



Effect of Integrated Nutrient Management on Performance of Chickpea (*Cicer arietinum* L.) and Soil Properties

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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

Present field experiment was conducted at farmer's field in Ringondiya village, Madhya Pradesh during rabi season 2018-19 to study the effect of integrated nutrient management practices on performance of chickpea, basic soil properties and nutrient availability. The performance of chickpea (cv. JG-322) was evaluated under seven treatments viz., T1-Control, T2-100% N:P:K (20:50:20), T3-50% N:P:K + FYM @5 t ha⁻¹, T4-50% N:P:K + vermicomposting @2 t ha⁻¹, T5-50% N:P:K + PSB @4 kg ha⁻¹, T6-50% N:P:K + FYM @5 t ha⁻¹ + PSB @4 kg ha⁻¹ and T7-50% N:P:K + vermicomposting @2 t ha⁻¹ + PSB @4 kg ha⁻¹ replicated thrice in a randomized block design. The grain yield, straw yield and harvest index of chickpea were determined at harvest. Similarly, the soil pH, electrical conductivity, soil organic carbon and soil available nutrients (N, P and K) were also determined in post harvest soil samples. The results revealed that the integrated nutrient management practice significantly improved the performance of chickpea. The soil organic carbon and available nutrients were also found increased under INM practices.

Keywords: INM; chickpea; yield; soil organic carbon; available nutrients.

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1. INTRODUCTION

Chickpea (*Cicer spp.*) is a Pulse crop of the Papilionaceae Family (Leguminaceae). It originated in South-West Asia (Turkey). Nutritionally, it contains 18-22% protein, 60-65% carbohydrates and 3-3.2% minerals [1]. It has the ability to fix atmospheric nitrogen in root nodules and can also tolerate high temperatures during and after flowering (Jenkins 2012). It is one of the earliest cultivated legumes, grown usually as a rain fed cool-season crop or as a dry climate crop in the semi-arid regions. Chickpea is the third most important pulse crop, after dry bean or peas produced in the world. It accounts for about 20% of the world pulses production. India is the one of the largest producer of chickpea. Chickpea is grown over an area of about 13.99 million ha, with a production of about 13.75 mt and productivity is the about 982.0 kg ha⁻¹ (FAO, 2018). Madhya Pradesh state is the single largest producer in the country, accounting for over 42 per cent of total production. The area under chickpea cultivation in Madhya Pradesh is 28.55 lakh ha which produces 29.65 lakh mt with an average yield of 1040 kg ha⁻¹ (Anonymous, 2018).

The indiscriminate and imbalanced application of chemical fertilizers posing many hazard including loss of soil fertility, deterioration of soil health, degraded produce quality, pollution of air, water and soil etc (Ajmal *et al.*, 2018). Therefore it is essential to restore the inputs for the Indian agriculture through enhancing the efficiency of the inorganic fertilizers and cost effectiveness of farming systems. Thus, in order to overcome the problem, INM is considered as the most appropriate and logical approach. It involve efficient and judicious supply of all the major components of plant nutrients in sources of nutrient fertilizers in conjunction with animal of manures in soil like compost, FYM, bio fertilizers, crop residues or waste recycle crops residues and other locally available nutrient sources for sustaining soil fertility or soil health and productivity of soil [2].

Chickpea is considered to sustain cropping system due to its ability to fix atmospheric nitrogen. The crop possesses nodules on its roots which act as a habitat for bacteria of the genus *Rhizobium* live. It converts the atmospheric nitrogen into the plant available form called biological nitrogen fixation [3]. In this an appreciable amount of free of the cost nitrogen is

deposited in the soil can be used by the Chickpea crop and subsequent crop. The efficiency of such Chickpea in fixing maximum nitrogen depends upon the cultivar and efficient strain or management practices in soil. Hence the use of microbial culture is gaining particular attention now days. Similarly, the application of vermicomposting and farmyard manure (FYM) is also known for their beneficial effects on sustaining soil health [4]. Considering these facts present experiment was conducted to study the effect of various INM modules on performance of chickpea and soil properties in central Indian state Madhya Pradesh.

2. MATERIALS AND METHODS

2.1 Study Area

The Rignodiya village is situated 22.43 N and 75.66 E with an altitude of 555.5 meters above the mean of sea level. The climate of this region is categorized as semi-arid and sub-tropical having minimum and maximum temperature of 5°C in winter and 43°C in the summer season, respectively. The area receives around 850 mm rainfall annually. The rainfall occurs mostly from last week of June to the first week of the October. The late commencement, early withdrawal of monsoon and two to three dry spells are the main features of rainy season.

2.2 Initial Soil Properties

The dominating soils of the study area are shallow, medium, and high black to deep black with dark brown coloration. Some patches of light textured soils are also found. Under broad classification, these soils are grouped into the Vertisols and associated soils. These soils are Montmorillonitic, calcareous, neutral to alkaline in reaction and having high swell-shrink properties. The cultivated soils are mostly clay loam in texture with high moisture retention capacity. The soils in general were neutral to slightly alkaline in reaction, with low to medium in soil fertility status with respect to available N and P, while they were high in K content (Table 1).

2.3 The Experiment

The experiment was laid out in a randomized block design (RBD) with 7 treatment combinations replicated 3 times (Table 2).

Table 1. Initial properties of experimental soil

| Soil properties | Value |
|------------------------------------|-------|
| pH | 7.8 |
| EC (dS m ⁻¹) | 0.18 |
| Organic carbon (%) | 0.70 |
| Available N (kg ha ⁻¹) | 223.4 |
| Available P (kg ha ⁻¹) | 12.96 |
| Available K (kg ha ⁻¹) | 391.9 |

Table 2. Treatment details

| Treatment | Details |
|----------------|--|
| T ₁ | Control |
| T ₂ | 100 % N:P:K (20:50:20) |
| T ₃ | 50 % N:P:K + FYM @5 t ha ⁻¹ |
| T ₄ | 50 % N:P:K + vermicompost @2 t ha ⁻¹ |
| T ₅ | 50 % N:P:K + PSB @4 kg ha ⁻¹ |
| T ₆ | 50 % N:P:K + FYM @5 t ha ⁻¹ + PSB @4 kg ha ⁻¹ |
| T ₇ | 50 % N:P:K + vermicompost @2 t ha ⁻¹ + PSB @4 kg ha ⁻¹ |

The details of the layout of experiment are given in Table 3. The experimental field was prepared by tractor drawn cultivator of followed by cross disking and power tiller, till fine seed bed and obtained in field. The treatment wise chemical fertilizers and manures were applied uniformly to each plot as basal dose in soil. The seeds of chickpea variety JG-322 were treated with fungicide and then with bio-culture PSB and sowing was carried out at seed of 80 kg ha⁻¹. The weed was controlled by hand weeding in all treatments. The irrigation was provided as and when required. The crop was harvested at maturity.

Table 3. Experiment details

| | | |
|--------------------------------|---|---|
| Design | : | RBD |
| Replications | : | 03 |
| Treatments | : | 07 |
| Crop | : | Chickpea |
| Variety | : | JG-322 |
| Plot size | : | 08 x 3.25 m |
| Net plot size | : | 07 x 03 m ² =21 m ² |
| Spacing between plots | : | 15 cm |
| Treatment size | : | 01 x 03 m |
| Spacing between rows | : | 30 cm |
| Spacing between plant to plant | : | 15 cm |
| Date of sowing | : | 10/11/ 2018 |
| Date of harvesting | : | 21/3/2019 |
| Date of threshing | : | 25/3/2019 |

2.4 Determination of Yield and Harvest Index

The harvested bundles of crop were air dried, and weighed. The seeds from the respective bundles were threshed and grain and straw yields of chickpea were recorded. The recorded yield was converted to kg ha⁻¹ using appropriate conversion factors. The harvest index was calculated by dividing the grain yield with total biomass.

2.5 Soil Sampling and Analysis

The soil samples were collected from 0-20 cm depth in each plot with the help of a tube auger and screw auger. The collected soil samples were air dried in a shade and crushed with wooden mortar and pestle. The visible stones, plant materials, roots, etc, were separated. The samples were then passed through 2 mm sieve and used for analysis. Soil pH was determined in a 1:2 soil: water suspension using a glass electrode pH meter [5]. After determination of pH, the same soil suspension was used for determinations of electrical conductivity (EC) after proper settlement of soil particles. The EC of supernatant liquid was determined using conductivity meter [5]. The soil organic carbon was determined by dichromate oxidation method [6]. Similarly, soil available N [7], P [8] and K [9] were determined by standard methods.

2.6 Statistical Analysis

The data obtained during the investigation was statistically analyzed and the differences among the treatment means were tested for their significance ($P < 0.05$) as per the standard methods outlined by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1 Performance of Chickpea under INM

The grain yield of chickpea ranged 1252-2185 kg ha⁻¹ with an average value of 1726 kg ha⁻¹ among the studied INM practices (Table 4). The application of 50% recommended dose of chemical fertilizers along with 2t vermicompost and 4 kg ha⁻¹ PSB culture (T7) followed by the treatment receiving the FYM @ 5t ha⁻¹ + PSB + 50% recommended dose of chemical fertilizers (T6) reflected as a best treatment with respect to the grain yield of chickpea. The treatment control (T1) showed poor performance. The application of sole PSB along with 50% NPK (T5) found statistically at par with the treatment receiving the 100% NPK alone (T2). Similarly, the straw yield of chickpea ranged 2021-3315 kg ha⁻¹ with an average value of 2723 kg ha⁻¹ among the studied INM practices (Table 4). The application of 50% recommended dose of chemical fertilizers along with 2t vermicompost and 4 kg ha⁻¹ PSB culture (T7) followed by the treatment receiving the FYM @ 5t ha⁻¹ + PSB + 50% recommended dose of chemical fertilizers (T6) reflected as a best treatment with respect to the straw yield of chickpea. The total biomass (seed+straw) of chickpea ranged 3273-5500 kg ha⁻¹ with an average value of 4449 kg ha⁻¹ among the studied INM practices (Table 4).

The application of 50% recommended dose of chemical fertilizers along with 2t vermicompost and 4 kg ha⁻¹ PSB culture (T7) followed by the treatment receiving the FYM @ 5t ha⁻¹ + PSB + 50% recommended dose of chemical fertilizers (T6) reflected as a best treatment with respect to the total biomass of chickpea. The INM treatments involving the application of either VC or FYM recorded significantly higher grain yield, straw yield and total biomass of chickpea. Further, the combined application of 50% NPK along with PSB (T5) found at par with the treatment receiving 100% NPK alone (T2). Thus the application of PSB showed better performance in determination of yield of chickpea. The harvest index (HI) of chickpea ranged between 35.6 and 40.9 among the studied treatments (Fig. 1). However, the INM practices did not show significant effect on HI of chickpea. The improved crop performance under INM practices may be due to the cumulative effects [10] on soil available nutrients resulting from enhanced organic carbon [11] and its mineralization by higher microbial population [12]. The positive effect of INM practices on crop performance has already been already documented [13].

3.2 Effect of INM on Soil Properties

The pH of soil determined at chickpea harvest ranged 7.58-8.11 with an average value of 7.80 among the studied INM practices (Table 5). Similarly, the EC of soil determined at chickpea harvest ranged 0.15-0.20 with an average value of 0.18 among the studied INM practices. However, the INM practices did not show significant effect on soil pH and EC at chickpea harvest. Yadav and Chhipa [14] and Solomou et al. [15] had also recorded non-significant changes in soil pH and EC with the application of

Table 4. Grain yield, straw yield and total biomass of chickpea under various INM practices

| Treatment | Grain yield (kg ha ⁻¹) | Straw yield (kg ha ⁻¹) | Total Biomass (kg ha ⁻¹) |
|----------------------------|------------------------------------|------------------------------------|--------------------------------------|
| T1: Control | 1252 | 2021 | 3273 |
| T2: 100 % N:P:K (20:50:20) | 1525 | 2205 | 3730 |
| T3: 50 % N:P:K + FYM | 1665 | 2670 | 4335 |
| T4: 50 % N:P:K + VC | 1886 | 2895 | 4781 |
| T5: 50 % N:P:K + PSB | 1575 | 2847 | 4422 |
| T6: 50 % N:P:K + FYM + PSB | 1995 | 3110 | 5105 |
| T7: 50 % N:P:K + VC +PSB | 2185 | 3315 | 5500 |
| SEm(±) | 148 | 218 | 366 |
| CD (P<0.05) | 406 | 638 | 1044 |

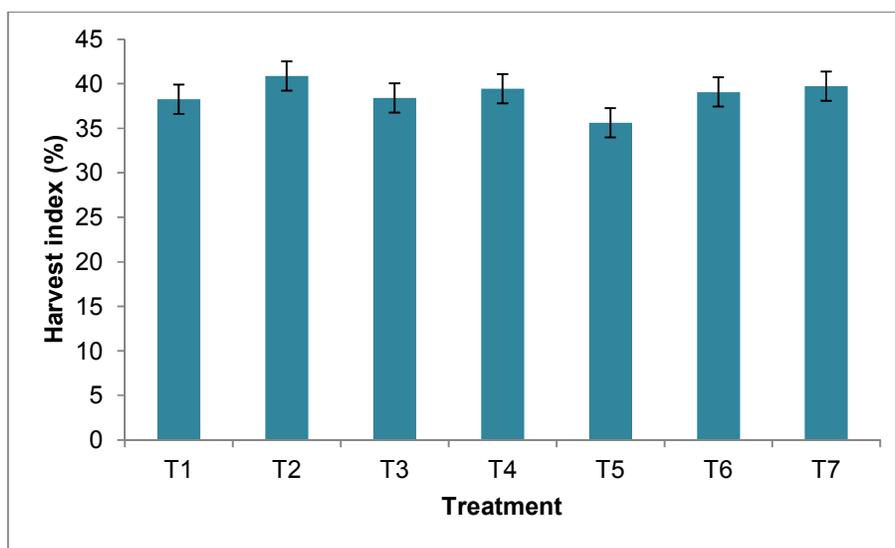


Fig. 1. Harvest index of chickpea under various INM practices (T1- Control; T2-100% N:P:K (20:50:20); T3-50% N:P:K + FYM; T4-50% N:P:K + VC; T5-50% N:P:K + PSB; T6-50% N:P:K + FYM + PSB; T7-50% N:P:K + VC +PSB; Error bar indicates standard deviation)

organic manures either alone or in combination with chemical fertilizers which may be attributed to the fact that the soil pH and EC is mainly affected by the parent material involved in soil formation and the climatic conditions [16]. However, in contrast, Hangarge et al. [17] reported significantly lower electrical conductivity with the combined application of organic manures.

The soil organic carbon (SOC) determined at chickpea harvest ranged 0.64-0.75% with an average value of 0.69% among the studied INM practices (Table 5).

The application of 50% recommended dose of chemical fertilizers along with 2t vermicompost and 4 kg ha⁻¹ PSB culture (T7) followed by the treatment receiving the FYM @ 5t ha⁻¹ + PSB + 50% recommended dose of chemical fertilizers (T6) reflected as a best treatment with respect to

the SOC increment at chickpea harvest. The treatment control (T1) recorded lowest SOC (0.64%) among all the treatments. In general, the INM treatments involving the application of either VC or FYM recorded significantly higher SOC at chickpea harvest. The observed increase in SOC attributed to the buildup of carbon in soil due to external carbon inputs. Aher et al. [18] reported significantly higher SOC under the application of organic manures. The INM application (50% organic and 50% chemical fertilizers also showed significantly higher organic carbon as compared to the sole 100% chemical fertilizer application in vertisol [13]. Manna et al. [19] and Lakaria et al. [20] also found increase in WBC with the application of FYM alone or in combination with recommended NPK fertilizers over absolute control and sole NPK fertilizer application. The results of this study are in good agreement with these findings.

Table 5. Soil pH, EC and organic carbon at chickpea harvest under various INM practices

| Treatment | pH | EC (dS m ⁻¹) | SOC (%) |
|----------------------------|------|--------------------------|---------|
| T1: Control | 7.74 | 0.17 | 0.64 |
| T2: 100 % N:P:K (20:50:20) | 8.11 | 0.19 | 0.65 |
| T3: 50 % N:P:K + FYM | 7.85 | 0.16 | 0.70 |
| T4: 50 % N:P:K + VC | 7.88 | 0.19 | 0.69 |
| T5: 50 % N:P:K + PSB | 7.78 | 0.20 | 0.68 |
| T6: 50 % N:P:K + FYM + PSB | 7.63 | 0.17 | 0.72 |
| T7: 50 % N:P:K + VC +PSB | 7.58 | 0.15 | 0.75 |
| SEm(±) | 0.40 | 0.15 | 0.02 |
| CD (P<0.05) | NS | NS | 0.03 |

Table 6. Soil available N, P and K at chickpea harvest under various INM practices

| Treatment | N (kg ha ⁻¹) | P (kg ha ⁻¹) | K (kg ha ⁻¹) |
|----------------------------|--------------------------|--------------------------|--------------------------|
| T1: Control | 212.8 | 13.5 | 362.3 |
| T2: 100 % N:P:K (20:50:20) | 174.4 | 14.2 | 383.4 |
| T3: 50 % N:P:K + FYM | 222.4 | 14.9 | 405.1 |
| T4: 50 % N:P:K + VC | 232.4 | 13.1 | 400.7 |
| T5: 50 % N:P:K + PSB | 229.4 | 14.9 | 392.0 |
| T6: 50 % N:P:K + FYM + PSB | 232.3 | 15.7 | 412.4 |
| T7: 50 % N:P:K + VC +PSB | 234.3 | 16.7 | 428.2 |
| SEm(±) | 8.7 | 0.47 | 26.9 |
| CD (P<0.05) | 24.3 | NS | NS |

The soil available nutrient (N, P and K) status under various INM practices is presented in Table 6. The soil available N ranged 174.4-234.3 kg ha⁻¹ with an average value of 219.7 kg ha⁻¹ under studied treatments. The various INM practices significantly influenced the soil available N. The application of 50% recommended dose of chemical fertilizers along with 2t vermin compost and 4 kg ha⁻¹ PSB culture (T7) followed by the treatment receiving the FYM @ 5t ha⁻¹ + PSB + 50% recommended dose of chemical fertilizers (T6) reflected as a best treatment with respect to the enhancement of availability of N in soil at chickpea harvest. Thus the INM treatments involving the application of either VC or FYM or PSB recorded significantly higher available N at chickpea harvest.

The various INM practices did not show significant effect soil available P and K. Upon addition of organic matter (FYM and VC in present experiment), the available nutrient status of soil increases considerably due to mineralization from soil as well as its own nutrient contents [14]. The significant increase in available N content of soil was due to the increased mineralization of organic N by active microorganisms [12]. The increment in soil available N under INM practices has already been reported [21].

4. CONCLUSION

Among the various INM practices studied, the application of 50% recommended dose of chemical fertilizers along with 2t ha⁻¹ vermicompost and 4 kg ha⁻¹ PSB culture reflected as a viable technology towards achieving optimum yield of chickpea along with improvement in soil properties. Thus any kind of INM practice is beneficial for obtaining the optimum crop yield sustainably.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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