



Nutrient Concentration, Uptake and Protein Content in Chickpea (*Cicer arietinum* L.) under Various Integrated Nutrient Management Practices in Central India

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Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2021/v33i1730546

Editor(s):

(1) Dr. Hon H. Ho, State University of New York, USA.

Reviewers:

(1) Fatemeh Ahmadnia, University of Mohaghegh, Iran.

(2) Bimael Justo Quispe Reymundo, Universidad Nacional del Centro del Perú, Peru.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/71934>

Original Research Article

Received 18 May 2021
Accepted 19 July 2021
Published 20 July 2021

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 nutrient concentration, uptake and protein content 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 + vermicompost @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 + vermicompost @2 t ha⁻¹ + PSB @4 kg ha⁻¹ replicated thrice in a randomized block design. The N, P, K and S concentration in seed and straw, nutrient removal by seed, straw and total and protein content at harvest stage were determined. The results revealed that the integrated nutrient management practice significantly improved the nutrient concentration, uptake and quality of chickpea.

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Keywords: Nutrient concentration; nutrient removal; INM; chickpea; protein.

1. INTRODUCTION

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 [1]. 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, biofertilizers, 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 (*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 [3]. It has the ability to fix atmospheric nitrogen in root nodules and can also tolerate high temperatures during and after flowering [4]. 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 [5]. 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 [6].

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 [7]. 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 vermicompost and farmyard manure (FYM) is also known for their beneficial effects on sustaining soil health [8]. Considering these facts present experiment was conducted to study the effect of various INM modules on nutrient concentration, removal and quality of chickpea 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

The details of the layout of experiment are given in Table 3. The experimental field was prepared by tractor drawn cultivator or 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.

2.4 Plant Sampling and Analysis

The plant and grain samples collected at harvest of chickpea crop were cleaned with double

distilled water and tipped with butter paper and air dried first. Then samples were dried in oven at 65°C till constant weight was reached. These samples were powdered in grinder and used for determining concentration of nutrients and protein. The total N was determined in a micro Kjeldhal [9] after digesting the samples in concentrated sulfuric acid [10]. The digestion of samples for determination of P, K and S were carried out using nitric acid and perchloric acid [11]. The P, K and S in the digest were determined following standard methods [12,13]. The protein concentration in chickpea seed was determined by the standard method outlined by Sadasivam and Manickam [14].

The nutrient uptake was calculated by multiplying the nutrient concentration of chickpea (seed and straw) with their respective yield. The total nutrient uptake was obtained by summation of the nutrient uptake of grain and straw.

2.5 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 [15].

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

Table 3. Experiment details

Design	:	RBD
Replications	:	03
Treatments	:	07
Crop	:	Chickpea
Variety	:	JG-322
Plot size	:	08 × 3.25 m
Net plot size	:	07 × 03 m ² = 21 m ²
Spacing between plots	:	15 cm
Treatment size	:	01 × 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

3. RESULT AND DISCUSSION

3.1 Nutrient Concentration in Chickpea Grain and Straw

The chickpea grain N, P, K and S concentration under various INM practices ranged 3.15-3.47%, 0.38-0.42%, 0.80-0.88% and 0.28-0.38%, respectively (Table 4).

The average concentration of N, P, K and S in chickpea grain was found 3.29%, 0.41%, 0.85% and 0.33%, respectively. The highest concentration of N, P, K and S in chickpea grain was found under the treatment receiving 50% recommended dose of chemical fertilizers (NPK) along with vermicompost and PSB culture (T7) followed by the INM treatment involving the application of 50% NPK+FYM+PSB (T6). Similarly, the chickpea straw N, P, K and S concentration under various INM practices ranged 0.39-0.52%, 0.11-0.17%, 0.86-1.00% and 0.11-0.17%, respectively (Table 5). The average concentration of N, P, K and S in chickpea straw was found 0.44%, 0.15%, 0.94% and 0.13%, respectively. The highest concentration of N, P, K and S in chickpea straw was found under the treatment receiving 50%

recommended dose of chemical fertilizers (NPK) along with vermicompost and PSB culture (T7) followed by the INM treatment involving the application of 50% NPK+FYM+PSB (T6).

In general, the treatments involving the application of organic input (VC/FYM) along with PSB culture positively influenced the nutrient concentration in grain and straw of chickpea. Davari et al. [16] also reported higher N, P, K and micronutrients content in wheat grain grown under organic nutrition as compared to the unfertilized control. Aher et al. [17] reported higher N, P and K content and micronutrients content in soybean seed and wheat grain under different organic treatment combinations as compared to the unfertilized control and chemical fertilizer application. Yashona et al. [18] also found higher protein content in pigeonpea under integrated nutrient management. The higher N [19], P [20] and K [21] under organic nutrition have already been documented. The higher concentration of N, P, K and S in chickpea grain is attributed to the enhanced availability of nutrients through improvement in soil chemical [22,23] and biological properties [24] due to applied organic manures and PSB culture.

Table 4. Nutrient concentration in chickpea grain under various INM practices

Treatment	Nutrient concentration (%)			
	N	P	K	S
T1: Control	3.15	0.38	0.80	0.28
T2: 100 % N:P:K (20:50:20)	3.20	0.39	0.81	0.29
T3: 50 % N:P:K + FYM	3.30	0.41	0.86	0.34
T4: 50 % N:P:K + VC	3.29	0.41	0.87	0.34
T5: 50 % N:P:K + PSB	3.23	0.41	0.85	0.34
T6: 50 % N:P:K + FYM + PSB	3.35	0.42	0.87	0.36
T7: 50 % N:P:K + VC +PSB	3.47	0.42	0.88	0.38
SEm(±)	0.08	0.01	0.02	0.02
CD (P<0.05)	0.20	0.02	0.05	0.01

Table 5. Nutrient concentration in chickpea straw under various INM practices

Treatment	Nutrient concentration (%)			
	N	P	K	S
T1: Control	0.39	0.14	0.86	0.11
T2: 100 % N:P:K (20:50:20)	0.40	0.15	0.86	0.11
T3: 50 % N:P:K + FYM	0.43	0.15	0.95	0.12
T4: 50 % N:P:K + VC	0.46	0.11	0.95	0.13
T5: 50 % N:P:K + PSB	0.43	0.15	0.94	0.13
T6: 50 % N:P:K + FYM + PSB	0.48	0.16	0.99	0.16
T7: 50 % N:P:K + VC +PSB	0.52	0.17	1.00	0.17
SEm(±)	0.02	0.01	0.02	0.01
CD (P<0.05)	0.05	0.01	0.05	0.02

3.2 Nutrient Uptake by Chickpea

The chickpea grain N, P, K and S uptake under various INM practices ranged 39.6-75.8 kg ha⁻¹, 4.6-9.1 kg ha⁻¹, 7.9-14.1 kg ha⁻¹ and 3.4-8.1 kg ha⁻¹, respectively (Table 6). The average uptake of N, P, K and S by chickpea grain across the studied INM treatments was found 57.0 kg ha⁻¹, 6.9 kg ha⁻¹, 12.5 kg ha⁻¹ and 5.7 kg ha⁻¹, respectively. The highest uptake of N, P, K and S by chickpea grain was found under the treatment receiving 50% recommended dose of chemical fertilizers (NPK) along with vermicompost and PSB culture (T7) followed by the INM treatment involving the application of 50% NPK+FYM+PSB (T6).

Similarly, the chickpea straw N, P, K and S uptake under various INM practices ranged 7.7-17.1 kg ha⁻¹, 2.8-5.5 kg ha⁻¹, 17.1-39.9 kg ha⁻¹ and 2.1-5.7 kg ha⁻¹, respectively (Table 7). The average uptake of N, P, K and S by chickpea straw was found 12.3 kg ha⁻¹, 4.3 kg ha⁻¹, 26.5 kg ha⁻¹ and 3.7 kg ha⁻¹, respectively. The highest uptake of N, P, K and S by chickpea straw was found under the treatment receiving 50% recommended dose of chemical fertilizers (NPK) along with vermicompost and PSB culture (T7) followed by the INM treatment involving the application of 50% NPK+FYM+PSB (T6).

The total nutrient (N, P, K and S) uptake (grain+straw) by chickpea is presented in Table 8. The total uptake of N, P, K and S by chickpea under various INM practices ranged 47.3-92.9 kg ha⁻¹, 7.5-14.6 kg ha⁻¹, 25.0-54.0 kg ha⁻¹ and 5.5-13.8 kg ha⁻¹, respectively (Table 8).

The average uptake of N, P, K and S by chickpea was found 69.3 kg ha⁻¹, 11.2 kg ha⁻¹, 39.0 kg ha⁻¹ and 9.4 kg ha⁻¹, respectively. The highest uptake of N, P, K and S by chickpea was found under the treatment receiving 50% recommended dose of chemical fertilizers (NPK) along with vermicompost and PSB culture (T7) followed by the INM treatment involving the application of 50% NPK+FYM+PSB (T6). In general, the treatments involving the application of organic input (VC/FYM) along with PSB culture positively influenced the nutrient (N, P, K and S) removal by chickpea. Reddy and Reddy [25] reported significant increase in uptake in all the treatments receiving NPK with FYM over NPK alone under soybean-wheat cropping cycle in a Vertisol of central India. Similarly, Patidar and Mali [26] reported that the application of NPK with FYM @ 10 t ha⁻¹ resulted in significant increase in the uptake of N, P and K by sorghum-wheat cropping system compared to NPK alone. The results of present study are in conformity with these findings.

Table 6. Nutrient uptake by chickpea grain under various INM practices

Treatment	Nutrient uptake (kg ha ⁻¹)			
	N	P	K	S
T1: Control	39.6	4.6	7.9	3.4
T2: 100 % N:P:K (20:50:20)	49.0	5.9	12.2	4.3
T3: 50 % N:P:K + FYM	55.1	6.9	13.1	5.6
T4: 50 % N:P:K + VC	61.6	7.6	13.2	6.3
T5: 50 % N:P:K + PSB	50.9	6.3	13.3	5.3
T6: 50 % N:P:K + FYM + PSB	66.7	8.1	13.7	7.1
T7: 50 % N:P:K + VC +PSB	75.8	9.1	14.1	8.1
SEm(±)	1.5	0.9	1.2	0.5
CD (P<0.05)	2.8	1.9	2.5	1.5

Table 7. Nutrient uptake by chickpea straw under various INM practices

Treatment	Nutrient uptake (kg ha ⁻¹)			
	N	P	K	S
T1: Control	7.6	2.8	17.1	2.1
T2: 100 % N:P:K (20:50:20)	8.1	3.3	18.8	2.4
T3: 50 % N:P:K + FYM	11.3	5.4	25.0	3.2
T4: 50 % N:P:K + VC	15.2	4.3	27.2	3.8
T5: 50 % N:P:K + PSB	12.3	4.2	27.0	3.7
T6: 50 % N:P:K + FYM + PSB	14.8	4.7	30.4	5.0
T7: 50 % N:P:K + VC +PSB	17.1	5.5	39.9	5.7
SEm(±)	2.7	1.3	1.4	1.0
CD (P<0.05)	5.6	2.74	2.8	2.0

Table 8. Total nutrient uptake by chickpea crop under various INM practices

Treatment	Nutrient uptake (kg ha ⁻¹)			
	N	P	K	S
T1: Control	47.3	7.5	25.0	5.5
T2: 100 % N:P:K (20:50:20)	57.1	9.2	31.0	6.7
T3: 50 % N:P:K + FYM	66.4	12.2	38.1	8.8
T4: 50 % N:P:K + VC	76.8	11.8	40.4	10.1
T5: 50 % N:P:K + PSB	63.1	10.5	40.3	9.0
T6: 50 % N:P:K + FYM + PSB	81.6	12.9	44.1	12.1
T7: 50 % N:P:K + VC +PSB	92.9	14.6	54.0	13.8
SEm(±)	4.2	2.2	2.6	1.5
CD (P<0.05)	11.3	6.3	7.3	4.4

3.3 Chickpea Protein Content under Various INM Practices

The protein concentration in chickpea seed ranged 19.5-22.9% with an average value of 21.0% under the studied INM practices (Fig. 1). The application of 50% recommended dose of chemical fertilizers along with 2t vermicompost and 4 kg ha⁻¹ PSB culture (T7) and 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 chickpea seed protein concentration. 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).

The application of VC/FYM along with PSB and chemical fertilizers significantly influenced the protein content of chickpea. Although, quality

constituents of the crops are generally controlled genetically but, agricultural practices like nutrient management, irrigation *etc.* also influence the produce quality [27]. The quality of produce is controlled by a complex interaction of factors, including soil type, and the ratios of minerals in added composts, manures and fertilizers. Kler et al. [28] and Ramana et al. [29] reported that crops grown under organic nutrition had more protein than grown with chemical fertilizers. The higher protein content in chickpea under INM practices might be ascribed to better availability and uptake of essential nutrients by plant. Aher et al. [17] reported higher protein content in soybean seed and wheat grain under different organic treatment combinations as compared to the unfertilized control and chemical fertilizer application. Yashona et al. [18] also found higher protein content in pigeonpea under integrated nutrient management.

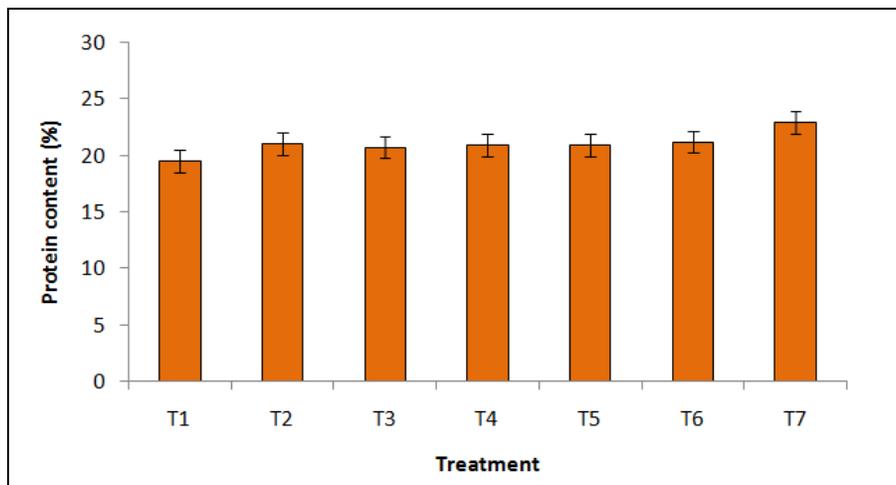


Fig. 1. Protein content in chickpea seed under various INM practices (T1- Control; T2-100% N:P:K (20:50:20); T3-50 % N:P:K + FYM; T4-50% N:P:K + VC; T5-50% N:P:K + PSB; T6-50% N:P:K + FYM + PSB; T7-50% N:P:K + VC +PSB; Error bar indicates standard deviation)

4. CONCLUSION

The integrated nutrient management practice is very promising in the context of fertilizer availability and affordability. Among the various INM practices studied, the application of 50% recommended dose of chemical fertilizers along with organic manure (VC @ 2t ha⁻¹ or FYM @ 5t ha⁻¹) and PSB culture @ 4 kg ha⁻¹ reflected as a viable technology towards improvement in nutrient concentration, removal and quality of chickpea.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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