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Effect of Various Organic and Inorganic Sources of Nutrients on Growth, Yield, and Economics of Kharif Greengram [*Vigna radiata*. (L.) Wilczek] in the Bundelkhand Region, 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.

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ABSTRACT

The application of organics alone does not result in a dramatic rise in crop yields due to their low nutritional status and large quantity demand, which is also a restriction. As a result of the aforementioned implications, Greengram may now be grown using a combination of organic and

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inorganic fertilizers, as well as bio-fertilizers. There for a felid experiment was conducted in Effect of various organic and inorganic sources of nutrients on growth, yield, and economics of Kharif Greengram [*Vigna radiata.* (L.) Wilczek] in the Bundelkhand Region.The experiment was laid out in randomized block design with 3 replication having 10 treatments. The application of *Rhizobium*culture @ 25g/kg of seed along withVermicompost @ 2.5 t ha^{-1}; FYM @5 t $ha^{-1}$and 100% RDF was found significantly superior in plant height (69.90cm), number of leaves per plant (60.50), leaf area index (1.88) and Number of Rhizobium nodules $plant^{-1}$ (123.37) at 45 DAS, number of branches (8.43), Plant dry matter (362.11 g m^{-2}), pods $plant^{-1}$ (28.60), grain pod^{-1} (11.20), Length of pods (9.87cm), **S**eed index (4.50g), grain yield (11.41q ha^{-1}), and straw yield (27.45q ha^{-1}), Gross monetary returns(82330 Rs ha^{-1}) were found higher in same treatment T_{10}, as compared to other combination and control. However, highest benefit: cost ratio (3.44) was recorded with use of Rhizobium culture and application of 100% RDF (T_2) as compared to other combination and control.

Keywords: Biofertilizer; FYM; INM; inorganic fertilizer; organic.

1. INTRODUCTION

Pulses are vital part of Indian dietary system since of its richness in proteins and other vital nutrients such as Ca & Fe, and vitamins viz., (*carotene, thiamine, riboflavin* and *niacin*) the majority of the Indian population is vegetarian, and pulses are the main source of protein for human growth and development. They are both the poor man's meat and the rich man's vegetables. Each person should consume 80 grams of pulses per day, as the World Health Organization recommends. It's most commonly grown in the kharif season because that's when the rains are. Its possible uses in contingency crop planning are as a vegetable, pulse, feed, and green manure crop. Biological nitrogen fixing maintains soil fertility, essential for long-term agricultural viability [1]. Green gram yielded 0.72 million acres (ha), 40 thousand tons (ton), and 555 kilograms per hectare (kg/ha) in the Uttar Pradesh region in the 2017–18 agricultural year. Greengram is grown mostly in the Bundelkhand region of Uttar Pradesh during the Kharif season when rain is abundant and the soil is most fertile. In 2016–17, Greengram was grown on 2,848 ha, yielded 893.8 tons, and had a productivity of 318 kg/ha in the Banda district of Uttar Pradesh, according to data from www.upkrishi.org.Marginal land sub-marginal fields with low soil fertility and insufficient fertilizer contribute to the low yields of this crop [2]. The lack of fertilizer use has been linked to a significant decrease in Kharif Greengram yields [3]. Improved grain quality, soil health, and sustainability are only two of the many benefits farmers get from adopting INM practices, which boost crop yields by 8-150% compared to conventional methods. Sustainable agriculture on a global scale might learn a lot from the INM approach, which has the potential to be both cutting-edge and gentle on the planet. [4,5]. While chemical fertilizers play a crucial role in ensuring that crops receive the nutrients they require, their excessive and prolonged use can have a negative impact on soil's physical, chemical, and biological characteristics, posing a threat to agricultural production's long-term viability and leading to pollution of the surrounding environment [6].

As rising energy prices make chemical fertilizers unaffordable to farmers, their use will become an increasingly important factor in future agricultural productivity. Therefore, in order to maximize crop yields and quality, it is essential to expand the use of biofertilizers and encourage the use of organic while decreasing the use of chemical fertilizers. However, organics alone do not significantly raise crop yields because of their low nutritional status and high quantity demand. Because of these ramifications, Greengram can now be cultivated with a wide variety of fertilizers, including organic, inorganic, and bio-fertilizers. In addition to increasing crop yields and ensuring their consistency over time, organic manures and inorganic fertilizers have improved the soil's physical qualities [7]. Integrated Nutrient Management (INM) increases crop yields and ensures the systems' continued sustainability when applied to various cropping systems. Aulak [8]. Root development, dry matter formation, and nodulation are just a few of the many physiological processes that phosphorus is essential for. In addition, it encourages the growth of both lateral and fibrous roots. Plant growth-promoting chemicals such as n-acetyl-l-alanine (NAA), cytokines (Gibberellins), and gibberellic acid (GA3) are also present in vermicompost together with the nitrogen, phosphate, potassium, copper, zinc, and iron. It has been shown that adding farmyard manure and vermicompost to soil can increase its cations exchange capacity, reduce the release of nutrients, and boost microbial activity, plant growth, and crop output. The biological decomposition of these materials can also provide the plants with nitrogen, phosphorous, potassium, and micronutrients, including Fe, S, Mo, and Zn. When it comes to INM, biofertilizers are a must-have component. They have a lot of potential for fixing atmospheric nitrogen and are cheap and environmentally benign inputs. In addition, they can cut the need for synthetic fertilizers by as much as 25 percent to fifty percent [9]. Soil nitrogen stores have been depleted due to intensive cropping systems like those used to produce the pulses in such high demand worldwide today. Reduced agricultural yields can be traced back to a lack of essential nutrients in the soil, further depleted by the widespread use of high-analysis fertilizers. An imbalance between domestic consumption and production, rising costs of chemical fertilizers, and a decline in soil health, physiological qualities, and microbial activity all point to a growing need for an Integrated Nutrient Management system. Soil, air, and water pollution result from inorganic fertilizers, which also reduce agricultural production. The INM system and others related to soil health and environmental management solve this problem. It's the lynchpin of long-term agricultural progress [10].

2. MATERIALS AND METHODS

The experiment was carried out in Banda, Uttar Pradesh, during the Kharif season of 2019–2020. Green gram growth, yield, and economics as affected by different organic and inorganic nutrient sources and the pursuit of the optimal integrated nutrition management strategy. The experiment consist total 10 treatment replicated thrice in randomised block design and the treatment includes (T_1) Control, (T_2) Seed Treatment with Rhizobium @ 400 g ha^{-1}, (T_3) T_2 + Recommended Dose of N,P fertilizer@ 25:50 kg ha^{-1}, (T_4) Application of Vermicompost @2.5t/ha, (T_5) Recommended Dose of N,P fertilizer@25:50kg ha^{-1} + T_4, (T_6) FYM@5t ha^{-1}, (T_7) FYM@5t ha^{-1} + Recommended Dose of N,P fertilizer@25:50kg ha^{-1}, (T_8) T_2 + T_4 + FYM@5t ha^{-1}, (T_9) T_2 + T_4 + FYM@5t ha^{-1} + 50% Recommended Dose of N,P Fertilizer@ 12.5:25 kg ha^{-1}, (T_{10}) T_2 + T_4 + FYM@5t ha^{-1} + 100% Recommended Dose of N,P Fertilizer@ 25:50 kg ha^{-1}. The soil of the experiment field was slightly alkaline black with Electrical conductivity was (0.21 ds/m) bulk density was (1.58), low available nitrogen and phosphors (184 kg ha^{-1}, 10.23 kg ha^{-1} respectively) and organic carbon(0.47%) and medium available Potassium (197.05 kg ha^{-1}).

3. RESULTS AND DISCUSSION

3.1 Effect of INM Treatments on Plant Growth Parameter

3.1.1 Plant height (cm)

The data presented in (Table 1) significantly highest plant height at at 45 DAS was found in treatment T_{10}. However; it was at par with treatments T_9, T_7, T_5, T_3 and T_8. Treatment T_8 was statistically equivalent with T_6 and T_4. Significantly lowest plant height was observed in treatment T_1 (control). Highest plant height at 60 DAS was found in treatment T_{10}; which was found to be at par withT_9, T_7, T_5, T_3, T_8 and T_6. Treatment T_6 was significantly equivalent with T_4. Significantly lowest plant heights were recorded in treatment T_1 (control). The fact that vermicompost includes growth hormones, organic matter, and growth enzymes, which promotes fast cell division and elongation, may be the cause of the rise in plant height. When FYM breaks down, it increases the amount of macro- and micronutrients in the soil and improves its physical, chemical, and biological processes. Its rapid vegetative development may have been caused by this. Rhizobium bacteria have been cited as the primary cause of the increased plant growth since they produce IAA and gibberellin. Additional applications of chemical fertiliser in the form of DAP boost the amount of phosphorus that is readily available in the root zone, which may have accelerated early root development and cell division. It may have increased the plant's ability to get nutrients from the soil's upper layers. The findings of Jat et al. [12] and Pandey et al. [12] are consistent with these ones.

3.1.2 Leaf area index

Leaf area index at 45 DAS significantly highest was found in treatment T_{10}; which was found to be at par with T_9, T_7, T_5, $T_3$and T_8. Treatment T_8 was at par with T_6, T_4 and T_4. Significantly lowest leaf area index was observed in treatment T_1 (Control). At 60 DAS leaf area index was observed to decline in all the treatments. Highest

LAI was found in treatment T_{10}; which was found to be at par with T_9, T_7, T_5, $T_3$and T_8. Treatment T_8 was at par with T_6 and T_4. Significantly lowest leaf area index was observed in treatment T_1 (Control).

3.1.3 Number of branches

A perusal of data (1) revealed that significantly treatment T_{10} had the maximum number of branches at 45 DAS compared to T_9, T_7, T_5, T_3, T_8, T_6, and T_4. The control treatment (T_1) had the fewest reported numbers of branches. Treatment T_{10} had the maximum number of branches at 60 DAS compared to T_9, T_7, T_5, T_3, and T_8. When compared to T_6 and T_4, TreatmentT_8 was statistically indistinguishable. The control treatment (T_1) had the fewest number of branches. This increases number of branches might be due to steady supply of essential nutrients to the crop in balance form of organic and inorganic and favorable soil physical environment and also the highest level of primary nutrient which would have promoted the auxiliary buds in to new shoot. Vermicompost presence of growth hormones it responsible for activation of cell division and cell elongation. Sushil et al. [13] and Singh et al. [14] have reported consistent results.

3.1.4 Number of rhizobium nodules plant^{-1}

A perusal of data (Table 1) indicated that significantly highest number of Rhizobium nodules at 45 DAS significantly highest number of Rhizobium nodules were observed in treatment T_{10}. However; it was at par with T_9, T_3 and T_8. Treatment T_8 was significantly equivalent with T_5 and T_7. T_7 was at par with T_2, which was further at par with T_4. Significantly lowest numbers of Rhizobium were observed in treatment T_1 (control). At 60 DAS no. of Rhizobium nodules were found Significantly decreased in all treatments, significantly highest numbers of Rhizobium nodules were observed in treatment T_{10}. However; it was at par with T_3 and T_9. Treatment T_9 was significantly equivalent with T_8 and T_5. T_5 was at par with T_7, which was further at par with T_2. Significantly lowest numbers of Rhizobium were found in treatment T_1 (control). The highest number of root nodule might be due to increased Nitrogenase activity by Rhizobium which act as growth promoter in legumes and also produce growth hormone, i.e. IAA auxins, gibberellins and vitamins which are conductive to better nodulation. Optimum dose of phosphorus enhances the root nodulation in legume resulted number of root nodules in treated plants are more and maximum at 45 DAS. Likewise, Pandey et al. [15] reported similar studies.

3.1.5 Plant dry matter (g m^{-2})

Treatment T_{10} had the greatest Plant dry matters at 45 DAS, outperforming T_9, T_7, T_5, T_3, and T_8 by a wide margin. T_8 treatment was statistically similar to T_6 and T_4. Plant dry matter was significantly lower in treatment T_1 (Control). Plant dry matter was considerably higher in the T_{10} treatment at 60 DAS. However, it was statistically equivalent to T_9, T_7, T_5, T_3, T_8, T_6, and T_4. Treatment T_1 (Control) had the lowest Plant dry matter by a significant margin. The combined application of Rhizobium, Vermicompost, FYM, and chemical fertilization to the treatments increased the availability of nutrients over a longer period, which had a beneficial influence on the growth metrics, resulting in higher plant dry matter. Consistent findings are also found by Dash et al. [16] and Singh et al. [17].

3.1.6 Effect of INM treatments on yield attributing parameter

The data (Table 2) shows that the treatment T_{10} yielded the maximum number of pods overall at harvest. However; it was at par with T_9, T_7, T_5, T_3, T_8 and T_6. T_6 treatment was shown to be statistically comparable to T_4. Treatment T_1 (Control) had the fewest pods by a significant margin. Rhizobium + V.C @2.5t ha^{-1} + FYM @5t ha^{-1} + 100% RDF, which supply more nutritional interims, may account for the improved flower-to-pod conversion that led to the higher pod yield per plant. These results corroborate those of Naveen et al. [18] and Rupa et al. [19]. Resulted in statistically significantly higher numbers of seeds per pod at harvest was observed in treatment T_{10}. It was, however, on par with T_9, which was, in turn, on par with T_7.T_7 treatment was on par with T_5 and T_3, whereas T_3 was on par with T_8 and T_6. The treatment T_1 (Control) yielded fewer seeds per pod than the other treatments. An increased number of seed pods per unit area may have occurred from adequate photosynthetic results and nutrition availability via organic, inorganic, and biofertilizer. The number of seed pods per plant was increased using Rhizobium, Vermicompost, FYM, and inorganic fertilizers. Kokani et al. [20] and Singh et al. [21] discover consistent results. Treatment T_{10} had the longest pods, followed closely by

Table 1. Effect of integrated nutrient management treatments on plant growth parameter

Treatments	Plant height (cm)		Leaf area index		Number of branches		No. of Nodules Plant^{-1}		Plant Dry Matter (g m^{-2})	
	45 DAS	60DAS	45 DAS	60DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
T_1	35.73	43.13	1.51	1.17	4.93	6.03	55.10	45.90	180.80	266.18
T_2	38.57	48.93	1.54	1.32	5.20	6.70	91.63	82.43	205.40	299.50
T_3	54.53	66.53	1.71	1.60	6.03	7.83	116.80	106.67	274.67	342.47
T_4	52.27	61.93	1.60	1.48	5.63	7.03	80.17	70.40	238.40	315.85
T_5	54.90	67.50	1.81	1.69	6.03	7.93	106.67	95.60	281.79	345.14
T_6	52.90	64.53	1.64	1.53	5.87	7.23	70.10	61.43	255.27	323.97
T_7	57.13	68.23	1.84	1.72	6.07	8.03	102.53	90.07	290.57	352.89
T_8	53.77	65.30	1.67	1.58	5.97	7.83	111.67	100.00	272.33	332.40
T_9	58.63	69.09	1.86	1.74	6.27	8.17	120.07	105.50	291.89	355.07
T_{10}	59.18	69.90	1.88	1.79	6.47	8.43	123.37	113.17	299.65	362.11
SEm±	2.24	2.31	0.06	0.07	0.29	0.34	5.19	3.78	12.31	16.39
CD(P=0.05)	6.66	6.86	0.18	0.21	0.85	1.01	15.41	11.23	36.58	48.70

Table 2. Effect of INM treatments on Yield attributing parameter, production and economics of green gram

Treatments	No. of pods plant^{-1}	No. of grain pod^{-1}	Length of pods^{-1} (cm)	Seed index	Grain (q ha^{-1})	Stover (q ha^{-1})	Biomass yield (q ha^{-1})	Harvest index (%)	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	19.80	8.77	7.00	3.03	6.48	19.72	26.20	24.77	47169.67	28325.67	2.50
T_2	20.07	9.40	7.30	3.30	7.23	20.15	27.38	26.48	52443.92	33543.92	2.77
T_3	26.07	10.13	7.83	4.03	9.73	24.40	34.31	28.36	69538.75	49070.75	3.40
T_4	22.23	9.60	7.40	3.63	8.68	22.65	31.34	27.87	62831.58	39787.58	2.73
T_5	26.40	10.30	7.90	4.17	10.16	25.58	35.57	28.54	73429.58	48817.58	2.98
T_6	24.30	9.77	7.60	3.67	8.85	23.40	32.25	27.39	63396.42	41752.42	2.93
T_7	26.87	10.50	8.57	4.20	10.57	25.99	36.56	28.95	76324.42	53112.42	3.29
T_8	25.43	9.93	7.80	3.93	9.32	24.11	33.43	27.80	66755.33	40855.33	2.58
T_9	27.50	10.90	9.13	4.23	11.03	26.80	37.83	29.18	79591.00	52907.00	2.98
T_{10}	28.60	11.20	9.87	4.50	11.41	27.45	38.86	29.36	82330.08	54862.08	3.00
SEm±	1.07	0.14	0.44	0.20	0.54	1.04	1.30	1.32	3849.74	3849.74	0.17
CD (P=0.05)	3.19	0.43	1.31	0.60	1.60	3.10	3.86	NS	11438.06	11438.06	0.51

treatments T_9 and T_7. It was determined that T_7, T_5, T_3, T_8, T_6, and T_4 are all statistically similar treatments. Pod lengths were significantly shorter in T_1 (Control) than in any other treatment. The increased number of long pods may result from adequate photosynthetic results and nutrition supply via organic, inorganic, and biofertilizer. Pod length was enhanced by applying Rhizobium+Vermicompost+FYM and inorganic fertilizers across the board. Kokani et al. [20] and Verma et al. [7] both provide results that are consistent with these findings. Significantly highest seed index was observed in treatment T_{10}. However; it was at par with T_9, T_7, T_5, T_3 and T_8. Treatment T_8 was significantly equivalent withT_6 and T_4. Significantly lowest seed index was observed in treatment T_1 (Control). Data indicated that Rhizobium+ Vermicompost+ FYM and inorganic fertilizers with all levels of fertility registered boldness and sound health of seeds which ultimately resulted in higher seed weight, and these also improved the size of grain by improving the availability of soil nutrients and translocation of manufactured food from source to sink in plant and ultimately increased the yield. A similar result has been reported by Singh et al. [16] and Rupa et al. [19].

3.1.7 Effect of INM treatments on production

The data (Table 2) shows that treatment T_{10} had the maximum grain yield, followed by treatments T_9 and T_7. Treatment T_5 had the lowest grain yield. It was determined that T_5, T_3, T_8, T_6, and T_4 are all statistically similar treatments. Treatment T_1 (Control) had the lowest grain yield by a statistically significant margin. It may have been caused by the improved growth and subsequent higher photosynthesis from an appropriate supply of nutrients provided by Vermicompost, FYM, Rhizobium, and inorganic fertilizers. It aided in the accumulation of photosynthesis and subsequent translocations towards the sink, boosting yield. Significantly highest Straw yield was observed in treatment T_{10} (Rhizobium + V.C @2.5t ha^{-1} + FYM@5t ha^{-1} + 100% RDF). However; it was at par with T_9, T_7, T_5 and T_3. Treatments T_3, T_8, T_6 and T_4 were found to be statistically equivalent. Significantly lowest Straw yield was found in treatment T_1 (Control). Treatment T_{10} had the best biological yield, as the data shows. But it held its own against T_9, T_7, and T_5. T_5, T_3, T_8, and T_6 were all statistically indistinguishable. Treatment T_1 (Control) produced the lowest biological yield by a significant margin. exhibit harvest index data; however, neither table nor figure shows a statistically significant difference. Treatment 10 had the greatest harvest index, followed by T_9 (Rhizobium + V.C @2.5t ha^{-1} + FYM @5t ha^{-1} + 50% RDF), T7 (FYM @5t ha^{-1} +RDF @25: 50kg ha^{-1}), Treatments 5, 3, 4, 8, 6, and 4. TreatmentT1 (Control) yielded the lowest harvest index. Singh et al. [21], and Singh et al. [17] all found similar things.

3.2 Economics

3.2.1 Gross monetary returns and benefit: cost ratio

The data showed in (Table 2) revealed that significantly highest gross monetary returns (Rs 82330) per hectare were observed in treatment T_{10} (Rhizobium + V.C @2.5t ha^{-1} + FYM@5t ha^{-1} + 100% RDF); which was found to be at par with treatment T_9, T_7 and T_5. TreatmentT_5 was significantly equivalent with T_3, T_8, T_5 and T_4. This was further at par with T2. Significantly Lowest Gross monetary returns of (Rs 47170) per hectare were found in treatment T_1 (Control). The data presented in (Table 2) significantly highest benefit: cost ratio (3.40) was observed in treatment T_3 (T_2 + Recommended Dose of N, P fertilizer@ 25:50 kg ha^{-1}); which was found to be at par with treatment T_7, T_{10}, T_9, T_5 and T_6. Treatment T_6 was significantly equivalent with T_2, T_4 and T_2. Significantly Lowest benefit: cost ratio (2.50) was observed in treatment T_1 (Control).The observations related to monetary return are directly related to grain and straw yields which resulted in terms of output after sale in the market. Findings are in accordance with those of Meena et al. [22], Kumari et al. [23] and Singh et al. [21].

4. CONCLUSION

On the basis of *Kharif* field experiment in Greengram it is concluded that integrated nutrient management practice of Rhizobium seed treatment @ 20g/kg of seed along with combined application of Vermicompost @ 2.5t ha^{-1}, FYM @ 5 t ha^{-1} and 100% recommended dose of fertilizer (25: 50 N & P) per hectare has been found best option for productivity and economic return. This combination has also helped to improved organic carbon, bulk density and nutrient status of the soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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