Effect of various organic and inorganic sources of nutrients on growth, yield, and economics ofKharifGreengram [*Vignaradiata*.(L.) Wilczek] in the Bundelkhand Region.

ABSTRACT

Background: Integrated Nutrient Management (INM) increases crop yields and ensures the systems continued sustainability when applied to various cropping systems. The study aim to investigatethe combined effect of Rhizobium, Vermicompost, FYM, inorganic sources of nutrients on growth, yield, and economics ofKharifGreengram.

Methods: The experiment was laid three replicates along with randomized block design.

Results: showed that at 45 days after sowing, plants growth with treatment (T10) Rhizobium culture applied at a rate of 25 g/kg of seed along with Vermicompost @ 2.5 t ha^{-1}; FYM @5 t $ha^{-1}$and 100% RDF had greater plant height (69.90 cm), number of leaves $plant^{-1}$ (60.50), leaf area index (1.88), and number of Rhizobium nodules $plant^{-1}$ (123.37), branches(8.43) Plant dry matter (362.11 g m^{-2}) and pods $plant^{-1}$ (28.60), grain pod^{-1} (11.20), Length of pods (9.87cm), **S**eed index (4.50g), grain yield (1141kg ha^{-1}), and straw yield (2745 kg ha^{-1}), Gross monetary returns(82330 $Rsha^{-1}$) were found higher in compared to the other combinations and the control, the benefit-cost ratio that was recorded (3.44.)with the use of application of Rhizobium and 100% RDF (T2) was the highest.

Keywords: INM, FYM, biofertilizers, growth,Organic and inorganic fertilizers.

Introduction

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Due to its high protein content and plenty of other essential minerals like calcium and iron, as well as the B vitamins (carotene, thiamine, riboflavin, and niacin), pulses play an important role in the Indian diet. Most Indians follow a vegetarian diet, and pulses provide most of the protein they need. 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 (Kannaiyan, 1999). 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 (Saravanan. et al., 2013). The lack of fertilizer use has been linked to a significant decrease in KharifGreengram yields (Singh and Sekhon, 2008). 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

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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. (Jatet al., 2015). 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 (Virmani, 1994).

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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 (Verma et al., 2012). Integrated Nutrient Management (INM) increases crop yields and ensures the systems' continued sustainability when applied to various cropping systems. Aulakh (2010).

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 (Pattanayak et al., 2007). 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 (Mahajan& Sharma, 2005).

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Materials and methods

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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}).

Results and Discussion

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Effect of INM Treatments on plant growth parameter

Plant height (cm)

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Treatment T10 had considerably the greatest plant height at 45 DAS. It was comparable to, but, the T9, T7, T5, T3, and T8 therapies. In terms of statistics, treatment T8 was equal to T6 and T4. In treatment T1 (control), the plant height was noticeably lowest. The treatment T10 was found to have the highest plant height at 60 DAS; it was determined to be comparable to treatments T9, T7, T5, T3, T8, and T6. Treatment T6 and T4 were considerably equal. In treatment T1 (control), plant heights were noticeably lowest.T6 treatment was statistically similar to T4 treatment. The control treatment (T1) yielded the shortest plants by a significant margin. 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 Jatet al. (2012) and Pandeyet al. (2019) are consistent with these ones.

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Leaf area index

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At 45 DAS, treatment T10 had the significantly greatest leaf area index; it was also shown to be comparable to treatments T9, T7, T5, T3, and T8. Treatment T8 compared favourably to T6, T4, and T4. In treatment T1 (Control), the leaf area index was noticeably lowest. At 60 DAS, a reduction in the leaf area index was seen across all treatments. The therapy T10 with the highest LAI was discovered to be comparable to T9, T7, T5, T3, and T8. Treatment T8 compared favourably to T6 and T4. In treatment T1 (Control), the leaf area index was noticeably lowest.

Number of branches

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Treatment T10 had the maximum number of branches at 45 DAS compared to T9, T7, T5, T3, T8, T6, and T4. The control treatment (T1) had the fewest reported numbers of branches.

Treatment T10 had the maximum number of branches at 60 DAS compared to T9, T7, T5, T3, and T8. When compared to T6 and T4, TreatmentT8 was statistically indistinguishable. The control treatment (T1) had the fewest number of branches. The highest level of primary nutrients would have encouraged the auxiliary buds to develop into new shoots, explaining the increased number of branches. Other possible explanations include a balanced organic and inorganic nutrient supply to the crop, a conducive soil physical environment, and a good climate. The presence of growth hormones in vermicompost is what stimulates cell division and cell elongation. Sushilet al. (2015) and Singh et al. (2019) have reported consistent results.

Number of Rhizobium nodules plant^{-1}

Treatment T10had the maximum Rhizobium nodules at 45 DAS. Though, it held its own against T9, T3, and T8. T8 was statistically comparable to T5 and T7, the two previous treatments. T7 matched the quality of T2, which matched the quality of T4. Treatment T1 (control) had the fewest Rhizobium counts by a wide margin. Rhizobium nodules were first observed at 60 DAS. While the total number of Rhizobium nodules decreased across all treatments, it was the highest in Treatment T10. Still, it matched up well against T3 and T9. T9 was statistically similar to T8 and T5. T5 was at the same level as T7, which was at the same level as T2. The control treatment (T1) had the fewest Rhizobium counts. Increased Nitrogenase activity by Rhizobium, which promotes growth in legumes and produces growth hormone (IAA auxins, gibberellins, and vitamins), may account for the greatest observed root nodule density.The maximum number of root nodules in treated plants occurs at 45 DAS after receiving the optimal amount of phosphorus, which stimulates root nodulation in legumes. Likewise, Pandeyet al. (2019) reported similar studies.

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

Treatment T10 had the greatest Plant dry matters at 45 DAS, outperforming T9, T7, T5, T3, and T8 by a wide margin. T8 treatment was statistically similar to T6 and T4. Plant dry matter was significantly lower in treatment T1 (Control). Plant dry matter was considerably higher in the T10 treatment at 60 DAS. However, it was statistically equivalent to T9, T7, T5, T3, T8, T6, and T4. Treatment T1 (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. (2017) and Singh et al. (2018).

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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		Plant Dry Matter (g m^{-2})	
	45 DAS	60DAS	45 DAS	60DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
T1	35.73	43.13	1.51	1.17	4.93	6.03	55.10	45.90	180.80	266.18
T2	38.57	48.93	1.54	1.32	5.20	6.70	91.63	82.43	205.40	299.50
T3	54.53	66.53	1.71	1.60	6.03	7.83	116.80	106.67	274.67	342.47
T4	52.27	61.93	1.60	1.48	5.63	7.03	80.17	70.40	238.40	315.85
T5	54.90	67.50	1.81	1.69	6.03	7.93	106.67	95.60	281.79	345.14
T6	52.90	64.53	1.64	1.53	5.87	7.23	70.10	61.43	255.27	323.97
T7	57.13	68.23	1.84	1.72	6.07	8.03	102.53	90.07	290.57	352.89
T8	53.77	65.30	1.67	1.58	5.97	7.83	111.67	100.00	272.33	332.40
T9	58.63	69.09	1.86	1.74	6.27	8.17	120.07	105.50	291.89	355.07
T10	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

Effect of INM treatments on Yield attributing parameter

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The data(Table 2) shows that the treatment T10 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. T6 treatment was shown to be statistically comparable to T4. Treatment T1 (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. (2012) and Rupa et al. (2014) . Resulted in statistically significantly higher numbers of seeds per pod at harvest was observed in treatment T10. It was, however, on par with T9, which was, in turn, on par with T7.T7 treatment was on par with T5 and T3, whereas T3 was on par with T8 and T6. The treatment T1 (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. Kokaniet al. (2014) and Singh et al. (2019) discover consistent results.Treatment T10 had the longest pods, followed closely by treatments T9 and T7. It was determined that T7, T5, T3, T8, T6, and T4 are all statistically similar treatments. Pod lengths were significantly shorter in T1 (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. Kokaniet al. (2014) and Vermaet al. (2017) both provide results that are consistent with these findings. Significantly highest seed index was observed in treatment T10. However; it was at par with T9, T7, T5, T3 and T8. Treatment T8 was significantly equivalent withT6and T4. Significantly lowest seed index was observed in treatment T1(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.* (2011) and Rupa*et al.*(2014).

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Effect of INM Treatments on Production

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The data (Table 2) shows that treatment T10 had the maximum grain yield, followed by treatments T9 and T7. Treatment T5 had the lowest grain yield. It was determined that T5, T3, T8, T6, and T4 are all statistically similar treatments. Treatment T1 (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 T10 (Rhizobium + V.C @2.5t ha^{-1} + FYM@5t ha^{-1} + 100% RDF). However; it was at par with T9, T7, T5and T3. Treatments T3, T8, T6and T4 were found to be statistically equivalent. Significantly lowest Straw yield was found in treatment T1(Control). Treatment T10 had the best biological yield, as the data shows. But it held its own against T9, T7, and T5. T5, T3, T8, and T6 were all statistically indistinguishable. Treatment T1 (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 T9 (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. (2018), and Singh et al. (2019) all found similar things.

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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})	Biomas s yield (q ha^{-1})	Harvest index(%)	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T1	19.80	8.77	7.00	3.03	6.48	19.72	26.20	24.77	47169.67	28325.67	2.50
T2	20.07	9.40	7.30	3.30	7.23	20.15	27.38	26.48	52443.92	33543.92	2.77
T3	26.07	10.13	7.83	4.03	9.73	24.40	34.31	28.36	69538.75	49070.75	3.40
T4	22.23	9.60	7.40	3.63	8.68	22.65	31.34	27.87	62831.58	39787.58	2.73
T5	26.40	10.30	7.90	4.17	10.16	25.58	35.57	28.54	73429.58	48817.58	2.98
T6	24.30	9.77	7.60	3.67	8.85	23.40	32.25	27.39	63396.42	41752.42	2.93
T7	26.87	10.50	8.57	4.20	10.57	25.99	36.56	28.95	76324.42	53112.42	3.29
T8	25.43	9.93	7.80	3.93	9.32	24.11	33.43	27.80	66755.33	40855.33	2.58
T9	27.50	10.90	9.13	4.23	11.03	26.80	37.83	29.18	79591.00	52907.00	2.98
T10	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

Economics:

Gross monetary returns and Benefit: cost ratio

The data showed in (Table 2) revealed that significantly highest gross monetary returns (Rs82330) 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 $T_{4.}$ Which was further at par with T_2.Significantly Lowest Gross monetary returns of (Rs47170) per hectare were found in treatment T_1 (Control). The data presented in (Table 2 and Fig. 1) 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.* (2015), Kumari*et al.*(2018) and Singh *et al.* (2018).

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