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Short Communication

Effect of integrated nutrient management on growth and yield of green gram [*Vigna radiata* (L) Wilczek].

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ABSTRACT

The impact of integrated nutrient management was studied on growth and production, in green gram (*Vigna radiata* L.). Ten nutrient management treatments including fertilizer levels with or without inorganic fertilizers, *Rhizobium*, PSB and FYM were used in the present study. The plant height, dry weight per plant, leaf area index, no. of root nodules per plant and number of pods per plant were significantly increased with the use of fertilizers, biofertilizers and FYM application. It also improved yield (grain yield by 164% and straw yield by 121%), and yield attributing factors. The addition of FYM, together with *Rhizobium* and PSB, assisted in boosting output in comparison to the control. However, 100% RDF + PSB + Rhizobium + FYM (2.5 t ha^{-1}) significantly improved the gross return (154%), net returns (551%), and benefit-cost ratio (137%). Therefore, higher yield of green gram can be achieved with integrated use of various nutrient sources were achieved usingsuch as inorganic fertilizers (RDF), bio-fertilizers, and FYM).

Key words: Farmyard manure, Green gram, Phosphate solubilizing bacteria, *Rhizobium*, *Vigna radiata*

Green gram is a short-duration, drought-tolerant pulse crop also referred to as "mungbean". Its seed contains 20-25% protein, 3% vitamin, and 51% carbohydrates (Ganesan and Xu 2018). India ranks first in green gram production and is grown in about 4.5 mha areas with a total production of 2.64 million tonnes with a productivity of 548 kg/ha and contributed 10 % to the total pulse production in the year of 2020-21. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Telangana, and Andhra Pradesh are the major pulse-producing states in India.

Integrated nutrient management includes blending and application of organic, inorganic (chemical fertilizers), and biofertilizers nutrients to soils to promote crop growth and increase the yields of high-quality products. However, artificial fertilizers are essential in helping the crop get the nutrients it needs. Chemical fertilizers have unfavorable impacts on the physical, chemical, and biological aspects of soil when used in an unbalanced manner, which not only results in environmental contamination but also affects the sustainability of crop production. *Rhizobium* inoculation is the least expensive, most straightforward, and risk-free method of delivering nitrogen to green gram through the well-known symbiotic nitrogen fixation process, compared to other bio-fertilizers. By secreting organic acids and enzymes, phosphate-solubilizing bacteria (PSB) play a crucial role in converting unavailable inorganic P (Ca-P, Fe-P, and Al-P) into available inorganic P forms (Singh, 1999). Therefore, when seeds are infected with *Rhizobium* and phosphate solubilizing bacteria inoculants, there may be a significant saving of applied nitrogen and phosphorus. Farmyard manure (FYM) increases the availability of both naturally occurring and applied nutrients while containing a sizeable amount of nutrients that become available to plants as they decompose (Chand 2007).

The field experiment was conducted at the Crop Research Centre, School of Agriculture, ITM University, Gwalior (M.P.) during the *Kharif* season of the year 2021-22 (26.1495′ N latitude and 78.1873′ E longitude and 211m Altitude). It falls under the Grid region of India.

Ten nutrient management treatments with three replications were used in the experiment's randomized block design, viz., T_1: control; T_2: 100% RDF (20:40:20 NPK kg ha^{-1}); T_3: 75% RDF + PSB (25 g kg^{-1} seeds); T_4: 75% RDF + *Rhizobium* (25 g kg^{-1} seeds); T_5: 75% RDF + FYM (2.5 t ha^{-1}); T_6: 75% RDF + PSB (25 g kg^{-1} seeds) + *Rhizobium* (25 g kg^{-1} seeds); T_7: 75% RDF + PSB (25 g kg^{-1} seeds) + *Rhizobium* (25 g kg^{-1} seeds) + FYM (2.5 ton ha^{-1}); T_8: 50%RDF+PSB (25g kg^{-1} seeds) + *Rhizobium* (25 g kg^{-1} seeds) + FYM (2.5 ton ha^{-1}).; T_9: 100%RDF + PSB (25g kg^{-1} seeds) + *Rhizobium* (25 g kg^{-1} seeds) + FYM (2.5 ton ha^{-1}); and T_{10}: 125%RDF + PSB (25g kg^{-1} seeds) + *Rhizobium* (25 g kg^{-1} seeds) + FYM (2.5 ton ha^{-1}). Urea, SSP, and MOP as nitrogen, phosphorus, and potassium sources, were used, respectively. The furrows were opened by roughly 5 cm after a basal dose of fertilizer, given in individual plots according to treatment allocation. PSB (at 25 g kg^{-1} green gram seed) and *Rhizobium* (at 25 g kg^{-1} green gram seed) were then applied to the green gram seeds. The inoculated seeds were dried in the shade and sown as soon as they were dry. To raise the crop, all recommended agronomic practices were followed consistently. The plant growth data were collected at 20, 40, and 60 days after sowing (DAS) as well as at the harvest stage during the experiment. The data recorded were subjected to statistical analysis for mean, standard error of the mean, and critical differences (Snedecor and Cochran 1994).

In the present study, plant height was recorded as significantly high in T_9 and T_{10} (49.24 and 49.86 cm) compared to the other treatments (Table 1). All of the treatments using NPK, FYM, and bio-fertilizer significantly increased plant height by 49.86 cm in T_{10} compared to 26.31 cm in T_1. The results corroborated the findings of Kumar and Singh (2010), and Pandey *et al.* (2019). The dry matter production of green gram was significantly influenced by the INM treatments. The crop accumulated the high dry matter at the harvest stage in T_9 and T_{10} (461.54 and 472.62 g m^{-2}) followed by T_7. The results are similar to Dhakal *et al*. (2016) and Tiwari and Tripathi (2020). Results indicated that the treatments T_9 and T_{10} (4.34 and 4.56) had a significantly high leaf area index compared to others and it was gradually increased as the crop aged up to 60 DAS before beginning to drop approaching harvest after that point. A similar trend was observed in the study of Aslam and Nagavani (2019). The higher number of nodules per plant at 60 DAS were observed in T_9 and T_{10} (47.94 and 48.63 $plant^{-1}$) compared to the rest of the treatments and were in conformation with Ghanshyam *et al*. (2010), Sharma and Abraham (2010) and Jat *et al.* (2012). Different treatments had a considerable impact on the quantity of pod $plant^{-1}$ in the green gram. Over all other treatments, T_9 and T_{10} (34.32 and 34.86 $plant^{-1}$) recorded a higher number of pods $plant^{-1}$. The results showed a favorable response to the application of NPK, FYM, and Bio-fertilizer (Kumavat *et al*. 2010, Dekhane and Chavan 2011).

Table 1. Effect of various treatments on plant height, dry matter accumulation, leaf area index, no. of root nodules and no. of pods

Treatments	Plant height (cm)	Dry matter accumulation (g m^{-2})	Leaf area index	No. of nodules $plant^{-1}$	No. of pods $plant^{-1}$
T_1	26.31	209.04	1.91	22.12	16.52
T_2	31.82	256.12	2.36	27.14	20.04
T_3	37.76	316.12	2.91	32.64	23.74
T_4	38.01	320.42	2.95	32.89	23.80
T_5	37.54	310.63	2.86	32.26	23.67
T_6	43.51	367.46	3.41	37.91	27.31
T_7	43.72	414.51	3.87	42.92	30.81
T_8	32.02	263.54	2.41	27.25	20.17
T_9	49.24	461.54	4.34	47.94	34.32
T_{10}	49.86	472.62	4.56	48.63	34.86
SEm±	1.85	15.68	0.14	1.64	1.18
CD (P=0.05)	5.48	46.60	0.44	4.89	3.50

The treatments T_9 and T_{10} produced the high straw (2658 and 2678 kg ha^{-1}) and grain yield (1148 and 1152 kg ha^{-1}) than those in the others whereas, the control produced the lower grain yields (436 kg ha^{-1}) (Table 2). Those were significantly better than other treatments on account of better nitrogen fixation (Lindström and Mousavi, 2019) and phosphirus availability (Bilal *et al*. 2021). Increased nutrient availability resulted the higher straw and grain yields, which allowed plants to convert energy more effectively and accumulate more dry matter (Sarada Devi *et al*. 2022). This could have been brought about by the beneficial effects of chemical, organic, and biological inoculant application on growth characteristics, which helped to increase photosynthates for the plant reproductive portions. The results confirmed the findings of Dhakal *et al*. (2016) and Patel *et al*. (2016). It follows logically that T_9 was preferable for obtaining a successful seed production of green gram. With an integrated application of organics (organic manures and bio inoculants), rather than only inorganics or organics alone, there was a potential to reduce cultivation costs, boost productivity, and maximize net return and Benefit: Cost ratio. The combined application of FYM and bio-inoculants along with different doses of RDF resulted in comparatively lower production costs and higher gross and net returns were observed in the treatment groups. As a result, a much greater benefit-cost ratio was recorded. The control plot, however, showed noticeably lower benefit-cost ratios, gross and net returns, and benefits. These results are in agreement with the results obtained by Arsalan Muhammad *et al*. (2016) in the case of green gram. The T_9 had the higher benefit-cost ratio (3.22), which was followed by T_{10} (but at par differences) and was superior to other treatments.

Table 2. Effect of various treatments on grain yield, straw yield, gross returns, net returns, and B-C ratio

Treatments	Grain yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B-C ratio (Rs re^{-1} invested)
T_1	436	1214	51380	13756	1.36
T_2	586	1486	67600	27400	1.68
T_3	741	1808	84770	45154	2.13
T_4	752	1842	86100	46484	2.17
T_5	737	1786	84190	44625	2.12
T_6	885	2116	100810	61134	2.54
T_7	1018	2388	115500	75815	2.91
T_8	605	1512	69570	30529	1.78
T_9	1148	2658	129900	89571	3.22
T_{10}	1152	2678	130460	89487	3.18
SEm±	42.35	90.01	--	--	--
CD (P=0.05)	125.82	267.44	--	--	--

This study concluded that the application of 100% of the recommended dose of fertilizers combined with PSB + *Rhizobium* + FYM to the green gram crop demonstrated its superiority over other INM treatments whereas, also the sole treatments of bio-inoculants (75% RDF + PSB; 75% RDF + Rhizobium) and inorganics 100% RDF were found to be more sustainable and productive.

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