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Effect of Biofertilizers on Nutrient Uptake by Green Gram [*Vigna radiata* (L.) Wilczek] under Agri-horti System in Vindhyan Region of Eastern Uttar Pradesh

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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

A field investigation was carried out in Factorial Randomized Block Design during autumn 2018 at agricultural farm, Rajiv Gandhi South Campus, Barkachha, Mirzapur (RGSC), Banaras Hindu University (U.P.) to investigate the impact of fertiliser and biofertilizer on the nutrient uptake by the green gram (*V. radiata* L.) plant and grain under guava (*P. guvajava* L.) trees. The twelve year old guava orchard was established in August 2006 with spacing of 7m x 7m. Seven fertilizer combination *viz.*, control, Rhizobium culture, press mud, phosphorus solubilizing bacteria, Rhizobium culture + fertilizer, phosphorus solubilizing bacteria + fertilizer and press mud + fertilizer were applied. Among them application of press mud + fertilizer performed better by recording highest nitrogen content in grain (3.75), nitrogen content in grain (1.50), removal of nitrogen in grain (33.09) Removal of nitrogen in straw (33.03) and phosphorus content in grain (0.41) phosphorus content in straw (0.30), phosphorus uptake in grain (3.62), phosphorus uptake in straw (5.61), and found significantly superior to rest of the treatments.

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1. INTRODUCTION

Given the demands of our nation's growing population, the production of pulses is extremely low and has become a challenging issue. In 1951, there were 69.9g of pulses available per person; this number dropped to 50g in 1971, 40g in 1982, and 27g in 2005. In comparison to the 85g per person per day that are needed for a balanced diet, pulse availability is currently extremely low. This production shortfall must be made up. It is now imperative to grow pulse crops on a larger scale and scientifically [1]. Green gram (*Vigna radiata* L.) is grown in tropical and subtropical areas of India as an important short duration pulse crop [2]. In many regions of the world when animal proteins are in short supply and expensive, pulses are consumed more frequently [3]. The green gram, also known as "Moong bean," has a protein content of 24.3%, is reasonably rich in carbohydrates, has a tiny amount of riboflavin and thiamine, and is also a good source of phosphorus and iron. It also includes high-quality tryptophan (60 mg/g N) and lysine (4600 mg/g N), which are consumed as whole grains or in the form of Dal for eating. Mung bean is said to be easily digestive, which is why patients prefer it. Mung bean sprouted seeds are also a good source of ascorbic acid (Vitamin C) [4].

Guava intercropping is done not just to generate more revenue, but it also improves land utilisation through optimum production and protects soil health by reducing soil erosion [5]. Guava is one of many fruit trees that are perennial in nature and need few years' time to reach a commercial bearing stage. The farmers' income from the orchard area is quite meagre in this early, less productive stage. Intercropping has therefore been used with the primary goal of better utilising the soil resources available in the spaces between the fruit trees for generating additional revenue by cultivating additional crops [6]. The phosphorus requirements vary depending upon the nutrient content of the soil [7]. Phosphorus shortage restricts the plant growth and remains immature. Reduced leaf extension, darker green leaves with higher chlorophyll contents (often with red pigments from anthocyanins), and a higher root-to-shoot ratio are typical diagnostic features of phosphorus deficiency [8–9]. This is because root growth is much less impacted by phosphorus deficiency than shoot growth. Because legumes require a high phosphorus supply to nodulate, phosphorus deficiency can also significantly decrease biological nitrogen fixation [9]. In many agricultural soils, the availability of phosphorus is a restricting factor for plant growth [10]. Phosphorus deficiency is especially prevalent in those areas, where phosphorus fertilisers have never been used before [8]. Iron and aluminium oxides can fix a significant amount of applied fertiliser phosphorus, rendering it unavailable to plants [11]. These facts highlight the importance of sound phosphorus management, particularly in circumstances where funding for fertiliser purchases is constrained, such as in smallholder agriculture in tropical regions. Some of these obstacles can be solved with the intervention of agroforestry techniques [12]. However, significant applications of phosphorus fertilisers are required in permanent agriculture to ensure economic and ecological sustainability due to generally low phosphorus concentrations in mulch materials, low atmospheric inputs, and low release via mineral weathering [13].

2. MATERIALS AND METHODS

The experiment was carried out in autumn season of 2018 at the agricultural Farm of Rajiv Gandhi South Campus, Banaras Hindu University ((BHU), Barkachha, Mirzapur, U.P. The experimental site was situated at 25o 10' latitude, 82o 37' longitude, and 147 metres above mean sea level comes under Vindhyan region of Mirzapur, which included an area of more than 1000 acres of land. The Mirzapur district is bordered by the Varanasi district to the north and north-east, the Sonbhadra district to the south, and the Prayagraj district to the north-west. Mirzapur falls in a region with a semiarid to sub humid climate. The twelve year old guava orchard which was established in August, 2006 with the spacing of 7m × 7m. Experiment was laid on randomized block design (RBD) with three replications and seven repeat treatment combination consisted T_1 control, T_2 Rhizobium culture, T_3 Phosphorus solubilizing bacteria, T_4 Pressmud, T_5 NPK +Rhizobium culture, T_6 NPK+phosphorus solubilizing bacteria and T_7 NPK+pressmud. After the field had reached a workable moisture level, it was ploughed with a disc plough, then harrowed and planked. The experiment was then set up according to the layout and design. A total 21 plots were prepared with gross plot size of 3 × 3 m. Seeds of green gram variety 'Samrat' was inoculated with both Rhizobium and phosphate solubilizing bacteria. After being evenly inoculated, the inoculated seed was disseminated, dried in the shade, and then immediately seeded in the kudal-made furrow at a row distance of 30 cm. For this variety, a seed rate of 17.5 kg ha-1 is advised. For optimum maintenance of the plant population, a greater seed rate of (20 kg ha-1) was applied. Recommended dose of nitrogen, phosphorus and potassium fertilizer was applied through urea, DAP and MOP respectively into each plot. About 15 days after sowing, a thinning operation was performed to maintain a plant spacing of 10 cm inside each row. Crop was harvested when visually observed to be fully mature. After harvest, the green gram grain and straw were dried at 70 °C for 48 hours. The resulting plant material was then ground with a grinder, put through a mesh sieve, and utilised to determine the N and P contents. Next, the material's nitrogen content was determined using the colorimetric (Nessler's reagent) method and its phosphorus content were determined using the vanadium molybdate yellow colour method. To reach a reliable conclusion, the investigation's observations were tabulated and statistically examined. According to Gomez and Gomez [14] description of the "Analysis of Variance" (ANOVA) standard methodology, the data were analyzed . The 'F' test was applied to assess the treatment's significance (Variance ratio). In each case, the standard error of the mean was calculated. Where necessary, appropriate diagrams were used to depict the results as they were thus acquired.

Critical difference in the treatment was used to test for differences in treatment means, and the following formula revealed significant differences (CD) at the 5% level of probability:

$$S.Em.\pm = \sqrt{\frac{\text{EMS}}{\text{n}}}$$

C.D. at 5% = SEm.± × $\sqrt{2}$ × t value at 5% of error (a) degree of freedom

3. RESULTS AND DISCUSSION

Results of the experiment revealed that the maximum amount of nitrogen in grain and straw of green gram was obtained with the application of press mud along with recommended dose of fertilizers (Table 1) which was significantly better than all the treatments under study closely followed by PSB and Rhizobium. However, minimum amount was noted under control. Similarly, highest amount of nitrogen removal was also observed with press mud + fertilizer dose which was significantly higher than rest of the treatments. Moreover, Rhizobium + fertilizer also enhanced N-content in grain + straw significantly higher than PSB + fertilizer and both the treatments proved significantly in structural in increasing over others. However, significantly minimum N-content in grain + straw was noted under control. Data on P content in grain and straw presented in Table 2 clearly indicate that the highest values of P content in grain and straw were obtained with the application of press mud along with recommended dose of fertilizers which proved significantly better than rest of treatment. Whereas, lowest amount of P content in grain and straw was observed under control. The application of press mud along with recommended dose of fertilizers also resulted in to maximum phosphate in grain as well as straw and total removal of phosphorus which is closely followed by PSB + recommended dose of fertilizers which is also significantly better than rest of the treatments under study. However, minimum phosphate was noted under control. It was indicated that applying press mud along with the recommended dose of fertiliser significantly boosted the bacterial and fungal populations in the soil. These populations play important roles in the breakdown of organic matter to release nutrients necessary for plant growth and development. Additionally, changes in soil organic matter content brought on by microbial enzymatic activities were evident in the greater C biomass and N levels in the soils treated with press mud.

The findings showed that when chemical sources of nutrients were given consistently, improved soil physical conditions were mirrored by a lower bulk density of soil. In order to increase soil fertility and improve its physical condition, it has been discovered that integrating organic sources is more efficient than applying them only once. Neutral soil organic carbon accumulation was measured in comparison to treatment press mud and the appropriate fertiliser dosage. With the application of phosphorus and PSB either separately or in combination the availability of nutrients N, P, and K in soil was increased [15]. This may be because the application of organic, inorganic, and biofertilizers together promotes root growth and cell division, which increases nutrient uptake from deeper soil layers and, ultimately, raises N, P, K, and S concentrations.

The application of 60 kg of phosphorus either alone or in conjunction with PSB and press mud enhanced the nutrient's availability. Bhabai et al. [16] and Singh et al. [17] both noted a considerable increase in the availability of nitrogen, phosphorus, and potassium relative to the control. This may be as a result of the application of phosphorus, which promoted root growth and established sound root systems. The application of phosphorus encourages nodulation and nodulation bacteria to fix more nitrogen from the atmosphere, increasing the amount of nitrogen in the soil as a result. When phosphorus was applied with Rhizobium and PSB inoculation alone or in combination over control over both years, the maximum nutrient availability was noticeably higher. The amount of phosphorus, or its proportion, in the soil during harvest is affected by phosphorus press mud and seed inoculation with PSB. Chemical fertilizer application, either alone or in combination with pressmud and PSB, enhanced all phosphorus factions (Fe-P, Al-P and ca-P). With the application of inorganic fertilizer and their combined use with press mud over the control, the amount recorded in Fe-P, Al-P, and Ca-P from increases significantly. According to Nath et al. [18], the application of press mud @5 t/ha considerably increases variance of faction (Fe-P, Al-P, Ca-P, and Total P) and the allocation of recommended inorganic phosphoric fertilizer greatly increases soil P-faction (Fe-P, Al-P, Ca-P, and Total P).

Table 1. Effect of fertilizer and biofertilizer on content (%) and removal (kg ha^{-1}) of nitrogen at harvest of green gram [*V. radiata* (L.) Wilczek] under guava (*P. gujava* L.) based Agri-horti system

Treatment	Nitrogen content (%)		Nitrogen removal (kg ha^{-1})		Total (Grain + Straw removal of nitrogen (kg ha^{-1})
	Grain	Straw	Grain	Straw	
Control	2.50	1.00	11.26	13.11	24.37
Rhizobium culture	2.98	1.10	18.74	18.38	37.12
Phosphorus solubilizing bacteria	2.70	1.03	14.87	15.26	30.13
Press mud	3.20	1.20	19.39	18.96	38.35
Rhizobium culture + Required dose of fertilizer	3.60	1.40	25.86	25.86	52.04
Phosphorus solubilizing bacteria + Required dose of fertilizer	3.40	1.30	25.30	25.30	49.91
Press mud + Required dose of fertilizer	3.75	1.50	33.09	33.03	66.12
SEM±	0.01	0.01	0.17	0.33	
CD (0.05)	0.04	0.04	0.52	1.01	

Table 2. Effect of fertilizer and biofertilizer on content (%) and removal (kg ha^{-1}) of phosphorus at harvest of green gram [*V. radiata* (L.) Wilczek] under guava (*P. gujava* L.) based Agri-horti system

Treatment	Phosphorus content (%)		Phosphorus removal (kg ha^{-1})		Total (Grain + Straw removal of phosphorus (kg ha^{-1})
	Grain	Straw	Grain	Straw	
Control	0.20	0.14	0.90	1.83	2.73
Rhizobium culture	0.23	0.16	1.27	2.36	3.63
Phosphorus solubilizing bacteria	0.26	0.19	1.64	3.17	4.81
Press mud	0.29	0.22	1.76	3.48	5.24
Rhizobium culture + Required dose of fertilizer	0.31	0.24	2.31	4.54	6.85
Phosphorus solubilizing bacteria + Required dose of fertilizer	0.35	0.26	2.51	4.86	7.37

Treatment	Phosphorus content (%)		Phosphorus removal (kg ha^{-1})		Total (Grain + Straw removal of phosphorus (kg ha^{-1})
	Grain	Straw	Grain	Straw	
Press mud + Required dose of fertilizer	0.41	0.30	3.62	5.61	9.23
SEM±	0.01	0.01	0.04	0.08	
CD (0.05)	0.02	0.02	0.14	0.26	

4. CONCLUSION

Based on the research findings, it is concluded that the application of press mud along with recommended dose of fertilizer (20:40:10 NPK) greatly increased the nitrogen and phosphorus contents in the grains and straw of green gram. However, maximum uptake of nutrient grain and straw were noted under application of press mud along with recommended dose of fertilizer under guava based agri-horti system in vindhyan region of Mirzapur.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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