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Response of vermicompost and neem cake on Soil health and yield attributes of cluster bean (*Cyamopsis tetragonoloba* L.) Var. Durgapura Safed

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Abstract
The present investigation carried out at research farm of department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Prayagraj, U.P. during the *kharif* season of 2019 with the objective to response of different levels of vermicompost and Neem cake on soil health, growth and yield attributes of Cluster bean [*Cyamopsis tetragonoloba* L.] Var Durgapura Safed. The experiment was laid out in a randomized block design with nine treatment combinations, consisting of three vermicompost levels (0, 50 and 100%) and neem cake (0, 50 and 100%). In soil parameters bulk density (Mg m^{-3}) of soil was recorded 1.28 Mg m^{-3} in treatment T_9 (100% vermicompost + 100% neem cake). Similar results were also reported in the particle density (Mg m^{-3}) of soil was recorded 2.72 Mg m^{-3} in treatment T_9 (100% vermicompost + 100% neem cake). Soil pore space was recorded 51.00% in treatment T_9 (100% vermicompost + 100% neem cake). It was observed that Soil pH after harvesting 7.20 which was recorded in T_9 (*i.e.* 100% vermicompost + 100% neem cake). Electrical conductivity (dS m^{-1}) after harvesting was 0.17 recorded with T_9 (*i.e.* 100% vermicompost + 100% neem cake). Organic carbon (%) of soil after harvesting was 0.70% in T_9 (*i.e.* 100% vermicompost + 100% neem cake). Available nitrogen in soil was 302.25 kg ha^{-1} after harvesting in T_9 (*i.e.* 100% vermicompost + 100% neem cake). Available phosphorus in soil was 27.69 kg ha^{-1} after harvesting and highest was in T_9 (*i.e.* 100% vermicompost + 100% neem cake). Available potassium in soil was 195.45 kg ha^{-1} after harvesting and highest was in T_9 (*i.e.* 100% vermicompost + 100% neem cake). It was observed that for postharvest, treatment T_9 (*i.e.* 100% vermicompost + 100% neem cake) was best in terms of growth, yield and economic parameters with maximum plant height 234.67 cm, number of leaves $plant^{-1}$ 42.91, number of clusters $plant^{-1}$ 31.96, pods $cluster^{-1}$ 12.82, pods $plant^{-1}$ 98.87, seeds per pod 8.87, pod yield 63.08 and maximum cost benefit ratio (C:B*)* of (1:4.28).

Keywords: Soil properties, organic fertilizers, vermicompost, neem cake, cluster bean

Introduction
Cluster bean popularly known as ‘guar’ is an important self pollinated, multipurpose, relatively drought resistant and restorative leguminous vegetable crop mainly grown under rainfed condition in arid and semi-arid regions of India during *kharif* season. It is grown for feed, fodder, vegetable, green manure as well as for gum production. Being legumes, it builds soil fertility and thus has a great role to play in nitrogen economy for succeeding crop. It is very hardy and drought tolerant crop. Its deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rainfed cropping. The crop also survives even at moderate salinity and alkalinity conditions. There is no other legume crop so hardy and drought tolerant as cluster bean, which is especially suited for soil and climate of Rajasthan. India is the source of about 80 per cent (3 million hectares) of the world production (Anonymous, 2011) [1]. Seed of cluster bean contain 28 to 33 per cent gum India leads the list of the major guar producing countries of the world contributing to around 75 to 80*%* in the world’s total production of around 7.5 to 10 lakh tonnes. In India Rajasthan is leading producer of the guar seed and guar gum. It around 70*%* of the total production in India. Haryana and Gujarat have second and third position respectively. Rajasthan has an area of 30 lakh hectare, production of 15.46 lakh tones with a productivity of 515 kg ha^{-1} (Anonymous,

2011) [1]. Haryana and Gujarat state themselves at the second and third positions regarding the production in India (Kherawat *et al*., 2013) [13]. The pods of cluster bean are as rich in food value as that of French bean. According to Aykroyd (1963) the composition of cluster bean is 81.0 (g) moisture, 10.8 (g) carbohydrate, 3.2 (g) protein, 1.4 (g) of fat, 1.4 (g) of minerals, 0.09 (mg) thiamine, 0.03 (mg) riboflavin, vitamin C, vitamin A (100 g^{-1}) of edible portion.

Vermicompost

Vermicompost is the product of the composting process using various species of worms, usually red wigglers, white worms and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicast (also called worm castings, worm humus, worm manure, or worm feces) is the end-product of the breakdown of organic matter by earthworms. These castings have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting. Vermicompost is rich in NPK (nitrogen 2-3%, phosphorus 1.55-2.25% and potassium 1.85-2.25%), micronutrients, beneficial soil microbes and also contain plant growth hormones & enzymes.

Neem cake

Neem cake has an adequate quantity of NPK in organic form for plant growth. Being a totally botanical product it contains 100% natural NPK content and other essential micro nutrients as N (Nitrogen 2.0 to 5.0%), P (Phosphorus 0.5 to 1.0%), K (Potassium 1.0 to 2.0%),

Ca (Calcium 0.5 to 3.0%), Mg (Magnesium 0.3 to 1.0%), S (Sulphur 0.2 to 3.0%), Zn (Zinc 15 to 60 ppm), Cu (Copper 4 to 20 ppm), Fe (Iron 500 to 1200 ppm), Mn (Manganese 20 to 60 ppm). It is rich in both Sulphur compounds and bitter limonoids**.** Neem cake improves the organic matter content of the soil, helping improve soil texture, water holding capacity, and soil aeration for better root development (Lokanadhan *et al.*, 2012) [19]. In spite of huge potential, it is being cultivated in limited area due to its low productivity levels and can be attributed mainly due to inadequate fertilization. Minimize the use of chemical fertilizers by addition of organic manures and biofertilizers of microbial origin (Gandhi *et al.*, 2010) [15]. Application of Organic manures like vermicompost showed an increased growth in terms of height and yield of the plant, it could be a better alternative to inorganic fertilizers (Tamilselvi *et al.*, 2009 and Indirabai *et al*., 2009).

Materials and Method

The experiment was conducted at research farm of department of Soil Science and Agricultural Chemistry which is situated six km away from Prayagraj city on the right bank of Yamuna river, the experimental site is located in the sub–tropical region with $25^0 24' 23''$N latitude, $81^0 50' 38''$E longitude and at an altitude of 98 m above mean sea level. The area of Prayagraj district comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ^{0}C-48 ^{0}C and seldom falls as low as 4 ^{0}C – 5 ^{0}C. The relative humidity ranges between 20 to 94 percent. The average rainfall in this area is around 1013.4 mm annually. The soil of experimental area falls in order of *Inceptisol*. The soil samples were randomly collected from three different sites in the experiment plot prior to tillage operation from a depth of 0-15 cm. The size of the soil sample was reduced by conning and quartering the composites soil sample and was air dried passed through a 2 mm sieve for preparing the sample for physical and chemical analysis.

Table 1: Treatment combinations of cluster bean

Treatment	Treatment combination
T_1	Control
T_2	@ 0% Vermicompost + @ 50% Neem cake
T_3	@ 0% Vermicompost + @ 100% Neem cake
T_4	@ 50% Vermicompost + @ 0% Neem cake
T_5	@ 50% Vermicompost + @ 50% Neem cake
T_6	@ 50% Vermicompost + @ 100% Neem cake
T_7	@ 100% Vermicompost + @ 0% Neem cake
T_8	@ 100% Vermicompost + @ 50% Neem cake
T_9	@ 100% Vermicompost + @ 100% Neem cake

Table 2: Physical analysis of pre sowing soil samples

Particulars	Results	Method employed
Sand (%)	58	Bouyoucos Hydrometer (Bouyoucos, 1927) [7]
Silt (%)	27	
Clay (%)	15	
Textural class	Sandy loam	
Soil Colour		Munsell Colour Chart (Munsell, 1971) [16]
Dry Soil	Pale brown Colour	
Wet Soil	Olive brown Colour	
Bulk density (Mg m^{-3})	1.37	Graduated Measuring Cylinder (Muthuaval *et. al.*, 1992 [17]
Particle density (Mg m^{-3})	2.42	
Pore Space (%)	47.53	

Table 3: Chemical Analysis of pre-sowing soil samples

Parameters	Method employed	Results
Soil pH (1:2)	Glass Electrode, pH meter (Jackson, 1958) [11]	7.50
Soil EC (dS m^{-1})	Electrical Conductivity meter (Wilcox, 1950) [27]	0.29
Organic Carbon (%)	Wet Oxidation Method (Walkley and Black's, 1947) [26]	0.39
Available Nitrogen (Kg ha^{-1})	Kjeldahl Method (Subbaih and Asija, 1956)	228.40
Available Phosphorus (Kg ha^{-1})	Colorimetric method (Olsen *et al*., 1954) [18]	20.00
Available Potassium (Kg ha^{-1})	Flame photometric method (Toth and Prince, 1949) [25]	148.30

Results and Discussion

After harvesting the maximum Bulk density (Mg m^{-3}) of soil was recorded 1.28 Mg m^{-3} in treatment T_1 (control) and minimum Bulk density (Mg m^{-3}) of soil was recorded 1.03 Mg m-3 in treatment T_9 (100% Vermicompost + 100% Neem cake). Similar results were also reported by Ramawat *et al.* (2017) [20] and Swapna *et al.* (2012). The maximum particle density (Mg m^{-3}) of soil was recorded 2.72 Mg m^{-3} in treatment T_9 (100% Vermicompost + 100% Neem cake) and minimum particle density (Mg m^{-3}) of soil was recorded 2.56 Mg m^{-3} in treatment T_1 (control). Similar results were also reported by Ramawat *et al.* (2017) [20] and Swapna *et al.* (2012). The maximum soil pore space was recorded 51.00% in treatment T_9 (100% Vermicompost + 100% Neem cake) and minimum soil pore space was recorded 44.90% in treatment T_1 (Control). Similar results were also reported by Ramawat *et al.* (2017) [20] and Swapna *et al.* (2012). The maximum soil pH was recorded 7.63 in treatment T_1 (control) and minimum soil pH was recorded 7.20 in treatment T_9 (100% Vermicompost + 100% Neem cake) Ramawatar *et al.* (2017) [20] and Swapna *et al.* (2012). The maximum EC (dS m^{-1}) of soil was recorded 0.17 dS m^{-1} in treatment T_9 (100% Vermicompost + 100% Neem cake) and minimum EC (dS m^{-1}) of soil was recorded 0.11 dS m^{-1} in treatment T_1 (control). Similar results were also reported by Sajid *et al.* (2009) [14] and Deepa *et al.* (2016) [9]. The maximum% organic carbon in soil was recorded 0.70% in treatment T_9 (100% Vermicompost + 100% Neem cake) which was significantly higher than any other treatment combination and the minimum% Organic carbon in soil was recorded 0.54% in treatment T_1 (control). Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were recorded by Jat *et al.* (2016). The maximum available Nitrogen in soil was recorded 302.25 kg ha^{-1} in treatment T_9 (100% Vermicompost + 100% Neem cake) which was significantly higher than any other treatment combination and the minimum available Nitrogen in soil was recorded 248.49 kg ha^{-1} in treatment T_1 (control). The increase in available Nitrogen in soil after crop harvest by Vermicompost and Neem cake seed inoculation might be due to increased efficiency of Nitrogen fixing capacity and nodule formation. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were also recorded by Muhammad *et al.* (2009) [14] and Deepa *et al.* (2016) [9]. The maximum available Phosphorus in soil was recorded 27.69 kg ha^{-1} in treatment T_9 (100% Vermicompost + 100% Neem cake) which was significantly higher than any other treatment combination and the minimum available Phosphorus in soil was recorded 21.00 kg ha^{-1} in treatment T_1 (control). Similar findings were also recorded by Muhammad *et al.* (2009) [14] and Deepa *et al.* (2016) [9]. The maximum available potassium in soil was recorded 195.45 kg ha^{-1} in treatment T_9 (100% Vermicompost + 100% Neem cake) which was significantly higher than any other treatment combination and the minimum available potassium in soil was recorded 115.65 kg ha^{-1} in treatment T_1 (control). Similar findings were also recorded by Kherawat *et al.* (2013) [13]

Table 4: Physical properties of soil sample after harvesting of cluster bean

Treatment	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Pore space (%)
T_1	1.28	2.56	44.90
T_2	1.27	2.61	45.58
T_3	1.25	2.64	46.38
T_4	1.22	2.65	46.69
T_5	1.20	2.66	47.40
T_6	1.17	2.68	48.09
T_7	1.07	2.68	49.27
T_8	1.05	2.71	50.38
T_9	1.03	2.72	51.00
F-test	S	S	S
S. Em (±)	0.017	0.025	0.03
C.D.	0.035	0.052	2.59

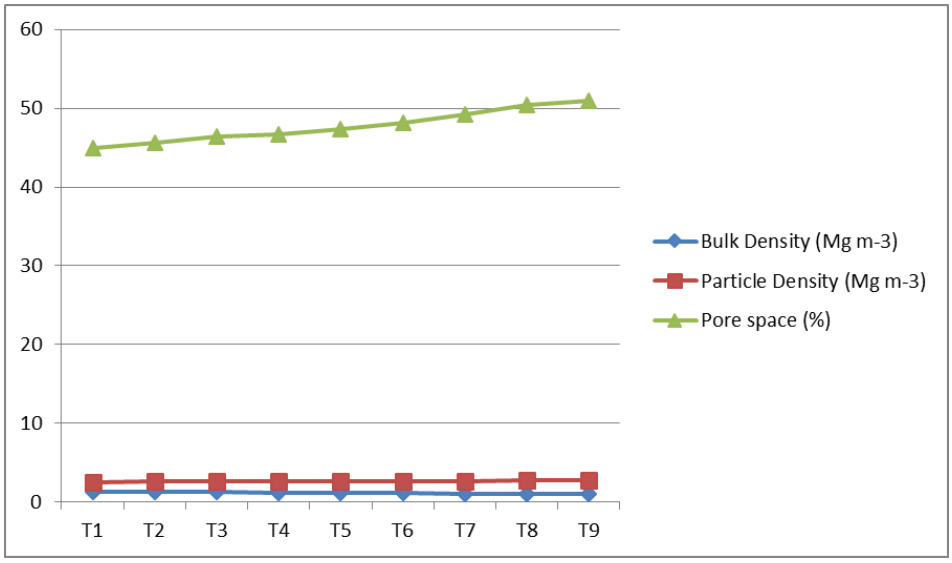

Fig 1: Physical properties of soil sample after harvesting of cluster bean

Table 5: Chemical properties of soil sample after harvesting of cluster bean

Treatments	pH	EC (dS m^{-1})	Organic Carbon (%)	Available Nitrogen (Kg ha^{-1})	Available Phosphorus (Kg ha^{-1})	Available Potassium (Kg ha^{-1})
T_1	7.63	0.11	0.54	248.49	21.00	115.65
T_2	7.70	0.12	0.55	253.29	21.42	124.02
T_3	7.67	0.13	0.58	262.09	22.20	132.22
T_4	7.43	0.13	0.61	266.73	22.49	145.45
T_5	7.37	0.14	0.62	273.11	22.75	157.49
T_6	7.33	0.14	0.64	278.89	23.55	167.75
T_7	7.25	0.16	0.67	288.42	24.83	174.78
T_8	7.20	0.16	0.68	297.22	25.97	183.73
T_9	7.20	0.17	0.70	302.25	27.69	195.45
F-test	S	S	S	S	S	S
S. Em. (±)	0.035	0.01	0.01	1.09	0.54	0.90
C.D. (P= 0.05)	0.075	0.02	0.02	2.32	1.15	1.90

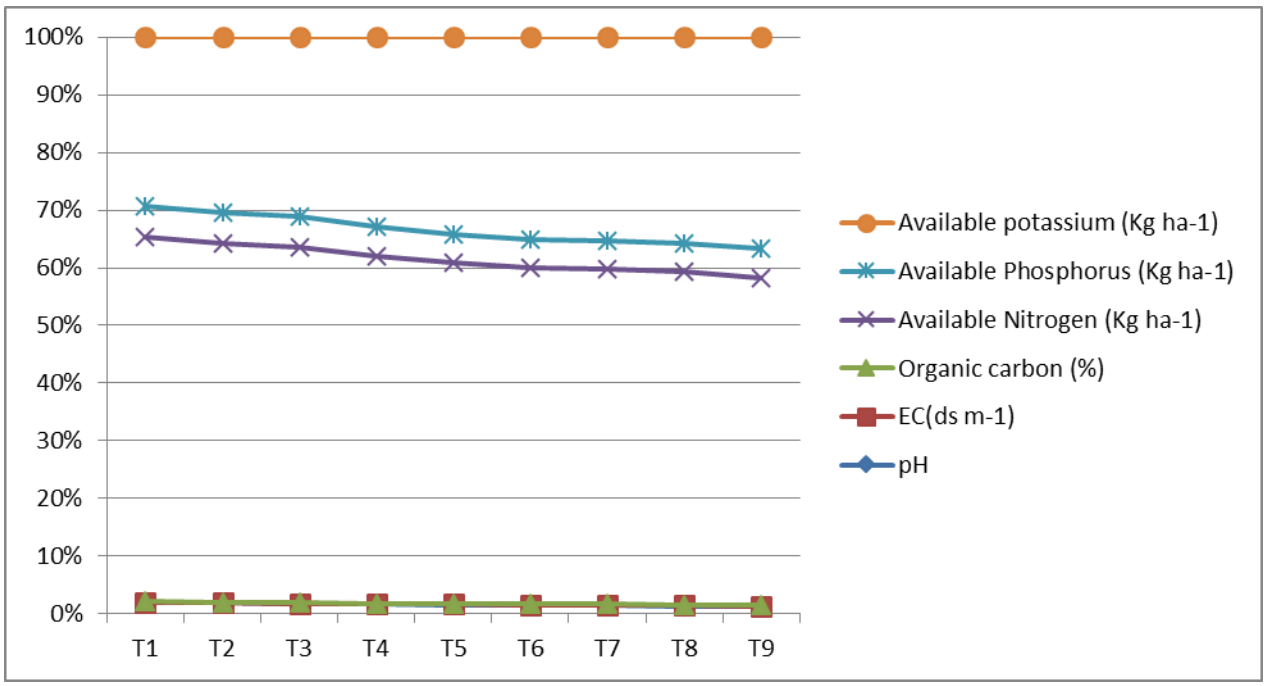

Fig. 2: Chemical properties of soil sample after harvesting of cluster bean

Summary

The salient findings of the present investigation are summarized as follows. As for as the growth and yield parameters are concerned maximum plant height 235.02 cm, number of leaves per plant 42.97, number of clusters per plant 32.15, pods per cluster 13.61, pods per plant 99.29, seeds per pod 8.96 and pod yield 64.19 remained with T_9 (*i.e.* 100% Vermicompost + 100%) neem cake followed by T_8 (*i.e.* 100% Vermicompost + 50% Neem cake). Plant height 79.07 cm, number of leaves 12.92, number of clusters per plant 11.79, pods per cluster 5.05, pods per plant 34.94, seeds per pod 4.24 and pod yield 34.26 was observed in the treatment T_1 (*i.e.* 0% Vermicompost + 0% Neem cake).Soil pH before sowing was 7.50 and after harvesting decreased to 7.20 which was recorded in T_9 and T_8 7.21 followed by 7.25 by T_7. Electrical conductivity dS m^{-1} of soil before sowing was 0.19 dS m^{-1} and after harvesting was 0.18 dS m^{-1} recorded with T_9 followed by T_8 -0.16 and T_7 (0.16). Organic carbon (%) of soil before sowing was 0.39 and after harvesting was 0.70% in T_9, followed by T_8- 0.68% Available nitrogen in pre-sowing soil was 228.4 kg ha^{-1} increased up to 302.25 kg ha^{-1} after harvesting and highest was in T_9 followed by T_8 297.22 kg ha^{-1}. Available phosphorus in pre-sowing soil was 20.0 kg ha^{-1} increased up to 27.69 kg ha^{-1} after harvesting and highest was in T_9, followed by T_8 25.97 kg ha^{-1}. Available potassium in pre-sowing soil was 148.30 kg ha^{-1} increased up to 195.45 kg ha^{-1} after harvesting and highest was in T_9, followed by T_8 183.73 kg ha^{-1}.

The Maximum gross return of ₹ 2,52,320.00 and Maximum net profit of ₹ 1,93,420.00 in treatment T_9 was best in increasing plant height, number of leaves, number of branches, yield, physical and chemical properties of soil like bulk density, particle density, pore space (%), EC, organic carbon, N, P, K, in guar plants. Maximum cost benefit ratio of 1:4.28 was in the treatment combination T_9 followed by 1:4.09 in T_8.

Conclusion

It was concluded that the treatment T_9 was the best in terms of all soil parameters like bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%), Soil pH, Electrical Conductivity (dS m^{-1}), Organic Carbon (%), Available Nitrogen, Phosphorus and Potassium (Kg ha^{-1}) and in growth parameters the plant height, number of leaves per plant, number of clusters per plant, pods per cluster, pods per plant, seeds per pod and pod yield was highest. Treatment T_9 (*i.e.* 100% vermicompost + 100% neem cake) was best in terms of economic parameters too with maximum gross return of ₹ 2,52,320.00 and net profit was ₹ 1,93,420.00 with cost benefit ratio (C: B) (1:4.28).

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