Effect of Integrated Nutrient Management on Soil Fertility and Yield of Kharif Greengram [Vigna radiata (L.) Wilczek] in Bundelkhand Region

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT

An agronomic investigation was conducted during Kharif season 2019 at the research farm of Banda University of Agriculture and Technology, Banda (U.P) to study the effect of Integrated Nutrient Management on soil fertility and yield of Kharif Greengram (Vigna radiata L.) in Bundelkhand region. An experiment was laid out in randomized block design replicated thrice with 10 treatments comprised with application of organic and inorganic fertilizers and their combinations. Application of Rhizobium culture @ 25 g/kg of seed along with Vermicompost @ 2.5 t ha⁻¹, FYM @5 t ha⁻¹ and 100% RDF was found to be responsible for highest availability of nitrogen (233.90 kg ha⁻¹), phosphorous (21.19 kg ha⁻¹) and potassium (239.20 kg ha⁻¹) in soil after harvest of crop. It was also resulted in higher grain yield (11.41 q ha⁻¹), straw yield (27.45 q ha⁻¹) as compared to other combinations and control.

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1. INTRODUCTION

Pulses are an integral part of Indian dietary system because of its richness in proteins and other important nutrients such as Ca & Fe, and vitamins viz., carotene, thiamine, riboflavin and niacine. Indian population is predominantly vegetarian and protein requirement for the growth and development of the human being is mostly met with pulses. They are said to be poor man's meat and rich man's vegetables. As per recommendation of WHO minimum requirement of pulses is 80 g capita\(^{-1}\) day\(^{-1}\). Greengram is one of the most important pulse crop and widely cultivated throughout the world including India, Bangladesh, Srilanka, Indonesia; Africa, and U.S.A. In India, Major cultivating states of Greengram are Maharashtra, Rajasthan, U.P., M.P, A.P and Karnataka. It is usually cultivated as rain-fed crop in kharif season and can also be grown in summer with important uses as vegetable, pulse, fodder and green manure crop and having wide scope in contingent crop planning. It maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in achieving the sustainability in agriculture [1]. Its area, production and productivity at national level is 4.2 million ha, 2.09 million tonnes and 472 kg/ha; respectively (Anonymous, 2018). In Uttar Pradesh area, production and productivity of Greengram was 0.72 lakh ha, 0.40 lakh tones and 555 kg/ha; respectively during 2017-18. In Bundelkhand region (U.P.) Greengram is cultivated mainly in Kharif season; because during this season adequate moisture availability is there for crop cultivation. The area, production and productivity of Greengram in Banda district of Uttar Pradesh is 2848 hectares, 893.8 tonnes and 318 kg/ ha respectively during 2016-17 (source: www.upkrishi.org).

The productivity of this crop is very low because of its cultivation on marginal land sub marginal lands of low soil fertility where little attention is paying to adequate fertilization [2]. In Kharif Greengram, a high reduction in yield has been reported due to non-use of fertilizers [3]. Integrated Nutrient Management (INM) increases crop yields by 8-150% as compared with conventional practices, increases water and nutrients use efficiency and the economic returns to farmers, while improving grain quality and soil health and sustainability. INM practice could be an innovative and environment friendly practice for sustainable agriculture worldwide [4]. Chemical fertilizers are playing a crucial role to meet the nutrients need of the crop, the imbalance and continuous use of chemical fertilizers has adverse effect on soil physical, chemical and biological properties thus affecting the sustainability of crop production, besides causing environmental pollution [5]. Besides, persistent nutrient depletion is posing a greater threat to the sustainable agriculture. Consumption of chemical fertilizers will also be quite alimenting factor of agricultural production in future, because of escalating energy cost, chemical fertilizers are not available at affordable price to the farmers. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase in the usage of bio fertilizers & promote organic to boost the yield and quality levels. On the other hand, use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status and huge quantity requirement also a constraint. Therefore, the aforesaid consequences have paved way to grow Greengram by integration of organic and inorganic fertilizers along with bio-fertilizers. Integration of organic manures and inorganic fertilizers has been found to be promising not only in maintaining sustainable higher productivity of crops and for providing stability in crop production, besides improving soil physical conditions [6]. The role of Integrated Nutrient Management (INM) enhances the crop yields in various cropping systems ensuring long-term sustainability of the system [7]. Integration of inorganic fertilizers and organic manures resulted in better growth, yield and nutrient uptakes in different crops as compared to sole application of organic manures and inorganic fertilizers [8].

Phosphorus play a key role in various physiological process like root growth, dry matter production and nodulation. It also promotes the formation of lateral and fibrous root. Vermicompost is an aerobically degraded organic matter which has undergone chemical disintegration by the enzymatic activity in guts of worms and also enzymic of the associated microbial population. It contains 0.80 to 1.10% nitrogen, 0.40 to 0.80% phosphorus and 0.80 to 0.98% K\(_2\)O; 10 to 52 PPM Cu, 186.60 PPM Zn, 930 PPM Fe and plant growth promoting substances such as NAA, cytokines, gibberellins etc. Farmyard Manure play an important role in obtain high yield and rich in major and minor nutrients. Application of FYM improves soil

Keywords: Nutrient management; agriculture; inorganic fertilizers; rhizobium culture.
fertility and availability of K₂O and P₂O₅ from FYM is similar to that from inorganic sources (www. Vanashree.in/FYM). Farm Yard manure and Vermicompost are able to supply nitrogen, phosphorus, potassium and micronutrients like Fe, S, Mo and Zn etc., in available form to the plants through biological decomposition and improve physico-chemical properties of soil, slow release of nutrients, and increase in cations exchange capacity and enhance the microbial activities, crop growth and yield. Bio fertilizers are also one of the important components in Integrated Nutrient Management system. They are low cost and eco-friendly inputs, which have tremendous potential of fixing atmospheric nitrogen and can reduce the chemical fertilizer dose by 25-50% [9]. In present global rising demand of pulses intensive cropping system has led to reduction of reserves nutrient in soil, they cause more nutrient deficiencies. The use of high analysis fertilizer depletion of soil micronutrient has also unbraced micronutrient deficiency causes considerable decrease the crop productivity. The increasing need of Integrated Nutrient Management system due to escalating prices of chemical fertilizers, imbalance in the ratio of NPK consumption, deterioration is soil health, physiological properties and microbial activity, imbalance between the consumption and domestic production. Consumption of nonrenewable energy by inorganic fertilizers, leads soil, air and water pollutions with decrease in the crop productivity through the use of inorganic fertilizers, so that all the problem of soil health and environment management through the INM system. It is the key role for sustainable agriculture development [10].

2. MATERIALS AND METHODS

The field experiment was conducted during Kharif season 2019-20 at the research farm of BUAT, Banda-210001, India to assess the effect of various organic and inorganic sources of nutrients on growth, yield and economics of green gram and finding out best suitable integrated nutrient management practice. The experiment consist total 10 treatment replicated thrice and the treatment includes (T₁) Control, (T₂) Seed Treatment with Rhizobium @ 400 g ha⁻¹, (T₃) T₂ + Recommended Dose of N,P fertilizer@ 25:50 kg ha⁻¹, (T₄) Application of Vermicompost @2.5t/ha, (T₅) Recommended Dose of N,P fertilizer @ 25:50kg ha⁻¹, (T₆) FYM @ 5t ha⁻¹, (T₇) FYM@5t ha⁻¹ + Recommended Dose of N,P fertilizer @ 25:50kg ha⁻¹, (T₈) T₂ + T₄ + FYM @ 5t ha⁻¹, (T₉) T₂ + T₄ + FYM @ 5t ha⁻¹ + 50% Recommended Dose of N,P Fertilizer @ 12.5:25 kg ha⁻¹, (T₁₀) T₂ + T₄ + 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 0.21, Bulk density1.58, 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 Soil Available Nutrients at after Harvest of the Crop

3.1.1 Soil pH and electrical conductivity

Data from the Table 1 showed that soil pH and Electrical conductivity were not significantly affected by various integrated nutrient management treatment. The Higher soil pH was found in treatment T₉ (Control) and higher electrical conductivity was observed in treatment T₅ (FYM @ 5 t ha⁻¹ + RDF @ 25: 50 kg ha⁻¹).

3.1.2 Organic carbon and available nitrogen

Data presented in Table 1 indicated that significantly highest organic carbon of soil was found in treatment T₁₀ (Rhizobium + V.C @2.5t ha⁻¹ + FYM@5t ha⁻¹ + 100% RDF); which was followed by treatment T₉, T₅, T₆, T₈, T₇, T₆ and T₃. Significantly lowest organic carbon of soil was found in treatmentT₁(control).Significantly highest available nitrogen of soil was found in treatmentT₉ (Rhizobium + V.C @ 2.5t ha⁻¹ + FYM @ 5t ha⁻¹ + 100% RDF); which found to be at par with T₉ and T₇. Treatment T₇, T₅, T₆, T₈ and T₄ was found to be statistically equivalent (Table 2 and Fig. 1). Significantly lowest available nitrogen in soil was found in treatment T₁ (control). Comparative analysis of initial and final data of soil fertility showed the significantly build upof organic carbon in soil after harvest of Greengram with application of Rhizobium + V.C @ 2.5t ha⁻¹ + FYM @ 5t ha⁻¹ + 100% RDF as compared to control. The increase in organic carbon content might be attributed to addition of organic materials and better root growth. Further, application of Rhizobium + V.C @ 2.5t ha⁻¹ + FYM@5t ha⁻¹ + 100% RDF significantly increased the content of nitrogen in soil after harvest of Greengram crop. The data indicated that available nitrogen content improvement in almost all the treatment. Highest increase was found in treatment T₁₀ (Rhizobium + V.C @ 2.5t ha⁻¹ + FYM @ 5t ha⁻¹ + 100% RDF); which was
lowest in T\textsubscript{1} (control). Significantly improved of soil available nitrogen in various treatments might be attributed to the direct addition of nitrogen through FYM, Vermicompost and DAP fertilizers to the available pool of soil along with increased activity of N fixing bacteria and increased organic N fixation of soil due to biochemical degradation and mineralization, there by resulting in higher accumulation of nitrogen in soil.

### 3.1.3 Available phosphorus

The data presented in (Table 2 and Fig. 1) indicates that significantly highest available phosphorus of soil was observed in treatment T\textsubscript{10} \text{ (Rhizobium + VC @ 2.5 t ha}^{-1} + FYM @ 5 t ha}^{-1} + 100\% RDF). However; it was at par with T\textsubscript{9}. Treatment T\textsubscript{9} was significantly equivalent with T\textsubscript{7}, T\textsubscript{5} and T\textsubscript{3}, which was further at par with T\textsubscript{8}, T\textsubscript{6} and T\textsubscript{4}. Significantly lowest available phosphorus of soil was observed in treatment T\textsubscript{1} (control). An increased phosphorus level in soil after harvest was observed in various nutrient management treatments. The increase in available phosphorus content of soil might be due to the addition of organic and inorganic fertilizers and direct addition of phosphorus as well as solubilization of native P through various organic acids.

### 3.1.4 Available potassium

Significantly highest available potassium of soil was found in treatment T\textsubscript{10} \text{ (Rhizobium + VC @ 2.5 t ha}^{-1} + FYM @ 5 t ha}^{-1} + 100\% RDF); which found to be at par with T\textsubscript{9} and T\textsubscript{7}. (Table 2 and Fig. 1). Treatment T\textsubscript{7}, T\textsubscript{5}, T\textsubscript{3}, T\textsubscript{8}, and T\textsubscript{6} was found to be statistically equivalent. Significantly lowest available potassium in soil was found in treatment T\textsubscript{1} (control). Available potassium content in soil was also affected by various nutrient management treatments. Significantly increased the content of available potassium in soil after harvest of Greengram crop with addition of treatment T\textsubscript{10} \text{ (Rhizobium + VC @ 2.5 t ha}^{-1} + FYM @ 5 t ha}^{-1} + 100\% RDF) and lowest were observed in T\textsubscript{1} (control). The increase in available Potassium in soil might be attributed to the beneficial effect of organic manure through addition of K by vermicompost, FYM and inorganic fertilizer to the available pool of soil. These finding are in close conformity with the results of Ahamad et al. [11], Gorade et al. [12] and Gohain et al. [13].

#### Table 1. Effect of INM treatments on soil pH, EC and OC after harvest

| Treatments | pH   | EC (dSm\textsuperscript{-1}) | OC % |
|------------|------|------------------------------|------|
| T\textsubscript{1}: Absolutely Control | 7.72 | 0.125 | 0.43 |
| T\textsubscript{2}: Seed Treatment with Rhizobium | 7.70 | 0.123 | 0.44 |
| T\textsubscript{3}: T\textsubscript{2} + Recommended Dose of N,P fertilizer @ 25:50 kg ha\textsuperscript{-1} | 7.66 | 0.127 | 0.44 |
| T\textsubscript{4}: Application of Vermicompost @ 2.5t/ha | 7.66 | 0.123 | 0.48 |
| T\textsubscript{5}: Recommended Dose of N,P fertilizer@25:50kg ha\textsuperscript{-1} + T\textsubscript{4} | 7.67 | 0.122 | 0.49 |
| T\textsubscript{6}: FYM@5t ha\textsuperscript{-1} | 7.68 | 0.123 | 0.47 |
| T\textsubscript{7}: FYM@5t ha\textsuperscript{-1} + Recommended Dose of N,P fertilizer @ 25:50kg ha\textsuperscript{-1} | 7.71 | 0.128 | 0.46 |
| T\textsubscript{8}: T\textsubscript{2} + T\textsubscript{4} + FYM @ 5t ha\textsuperscript{-1} | 7.66 | 0.121 | 0.44 |
| T\textsubscript{9}: T\textsubscript{2} + T\textsubscript{4} + FYM @ 5 t ha\textsuperscript{-1} + 50\% Recommended Dose of N,P Fertilizer @ 12.5:25 kg ha\textsuperscript{-1} | 7.61 | 0.117 | 0.51 |
| T\textsubscript{10}: T\textsubscript{2} + T\textsubscript{4} + FYM @ 2.5 t ha\textsuperscript{-1} + 100\% Recommended Dose of N,P Fertilizer @ 25:50 kg ha\textsuperscript{-1} | 7.60 | 0.115 | 0.52 |

SEm ± 0.05 0.00 0.02
CD(P=0.05) NS NS 0.06
CV (%) 1.02 4.05 6.93
GM 7.67 0.12 0.46
Table 2. Effect of INM treatments on soil available nutrients after harvest

| Treatments | N kg ha⁻¹ | P₂O₅ kg ha⁻¹ | K₂O kg ha⁻¹ |
|------------|-----------|---------------|--------------|
| T₁: Absolutely Control | 182.12 | 14.18 | 187.0 |
| T₂: Seed Treatment with *Rhizobium* | 188.85 | 15.34 | 195.9 |
| T₃: T₂ + Recommended Dose of N,P fertilizer @ 25:50 kg ha⁻¹ | 205.29 | 18.49 | 215.3 |
| T₄: Application of Vermicompost @ 2.5t/ha | 192.78 | 16.56 | 197.3 |
| T₅: Recommended Dose of N,P fertilizer @ 25:50kg ha⁻¹ + T₄ | 208.52 | 19.04 | 217.6 |
| T₆: FYM @ 5t ha⁻¹ | 199.31 | 17.13 | 200.4 |
| T₇: FYM @ 5t ha⁻¹ + Recommended Dose of N,P fertilizer @ 25:50kg ha⁻¹ | 213.12 | 19.48 | 218.6 |
| T₈: T₂ + T₄ + FYM @ 5t ha⁻¹ | 197.91 | 17.75 | 210.6 |
| T₉: T₂ + T₄ + FYM @ 5t ha⁻¹ + 50% Recommended Dose of N,P Fertilizer @ 12.5:25 kg ha⁻¹ | 228.23 | 20.39 | 234.9 |
| T₁₀: T₂ + T₄ + FYM @ 5t ha⁻¹ + 100% Recommended Dose of N,P Fertilizer @ 25:50 kg ha⁻¹ | 233.90 | 21.19 | 239.2 |

SEm ± 7.88 0.72 6.93
CD(P=0.05) 23.42 2.15 20.59
CV (%) 6.66 6.99 5.67
GM 205 17.96 211.68

Table 3. Effect of integrated nutrient management treatments on yield of Greengram

| Treatments | Grain (q ha⁻¹) | Stover (q ha⁻¹) |
|------------|----------------|-----------------|
| T₁: Absolutely Control | 6.48 | 19.72 |
| T₂: Seed Treatment with Rhizobium | 7.23 | 20.15 |
| T₃: T₂ + Recommended Dose of N,P fertilizer@ 25:50 kg ha⁻¹ | 9.73 | 24.40 |
| T₄: Application of Vermicompost @2.5t/ha | 8.68 | 22.65 |
| T₅: Recommended Dose of N,P fertilizer@25:50kg ha⁻¹ + T₄ | 10.16 | 25.58 |
| T₆: FYM@5t ha⁻¹ | 8.85 | 23.40 |
| T₇: FYM@5t ha⁻¹ + Recommended Dose of N,P fertilizer @ 25:50kg ha⁻¹ | 10.57 | 25.99 |
| T₈: T₂ + T₄ + FYM@5t ha⁻¹ | 9.32 | 24.11 |
| T₉: T₂ + T₄ + FYM@5t ha⁻¹ + 50% Recommended Dose of N,P Fertilizer @ 12.5:25 kg ha⁻¹ | 11.03 | 26.80 |
| T₁₀: T₂ + T₄ + FYM@5t ha⁻¹ + 100% Recommended Dose of N,P Fertilizer @ 25:50 kg ha⁻¹ | 11.41 | 27.45 |

SEm± 0.54 1.04
CD(P=0.05) 1.60 3.10
CV (%) 9.96 7.53
GM 9.35 24.03

3.2 Effect of Integrated Nutrient Management Treatments on Yield

3.2.1 Grain yield

Significantly highest grain yield was observed in treatment T₁₀ (*Rhizobium + V.C @2.5t ha⁻¹ + FYM @ 5t ha⁻¹ + 100% RDF*); which was found to be at par with T₈, T₇, and T₅. (Table 3 and Fig. 2). Treatments T₅, T₃, T₈, T₆ and T₄ were found to be statistically equivalent. Significantly lowest grain yield was observed in treatment T₁ (Control). This might be due to an adequate supply of nutrient from Vermicompost, FYM, *Rhizobium*, and inorganic fertilizers resulting in enhanced availability of nutrients and helped in better growth resulting into increased photosynthesis. This helped in storage of more photosynthesis and their translocations towards sink and this contributed to increased yield.
These findings are in close conformity with the results of Jat et al. [4], Patel et al. [14], Singh et al. [15] and Singh et al. [16].

3.2.2 Straw yield

Significantly highest Straw yield was observed in treatment $T_{10}$ ($\text{Rhizobium} + \text{V.C}$ @ 2.5 t ha$^{-1}$ + FYM @ 5 t ha$^{-1}$ + 100% RDF). However, it was at par with $T_9$, $T_7$, $T_8$, and $T_3$. Treatments $T_3$, $T_8$, $T_4$, and $T_6$ were found to be statistically equivalent. Significantly lowest Straw yield was found in treatment $T_1$ (Control).

![Fig. 1. Effect integrated nutrient management treatments on soil available nutrients after harvest](image)

![Fig. 2. Effect of different integrated nutrient management on production](image)

4. CONCLUSION

It can be concluded from the present experiment that Integrated Nutrient Management with combine application of $\text{Rhizobium}$ culture @ 25 g/kg seed; Vermicompost @ 2.5 t ha$^{-1}$; FYM @ 5 t ha$^{-1}$ and 100% RDF is beneficial for increasing availability status of N, P and K along with improvement in organic carbon content and grain yield in greengram.
COMPETING INTERESTS
Authors have declared that no competing interests exist.

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