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Optimization of organic nutrient sources for green gram (*Vigna radiata* L. Welczek) under rainfed conditions

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ABSTRACT

A field investigation was conducted during the *kharif* season of 2012 at the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland. Sole and combined applications of different organic nutrient sources *viz.*, FYM, vermicompost, pig manure, *rhizobium* and PSB (Phosphate Solubilizing Bacteria) were evaluated in order to optimize organic nutrient management for green gram under rainfed conditions. Results showed that the combined application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha was found to be the most responsive nutrient management practice recording significantly higher crop growth and yield attributes and ultimately recording the highest seed and stover yields of 369 and 989 kg/ha respectively. Soil available N and K status after harvest as well as seed and stover NPK uptake was found to be significantly higher with combined application of organic manures viz., vermicompost and FYM along with biofertilizers *rhizobium* and PSB.

Key words: Biofertilizers, Green gram, Growth, Organic manures, Yield.

INTRODUCTION

Across the larger part of the globe excess and unsustainable use of chemical fertilizers has led to several issues of environmental pollution and land degradation. The land is loosing its fertility consequently forcing farmers to use higher doses of such chemicals and this coupled with the hike in cost of chemical fertilizers and the monetary constraints of farmers, especially in a developing country like India, has aggravated the problems and is making agricultural systems unsustainable. In this context there is an urgent need to develop and evolve economic and sustainable technologies and practices on alternative/ organic sources of plant nutrients such as organic manures and biofertilizers to reduce the dependency on synthetic sources of plant nutrients. Organic nutrient sources such as animal manures, compost, vermicompost, green manures and biofertilizers add organic matter to the soil, improve the soil properties, conserve the nutrients in soil and enhance the soil microbial activity and diversity thereby improving soil quality and fertility and ecosystem sustainability. Organic manures improves soil structure, increase organic matter content, promotes nutrient mobilization, increase water holding capacity of the soil, promotes formation of soil aggregates, suppresses certain plant diseases and soil borne pathogens and encourage the growth of beneficial microorganisms (Chen, 2006). Organic manures like FYM, vermicompost, poultry manure, etc. helps in the improvement of soil structure, aeration and water holding capacity of soil. Further, they increase the availability of macro and micro-nutrients to the plants through enhanced biological processes, increases solubility of nutrients and alters soil salinity, sodicity and pH (Alabadan *et al*., 2009). *Rhizobium* and Phosphate Solubilizing Bacteria (PSB) are biofertilizers, which enhance biochemical processes of nitrogen fixation and phosphorus solubilization, enhancing and promoting plant growth. Biofertilizers provide economically judicious and ecologically sound means of fertilization (Patel *et al.,* 2013) and are important components in sustainable agriculture. Furthermore, these organic fertilizers are cost effective and do not leave toxic residues in the environment and are thus perfect components for developing economically sound and ecofriendly practices and packages for sustainable crop production. Hence, keeping in view the above facts, the present investigation was conducted to study the performance of green gram under different sources of organic manures in order to evolve optimized practices for organic nutrient management in green gram under rainfed conditions.

MATERIALS AND METHODS

The present investigation was conducted during *kharif* season, 2012 at the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland. The experimental farm lies in a humid sub-tropical zone with an average rainfall ranging from 2000 – 2500 mm with mean temperature ranges from 21°C – 32°C during summer. The soil of the experimental field was well-drained and sandy

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loam in texture with high organic carbon (1.29), low in available N (250.9 kg/ha) and medium in available P and K content (21.05 and 234.1 kg/ha respectively). Eight organic nutrient treatments viz., FYM @ 10 t/ha (T_1), Vermicompost @ 1.4 t/ha (T_2), Pig manure @ 5 t/ha (T_3), *Rhizobium* + PSB (T_4), *Rhizobium* + PSB + FYM @ 5 t/ha (T_5), *Rhizobium* + PSB + Vermicompost @ 0.7 t/ha + (T_6), *Rhizobium* + PSB + Pig manure @ 2.5 t/ha (T_7) and Control (T_8) were tested in randomized block design with three replications. Field preparation was carried out between the last week of March to the third week of May with tractor drawn plough, harrow and rotovator. To facilitate thorough decomposition, organic manures *viz.,* FYM and pig manure were applied 15 days prior to sowing and thoroughly incorporated into the soil. Vermicompost was applied as band placement just before sowing and mixed thoroughly with the soil along the band. Biofertilizers *viz*., *Rhizobium* and Phosphorus Solubilizing Bacteria (PSB) were applied as seed treatment just before sowing. Green gram variety K-851 was sown in lines on the 24th of June maintaining a spacing of 30 x 10 cm with a seed rate of 20 kg/ha. Standard intercultural operations and need based pest and diseases management were uniformly applied to all the plots. Biometrical observation viz., plant height, fresh and dry weight of plant, number of branches and root nodules/plant, fresh weight of nodules/plant, number of pods/ plant, pod length, number of seeds/pod, test weight, grain and stover yield and harvest index were recorded to study the response of the crop to the various treatments. Soil fertility status (pH, organic carbon and available NPK) after harvest and seed and stover NPK content were analyzed using standard procedures. Data recorded were analyzed statistically using standard techniques of analysis of variance and the significant differences were tested by F test.

RESULTS AND DISCUSSION

Growth attributes: Combined applications of organic manures *viz.,* FYM, vermicompost and pig manure along with biofertilizers *rhizobium* and PSB were found to register significantly higher crop growth attributes over control treatment at all stages of observations (Table-1). Whereas sole application of different organic sources did not consistently record significant variations over control treatment at all stages of observations. At 30 DAS and at harvest, application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha (T_6) recorded the tallest plants whereas, the treatments T_5 (*rhizobium* + PSB + FYM @ 5 t /ha) and T_7 (*rhizobium* + PSB + pig manure @ 2.5 t/ha) were also at par with it at both the stages. Plant dry weight at 15 and 45 DAS and number of nodules per plant at harvest were also found to be significantly higher under the treatment T_6. The treatments T_5 and T_2 (vermicompost @1.4 t/ha) were also found to be at par with T_6 with respect to plant dry weight at 15 and 45 DAS whereas treatments T_5 and T_7 were at par with T_6 with respect to number of nodules at harvest. The maximum number of branches per plant at both 45 DAS and at harvest was also recorded with the treatment T_6 whereas the treatments T_1 (FYM @ 10 t/ha), T_2, T_5 and T_7 were also at par with it at both stages. At all stages of observation, control treatment was found to record significantly lower growth attributes as compared to T_6 and T_5. Improved crop growth with application of FYM, vermicompost and PSB and their combinations has also been reported by Yadav (2002), Kumawat *et al.* (2009) and Das *et al*. (2002) whereas, significantly higher growth characters due to coinoculation of *rhizobium* and PSB has been reported by Patel *et al.* (2016) (plant height and branches per plant) and Singh *et al.* (2012) (plant height, fresh weight and nodule number). Significantly better crop growth attributes recorded under integrated application of biofertilizers and organic manures viz., T_6 and T_5 could be attributed to combined effect of biofertilizers and organic manures resulting in enhanced availability and uptake of nutrients by the crop. The application of vermicompost and FYM under treatments T_6 and T_5

Table-1: Crop growth attributes of green gram as affected by application of different sources of organic nutrient

Treatment	Plant height (cm)		Plant dry weight (g)		Number of nodules per plant	Number of branches per plant	
	30 DAS	Harvest	15 DAS	45 DAS	Harvest	45	At harvest
T_1 - FYM @ 10 t/ha	25.76	51.69	1.40	32.73	32.73	1.73	1.93
T_2 - Vermicompost @ 1.4 t/ha	24.31	55.69	1.61	34.50	34.50	2.27	2.40
T_3 - Pig manure @ 5 t/ha	25.73	54.41	1.18	25.90	25.90	1.70	1.80
T_4 - *Rhizobium* + PSB	23.15	50.64	1.34	23.87	23.87	1.53	1.87
T_5 - *Rhizobium* + PSB + FYM @ 5 t/ha	27.76	67.15	1.66	35.57	35.57	2.27	2.60
T_6 - *Rhizobium* + PSB + vermicompost @ 0.7 t/ha	29.71	68.21	1.73	35.79	35.79	2.37	2.63
T_7 - *Rhizobium* + PSB + pig manure @ 2.5 t/ha	26.49	60.26	1.36	27.63	27.63	2.13	2.47
T_8 - Control	22.85	50.37	1.17	22.71	22.71	1.27	1.53
SEm±	1.32	3.67	0.09	2.56	2.56	0.22	0.23
CD (P=0.05)	4.71	13.11	0.33	9.15	9.15	0.80	0.82

respectively may have resulted in increased organic matter content and thereby microbial activity leading to conducive soil conditions for higher availability of nutrients to the crop whereas, dual inoculation of *rhizobium* + PSB under the treatments T_5 and T_6 may have resulted in better biochemical processes of N fixation and phosphorous solubilization thereby enhancing nutrient availability and promoting crop growth. Organic manures and biofertilizers influence the soil nutrient availability through better microbial activity and by releasing the nutrients from the soil, which helps in ample absorption and utilization of nutrients by the plants (Kuar, 2016).

Yield attributes and yield: Yield and yield attributes of the crop was significantly affected by the different sources of nutrients (Table 2). The treatments with sole applications *viz.,* T_1, T_2 and T_3 did not give consistent variations over control treatment however, the combined application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha (T_6) was found to consistently record significantly higher number of pods per plant, length of pods, number of seeds per pod and test weight over the treatments T_4 (*rhizobium* + PSB) and T_8 (control). Application of *rhizobium* + PSB + FYM @ 5 t /ha (T_5) was also at par with and T_6 and recorded significantly superior yield attributes over T_4 and T_8. Significantly higher yield attributes observed under treatments T_6 and T_5 could be attributed to enhanced availability and uptake of nutrients, higher photosynthesis and translocation of photosynthates. PSB and *rhizobium* inoculation under these treatments may have increased nitrogen fixation, solubilization of native phosphorus and production of secondary metabolites resulting in enhanced availability and uptake of phosphorous and nitrogen, better root growth and higher root nodules and hence higher nutrient uptake and plant growth and development. Whereas, rapid mineralization of organic manures viz., vermicompost and FYM may have optimized nutrient availability to the plants thereby stimulating plant growth and development. Increased yield attributes of green gram with application of organic manures and biofertilizers *viz.,* vermicompost, FYM, PSB and *rhizobium* has also been reported by Saig and Yadav (2004), Meena *et al.* (2016) and Singh and Pareek (2003). The seed and stover yield showed significant variations as influenced by different source of organic nutrients and their combinations. The highest seed and stover yield of 369 and 989 kg/ha respectively were recorded with the application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha (T_6) which was significantly higher over the rest of the treatments and was followed by the treatment *rhizobium* + PSB + FYM @ 5 t /ha (T_5). Higher seed and stover yield recorded under treatments T_6 and T_5 could be attributed to better yield contributing characters viz., number of pods per plant, length of pods, number of seeds per pod and test weight as recorded by both the treatments. Higher nutrient availability under T_6 and T_5 may also have resulted in higher production of photosynthates and better translocation within plants resulting in better development of sink source ratio of photosynthates. Significantly higher stover yields recorded by T_6 and T_5 could be attributed to better plant growth viz., higher plant height and dry matter accumulation as recorded under these treatments.

Soil nutrient status after harvest: Different sources of organic nutrients and their combinations did not record any significant differences with respect to soil pH, soil organic carbon and soil available P however, significant variations in soil available N and K were recorded among the different treatments (Table 3). Application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha (T_6) recorded the highest soil available N which was significantly superior over the treatments T_4 (*rhizobium* + PSB) and T_8 (Control) whereas, the treatments T_5 (*rhizobium* + PSB + FYM @ 5 t /ha), T_1 (FYM @ 10 t/ha), T_2 (vermicompost @ 1.4 t/ha), T_3 (pig manure @ 5 t/ha) and T_7 (*rhizobium*+ PSB+ pig manure @ 2.5 t/ha) were also found to be at par with T_6. Soil available K was found to be highest with application of *rhizobium* +

Table-2: Yield and yield attributes of green gram as affected by application of different sources of organic nutrient

Treatment	Number of pods per plant	Number of seeds per pod	Length of pod(cm)	Test weight(g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index
T_1 - FYM @ 10 t/ha	18.17	8.22	5.83	28.08	316	809	26.84
T_2 - Vermicompost @ 1.4 t/ha	19.07	9.12	5.98	30.43	334	843	29.77
T_3 - Pig manure @ 5 t/ha	18.73	8.43	5.74	30.25	271	727	24.27
T_4 - *Rhizobium* + PSB	16.67	7.60	5.31	29.00	194	724	21.61
T_5 - *Rhizobium* + PSB + FYM @ 5 t/ha	22.53	9.40	6.00	31.77	358	978	24.21
T_6 - *Rhizobium* + PSB + vermicompost @0.7t/ha	25.00	9.47	6.07	32.96	368	989	26.39
T_7 - *Rhizobium* + PSB + pig manure @ 2.5 t/ha	19.00	8.74	5.92	29.98	275	815	24.28
T_8 - Control	15.87	7.35	5.22	28.98	193	717	21.69
SEm±	1.63	0.42	0.17	0.76	0.23	0.64	3.05
CD (P=0.05)	5.84	1.50	0.63	2.37	0.82	2.30	NS

Table 3: Effect of different sources of organic nutrient on the fertility of the soil after harvest

Treatment	pH	Organic carbon(%)	Available N(Kg/ha)	Available P(Kg/ha)	Available K(Kg/ha)
T_{1-} - FYM @ 10 t/ha	4.63	1.33	309.4	17.61	256.0
T_2 - Vermicompost @ 1.4 t/ha	4.57	1.33	303.9	16.77	249.0
T_3 - Pig manure @ 5 t/ha	4.67	1.31	287.8	16.31	231.1
T_4 - *Rhizobium* + PSB	4.50	1.22	194.8	15.22	227.6
T_5 - *Rhizobium* + PSB + FYM @ 5 t/ha	4.53	1.37	310.4	17.86	263.8
T_6 - *Rhizobium* + PSB + vermicompost @ 0.7 t/ha	4.60	1.35	324.7	18.25	259.0
T_7 - *Rhizobium* + PSB + pig manure @ 2.5 t/ha	4.60	1.34	280.3	17.10	243.5
T_8 - Control	4.53	1.27	193.3	15.20	226.5
SEm±	0.04	0.06	23.8	1.44	4.6
CD (P=0.05)	NS	NS	84.8	NS	16.4

PSB + FYM @ 5 t /ha (T_5) which was significantly superior over the treatments T_3 (pig manure @ 5 t/ha), T_4 (*rhizobium* + PSB) and T_8 (Control) whereas, the treatments T_6 (*rhizobium* + PSB + vermicompost @ 0.7 t/ha, T_1 (FYM @ 10 t/ha) and T_2 (vermicompost @ 1.4 t/ha), were also found to be at par with T_5. Results show that soil available N and K were significantly higher with sole application of organic manures viz., vermicompost and FYM or combined application with biofertilizers *rhizobium* and PSB. This could be due to slow mineralization and sustained availability of nutrients applied through organic manures or increased soil nutrient status through fixation, decomposition and solubilization by soil microorganism due to application of biofertilizers or combined effect of both. Similar increased soil available NPK in response to application of vermicompost (Rajkhowa *et al.*, 2003) and FYM (Jat *et al.,* 2012) and increased soil available potassium due to application of biofertilizers (Kuar, 2016) have been reported.

NPK uptake by seed and stover: Significant variations were recorded in seed and stover NPK uptake as affected by application of different sources of organic nutrient (Table-4). The uptake of N and P by both seed and stover was found to be highest with application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha (T_6) followed by the treatment T_5 (*rhizobium* + PSB + FYM @ 5 t/ha) which was at par with T_6 with both treatments recording significantly higher N and P uptake over the treatments T_7 (*rhizobium*+ PSB+ pig manure @ 2.5 t/ha) and T_8 (control). The treatments T_1 (FYM @ 10 t/ha) and T_2 (vermicompost @ 1.4 t/ha) were also found to be at par with the treatment T_6 however they did not record significant uptake of N and P over control. K uptake by seed and stover was also found to be higher under the treatment T_6 followed by T_5 with both treatments being at par and recording higher K uptake over the treatments T_3 (pig manure @ 5 t/ha), T_4 (*rhizobium* + PSB) and T_8 (Control). In general sole application of vermicompost or FYM or their combined application with both rhizobium and PSB were found to exhibit better NPK uptake by both seed and stover, the uptake being higher under combined application. Enhanced soil fertility and better nutrient availability to the crop due to combined application of organic manures and biofertilizers may be attributed for the increased nutrient uptake by the crop. Singh *et al.* (2014) also reported increased concentration of NPK in plants with integrated application of organic and inorganic sources of nutrients and biofertilizers. Increased uptake of NPK with integrated application of vermicompost (Das *et al*., 2002) and N and P with *rhizobium* + PSB coinoculation (Singh and Pareek, 2003) have also been reported. Treatments T_6 and T_5 were also observed to record significantly higher seed as well as stover yields which may also be attributed for higher seed and stover NPK uptake as recorded under these treatments.

Table 4: Seed and stover nutrient uptake as affected by different sources of organic nutrients

Treatment	Nutrient uptake (Kg/ha)					
	Seed			Stover		
	N	P	K	N	P	K
T_{1-} - FYM @ 10 t/ha	21.53	2.87	19.03	29.94	4.77	37.37
T_2 - Vermicompost @ 1.4 t/ha	22.52	2.93	18.57	30.87	4.87	37.30
T_3 - Pig manure @ 5 t/ha	20.07	2.80	16.10	28.16	4.40	27.57
T_4 - *Rhizobium* + PSB	19.85	2.80	16.45	27.84	4.50	29.00
T_5 - *Rhizobium* + PSB + FYM @ 5 t/ha	23.80	3.30	20.70	31.26	5.13	40.87
T_6 - *Rhizobium* + PSB + vermicompost @ 0.7 t/ha	24.42	3.44	21.30	32.86	5.33	41.70
T_7 - *Rhizobium* + PSB + pig manure @ 2.5 t/ha	19.80	2.57	18.93	23.55	4.37	33.77
T_8 - Control	18.56	2.53	15.00	23.14	4.33	26.90
SEm±	1.11	0.18	1.18	1.57	0.18	2.63
CD (P=0.05)	3.97	0.64	4.22	5.62	0.65	9.52

CONCLUSION

It may be concluded from the present study that combined application of *rhizobium* + PSB + vermicompost @ 0.7 t/ha was found to be the most responsive organic nutrient management practice for green gram under rainfed conditions resulting in increased soil fertility and enhanced NPK uptake by the crop registering superior crop growth and seed and stover yields of 369 kg/ha and 989 kg/ha respectively.

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