

Original Research Article

Nutrient uptake and physico-chemical properties of soil as affected by application of vermicompost, biofertilizers and inorganic fertilizers in chickpea (*Cicer arietinum* L.)

1. ABSTRACT

A field trial was conducted during *Rabi* 2020-21 in randomized block design with three replications and seven treatments comprising individual and combined application of various organic and inorganic nutrient sources at Research Farm, MMU Sadopur (Ambala), Haryana. The experiment was intended to evaluate the effect of vermicompost, biofertilizers and inorganic fertilizers applied in chickpea on nutrient uptake and physico-chemical properties of soil pH (8.24). The highest organic carbon (0.58%), electrical conductivity (0.51 dS m^{-1}), particle density (2.50 g/cm^3) and porosity (48.47%) along with maximum available N (126.5 kg ha^{-1}), P (23.2 kg/ha) and K (98.33 kg/ha) were observed in the treatment of T_6 i.e., 3 t/ha Vermicompost + *Rhizobium* + PSB. Similarly, the nutrient content (N, P and K) was maximum in seed and stover of chickpea harvested from the plots receiving 3 t/ha Vermicompost + *Rhizobium* + PSB, which was statistically at par with T_7 i.e., 2.5 t/ha Vermicompost + *Rhizobium* + PSB. The highest net return was recorded in plots treated with 50% RDF (Recommended dose of fertilizer) + *Rhizobium* + PSB and 75% RDF + *Rhizobium* + PSB with a benefit cost ratio (B: C) of 3.2 and 3.1, respectively. However, the seed yield in integrated nutrient management was comparable to recommended dose of chemical fertilizers.

Keywords: Chickpea, vermicompost, biofertilizer, inorganic fertilizers, *Rhizobium*, phosphate solubilizing bacteria

2. INTRODUCTION

Chickpea (*Cicer arietinum* L.), also known as Bengal gram, gram, *garbanzo* (Spanish), *Chana* (Hindi) and *Chanaka* (Sanskrit) is an important winter grain legume grown all over the world. It is an important source of protein for the vegetarians and is a good substitute of meat. Chickpea cultivation in India accounted for 85% of the world acreage and 69.75% of the chickpea production followed by Turkey (4.42%) and Russia (3.55%) (Anonymous, 2021a). Chickpea is cultivated on 9.85 mha of land with an annual production of 11.99 mt (Anonymous, 2021a). However, in Haryana, the crop is cultivated on a limited area of 44,000 ha with a production of 47,000 tonnes and productivity of 1068 kg/ha (Anonymous, 2021b). The crop requires annual rainfall of 600-1000 mm and average temperature of 20°C. It contains 18-22% protein and 65-70% carbohydrate, 4-10% fat and sufficient quantity of other minerals like calcium, phosphorus, iron, and vitamins along with calorific value of 365 kcal/100 g. Besides, it is also used as livestock feed and cash crop and helps in improving the soil fertility by virtue of its capacity to fix atmospheric nitrogen (Kumari *et al.*, 2019).

Low productivity of chickpea in India is primarily due to its cultivation on marginal soil. Various factors such as phosphorus solubilizing bacteria, seed priming and *Rhizobium* inoculation are known to have significant effect on chickpea production and productivity. The higher chickpea productivity and grain yield can be achieved through proper crop management (Sangma, 2018). Although the use of inorganic fertilizers are necessary to fulfill the plant requirement for nitrogen, phosphorus, potassium and other micro-nutrients but their excessive use leads to reduction in soil fertility and quality of the produce. Therefore, it is necessary to balance this negative effect of inorganic fertilizers with the use of organic amendments and biofertilizers. Application of vermicompost has been considered as one of the best organic method to increase the soil fertility as it provides essential macro- and micro-nutrients beneficial for crop growth (Aseware *et al.*, 2003).

The application of vermicompost also exerts a positive effect on the physical and biological properties of the soil including increase in macropore space, soil pH, microbial population and soil enzyme activities. Biofertilizers are cost effective and eco-friendly source of plant nutrition. Biofertilizers such as *Rhizobium* culture and phosphorus solubilizing bacteria (PSB) help in enhancing the productivity and profitability of pulse crops by fixing atmospheric nitrogen and by solubilizing insoluble soil phosphates and discharging plant growth substances

in the soil (Bajracharya and Rai, 2009). Therefore, present investigation was conducted to study the effect of vermicompost, biofertilizer and inorganic fertilizers on nutrient uptake, soil properties, seed and stover yield and economics of chickpea production.

3. MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2020-21 at the Research Field of Department of Agriculture, Maharishi Markandeshwar University, Sadopur, Ambala (Haryana) in triplicate sets of randomized block design (RBD) with seven treatments viz. T₁-Control, T₂-100% recommended dose of fertilizer (RDF), T₃- 75% RDF + *Rhizobium*+ phosphorus solubilizing bacteria (PSB), T₄-50% RDF + *Rhizobium* + PSB, T₅- 5 t/ha Vermicompost, T₆- 3 t/ha Vermicompost + *Rhizobium* + PSB and T₇- 2.5 t/ha Vermicompost + *Rhizobium* + PSB replicated thrice. Seeds of chickpea variety HC-5 were sown at 95 kg ha⁻¹ with a row spacing of 30 cm in triplicated plots of 4×3m. The gross and net size of the plots was 4.0×3.0 m and 3.7×2.5 m respectively.

The experimental site is situated at 30°42'39" N latitude and 76°77'69" E longitude and at an altitude of 264 m above mean sea level. The climate of the experimental site is designated as sub-tropical and semi-arid with hot and dry summer (April-June), hot and humid monsoon period (July-September) and cold winter (December-February).

Seed and stover yield per plot were recorded and converted to kg/ha. Soil samples randomly collected from different sites of the field up to a depth of 0-15 cm were analyzed for the physico-chemical properties.

The data was subjected to analysis of variance and the treatments were compared at 5% level of significance (P= 0.05) following Statistical Software Package for Agricultural Research Workers (Sheoran *et al.*, 1998).

Economics (net and gross returns) of various treatments in chickpea cultivation was worked out on the basis of prevailing market price of various inputs and seed and stover yield

of chickpea. The gross returns of the treatments were calculated based on sale price of chickpea in market during the period under study. The net return was worked out by subtracting the cost of cultivation from gross return and B:C was calculated by dividing net returns of the treatments by their cost of cultivation.

4. RESULTS AND DISCUSSION

Physico-chemical properties of soil

Table 1: Effect of vermicompost, biofertilizers and inorganic fertilizers on physico-chemical properties of soil

Treatments	pH (1:2)	EC (dS m ⁻¹)	OC (%)	Bulk density (g/cm ³)	Particle density (g/cm ³)	Porosity (%)
T ₁ : Control	7.21	0.40	0.42	1.37	2.36	45.08
T ₂ : 100% RDF	7.30	0.42	0.46	1.34	2.41	45.17
T ₃ : 75% RDF + <i>Rhizobium</i>	7.45	0.45	0.54	1.31	2.43	45.22
T ₄ : 50% RDF + <i>Rhizobium</i> + PSB	7.63	0.43	0.51	1.30	2.39	46.12
T ₅ : 5 t/ha Vermicompost	7.92	0.46	0.49	1.29	2.44	44.32
T ₆ : 3 t/ha Vermicompost + <i>Rhizobium</i> + PSB	8.24	0.51	0.58	1.26	2.50	48.47
T ₇ : 2.5 t/ha Vermicompost + <i>Rhizobium</i> + PSB	8.11	0.48	0.55	1.27	2.47	47.60
S.E.m(±)	0.02	0.006	0.004	0.011	0.02	0.022
C.D. (P=0.05)	0.061	0.019	0.014	0.034	0.061	0.067
CV (%)	0.439	2.375	1.491	1.423	1.401	0.081

The data presented in table 1 revealed that the highest pH (8.24) and organic carbon (0.58%) of soil was observed with the treatment T₆: 3 t/ha vermicompost + *Rhizobium* + PSB and electrical conductivity (0.51dS m⁻¹) which were significantly better than 100% RDF and combinations of inorganic fertilizers with Rhizobium and PSB, followed by T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB. In Ethiopia, Chala and Obsa (2017) found that the highest organic carbon contents 3.40% and 3.36% were found in plots treated with full doses of farm yard manure and compost, respectively. However, the lowest pH, electrical conductivity and organic carbon were recorded with untreated control plots. The maximum bulk density (1.37 g/cm³) was recorded in the treatment T₁: Control while it was the lowest (1.26 g/cm³) in treatment T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB, T₇: 2.5 t/ha vermicompost + *Rhizobium* + PSB and T₅: 5 t/ha vermicompost, which were statistically on par with each other. On the other hand, maximum particle density (2.50 g/cm³) and porosity (48.47%) were recorded with the treatment T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB and the minimum particle density and porosity of 2.36 g/cm³ and 45.08%, respectively were recorded in treatment T₁: Control (Table 2).

Yadav *et al.* (2022) indicated that available nitrogen, phosphorus, potassium were observed significantly maximum under the application of 2 t ha⁻¹ vermicompost compared to other organic manure treatments while bulk density, particle density, pH, EC were non-significant due to organic manure treatment and liquid organic manure treatment

Available nitrogen, phosphorus and potassium in soil (kg ha⁻¹)

Table 2: Effect of vermicompost, biofertilizers and inorganic doses on soil available NPK content

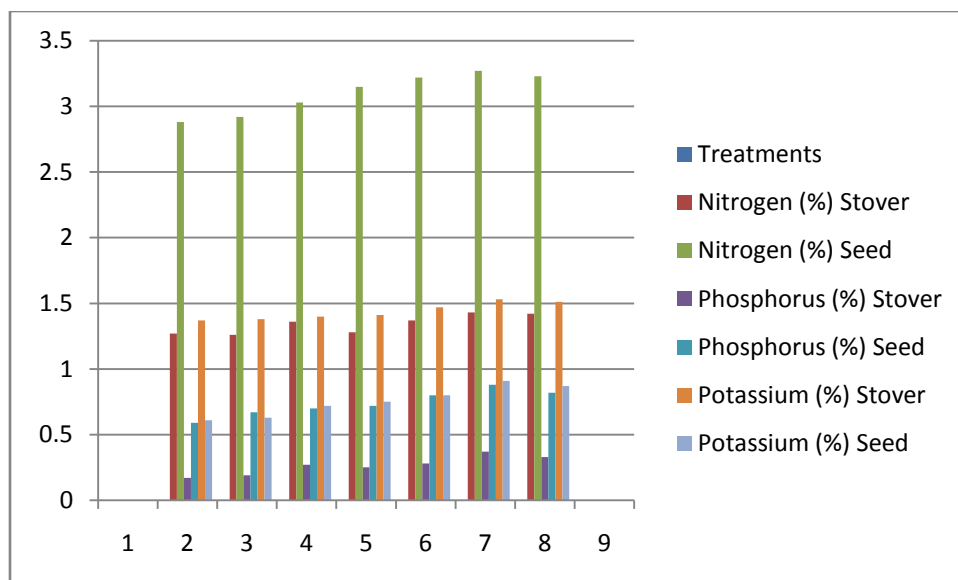
Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T1: Control	106.5	15.8	78.3
T2: 100% RDF	110.1	16.7	80.4
T3: 75% RDF + <i>Rhizobium</i>	114.7	18.4	85.2
T4: 50% RDF + <i>Rhizobium</i> + PSB	112.5	17.2	83.8

T5: 5 t/ha Vermicompost	120.1	19.4	88.3
T6: 3 t/ha Vermicompost + <i>Rhizobium</i> + PSB	126.5	23.2	98.3
T7: 2.5 t/ha Vermicompost + <i>Rhizobium</i> + PSB	123.2	21.6	94.3
S.E.m(±)	0.052	0.061	0.057
C.D. (P=0.05)	0.162	0.189	0.177
CV (%)	0.077	0.555	0.113

The available N, P and K in the soil after harvest was significantly higher (126.5 kg/ha), (23.2 kg/ha) and (98.3 kg/ha) in treatment T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB followed by T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB while the control plots had significantly lower available N(106.5 kg/ha), P (15.8 kg/ha) and K (78.3 kg/ha). Among the various treatments, the treatments having biofertilizers resulted in higher nitrogen, phosphorus and potassium content after harvesting as the biofertilizers contain micro-organisms and are known to fix atmospheric nitrogen or solubilize insoluble phosphate or produce hormones, vitamins and other growth regulators required for plant growth. Balai *et al.* (2017) found that increasing level of phosphorus application increased the available nitrogen, phosphorus and potassium content in soil after harvest of the crop. Likewise, the highest available phosphorus (23.2 kg/ha) and potassium (98.3 kg/ha) in the soil after harvest of chickpea crop was recorded in treatment T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB which was statistically at par with treatment T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB.

Nitrogen, phosphorus and potassium content (%) in stover and seed

Figure 1: Effects of vermicompost, biofertilizers and inorganic fertilizers on NPK content in stover and seed of chickpea



The data presented in Figure 1, revealed that the maximum N, P and K content in stover (1.43, 0.37 and 1.53%) and seed (3.27, 0.88 and 0.91%) was found with the application of T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB and T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB while the N, P, K content in stover (1.27, 0.17%, 1.37%) and seed (2.88, 0.59%, 0.61%) was minimum in unfertilized plots. They also observed that N content and uptake in seed and straw increased significantly with increasing levels of phosphorus upto 60 kg ha⁻¹ in straw increased significantly upto 40 kg P₂O₅ ha⁻¹. Balai *et al.* (2017) reported that P content and uptake by grain and straw was significantly increased by applying increasing level of phosphorus upto 60 and 40 kg P₂O₅ ha⁻¹, respectively.

Kemal *et al.* (2018) reported that in the first season, the maximum amount of nitrogen taken up by the grain (127.96 kg ha⁻¹) was recorded with application of 100% RDF (18 kg N ha⁻¹ and 46 P₂O₅ kg ha⁻¹) followed by application of INM treatments, while the lowest value (50.22 kg ha⁻¹) was recorded from the unfertilized plot. The second season result indicated that application of chemical fertilizer and INM treatments were statistically at par and significantly improved grain N uptake compared to the unfertilized treatment. The two years mean result also indicated that application of chemical fertilizer and INM treatments significantly improved straw N uptake.

Table 3: Effect of vermicompost, biofertilizers and inorganic fertilizers on yield and harvest index of chickpea

Treatments	Seed yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T ₁ : Control	12.37	17.89	30.26	40.87
T ₂ : 100% RDF	13.43	18.86	32.29	41.69
T ₃ : 75% RDF + <i>Rhizobium</i>	14.92	19.50	34.43	43.42
T ₄ : 50% RDF + <i>Rhizobium</i> + PSB	15.86	20.80	36.67	43.24
T ₅ : 5 t/ha Vermicompost	16.79	21.41	38.20	43.88
T ₆ : 3 t/ha Vermicompost + <i>Rhizobium</i> + PSB	18.89	23.47	42.36	44.43
T ₇ : 2.5 t/ha Vermicompost + <i>Rhizobium</i> + PSB	16.97	21.40	38.37	44.22
SEM(±)	1.19	1.20	1.96	1.97
C.D. (P=0.05)	3.71	3.76	6.12	3.48
CV (%)	13.24	10.20	9.44	7.92

Seed and stover yield

The data presented in Table 3 revealed that the highest seed yield (18.89 q ha⁻¹), stover yield (23.47 q ha⁻¹) was recorded with application of T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB which was statistically at par with T₄: 50% RDF + *Rhizobium* + PSB, T₅: 5 t/ha Vermicompost and T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB (16.97 q ha⁻¹). The minimum seed and stover yield (12.37 and 17.89 q ha⁻¹) was observed in the control plots. Treatment T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB gave the highest harvest index of 44.43% closely followed by T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB and T₅: 5 t/ha Vermicompost. The highest biological yield was observed in T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB (42.36q ha⁻¹) which was statistically at par with T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB (38.37 q ha⁻¹) and the lowest biological yield was observed in T₁: Control (30.26q ha⁻¹) (Table 3).

Economics of different treatments

Table 4: Effect of vermicompost, biofertilizers and inorganic fertilizers on economics of different treatments

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C
T ₁ : Control	15657	56520	40863	2.6
T ₂ : 100% RDF	18468	74680	56212	3.0
T ₃ : 75% RDF + <i>Rhizobium</i> + PSB	19895	82520	62625	3.1
T ₄ : 50% RDF + <i>Rhizobium</i> + PSB	18349	78440	60091	3.2
T ₅ : 5 t/ha Vermicompost	35657	83600	47943	1.3
T ₆ : 3 t/ha Vermicompost + <i>Rhizobium</i> + PSB	29787	98760	68973	2.3
T ₇ : 2.5 t/ha Vermicompost + <i>Rhizobium</i> + PSB	27787	91560	63773	2.2

The data on economics of various treatments presented in Table 4 indicated that the cost of cultivation varied according to the application of different treatments. Among the various treatments, the cost of cultivation was the minimum 15657 ₹/ha in untreated control and maximum (35657 ₹/ha) in treatment T₅: 5 t/ha Vermicompost. Significantly higher gross returns were 98760 ₹/ha recorded with the application of T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB and T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB (91560 ₹/ha). Significantly higher net return of 68973 ₹/ha recorded with the application of T₆: 3 t/ha Vermicompost + *Rhizobium* + PSB followed by T₇: 2.5 t/ha Vermicompost + *Rhizobium* + PSB (63773 ₹/ha). The minimum net return 40863 ₹/ha was recorded with the treatment T₁: Control. The highest B: C ratio of 3.2 and 3.1 was observed with the treatment T₄: 50% RDF + *Rhizobium* + PSB and T₃: 75% RDF + *Rhizobium*, respectively followed by 100% RDF (3.0). The treatments comprising of vermicompost + *Rhizobium* + PSB were found to be less economical as compared to T₃: 75% RDF + *Rhizobium* and T₄: 50% RDF + *Rhizobium* + PSB due to higher cost of vermicompost.

5. CONCLUSION

In present investigation, comparative analysis was intended to assess the efficacy of various components providing nutrients to chickpea crop. Seven treatments viz. T₁-Control, T₂-100% recommended dose of fertilizer (RDF), T₃- 75% RDF + *Rhizobium*+ phosphorus solubilizing bacteria (PSB), T₄-50% RDF + *Rhizobium* + PSB, T₅- 5 t/ha Vermicompost, T₆- 3 t/ha Vermicompost + *Rhizobium* + PSB and T₇- 2.5 t/ha Vermicompost + *Rhizobium* + PSB replicated thrice were compared for their effect on seed yield and its components, nutrient in grain and straw and soil properties.

Among seven nutrition treatments, combination of 3 t/ha Vermicompost + *Rhizobium* + PSB appeared best for better physico-chemical properties of soil, NPK content in stover and seed of chickpea, higher seed and stover yield and economics of chickpea.

Higher seed yield and nutrient uptake in seed and straw could be attributed to favourable effects of organic carbon provided through vermicompost, recommended dose of nitrogen supplemented by biological nitrogen fixation through rhizobium post-interaction and phosphorus solubilization and mobilization by phosphate solubilizing bacteria. Such synergetic effects among components of integrated nutrient management has been reported in some leguminous crops including chickpea (Kemal *et. al.* 2018), mungbean (Hou *et. al.* 2019).

The seed yield and nutrient contents in grain and straw were higher in T₆ that indicated its worth for food for human beings and feed for livestock. Also, its economics was higher than the RDF, because of higher production and lower input cost. Also, the soil ecosystem is expected to be improved leading to better nutrient dynamics and higher nutrient use efficiency due to favourable impacts of organic adjuvants like vermicompost and PSP's, a view of above facts, it is concluded that integrated nutrient management including vermicompost, *rhizobium* should be followed for sustainable chickpea production and better soil environment.

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