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Optimizing Chickpea (*Cicer arietinum* L.) Yield Through Balanced Fertilization Strategies

Kiran Prasad Upadhayaya [1], Arati Chapai [2]
1 Agriculture Section, Madi Municipality, Chitwan, 44200, Nepal
2 Agriculture and Forestry University, Rampur, Chitwan, 44800, Nepal
Co-Corresponding email: wordsforkiran@gmail.com; chapaiarati100@gmail.com
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Abstract The study was conducted to determine fertilizer dosage that maximizes Chickpea yield, focusing on the Dhanush variety. Twelve fertilizer treatments were assessed at the research field of Agro Nine Company Pvt. Ltd., Madi, Chitwan, using a Randomized Block Design (RBD) replicated three times. Data were collected from five sample plants per plot. Results indicate that among the treatments, RDF supplemented with 25% vermicompost on a nitrogen basis yielded the highest output (2,799.73 kg/ha), followed by RDF supplemented with 25% FYM on a nitrogen basis (2,643.42 kg/ha). Treatment T4 exhibited the highest biological yield (6,537.38 kg/ha) and test weight (141.63 gm). Conversely, the control treatment displayed lower yields and poor growth and development across multiple parameters. These findings underline the need for further research to optimize fertilizer dosages for enhancing Chickpea yield, potentially benefiting farmers' economic standards.
Keywords Chickpea; Vermicompost; Integrated nutrient management; Madi; Chitwan

Introduction

Chickpea (*Cicer arietinum* L.), popularly called vegetable meat, is globally recognized as the third most significant pulse crop, following beans and peas. Botanically, cowpea belongs to the family Leguminosae and the subfamily Fabaceae. It is the only cultivated species in the genus Cicer and a self-pollinated diploid (2n = 2x = 16) crop (Varshney et al., 2013). It is a rich source of nutrients such as proteins (23%), carbohydrates (40%), vitamins, and essential amino acids (Jukanti et al., 2012). Chickpea (*Cicer arietinum* L.) is an important pulse crop grown and consumed all over the world, especially in the Afro-Asian countries. It is a good source of carbohydrates and protein, and protein quality is considered to be better than other pulses. Chickpea has significant amounts of all the essential amino acids except sulphur-containing amino acids, which can be complemented by adding cereals to the daily diet. Starch is the major storage carbohydrate followed by dietary fibre, oligosaccharides and simple sugars such as glucose and sucrose. Although lipids are present in low amounts, chickpea is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acids. β-Sitosterol, campesterol and stigmasterol are important sterols present in chickpea oil. Ca, Mg, P and, especially, K are also present in chickpea seeds. Chickpea is a good source of important vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor β-carotene. As with other pulses, chickpea seeds also contain anti-nutritional factors which can be reduced or eliminated by different cooking techniques. Chickpea has several potential health benefits, and, in combination with other pulses and cereals, it could have beneficial effects on some of the important human diseases such as CVD, type 2 diabetes, digestive diseases and some cancers. Overall, chickpea is an important pulse crop with a diverse array of potential nutritional and health benefits (Jukanti et al., 2012). Chickpea seeds contain more β-carotene than golden rice endosperm based on dry weight, as reported by Ye et al. (2000) and Abbo et al. (2005).

The area under cultivation of chickpeas in Nepal is about 17,005 ha with production and productivity only of 9,380 tons and 0.55 tons/ha, respectively (STATISTICAL-INFORMATION-ON-NEPALESE-AGRICULTURE-2071-72.Pdf, n.d.). Though the cultivated area of chickpea occupies an area to a great extent but its overall productivity in Nepal is comparatively low due to various factors. Since most of the soil is going to be depleted against the nutrients due to the continuous use of chemical fertilizer and imbalanced nutrition. The excessive and unbalanced use of chemical fertilizers has led to various issues such as a decrease in soil organic matter, rising salinity and sodicity, increased soil pollution, and heightened risks from pests and diseases (Chakrarborti and Singh, 2004).

Organic manures are very good source for the growth and development of microorganisms. Organic fertilizers such as farmyard manure, vermicompost, poultry manure, and oilcake aid in enhancing soil structure, promoting better aeration, and increasing the soil's capacity to hold water. Further, it boosts microbial activity, facilitating enhanced biological processes that aid the plant in obtaining both macro and micronutrients, thus increasing nutrient solubility. Moreover, organic manures also enhance the utilization efficiency of inorganic fertilizers (Singh and Biswas, 2000).

Integrated use of organic and inorganic fertilizers could help to uphold crop yield strength through the alleviation of deficiencies of nutrients, increasing the efficiency of the applied nutrients, and offering a favorable soil atmosphere (Muddukumar, 2007). Integrated nutrient management aims to sustain crop productivity by supplying essential plant nutrients while minimizing harm to soil health and the environment (Balasubramanian, 1999) .

There is a scope for improving the production potential of this crop by use of organic manures, inorganic manures and biofertilizers. Hence,The main objective of the present study is to assess the effect of integrated nutrient management on the growth and yield of chickpeas.

1 Materials and Methods

The experiment was conducted at the Research Farm of Agro Nine Company Pvt. Ltd., Madi, Chitwan, Geographically situated at 27°26’N latitude and 84°18’E longitude at an altitude of 200 m above mean sea level. The weather parameters were optimum for the chickpea crop. There were no drought weeks during the crop growth period. The soil is identified as sandy clay loam with poor aggregation. The pH of the soil is 7.6.

The Dhanush variety of Chickpea was subjected to a Randomized Block Design (RBD) experimental setup. This design encompassed 12 treatments replicated across 3 blocks. The dimensions of the plots were as follows: a gross size of 5.0 m × 3.6 m, and a net size of 4.0 m × 2.7 m, with a spacing of 1.5 m between replications and 1.0 m between individual plots. The rows were spaced 30 cm apart, with plants spaced 10 cm from one another. The seeding rate applied was 80 kg/ha, while the recommended fertilizer dosage included NPK at 20:40:20 kg/ha (https://molmac.lumbini.gov.np/publications/46).

The experiment consisted of twelve treatments as follows: T1 with 125% RDF, T2 with RDF alone, T3 with RDF supplemented with 25% FYM on a nitrogen basis, T4 with RDF supplemented with 25% vermicompost on a nitrogen basis, T5 with RDF supplemented with 25% Poultry Manure on a nitrogen basis, T6 with 50% RDF and 50% FYM on a nitrogen basis, T7 with 50% RDF and 50% vermicompost on a nitrogen basis, T8 with 50% RDF and 50% Poultry Manure on a nitrogen basis, T9 with 75% RDF and 25% FYM on a nitrogen basis, T10 with 75% RDF and 25% vermicompost on a nitrogen basis, T11 with 75% RDF and 25% Poultry Manure on a nitrogen basis, and T12 serving as the control group.

The FYM (0.5% N, 0.21% P_2O_5 and 0.45% K_2O), vermicompost (1.31% N, 0.9% P_2O_5 and 1.40% K_2O) and Poultry manure (1.2% N, 0.95% P_2O_5 and 0.6% K_2O) were incorporated into the soil as per treatments 5 days before sowing. Recommended doses of fertilizers were applied in the form of DAP and murate of potash as per treatments. Five plants in each plot were selected and were tagged and numbered. Observations for each treatment were taken on these plants.

The observations were made on the growth and yield of the Chickpea. Pre-harvest studies like Plant height, Number of branches, Number of compound leaves, Number of nodules and Number of pods were studied. Similarly, Post-harvest studies like Grain yield, Stover yield, Biological yield, Test weight and Harvest Index were studied.

2 Results and Analysis

2.1 Pre-harvest studies

The data revealed that different treatments significantly affected the plant height at different growth stages (Table 1). After 30, 60 and 90 days of sowing, the significantly highest plant height was recorded with treatment T4 followed by treatment T3 and T5 respectively whereas, the significantly lowest plant height was observed with control treatment. At harvest, the significantly highest plant height was observed with treatment T4 over other treatments except treatment T3 which was statistically similar to treatment T4 while, the significantly lowest plant height was observed in treatment T12 (control). Similarly, vermicompost amendments were reported to increase the plant heights of potatoes (Alam, 2007). Ali and Kashem (2018) found comparable outcomes regarding cabbage plant height when influenced by the combination of inorganic fertilizer and vermicompost.

Similarly, the results indicated that (Table 1), during the growing period, the significantly maximum number of branches, compound leaves, nodules and pods per plant was recorded in treatment T4 over all treatments. The significantly minimum number of such attributes was observed in treatment T12 (control). The growth parameters of chickpeas likely increased due to the higher availability of nutrients from the recommended dose of fertilizers (RDF) combined with vermicompost, facilitating the synthesis of nucleic acids, amino acids, and amide substances in the growing region and meristematic tissue, thereby enhancing cell division and leading to increased growth attributes in these treatments. All integrated nutrient levels outperformed the control group in plant height, branches per plant, seeds per pod, pods per plant, grain weight, stover yield, grain yield, biological yield, and harvest index during the study.

The application of vermicompost, either alone or in combination with other organic or chemical fertilizers, has been demonstrated to effectively enhance the growth and yield of various plants, which was supported by (Singh et al., 2011) in French bean and (Javed and Panwar, 2013) in black gram and Soyabean. Plant growth and development are facilitated by the existence of humic acids (Arancon et al., 2005) and the presence of micro and macronutrients within vermicompost (Atiyeh et al., 2000). Atiyeh et al. (2000) demonstrated that vermicomposts have the potential to enhance plant growth when incorporated into soil. The growth and yield of various plants are boosted by vermicompost, which offers high porosity, aeration, drainage, and water-holding capacity along with beneficial microflora (Tomati et al., 1987). Islam et al. (2016) demonstrated that the highest pod number was observed with the vermicompost treatment.

2.2 Post-harvest studies

It is clearly evident from the data that the grain yield, stover yield, Biological yield, test weight and harvest index of chickpea were deviated significantly due to various treatments (Table 2). The significantly highest grain yield, stover yield and Biological yield were obtained under the treatment T4, while, significantly lowest results were obtained with treatment T12 (Control).

The observed effects could be attributed to the application of RDF alongside vermicompost, which enhanced the physicochemical and biological properties of the soil, thereby promoting vigorous plant growth, increased production of functioning leaves, and greater accumulation of carbohydrates and proteins, which were then translocated to the reproductive organs, ultimately resulting in enhanced crop yield. Similar findings were reported by Verma et al. (2017) in chickpeas. Additionally, Singh and Singh (2014) noted significant differences in harvest index under these treatments, possibly due to proportionately higher grain production compared to straw yield.

Table 1 Effect of treatments on plant height, branches, compound leaves, root nodules and pods of chickpea

Treatments	Plant height (cm)				Number of branches/plant				Number of compound leaves/plant				Root nodules/ plant		Number of Pods/plant
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	40 DAS	60 DAS	At harvest
T1- 125% RFD	11.6	21.21	32.16	36.11	4.41	8.61	11.76	13.36	15.21	60.62	149.41	176.97	12.23	17.12	30.14
T2- RFD	11.8	21.82	33.81	38.77	4.48	8.68	12.01	13.66	14.15	59.68	146.72	174.57	13.81	19.75	30.02
T3- RDF+ 25% FYM (% N basis)	14.1	23.41	36.64	43.57	4.98	10.38	14.13	16.23	15.61	63.11	162.28	210.32	18.26	29.82	31.41
T4- RDF+ 25% vermicompost (% N basis)	15.6	23.62	38.84	45.56	5.61	10.82	14.82	16.92	16.28	65.67	165.67	222.74	23.66	33.73	32.28
T5- RDF+ 25% Chicken Manure (% N basis)	12.2	23.01	35.48	41.32	4.71	9.94	13.54	15.64	15.23	61.61	158.63	199.52	20.33	28.66	30.27
T6- 50% RDF + 50% FYM (% N basis)	8.6	15.68	28.28	31.33	3.21	6.43	9.43	11.24	12.24	55.42	123.44	150.38	10.88	16.11	21.32
T7- 50% RDF + 50% vermicompost (% N basis)	9.1	16.36	29.67	32.67	3.38	6.58	9.58	11.39	12.29	58.11	127.43	160.41	12.31	17.84	23.92
T8- 50% RDF + 50% Chicken Manure (% N basis)	8.21	15.41	27.38	29.38	3.03	6.21	9.21	11.02	11.26	54.83	114.47	139.56	11.07	16.23	19.54
T9- 75% RDF + 25% FYM (% N basis)	11	19.11	30.22	36.15	3.72	7.93	11.08	12.96	13.23	59.36	137.49	168.39	13.66	21.52	27.55
T10- 75% RDF + 25% vermicompost (% N basis)	11.58	19.26	31.86	37.79	3.98	8.19	11.44	13.32	13.82	59.61	140.65	175.58	16.84	23.32	29.87
T11- 75% RDF + 25% Chicken Manure (% N basis)	10.88	19	29.21	34.88	3.67	7.87	10.97	12.85	12.81	58.68	131.89	160.74	14.44	20.91	25.11
T12- Control	6.8	13.62	23.81	26.67	2.47	4.65	7.15	8.95	9.11	48.23	98.66	120.55	7.32	12.11	16.76
SEm±	0.36	0.54	0.64	0.79	0.11	0.25	0.33	0.38	0.31	1.58	2.99	3.59	0.53	0.65	0.61
C.D. at 5% level	1.07	1.6	1.9	2.33	0.34	0.73	0.97	1.14	0.93	4.67	8.84	10.6	1.56	1.92	1.81

Table 2 Effect of treatments on Number of seeds/pod, grain yield, stover yield, biological yield and harvest index of chickpea

Treatments	Number of seeds/pod	Grain yield (kg/ha)	Stover yield (kg/ha)	Test weight (g)	Biological yield (kg/ha)	Harvest index (%)
T1- 125% RFD	2.01	2179.61	3042.73	140.27	5222.34	41.74
T2- RFD	1.98	2146.24	3014.42	140.26	5170.67	41.7
T3- RDF+ 25% FYM (% N basis)	2.14	2643.42	3568.62	141.18	6212.05	42.55
T4- RDF+ 25% vermicompost (% N basis)	2.16	2799.73	3737.65	141.63	6537.38	42.83
T5- RDF+ 25% Chicken Manure (% N basis)	2.08	2406.73	3321.29	140.82	5728.02	42.02
T6- 50% RDF + 50% FYM (% N basis)	1.65	1121.79	1637.81	139.61	2759.6	40.65
T7- 50% RDF + 50% vermicompost (% N basis)	1.75	1322.39	1924.07	139.89	3246.46	40.73
T8- 50% RDF + 50% Chicken Manure (% N basis)	1.61	1024.39	1498.79	139.76	2523.18	40.6
T9- 75% RDF + 25% FYM (% N basis)	1.92	1771.75	2486.65	140.24	4258.4	41.61
T10- 75% RDF + 25% vermicompost (% N basis)	1.99	1985.57	2769.88	140.26	4755.45	41.75
T11- 75% RDF + 25% Chicken Manure (% N basis)	1.83	1523.45	2132.82	140.22	3656.27	41.67
T12- Control	1.48	742.56	1127.2	138.21	1869.76	39.71
SEm±	0.08	38.29	52.43	0.41	107.17	0.32
C.D. at 5% level	0.23	113.02	154.75	1.19	316.36	0.93

The increased mobilization of photosynthates to developing seeds due to the application of macronutrients could be the reason for the increase in the test weight of the seed. Significant effects were observed on the growth and yield of beans in plots fertilized with a combination of 50% vermicompost supplemented with Inorganic fertilizer. In plots treated with NPK and Vermicompost, pod length, the number of seeds per pod, the number of pods per plant, and pod weight were notably higher (Manivannan et al., 2009). Vermicompost acts as a naturally generated, slow-release supplier of plant nutrients, and incorporating it has been proven to enhance plant dry weight. Combining vermicompost with chemical fertilizer has been found to enhance leaf area index, making plants more photosynthetically active and leading to improvements in yield attributes (Sharma and Mitra, 1988). The inclusion of vermicompost led to a notable positive impact on the growth, yield, and elemental content of plants compared to the control group. Plots treated with vermicompost exhibited a significant increase in plant height, leaf length, and fruit yield of pepper plants (Narkhede et al., 2011). The application of vermicompost improves soil's physical and chemical conditions, leading to enhanced uptake by plants, ultimately resulting in increased growth, yield, and quality of beans (Manivannan et al., 2009).

(Kumar et al., 2018) conducted a trial to find out the effect of integrated nutrient management on the growth, yield and economies of chickpeas. Based on experimental results, it was found that the highest grain yield was recorded with the treatment RDF, Vermicompost at 5 tonnes per ha, Rhizobium culture and PSB applied.

3 Conclusion

From this study, it is recommended that the recommended dose of NPK fertilizer along with 25% vermicompost may be more beneficial in terms of growth and productivity. The significantly highest grain yield (2,799.73 kg/ha) and stover yield (3,737.65 kg/ha) was obtained under the treatment T4 (RDF + 25% vermicompost) followed by the treatments T3 (2,643.42 kg/ha and 3,568.62 kg/ha) and T5 (2,406.73 kg/ha and 3,321.29 kg/ha) while, significantly lowest grain yield (742.56 kg/ha) and stover yield (1,127.20 kg/ha) were obtained with treatment T12 (control). The significantly highest biological yield of chickpea (6,537.38 kg/ha) was obtained under treatment T4 (RDF + 25% vermicompost) over other treatments followed by T3 and T5. It is suggested that the application of a recommended dose of fertilizer with 25% vermicompost is a more scientific management of nutrients in sandy loam soil for chickpea crops in Madi Valley of Chitwan, Nepal.

Authors' contributions

KPU: Contribution to design and implementation of the research, interpretation of the results, writing the manuscript. AC: Implementation of the research, analysis of data, interpretation of the results, writing the manuscript. Both authors read and approved the final manuscript.

References

Abbo S., Molina C., Jungmann R., Grusak M.A., Berkovitch Z., Reifen R., Kahl G., Winter P., and Reifen R., 2005, Quantitative trait loci governing carotenoid concentration and weight in seeds of chickpea (*Cicer arietinum* L.), Theoretical and Applied Genetics, 111(2): 185-195.
https://doi.org/10.1007/s00122-005-1930-y
PMid:15918010

Alam M.N., Jahan M.S., Ali M.K., Islam M.S., and Khandaker S.M.A.T., 2007, Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth, Australian Journal of Basic and Applied Sciences, 1(4): 706-716.

Ali S., and Kashem M.A., 2018, Effect of Vermicompost on the Growth and Yield of Cabbage, Journal of Agricultural Engineering and Food Technology, 5(1): 45-49.

Arancon N., Edwards C., Bierman P., Metzger J., and Lucht C., 2005, Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field, Pedobiologia, 49: 297-306.
https://doi.org/10.1016/j.pedobi.2005.02.001

Atiyeh R.M., Subler S., Edwards C.A., Bachman G., Metzger J., and Shuster W., 2000, Effects of vermicomposts and composts on plant growth in horticultural container media and soil, Pedobiologia, 44: 579-590.
https://doi.org/10.1078/S0031-4056(04)70073-6

Balasubramanian V., 1999, Managing soil quality for sustainable rice production. Tamilnadu Rice Research Institute, 11-24.

Chakraborti M., and Singh N.P., 2004, Bio-compost: a novel input to organic farming, Agrobios Newsletter 2(8): 14-15.

Islam M.A., Boyce A.N., Rahman M.M., Azirun M.S., and Ashraf M.A., 2016, Effects of organic fertilizers on the growth and yield of bush bean, winged bean and yard long bean. Brazilian Archives of Biology and Technology, 59: e16160586.
https://doi.org/10.1590/1678-4324-2016160586

Javed S., and Panwar A., 2013, Effect of biofertilizer, vermicompost and chemical fertilizer on different biochemical parameters of Glycine max and Vigna mungo, Recent Research in Science and Technology, 5(1): 40-44.

Jukanti A.K., Gaur P.M., Gowda C.L.L., and Chibbar R.N., 2012, Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review, British Journal of Nutrition, 108(S1): S11-S26.
https://doi.org/10.1017/S0007114512000797
PMid:22916806

Kumar V., Jat H.S., Sharma P.C., Gathala M.K., Malik R.K., Kamboj B.R., Yadav A.K., Ladha J.K., Raman A., Sharma D.K., and McDonald A., 2018, Can productivity and profitability be enhanced in intensively managed cereal systems while reducing the environmental footprint of production? Assessing sustainable intensification options in the breadbasket of India. Agriculture, Ecosystems & Environment, 252: 132-147.
https://doi.org/10.1016/j.agee.2017.10.006
PMid:29343882 PMCid:PMC5727681

Manivannan S., Balamurugan M., Parthasarathi K., Gunasekaran G., and Ranganathan L., 2009a, Effect of vermicompost on soil fertility and crop productivity-Beans (*Phaseolus vulgaris*), Journal of Environmental Biology, 30(2): 275-281.

Muddukumar C.L., 2007, Organic nutrient management and plant protection in green chickpea production system (Doctoral dissertation, M. Sc. Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.

Narkhede S.D., Attarde S.B., and Ingle S.T., 2011, Study on effect of chemical fertilizer and vermicompost on growth of chilli pepper plant (*Capsicum annum*), Journal of Applied Sciences in Environmental Sanitation, 6(3).

Sharma A., and Mitra B., 1988, Effect of green manuring and mineral fertilizer on growth and yield of crops in rice-based cropping on acid lateritic soil, The Journal of Agricultural Science, 110(3): 605-608.
https://doi.org/10.1017/S0021859600082198

Singh B., Pathak K.A., Verma A.K., and Verma V., 2011, Effects of Vermicompost, Fertilizer and Mulch on Plant Growth, Nodulation and Pod Yield of French Bean (*Phaseolus vulgaris* L.), Vegetable Crops Research Bulletin, 74: 153-165.
https://doi.org/10.2478/v10032-011-0013-7

Singh G.B., and Biswas P., 2000, Balanced and integrated nutrient management for sustainable crop production. Limitations and future strategies, pp.55-60.

Singh D.S., and Singh R.P., 2014, Effect of integrated nutrient management on growth, physiological parameters and productivity of lentil (*Lens culinaris* Medik.), pp.175-178.

Tomati U., Grappelli A., and Galli E., 1987, The presence of growth regulators in earthworm-worked wastes, In On earthworms. Proceedings of international symposium on earthworms. Selected symposia and monographs, Unione Zoologica Italiana, (2): 423-435.

Varshney R.K., Song C., Saxena R.K., et al., 2013, Draft genome sequence of chickpea (*Cicer arietinum*) provides a resource for trait improvement, Nature Biotechnology, 31(3): 240-246.
https://doi.org/10.1038/nbt.2491
PMid:23354103

Verma P., Yadav A.N., Khannam K.S., Saxena A.K., and Suman A., 2017, Potassium-solubilizing microbes: diversity, distribution, and role in plant growth promotion, Microorganisms for green revolution: Volume 1: Microbes for sustainable crop production, 125-149.
https://doi.org/10.1007/978-981-10-6241-4_7

Ye X., Al-Babili S., Klöti A., Zhang J., Lucca P., Beyer P., and Potrykus I., 2000, Engineering the provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. Science (New York, N.Y.), 287(5451): 303-305.
https://doi.org/10.1126/science.287.5451.303
PMid:10634784