RESEARCH ARTICLE

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Effect of Integrated Nutrient Management Through Organic Sources on Yield and Economics of Chickpea (*Cicer arietinum* L.) in Bundelkhand Region

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ABSTRACT

Background: Chickpea (*Cicer arietinum* L.) is the most important (third) food amongst legume, cultivated across the globe due to its nutritious property and cheaply available to the wide population rather than other nutrious food material. Over the time, use of chemical fertilizers has increased significantly, leading to the contamination of produce with toxic chemical elements which impart hazardous impact on human and animal health. The inclusion of natural substances (organic manures) likes; Farm yard manure, vermi-compost, poultry manure and seed treatment with PSB culture will have better consequences on soil and produce both.

Methods: The field experiment was conducted during *Rabi* Season of 2018-19 at karguan ji agriculture farm Bundelkhand University Jhansi (UP) to study on the effect of integrated nutrient management through organic sources on yield and economics of chickpea in Bundelkhand region. Experimental units were implemented in randomized block design (RBD) with three replications and nine treatments.

Result: The entire yield attributes, *i.e.*, number of pods plant^{-1}, weight of pods plant^{-1}, yield plant^{-1} were found to be significantly maximum with the supplemented dose of (1/3 Farmyard manure+1/3 Vermi-compost+1/3 Poultry manure). The yield parameters such that grain yield, straw yield and biological yield were also found to be maximum when given with the supplemented dose of 1/3 Farmyard manure+1/3 Vermi-compost+1/3 poultry manure. The maximum net return of 116671 ha^{-1} were obtained in the same above mentioned treatment and the highest benefit cost ratio was recorded in T_1 (100% through farmyard manure). Therefore, based on present study it can be concluded that application of (1/3 dose of Farmyard manure+1/3 dose of vermi-compost+1/3dose of poultry manure) is best suited for obtaining better yield and economics in Bundelkhand region of Uttar Pradesh.

Key words: Chickpea, Integrated nutrient management, PSB, Yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is most preferred among food legumes due to its numerous uses making it essential for growing global population. During 2017-18, it was grown on 149.66 lakh hectares of land worldwide, yielding 162.25 lakh tons (FAOSTAT, 2019) with an average productivity of 1252 kg/ha.

India contributes 71% of global area and 70% of global production of chickpea, ranking first in both area and production, but it trails in terms of productivity amongst several countries due to farmers' failure to adopt improved varieties and package of practices respectively. Apart from India, the world's largest chickpea producing countries include Australia (12.35%), Myanmar (3.25%) and Ethiopia (2.92%). Chickpeas are exported to India from Australia, Canada, France, Iran, Myanmar, Pakistan, Tanzania and Turkey. India became the largest importer of chickpea (5.90 lakh tons) in 2017-18 due to stagnating productivity and domestic shortages.

Despite this, India ranks third among global exporters of chickpea with 2.12 lakh tons exported in 2019 (FAO) and its export destinations include Saudi Arabia, the USA, UAE, the UK, Malaysia and Sri Lanka. Among the state Uttar Pradesh contributes 6% in area and production in which ranks fifth in area (0.62 M ha) and production (0.77 MT) and sixth in productivity of chickpea in India (Anonymous, 2018).

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Madhya Pradesh is the first state in terms of area and production, accounting for around 25% and 30% of gram's total area and production in the country (Annual Report 2021-22, Directorate of Pulses Development). More than 90% of the country's gram production during the reporting period was achieved by ten states: Madhya Pradesh, Maharashtra, Andhra Pradesh, Rajasthan, Uttar Pradesh, Karnataka, Gujarat, Chhattisgarh, Jharkhand and Telangana.

Chickpeas include 21.1% protein, 61.5% carbs and 4.5% fat. It is also high in calcium, iron and niacin. A 100-gram serving of chickpea seeds provides 360 calories, offering more energy than most other legumes, except for groundnut and lucerne. The application of vermicompost + Ghana jeevamrutha @ 100% RDP + Rhizobium + PSB recorded significantly higher soil organic carbon (SOC) (0.70%), soil available nitrogen (291.39 kg ha^{-1}), phosphorus (36.30 kg ha^{-1}) and potassium (580.53 kg ha^{-1}) and significantly higher uptake of nutrients *i.e.*, nitrogen (52.07 and 75.43 kg ha^{-1}), phosphorus (10.12 and 16.08 kg ha^{-1}) and potassium (37.67 and 55.42 kg ha^{-1}) at 45 and 75 DAS compared to all other treatments. Similarly, application of FYM + vermicompost @ 100% RDP + Rhizobium + PSB has recorded the highest microbial count of bacteria [24.40 $\times$ 10^6 CFU (Colony Forming Units) g^{-1}], fungi (17.0 $\times$ 10^3 CFU g^{-1}) and actinomycetes (7.50 $\times$ 10^3 CFU g^{-1}) (Kumar *et al.,* 2024). All the yield parameters, nutrient content and uptake significantly increased under application of FYM (5 ton ha^{-1}) and bio fertilizer (Rhizobium + LMn16) over control plot and sole application of Rhizobium and LMn16 respectively (Danga *et al.,* 2024). Phosphate solubilizing bacteria convert the unavailable phosphorus of soil into available form to the crop plant. Inoculation of seeds with PSB and KSB culture increases nodulation, crop growth, nutrient uptake and crop yield (Patel *et al.,* 2018).

Growing chickpea in crop rotation improved crop yield and sustainability in the semi-arid region. The maintenance and control of soil fertility is the key of developing sustainable food production systems (Shah *et al.,* 2019). Chickpea also have the ability to fix atmospheric nitrogen through symbiotic processes to the soil and it has been calculated that the chickpea has the capability to fix 140 kg N/ha in a growing season (Reddycherla *et al.,* 2024). Increment in irrigation resources are one of the key causes for the decline in chickpea area because of secondary salinization and in such cases, chickpea farming is less suitable in respect to monetary return than wheat and raya crops. Consequently, chickpea production is now confined to low fertility, in moisture-conserving belts.

Among other hurdles, one of the most important yield-confiding problems in chickpea is poor weed control, which includes brackish irrigation water, hungry and abandoned soils, a lack of promising cultivars, inappropriate fertilization, pests and diseases *etc.* Weed invasion in *Rabi* pulses has been found to give substantial competition and cause yield reductions of up to 75% in chickpea (Chaudhary *et al*., 2005). After green revolution, numerous problems raises, which are currently challenges the sustainability of Indian agriculture in its entirety and serious concerns about the food security of the nation are being raised. These include fixture or even decrement in production and productivity, growth rates of major crops, deterioration of soil fertility, declining factor productivity and low production diversity. Intensive cropping, along with uneven nutritional supplementation, has resulted in a soil deficit. Balanced plant nutrition has an important role in increasing production and using organic nutrition sources may offer a sustainable alternative to chemical fertilizers. With the aforementioned factors in mind, the current study entitled effect of integrated nutrient management through organic sources on yield of chickpea (*Cicer arietinum* L.) in Bundelkhand region was carried out during *rabi* season of 2018-2019 at the Agricultural Research Farm located in Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh.

MATERIALS AND METHODS

Experiment was conducted at Organic farming block of Agriculture Research Farm which is situated in karguanji agriculture farm Jhansi behind BU campus in foot hills of Kamashin Mata Temple. Geographically, the Karguaji Farm of Bundelkhand University, Jhansi is situated at Latitude: 25°N. Longitude: 78°E. The latitude level of Bundelkhand University Jhansi plains is about 285 m. above mean sea level. Plains of Jhansi lies in Agro Climatic Zone-VIII: Central Plateau and Hills region; agro climatic sub-zone Bundelkhand (Uttar Pradesh). Total rainfall received during crop growing period was 15.6 mm. and the maximum temperature of 39°C was recorded in the month of April whereas the minimum temperature of 6°C was observed in the January. Weekly bright sunshine duration were recorded 9.8 hrs to 4.4 hrs day^{-1}, respectively and the average ET during the period of experiment varied from 0.9-5.1 mm/day. The soil of experimental field was a yellowish, light-colored variety of red soil (Alfisols soil) is found across UP Bundelkhand and it is also known as parua (a type of red soil).

The experiment was laid out in randomized block design, with three replications and nine treatment formulations shown in Table 1:

Table 1: Treatment details.

Treatment	Treatment formulation
T_0	RDF (Chemical)
T_1	100% through farm yard manure (FYM)
T_2	100% through vermi-compost
T_3	100% through poultry manure
T_4	50% dose of FYM+50% dose of vermi-compost
T_5	50% dose of farmyard manure+ 50% dose of poultry manure
T_6	50% dose of vermi-compost+50% dose of poultry manure
T_7	1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure
T_8	(1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure)+ PSB

The field was prepared and the chickpea variety 'JG-14' was sown in plots following the specified set of techniques. The field was ploughed with a Desi Plough for 7 days before receiving a pre-sowing irrigation. Four cross ploughings were done to bring the soil to right tilth with a Desi Plough. Other intercultural operation such as, weeding and plant protection were used as needed. Phosphate Solubilizing Bacteria (PSB) culture was received from the state agriculture department and chickpea seeds were treated with the rate of 2 g/kg before sowing.

The economics of different treatments was worked out by taking into consideration of all the expenses incurred. The cost of input and price of produce prevalent at the Organic Farming Block of Agriculture Research Farm, Bundelkhand University were taken into considerations for calculating economics of different treatments and expressed as net return and benefit cost ratio (B:C).

Gross return (₹ ha^{-1})

Gross return was worked out by multiplying grain and straw yield with their prevailing market prices and expressed in rupees per hectare.

Net return (₹ ha^{-1})

The net return was calculated as follows:

Net return (₹ ha^{-1}) =

Gross return (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

Benefit: cost ratio

The benefit cost ratio was calculated as follows:

$$\text{Benefit: Cost ratio (BCR)} = \frac{\text{Net return (₹ ha}^{-1})}{\text{Cost of cultivation (₹ ha}^{-1})}$$

The data from the field experiment were statistically evaluated to compare treatments using Analysis of Variance (ANOVA) for RBD design and the results were interpreted at the 5% level of significance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on yield attributes

The result stipulated that differences in number of pods plant^{-1} of chickpea were found significant which was furnished in Table 3. Statistically, maximum number of 118.7 pods plant^{-1} was recorded in the treatment supplemented with the dose of 1/3 dose of farmyard manure+1/3 dose of Vermi-compost+1/3 dose of poultry manure (T_7) as which was comparable with 50% dose of farmyard manure + 50% dose of poultry manure (105.3 Nos.) (T_5) and (T_1) 100% through farmyard manure (101.1 Nos.). While minimum number of pods plant^{-1} (62.8 Nos.) were obtained in T_2 (100% through Vermi-compost) as presented in Table 2.

The result depicted that yield per plant of chickpea was found significant, presented in Table 2. Among all tested formulation of organic sources, significantly, highest yield (36.9 g) per plant of chickpea was recorded in T_7 (1/3 dose of farmyard manure +1/3 dose of vermi-compost +1/3 dose of poultry manure) as compared to control treatment which was on par with the 100 % through farmyard manure (T_1) (29.9 g) and 50% dose of farmyard manure+50% dose of poultry manure (T_5) (29.9 g). The minimum yield per plant^{-1} (17.4 g) were resulted in T_8 (1/3 dose of farmyard manure +1/3 dose of Vermi-compost+1/3 dose of poultry manure) + Phosphate Solubilizing Bacteria (Table 2).

In general, the data showed that the maximum no. of pods per plant and yield per plant recorded relatively higher in T_7 (1/3 dose of farmyard manure+1/3 dose of vermi-compost + 1/3 dose of poultry manure) than the other treatments. It was may be due to application of a good nutrients through formulation of organic sources to the soil as (1/3 dose of farmyard manure+1/3 dose of vermi-compost+1/3 dose of poultry manure) by which soil remained rich in organic carbon (matter) and improve soil porosity and give the favorable environment to the microbial activities and better nodulation. This rise in yield attributes could be attributed to improved photosynthate translocation towards the sink, resulting in higher grain yield. Similar findings were reported by Jat and Ahlawat (2004); Patel and Thanki (2020).

The data based on the parameter weight of pods plant^{-1} was depicted and Table 2 were found significant. Among all, treatments significantly highest weight of pods plant^{-1} (42.8 g)was recorded in T_7 (1/3 dose of farmyard manure+1/3 dose of vermi-compost+1/3 dose of poultry manure), which was closely followed by T1(100% through farmyard manure) and T_5 (50% dose of farmyard manure+ 50% dose of Poultry manure). While minimum weight of pods plant^{-1} (22.8 g) were recorded in T_8 (1/3 dose of farmyard manure+1/3 dose of Vermi-compost+1/3 dose of poultry manure+Phosphate Solubilizing Bacteria.

The result revealed that maximum weight of pods per plant was recorded under formulation of organic sources with (1/3 dose of farmyard manure+1/3 dose of vermicompost +1/3 dose of poultry manure), may be due to application of organic manures which could improve soil nutrient status, soil structure and soil porosity which helps to proliferate maximum number of branches per plant and obtain maximum number of pods. These findings were similar to the results of, Pandey *et al.* (2006).

The data pertained to no. of seeds pods^{-1} were found non- significant. Among all tested formulation of organic sources, non-significantly highest no. of seeds pods^{-1} of chickpea was recorded in T_7 (1/3 dose of farmyard manure + 1/3 dose of Vermi-compost+1/3 dose of poultry manure) as compared to other treatment formulations, while minimum no. of seeds pods^{-1} were recorded in T6 (50% dose of vermi-compost+50% dose of poultry manure).

The result indicated that 100-seed weight (seed index) was found non-significant, as presented in Table 3. Among all tested formulation of organic sources, non-significantly maximum 100-seed weight (seed index); (28.2) of chickpea was recorded in T_3 (100% through poultry manure) as compared to other treatment formulations, which was closely followed by T_7 (26.8) and T_6 (26.2) respectively. While minimum no. of seeds pods^{-1} (24.1) were recorded in T_4 with (50% dose of farmyard manure +50% dose of vermi-compost).

Effect on yield

The data based on the parameter grain yield, straw yield and biomass (q/ha.) as presented in Table 3, were found non-significant. Among all tested formulation of organic sources, highest grain yield (31.3 q/ha.) of chickpea was recorded in T_7 with the application of (1/3 dose of farmyard manure+1/3 dose of vermi-compost+1/3 dose of poultry manure) as compared to other treatment formulations, which was closely followed by T_1 (28.1 q/ha.) and T_4 (27.9 q/ha.) respectively, while minimum grain yield (22.9 q/ha.) was recorded in treatment T_6.

Non-significantly highest straw yield (57.3 q/ha.) of chickpea was recorded in T_5 with the application of (50% dose of farmyard manure+ 50% dose of poultry manure) as compared to other treatment formulations, which was closely followed by T_3 (51.5 q/ha.) and T_7 (46.9 q/ha.) respectively, while minimum straw yield (39.5 q/ha.) was recorded in treatment T_8.

It is clear from (Table 3) that biomass yield of chickpea was non-significantly affected by the combination of organic sources applied on chickpea in T_5 enriched with (50% dose of farmyard manure+ 50% dose of poultry manure) could result in maximum quantum of biomass yield (84.5 q/ha) as compared to other treatment combinations, which was closely followed by T_3 (79.6 q/ha.) and T_7 (78.2 q/ha.) respectively, while minimum biomass yield (64.9 q/ha.) was recorded in treatment T_6/T_8.

On the basis of present finding, the concept of eco-friendly integrated nutrient management is sincerely endorsed particularly in organic cultivation of chickpea

Table 2: Effect of integration of organic manures on 'pod and yield per plant, weight of pods and number of seeds per plant of gram under organic condition.

Treatment	Treatment formulation	Pod and yield per plant		Wt. of pods/	Number of	100 seed
		No. of pods	Yield in g	plant (g)	seeds/pod	weight (g)
T_0	RDF (Chemical)	87.1	24.7	31.7	1.8	25.3
T_1	100% through farm yard manure (FYM)	101.1	30.9	40.5	2.0	24.8
T_2	100% through vermi-compost	62.8	17.8	25.6	1.7	25.5
T_3	100% through poultry manure	82.1	25.1	32.8	1.7	28.2
T_4	50% dose of FYM+50% dose of vermi-compost	84.7	21.1	28.8	2.0	24.1
T_5	50% dose of farmyard manure + 50% dose of poultry manure	105.3	29.9	38.3	1.7	26.0
T_6	50% dose of vermi-compost + 50% dose of poultry manure	74.9	21.0	27.2	1.6	26.2
T_7	1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure	118.7	36.9	42.8	2.2	26.8
T_8	(1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure + PSB	67.9	17.4	22.8	1.9	25.4
SEM ±		1.44	1.07	1.46	0.14	1.5
CD at 5%		4.34	3.22	4.42	NS	NS

Table 3: Effect of INM on grain yield, straw yield and biomass yield (q/ha) of gram under organic conditions.

Treatment	Treatment formulation	Yield (q/ha)		
		Grain	Straw	Biomass
T_0	RDF (Chemical)	26.1	42.2	68.4
T_1	100% through farm yard manure (FYM)	28.1	39.6	67.7
T_2	100% through vermi-compost	25.5	40.8	66.3
T_3	100% through poultry manure	27.8	51.8	79.6
T_4	50% dose of FYM + 50% dose of vermi-compost	27.9	39.6	67.4
T_5	50% dose of farmyard manure+50% dose of poultry manure	27.2	57.3	84.5
T_6	50% dose of vermi-compost+50% dose of poultry manure	22.9	42.1	64.9
T_7	1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of Poultry manure	31.3	46.9	78.2
T_8	(1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure)+ PSB	25.4	39.5	64.9
SEM±		2.46	6.67	7.03
CD at 5%		NS	NS	NS

Table 4: Economics of different treatment formulations.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Gross return (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	Benefit: cost ratio
T_0	26.1	42.2	124802	26721	98081	3.67
T_1	28.1	39.6	133782	26775	107007	3.99
T_2	25.5	40.8	121890	35850	86040	2.40
T_3	27.8	51.8	133616	35250	98366	2.79
T_4	27.9	39.6	132858	31312	101546	3.24
T_5	27.2	57.3	131394	31012	100382	3.24
T_6	22.9	42.1	110008	35550	74458	2.09
T_7	31.3	46.9	149296	32625	116671	3.58
T_8	25.4	39.5	121298	32760	88538	2.70

Sale price of grain chickpea= 4620 rs. q^{-1} and straw of chickpea= 100 rs. q^{-1} and the sale price for organic treatments should be 20% higher than control treatment. FYM = 750 rs. $tones^{-1}$, Vermi-compost= 1200 rs. q^{-1} and poultry manure= 1400 rs. q^{-1}.

because grower would like to eat/use toxin free and healthy agriculture produce. It is therefore, minimal residue containing seed would be very safe and noteworthy for consumer and also for growers to get high remuneration. The grain, straw and biomass yield were influenced non-significantly with thesupply of organic source of nutrients. These findings were similar to the results of Asewar, (2003); Siag and Yadav, (2004); Jat and Ahlawat, (2006); Muddukumar, (2007); Chauhan *et al.* (2010) and Kanwar and Paliyal, (2002).

Economics

It is perceptible from data that the maximum net return in chickpea (116671 ha^{-1}) were obtained in T_7 enriched with (1/3 dose of Farmyard manure + 1/3 dose of vermi-compost +1/3 dose of Poultry manure) which was closely followed by T_1 and T_4 respectively and benefit: cost ratio was found maximum in T_1 enriched with (100% through Farmyard manure) which was closely followed by T_0 and T_7 respectively, presented in (Table 4).

Among the treatments, the gross return was highest under combination of (1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure) followed by (100% through FYM), (100% through poultry manure) respectively. The net return was highest with when nutrient applied in combination of organic manures (1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure) followed by (100% through FYM). It was due to obtained maximum grain and straw yield and less cost of cultivation than rest of the treatments. The application of 100% vermi-compost recorded the higher cost of cultivation than the rest of treatments while the maximum benefit: cost ratio was observed under application of 100% through FYM. It was due to less cost of cultivation than the combination of (1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure) while lowest cost of cultivation was observed under control treatment. These findings were similar to the results of Pandey *et al.* (2006).

CONCLUSION

Based on the results of the present study, the following inferences can be made in Bundelkhand region of U.P., nutrients application through (1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure) was found best for obtaining maximum yield (31.3 q/ha).In irrigated late sown condition, Application of nutrients through the combinations of (1/3 dose of farmyard manure + 1/3 dose of vermi-compost + 1/3 dose of poultry manure) was found better for obtaining higher net return while application of 100% through FYM was found better for obtaining higher benefit: cost ratio in irrigated conditions of Bundelkhand region for practicing organic farming.

Conflict of interest

We confirm that there are no financial, personal or professional conflicts of interest that could have influenced the research work presented in this manuscript.

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