}
3.	T_3	RDF@ 0% + $ZnSO_4$ @ 0 % + Vermicompost @10 t ha^{-1}
4.	T_4	RDF @ 50% + $ZnSO_4$ @ 50%+ Vermicompost @ 0 t ha^{-1}
5.	T_5	RDF@ 50 % + $ZnSO_4$ @ 50%+ Vermicompost @ 5 t ha^{-1}
6.	T_6	RDF @ 50 % + $ZnSO_4$ @ 50 % + Vermicompost @10 t ha^{-1}
7.	T_7	RDF @ 100 % +$ZnSO_4$ @ 100%+ Vermicompost @ 0 t ha^{-1}
8.	T_8	RDF @ 100 %+ $ZnSO_4$ @ 100 % + Vermicompost @ 5 t ha^{-1}
9.	T_9	RDF@ 100 % + $ZnSO_4$ @ 100 % + Vermicompost @10 t ha^{-1}

Table 2. Effect of different levels of NPK, Vermicompost and zinc on bd, pd, pore space, WHC, and pH

S. No.	Treatments No.	Treatment combinations	Bulk Density (Mg m^{-3})		Particle Density (Mg m^{-3})		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
1	T_1	Control	1.194	1.580	2.377	2.600	45.703	42.900	41.103	40.193	7.657	7.810
2	T_2	RDF@ 0% +$ZnSO_4$ @ 0 % + Vermicompost @5 t ha^{-1}	1.186	1.551	2.369	2.574	45.907	42.980	42.183	40.550	7.553	7.767
3	T_3	RDF@ 0%+$ZnSO_4$ @ 0%+ Vermicompost @10 t ha^{-1}	1.182	1.499	2.260	2.547	46.317	43.710	42.340	41.663	7.537	7.697
4	T_4	RDF@ 50 %+$ZnSO_4$ @ 50 %+ Vermicompost@ 0 t ha^{-1}	1.180	1.502	2.255	2.559	46.307	43.790	41.277	41.107	7.503	7.660
5	T_5	RDF@ 50 % +$ZnSO_4$@ 50 %+ Vermicompost @5 t ha^{-1}	1.178	1.501	2.253	2.556	46.353	43.917	43.170	42.080	7.487	7.663
6	T_6	RDF@ 50 %+$ZnSO_4$@ 50 %+ Vermicompost @10 t ha^{-1}	1.176	1.492	2.241	2.533	46.280	44.010	43.670	42.344	7.403	7.633
7	T_7	RDF@ 100 %+$ZnSO_4$@ 100 %+ Vermicompost @ 0 t ha^{-1}	1.177	1.498	2.240	2.554	46.356	44.021	41.550	41.383	7.400	7.657
8	T_8	RDF@ 100 %+$ZnSO_4$@ 100 %+ Vermicompost @5 t ha^{-1}	1.175	1.479	2.234	2.526	46.453	44.327	44.630	42.518	7.367	7.603
9	T_9	RDF@ 100 %+$ZnSO_4$@ 100 %+Vermicompost @10 t ha^{-1}	1.172	1.462	2.228	2.503	46.533	44.404	44.840	42.827	7.250	7.567
		F-Test	**NS**	**S**	**S**	**NS**	**NS**	**NS**	**S**	**S**	**NS**	**NS**
		C. D. at 5%	**0.05**	**0.07**	**0.10**	**0.14**	**2.06**	**2.29**	**1.88**	**1.57**	**0.34**	**0.25**
		S. Em. (±)	**0.02**	**0.02**	**0.03**	**0.05**	**0.69**	**0.76**	**0.63**	**0.52**	**0.11**	**0.08**

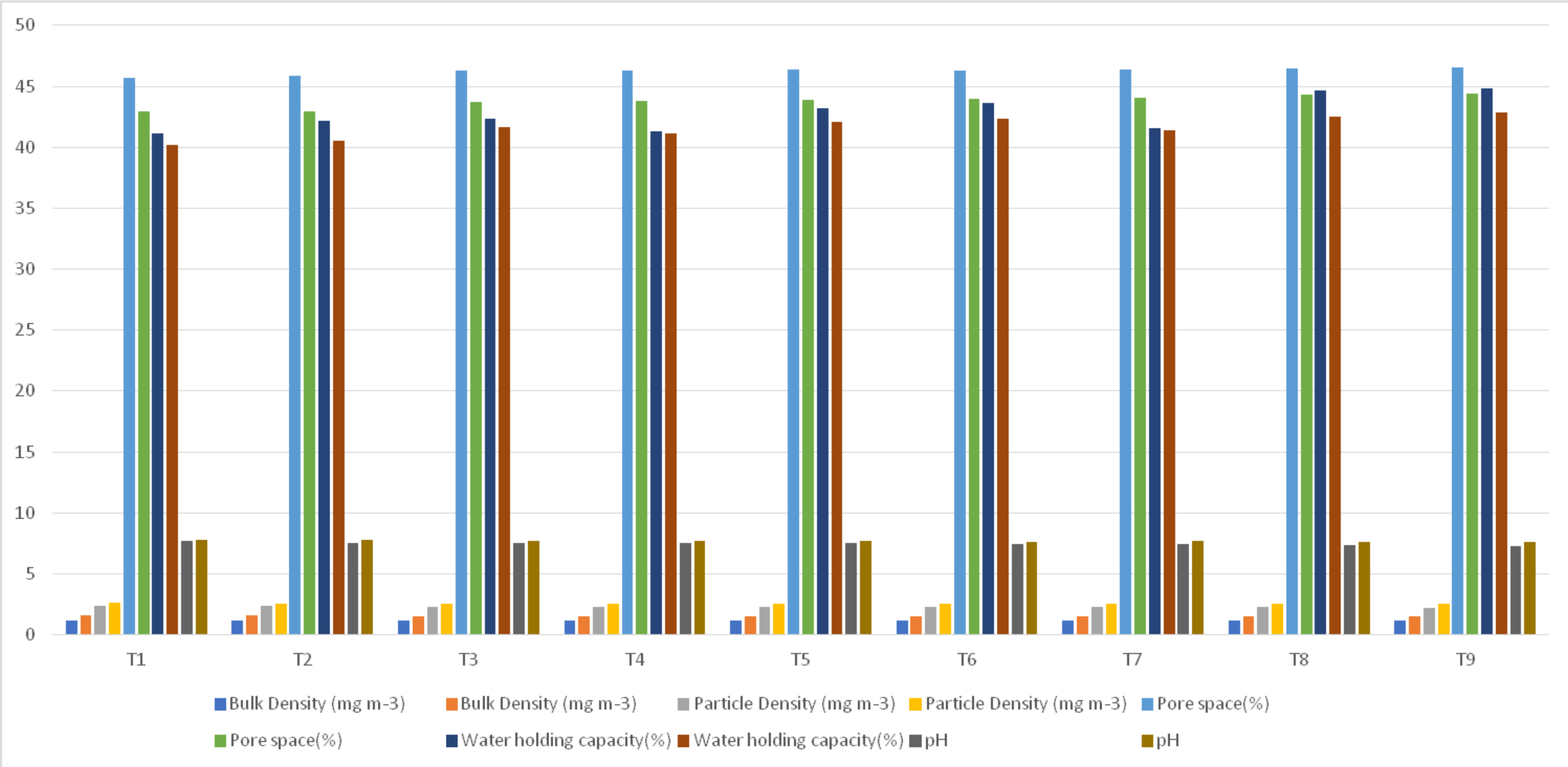

Fig. 1. Effect of different levels of NPK, Vermicompost, Zinc on bd, pd. pore space, water holding capacity and ph

Table 3. Effect of different levels of NPK, Vermicompost and zinc on Ec, Oc, N, P, K and Zinc

S. No.	Treatments No.	Treatment combinations	EC ds m^{-1}		Organic carbon (%)		Nitrogen (Kg ha^{-1})		Phosphorus (Kg ha^{-1})		Potassium (Kg ha^{-1})		Zinc (Mg 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
1	T_1	Control	0.353	0.326	0.32	0.30	280.53	271.76	20.270	17.267	209.330	177.427	0.56	0.41
2	T_2	RDF@ 0 %+$ZnSO_4$ @ 0 %+ Vermicompost @5 t ha^{-1}	0.294	0.290	0.41	0.39	284.61	273.20	23.790	17.987	212.420	179.267	0.72	0.57
3	T_3	RDF @ 0 %+ $ZnSO_4$ @ 0 % + Vermicompost @10 t ha^{-1}	0.284	0.282	0.42	0.40	287.33	272.21	24.930	21.140	214.510	178.960	0.75	0.60
4	T_4	RDF @ 50 % + $ZnSO_4$ @ 50 %+ Vermicompost @ 0 t ha^{-1}	0.280	0.279	0.43	0.42	291.42	282.77	27.443	22.693	229.853	185.023	0.61	0.58
5	T_5	RDF @ 50 % +$ZnSO_4$ @ 50 %+ Vermicompost @5 t ha^{-1}	0.272	0.270	0.45	0.43	296.23	291.12	29.053	24.340	230.763	187.200	0.81	0.67
6	T_6	RDF @ 50 % + $ZnSO_4$ @ 50 %+ Vermicompost @10 t ha^{-1}	0.267	0.263	0.47	0.41	308.75	301.49	30.027	24.540	231.657	187.570	0.86	0.75
7	T_7	RDF @ 100 %+$ZnSO_4$ @ 100 %+ Vermicompost @ 0 t ha^{-1}	0.265	0.264	0.46	0.44	313.87	304.98	30.177	25.557	232.107	194.237	0.88	0.78
8	T_8	RDF @ 100 %+$ZnSO_4$ @ 100 %+ Vermicompost @5 t ha^{-1}	0.264	0.262	0.54	0.51	325.41	315.27	31.423	27.247	233.803	195.957	0.090	0.79
9	T_9	RDF @ 100 % +$ZnSO_4$ @ 100 %+Vermicompost @10 t ha^{-1}	0.260	0.257	0.56	0.53	328.32	310.83	33.063	29.867	234.893	197.617	0.95	0.80
		F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
		C. D. at 5%	**0.044**	**0.038**	**0.021**	**0.010**	**0.043**	**0.274**	**0.713**	**0.526**	**0.713**	**0.526**	**0.51**	**0.057**
		S. Em. (±)	**0.021**	**0.018**	**0.010**	**0.005**	**0.021**	**0.129**	**0.336**	**0.248**	**0.336**	**0.248**	**0.024**	**0.027**

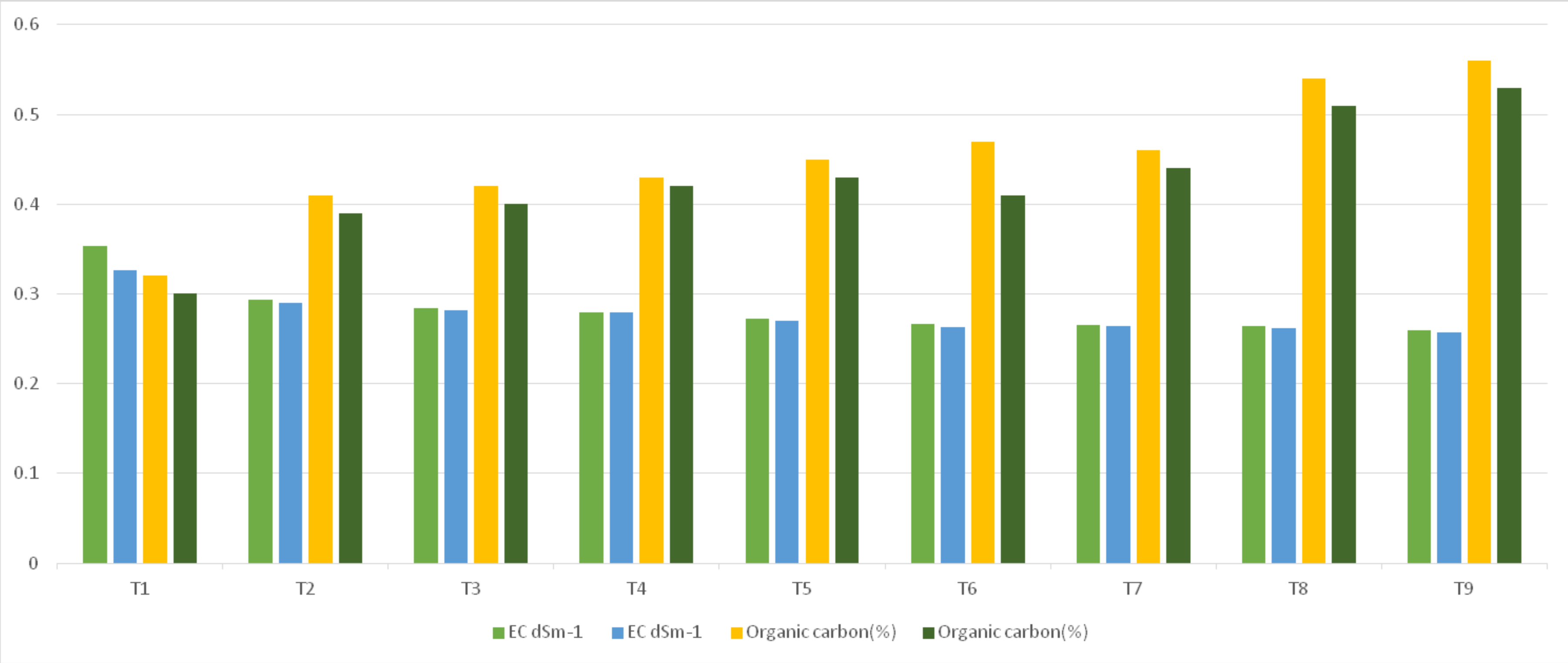

Fig. 2. Effect of different levels of NPK, vermicompost and zinc on EC, organic carbon

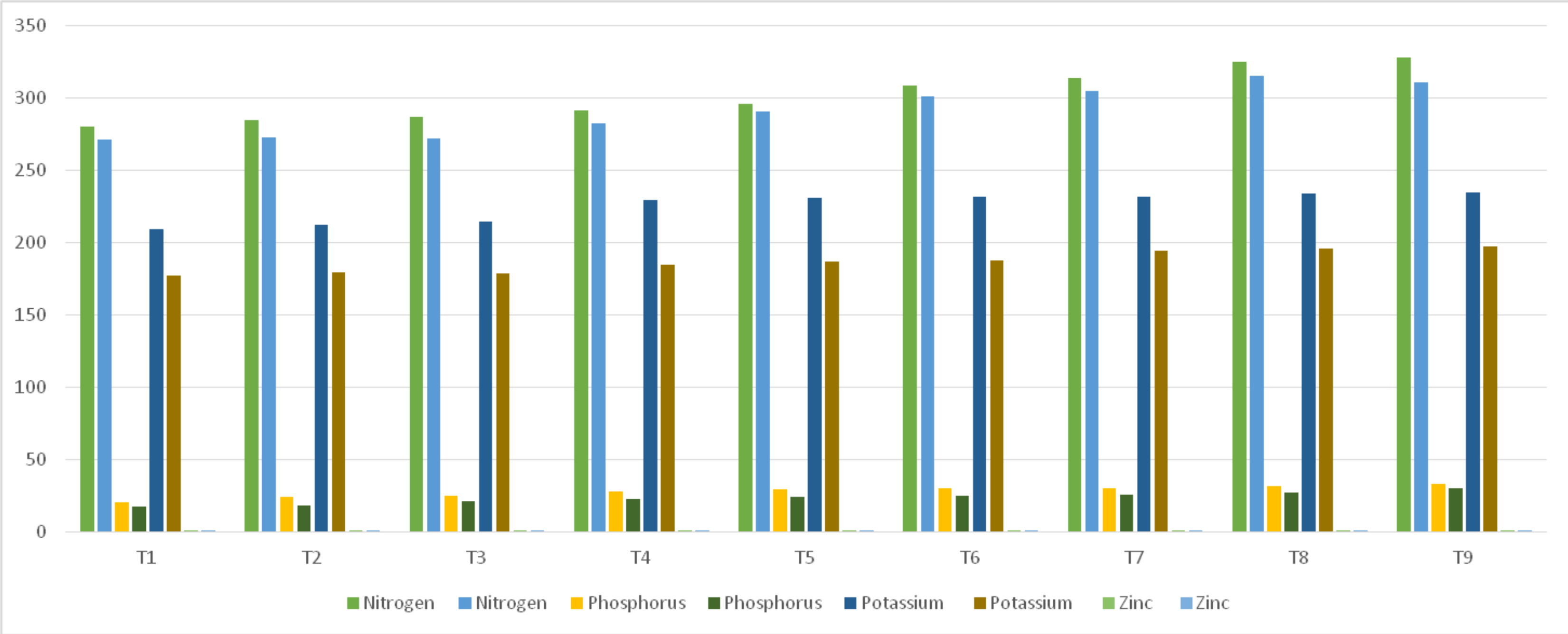

Fig. 3. Effect of different levels of NPK, Vermicompost and Zinc on Nitrogen, Phosphorus, potassium, and zinc

Table 4. Effect of different levels of NPK, Vermicompost and zinc on growth and yield attributes of cluster bean

			Plant height			No of leaves per plant			Pod length	No of pods per cluster	Pod wt.	Pod yield per plant	Pod yield t ha-1
S. No.	**Treatment no.**	**Treatment combination**	**30DAS**	**60DAS**	**90DAS**	**30DAS**	**60DAS**	**90DAS**					
1	T_1	Control	15.82	33.74	80.81	16.13	25.93	49.65	10.01	5.17	2.05	45.83	10.08
2	T_2	RDF @ 0 %+ $ZnSO_4$ @ 0 % + Vermicompost @5 t ha^{-1}	19.04	47.31	97.75	21.05	31.39	68.74	12.24	6.1	2.2	71.85	15.81
3	T_3	RDF @ 0 %+ $ZnSO_4$ @ 0 %+ Vermicompost @10 t ha^{-1}	19.25	48.83	102.28	21.93	38.61	71.82	13.01	6.18	2.24	77.73	17.11
4	T_4	RDF @ 50 % + $ZnSO_4$ @ 50 %+ Vermicompost @ 0 t ha^{-1}	18.39	41.42	90.17	17.81	33.41	62.97	11.43	5.84	2.12	64.22	14.13
5	T_5	RDF @ 50 % + $ZnSO_4$ @ 50 % + Vermicompost @5 t ha^{-1}	19.37	50.39	106.77	23.91	40.28	72.91	12.86	6.36	2.26	84.33	18.55
6	T_6	RDF@ 50 % + $ZnSO_4$ @ 50 %+ Vermicompost @10 t ha^{-1}	20.35	51.79	115.75	25.75	42.81	75.91	13.17	6.79	2.28	93.21	20.51
7	T_7	RDF @ 100 %+$ZnSO_4$ @ 100 %+ Vermicompost @ 0 t ha^{-1}	18.81	45.86	93.42	19.02	36.19	66.06	12.04	5.64	2.17	61.89	13.62
8	T_8	RDF @ 100 %+$ZnSO_4$ @ 100 %+ Vermicompost @5 t ha^{-1}	21.41	52.61	118.21	27.26	45.51	78.85	13.73	7.34	2.32	105.31	23.17
9	T_9	RDF @ 100 %+$ZnSO_4$ @ 100 %+ Vermicompost @10 t ha^{-1}	23.03	54.22	121.86	29.11	47.74	82.61	14.11	7.47	2.35	113.79	25.03
		F-Test	S	S	S	S	S	S	S	S	S	S	S
		C.D.at 5%	1.391	2.879	4.167	1.901	2.302	3.142	0.705	0.262	0.031	3.984	0.876
		S. Em. (±)	0.656	1.358	1.966	0.897	1.086	1.482	0.333	0.124	0.015	1.879	0.413

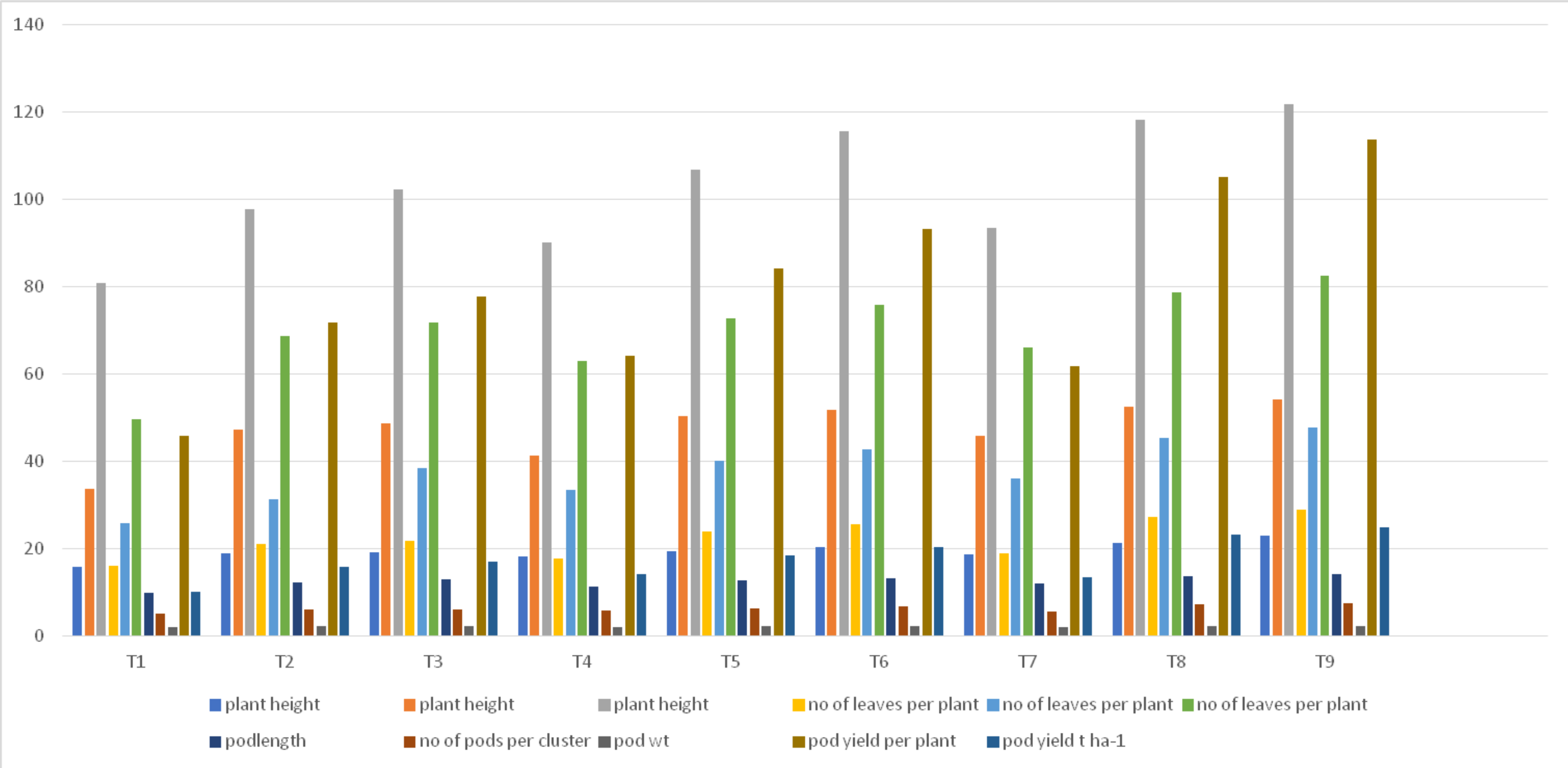

Fig. 4. Effect of different levels of NPK, Vermicompost and Zinc on growth and yield attributes

3.3 Effect of Integrated Nutrients on Growth Parameters and Yield Attributes of Cluster Bean

It is indicated from Table 4 that nutrient sources significantly improved the growth and yield attributes sof cluster bean. Among the nutrient sources100%RDF+100%$ZnSO_4$+ Vermicompost @10 t ha^{-1} gave highest values of plant height at 90DAS (121.86), no of leaves per plant at 90DAS (82.60) pod length (14.17), no of pods per cluster (7.47), pod weight (2.35g), pod yield per plant (113.79g), pod yield per plot (10.01kg), pod yield t ha^{-1} (25.03) [16,17].

4. CONCLUSION

Based on findings, it is concluded that the treatment combination 100% RDF+100% $ZnSO_4$+ Vermicompost @10 t ha^{-1} i.e., Treatment T_9 shows best result on physio-chemical properties of soil analysis after harvest of cluster bean (*Cyamopsis tetragonoloba* L.) in comparison to other treatment combination. The minimum bulk density (mg m^{-3}), particle density (mg m^{-3}), Water holding capacity, pH and EC ds m^{-1} was noted in 100% RDF+100%$ZnSO_4$+ Vermicompost @10 t ha^{-1} which was significantly superior over T_0 Control. Whereas the maximum pore space (%), organic carbon, available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}), Zinc (mg ha^{-1}) was noted in 100% RDF+100%$ZnSO_4$+ Vermicompost @10 t ha^{-1} which was significantly superior over T_0 Control.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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