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Effect of integrated nutrient management on growth and yield character of chickpea

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Abstract
A field experiment was conducted during rabi season of 2023-24 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Effect of integrated nutrient management on growth and yield characters of chickpea (*Cicer arietinum* L.). The soil was normal in pH of 7.68, electrical conductivity (EC) of 0.23 dSm^{-1}, organic carbon content of 0.45%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 216.12, 19.50, and 148.30 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 14 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications.

Keywords: INM, chickpea, RDF

Introduction
The leguminous crop known as chickpea (*Cicer arietinum* L.), a diploid annual crop with 16 chromosomes, is an ancient self-pollinated leguminous crop that has been grown since 7000 BC in various parts of the world. However, its cultivation is primarily focused in semi-arid environments. From South East Asia to India, as well as the Middle East and Mediterranean countries, it is grown and consumed in vast quantities. Of all the pluses in the world, it comes in second in area and third in production. The chickpea, also known as the gram, is the third most important pulse crop globally and is cultivated on all continents with the exception of Antarctica. It was one of the first grain legumes domesticated by humans (Singh *et al*., 2009) [1]. It is the most important pulse crop grown mostly in rainfed conditions in India. Central and northern India, the North African region, Eastern Africa, and Latin America are the main producers of chickpeas. Regarding 29.36 million hectares, 24.51 million tons are produced, and the crop's productivity is 835 kg ha^{-1}. According to DES, Ministry of Agri. & FW (DAC & FW), Govt. of India, it is the leading food legume crop in India. India leads the world in both production (45.53%) and area (36.01%) (DES, Ministry of Agri. & FW (DAC & FW), Govt. of India; 2017–18). Plus crops are imported and exported in India totaling 8296.04 tonnes and $135.42 billion worldwide. (Ministry of Commerce, DGCI & S, 2017–18). In India, there are 10.57 million hectares of chickpeas grown, yielding 11.16 million tons of product and 1056 kg/ha^{-1} of productivity. (DES, Government of India, Ministry of Agri. &FW (DAC&FW); 2017-18). With a productivity of 909 kg/ha, Uttar Pradesh produces 6.84 lakh tons of goods on an area of roughly 6.11 lakh hectares. Government of India, Ministry of Agriculture and Fisheries (DAC&FW); 2017–18

For adult males and females, the Recommended Dietary Allowances (RDA) are 60 g and 55 g daily, respectively. The daily availability of pulses per capita is 52.9 g, and the annual requirement is 19.3 kg. (Source: Ministry of Agriculture & Farmers Welfare, Press Information Bureau, 2017–18). The main source of vegetable protein in the diet of humans is pulses. A diet low in protein can result in protein energy malnutrition (PEM), which can cause anemia in a number of forms. As food legumes, pulses provide a wealth of nutrients for the human diet. They also contribute to atmospheric nitrogen fixation, removing between 72 and 350 kg per hectare annually, and they create soil cover, which maintains soil health (Dept. of Economics and Statistics, 2017).

In addition to being a highly nutritious crop, chickpeas have numerous medical uses. In addition to providing the Indian population with 4.7% (2.7 g) of protein and 2.3% (56 K cal) of energy per day, 14 g of chickpeas are an important source of calcium and iron (10–12%). Rats' cholesterol levels have been found to be effectively controlled by germinated chickpeas. The leaves, stems, and pods contain malice and oxalic acids, which are used medicinally for aphrodisiac, bronchitis, catarrh, cutamenia, cholera, constipation, diarrhea, digestive disorders, flatulence, sunstroke, and warts. It is also known that these acids reduce blood cholesterol levels. It is believed that seeds are antibilious. Through enhancing the physical, chemical, and biological characteristics of the soil and retaining atmospheric nitrogen in their root nodules, chickpeas also contribute significantly to the maintenance of soil productivity. Up to 141 kg of N/ha could be fixed by a healthy chickpea crop. However, crop management techniques like planting date and nutrient use have a significant impact on how much biological nitrogen is fixed by chickpea. Chickpeas save 56–68 kg N/ha of nitrogen that would otherwise need to be applied to succeeding cereals. With regard to crop diversification, chickpeas have demonstrated a comparative advantage in the development of short-duration varieties.

Because high amounts of artificial chemical fertilizer have been used consistently Without the use of organic sources and an intensive system of cultivation techniques, the physio-chemical condition of the soil changes, and nutritional deficiencies—particularly with regard to micronutrients, which are crucial for plant growth—are common. In this endeavor, maintaining soil health and increasing yield both depend on the right blend of inorganic and organic fertilizer. India is thought to have 600 million and 16 million tons of potential for compost in its rural and urban areas, respectively. As a result, the annual average consumption has been roughly 2 tons/ha. Since a significant portion of FYM is lost as fuel and disappears into non-agricultural land, less than 50% of FYM is used in crop production. Microbial biofertilizers are far less expensive, pollution-free, and renewable (Mukherjee and Rai, 2000) [12].

Vermicompost, which is primarily made by composting with worms, has nutrients that promote plant growth and microbial population, including growth hormone, vitamins, and 0.45% sulfur, 0.45% calcium, 0.45% magnesium, 0.45% phosphorus, 0.80% potassium, 0.444% calcium, 0.45% zinc, and 175.2 ppm iron. All organic matter eventually breaks down in nature. The yield of chickpea grains rose as the dose of vermicompost was gradually increased from 0 to 3 t ha^{-1}, with 2 t ha^{-1} appearing to be the ideal amount. (Singh and others, 2012) [13].

Potassium is another essential element for plants, helping them to produce high-quality food, support numerous physiological processes, and guard against pests and illnesses. The greatest growth, grain yield, and financial benefit in chickpea under late-sown conditions were obtained by applying 60 kg of potash (K_2O ha) at sowing, foliar spraying 2% urea, and applying 0.25% multiplex at the pre-flowering stage.

A key component of sustainable agriculture is integrated nutrient management (INM), which calls for resource management that meets changing human needs without compromising environmental quality or depleting essential natural resources. The goal for crop production at the turn of the century is approximately 225 million tons, which will feed the nation's population of over one billion people. Fertilizer, organic manures, biofertilizer, green manures, and other materials can provide the nutrients that all plants need.

Materials and Methods

A field experiment was conducted during rabi season of 2023-24 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Effect of integrated nutrient management on growth and yield characters of chickpea (*Cicer arietinum* L.).The soil was normal in pH of 7.68, electrical conductivity (EC) of 0.23 dSm^{-1}, organic carbon content of 0.45%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 216.12, 19.50, and 148.30 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 14 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications. T_1: Mastery, T_5: 100% RDF+ FYM @ 5 t ha^{-1}, T_6: 100% RDF + Vermicompost @ 3 t ha^{-1}, T_2: 100% RDF, T_3: 75% RDF, T_4: 50% RDF, T_7: Rhizobium + PSB + 100% RDF T_9: 75% RDF + Vermicompost @ 3 t ha^{-1}, T_{10}: 75% RDF + Rhizobium + PSB, T_8: 75% RDF+ FYM @ 5 t ha^{-1}, T_{12}: 50% RDF + Vermicompost @ 3 t ha^{-1}, T_{13}: 50% RDF + Rhizobium + PSB, T_{11}: 50% RDF + FYM @ 5 t ha^{-1}, T_{14}: Data on five plants selected from each plot were collected for FYM @ 5 t ha^{-1}+ VC @ 3tha^{-1}+ Rhizobium + PSB.

Results and Discussion

Yield & Yield attributes

Number of pods plant^{-1}

In comparison to the control, number of pod plant-1 increased dramatically in all treatments. T_7 (100% RDF + Rhizobium + PSB) produced the highest number of pod plants-1, 65.78 and 69.83, while T_6 (100% RDF + VC @ 3 t ha^{-1}) produced the lowest number, 28.12 at control (T_1).

Number of pod plant-1 over 100% RDF was also impacted by the integration of biofertilizer, FYM, and vermicompost with 100% RDF (T_2). The integration of 75% RDF + Rhizobium + PSB (T_{10}) was also found to influence more pod plants per hectare than 75% RDF VC @ 3 t ha^{-1} with (T_9) and 75% RDF+ FYM @ 5 t ha^{-1} (T_8). In terms of the number of pods per plant, the applications of 100% RDF + Rhizobium + PSB (T_6) and 100% RDF + VC @ 3 t ha^{-1} (T_7) remained statistically equal.

Number of seeds/pods

All of the treatments had a significant impact on the number of seed pod-1 compared to the control. T_7 (100% RDF + Rhizobium + PSB) produced the highest number of seed pod-1, 1.68 and 1.72, whereas T_6 (100% RDF + VC @ 3 t ha^{-1}) produced the lowest number, 1.05 and 1.08, at control (T_1).

Number of seed pod-1 over 100% RDF was also impacted by the integration of FYM and vermicompost with 100% RDF (T_2). Additionally, a higher number of seed pod-1 was observed with integration of 75% RDF +RC+ PSB (T_{10}) compared to 75% RDF VC @ 3 t ha^{-1} with (T_9) and 75% RDF+ FYM @ 5 t ha^{-1} (T_8), respectively. In terms of the number of seeds per pod, the applications of 100% RDF + Rhizobium + PSB (T_6) and 100% RDF + VC @ 3 t ha^{-1} (T_7) remained statistically equal.

Test weight (1000 grains)

The findings showed that the various treatments had no discernible effect on test weight in grain. Test weight increases with T_7 (100% RDF + Rhizobium + PSB) were maximum at 185.78 g, minimum at 176.15 g at control (T_1), and maximum at 183.37 g with T_6 (100% RDF + VC @ 3 t ha^{-1}).

Test weight was also impacted by the integration of FYM and vermicompost with 100% RDF, however the increase in test weight was not statistically significant. Vermicompost integration resulted in a greater test weight increase over FYM. It was also noted that the application of 75% RDF + Rhizobium + PSB (T_{10}) exhibited an excessive increase in test weight when compared to the application of 75% RDF + FYM @ 5 t ha^{-1} (T_8) and 75% RDF VC @ 3 t ha^{-1} with (T_9).

Biomass yield

T_7 (100% RDF + Rhizobium + PSB) produced the highest biological yield, 53.06 q ha^{-1}, which was followed by T_6 (100% RDF + VC @ 3 t ha^{-1}) at 51.01 q ha^{-1}, and the control (T_1) at the lowest biological yield, 23.13 q ha^{-1}. Additionally, it was noted that the biological yield of the integration of 75% RDF + Rhizobium + PSB (T_{10}) significantly increased when compared to 75% RDF with VC @ 3 t ha^{-1} (T_9) and 75% RDF with FYM @ 5 t ha^{-1} (T_8). 100% RDF + VC @ 3 t ha^{-1} (T_7) and 100% RDF + Rhizobium + PSB (T_6) applied together demonstrated statistically equivalent biological yield.

Grain yield

The application of 100% RDF + Rhizobium + PSB (T_7), the highest grain yield of 22.16 q ha^{-1} and 23.54 q ha^{-1} was recorded; this was found to be 133.75% and 121.65% higher than the lowest yield of 9.48 q ha^{-1} and 10.62 q ha^{-1} at control (T_1). In comparison to the 100% RDF (T_2) treatment, the integration of 100% RDF with VC @ 3 t ha^{-1} (T_6) resulted in a 17.35% and 15.50% higher grain yield. Grain yield was affected by the application of 100% RDF with FYM @ 5 t ha^{-1} (T_5) and was 8.16% higher than that of the 100% RDF (T_2) treatment.

On average, the application of 75% RDF with FYM @ 5 t ha^{-1} (T_8), 75% RDF with VC @ 3 t ha^{-1} (T_9), and 75% RDF + Rhizobium + PSB (T_{10}) resulted in grain yields that were 29.77%, 39.89%, and 43.90% higher than that of 75% RDF (T_3). Compared to 50% RDF (T_4) application, the application of 50% RDF with FYM @ 5 t ha^{-1} (T_{11}), 50% RDF with VC @ 3 t ha^{-1} (T_{12}), and 50% RDF + Rhizobium + PSB (T_{13}) produced, on average, 18.08%, 26.56%, and 35.34% higher grain yields, respectively. In terms of grain yield, the applications of 100% RDF + Rhizobium + PSB (T_7) and 100% RDF + VC @ 3 t ha^{-1} (T_6) remained statistically equal.

Stover yield

Management practices involving organic, inorganic, and biofertilizers had a significant impact on the stover yield of chickpeas. The maximum stover yield was 30.90 q ha^{-1} with treatment T_7 (100% RDF + Rhizobium + PSB), followed by 29.71 q ha^{-1} (100% RDF + VC @ 3 t ha^{-1}) with treatment T_6 and a minimum of 13.65 q ha^{-1} control (T_1). The stover yield roughly followed the same pattern as the grain yield. When 100% RDF was combined with different combinations of organic, inorganic, and biofertilizers, the stover yield of 100% RDF was consistently found to be lower. The annual variation in stover yield has been significantly impacted by the combined application of organic, inorganic, and biofertilizers. In terms of stover yield, the applications of 100% RDF + VC @ 3 t ha^{-1} (T_7) and 100% RDF + Rhizobium + PSB (T_6) remained statistically equal.

Harvest index

The ratio of grain yield to biological yield is known as the harvest index. Harvest index data are shown in Table 1. Their analysis of variance, which is included in Appendix-VIII, shows that harvest index was not significantly impacted by any of the treatments. The application of 100% RDF + Rhizobium + PSB (T_7) recorded the highest harvest index at 42.30%, followed by 42.15% with 50% RDF (T_4) in comparison to other treatments, and minimum 40.81% with 75% RDF+ FYM @ 5 t ha^{-1} (T_8). Harvest index was higher by 42.10% with the combined application of FYM @ 5 t ha^{-1} + VC @ 3t ha^{-1}+Rhizobium + PSB (T_{14}), and minimum was visual 40.98% in the control (T_1).

Table 1: Effect of organic, inorganic and biofertilizers on yield attributes of chickpea.

Treatment	No of pods/plant	No of seeds/pod	Test weight (g)
T_1: Control	28.12	1.05	176.15
T_2: 100% RDF	53.84	1.43	181.86
T_3: 75% RDF	42.71	1.15	179.92
T_4: 50% RDF	37.97	1.09	178.51
T_5: 100% RDF+ FYM @ 5 t ha^{-1}	59.32	1.58	182.99
T_6: 100% RDF + VC @ 3 t ha^{-1}	63.18	1.62	183.37
T_7: 100% RDF + RC + PSB	65.73	1.68	185.78
T_8: 75% RDF+ FYM @ 5 t ha^{-1}	53.99	1.44	180.91
T_9: 75% RDF + VC @ 3 t ha^{-1}	59.17	1.55	181.03
T_{10}: 75% RDF +RC+ PSB	60.27	1.60	181.81
T_{11}: 50% RDF +FYM @ 5 t ha^{-1}	44.79	1.27	179.12
T_{12}: 50% RDF+VC @ 3 t ha^{-1}	48.11	1.35	179.32
T_{13}: 50% RDF + RC + PSB	51.61	1.46	179.66
T_{14}: FYM @ 5 t ha^{-1} + VC @ 3 t ha^{-1} + RC +PSB	52.74	1.49	180.71
SEm ±	1.54	0.04	2.83
CD at 5%	4.48	0.12	N. S

Table 2: Effect of organic, inorganic and biofertilizers on grain yield of chickpea

Treatment	Grain yield (q/ha)	Stover yield (q/ha)	Biomass yield (q/ha)
T_1: Control	9.48	13.65	23.13
T_2: 100% RDF	18.15	25.23	43.38
T_3: 75% RDF	14.40	19.95	34.35
T_4: 50% RDF	12.80	17.66	30.47
T_5: 100% RDF + FYM @ 5 t ha^{-1}	20.00	27.85	47.85
T_6: 100% RDF + VC @ 3 t ha^{-1}	21.30	29.71	51.01
T_7: 100% RDF + RC + PSB	22.16	30.90	53.06
T_8: 75% RDF + FYM @ 5 t ha^{-1}	18.20	25.30	43.50
T_9: 75% RDF + VC @ 3 t ha^{-1}	19.61	27.26	46.87
T_{10}: 75% RDF + RC + PSB	20.32	28.30	48.62
T_{11}: 50% RDF + FYM @ 5 t ha^{-1}	15.10	20.88	35.98
T_{12}: 50% RDF + VC @ 3 t ha^{-1}	16.22	22.48	38.70
T_{13}: 50% RDF + RC + PSB	17.40	24.10	41.50
T_{14}: FYM @ 5 t ha^{-1}+ VC @ 3 t ha^{-1} + RC + PSB	17.78	24.45	42.23
S.Em ±	0.76	0.92	1.54
CD at 5%	2.19	2.69	4.48

Conclusion

The growth, yield attributes, and chickpea yield of 100% RDF + Rhizobium + PSB and 100% RDF with Vermicompost @ 3 t ha^{-1} were comparable. In addition to biofertilizers, inorganic fertilizers were applied to the soil to improve its physico-chemical qualities following crop harvest. Therefore, it can be said that applying 100% RDF in conjunction with biofertilizers is a good way to increase the chickpea crop's yield and net return while also enhancing the soil's physico-chemical and biological qualities.

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