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Effect of Carrier and Liquid based Biofertilisers on Summer Green Gram [*Vigna radiata* (L.) Wilczek] Grown in Red Laterite Soil

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ABSTRACT

Background: Biofertiliser formulations are available as carrier based and liquid based. Liquid formulations are known to have better shelf life, viability and higher cell count. Little is known about the comparison between the two formulations in field condition. The present experiment was conducted to study the effect of seed treatment of carrier or liquid-based formulations of biofertilisers (Rhizobium and PSB) when integrated with different doses of inorganic fertilisers.

Methods: A field experiment was conducted in randomised block design during the summer seasons of 2018 and 2019 on green gram [*Vigna radiata* (L.) Wilczek] in the red laterite soil of West Bengal. Ten treatment combinations were replicated thrice. Growth attributes, yield components, yield, soil characteristics, nutrient uptake and economics were studied.

Result: The results revealed that application of recommended doses of fertilisers (RDF) + liquid based Rhizobium + PSB registered significantly highest growth, yield, nutrient uptake in plants, economic return as well as improved soil characteristics. Economic return in plants treated with 75% RDF + Liquid based Rhizobium + PSB was found at par with plants applied with RDF + Carrier based Rhizobium + PSB, RDF + Liquid based PSB and RDF + Liquid based Rhizobium.

Key words: Biofertilisers, Integrated nutrient management, Mung bean, Pulse.

INTRODUCTION

Grain legumes are one of the most important crop to maintain the agricultural sustainability (Nadia and Haythem, 2020) vis-à-vis nutritional security. Green gram [*Vigna radiata* (L.) Wilczek] is one of the important short duration summer pulse crop of eastern India which is quite popular amongst the resource-challenged farmers due to its low input requirement and quick growing habit (Patil and Tiwari, 2021). India is not only the largest producer and consumer of pulses but also the largest importer of pulses. The increasing use of fertilisers in cereal-based cropping system showed immediate impressive results but decreased soil fertility by steadily exhausting nutrients (Jat *et al*., 2011). Diversification of cereal-based cropping systems with the inclusion of grain legumes in summer fallows is one of the sustainable option of horizontal expansion for improvement of soil organic matter through biological nitrogen fixation, root exudates, leaf shedding and higher below-ground biomass (Sravan and Murthy, 2018). Bio-fertilisers can prove as an alternative to reduce the usage of inorganic fertiliser inputs and in long run improve soil health by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilize insoluble soil phosphates and produces plant growth substances in the soil (Venkatashwarlu, 2008). Based on the physical nature, biofertilisers are carrier or liquid-based preparations containing microorganisms, which benefit plant growth and nutrition (Anjali, Sharma and Nagpal, 2021). Non-toxic materials like Peat are commonly used as carrier material for seed inoculation. Green gram, being a legume crop does not require high doses of fertiliser if inoculated properly (Mazid and Khan, 2015). Due to their high cell count, zero contamination, better viability and survivability, liquid biofertiliser formulations may facilitate better crop growth (Anjali, Sharma and Nagpal, 2021). Hence, the present study was conducted to assess the effect of integration of carrier or liquid-based formulations of biofertilisers (Rhizobium and PSB) with different doses of inorganic fertilisers in green gram cultivation in red and laterite soil of West Bengal.

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MATERIALS AND METHOD

The experiment was conducted during two consecutive summer seasons of 2018 and 2019 in Agricultural Research Farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal (23°39' N latitude and 87°42' E longitude and 58.90 m above mean sea level).

The experimental soil (0-15cm depth) was sandy loam in texture containing 72.60% sand, 17.8% silt and 9.6% clay with 5.64 pH (1:2.5 soil : water ratio), EC 0.54 ds/m and 0.38% organic carbon. Available N, P_2O_5 and K_2O contents were 271.04, 39.01 and 100.23 kg/ha, respectively.

The experiment was laid down in randomised block design (RBD) with three replications comprising ten nutrient treatment combinations *viz.*

T1: Recommended dose of fertilisers (RDF) (20 kg/ha of N, 40 kg/ha P_2O_5, 20 kg/ha K_2O), T2: RDF + Carrier based Rhizobium, T3: RDF + Carrier based PSB, T4: RDF + Carrier based Rhizobium + PSB, T5: RDF + Liquid based Rhizobium, T6: RDF + Liquid based PSB, T7: RDF + Liquid based Rhizobium + PSB, T8: 75% RDF + Carrier based Rhizobium + PSB, T9: 75% RDF + Liquid based Rhizobium + PSB, T10: Absolute Control.

Recommended fertilisers dose (Department of Agriculture and Cooperation, 2013) were applied using urea, single super phosphate and muriate of potash, according to the treatment combinations.

The seeds of green gram variety Samrat (PDM 84-139) were sown on 23rd March and 20th March of 2018 and 2019 respectively. Seeds were treated with biofertilisers in the morning and shade dried before sowing. Biofertilizers were applied following the dose mentioned in the products (250 g per 10 kg seeds for carrier based and 10 ml/kg seeds for liquid biofertilisers). Jaggery was applied @ 250g/10 kg seeds which provides good adherence of biofertilizers and also helps in their initial growth. Row to row spacing of 30 cm and 10 cm plant to plant distance was followed. All necessary field operations and management were done following best agronomic practices (K.V.K.K.N, 2021).

Two hand pickings were done at physiological maturity and the final harvest was done on 17th and 10th June of 2018 and 2019 respectively. Soil physical and chemical characteristics and plant uptake status were estimated following standard procedures. The protein content of seeds was calculated by multiplying percent grain nitrogen with 6.25 (Mariotti, Tomé and Mirand, 2008).

Economic analysis was done following standard procedures. Statistical analysis was done following principles of Gomez and Gomez (1984) using SPSS Software.

RESULT AND DISCUSSION

Growth attributes

The growth characteristics of green gram was influenced significantly on application of the biofertilisers along with RDF (Table 1). At 40 and 80 days after sowing (DAS), the highest plant height (46.9 and 60.35 cm), dry matter accumulation (DMA) (89.67 and 277.1g/m^2) and crop growth rate (CGR) (7.8 and 1.54g/m^2/day) was recorded in T7 treated plants. Dual inoculation of Rhizobium and PSB on green gram was also studied by Patel *et al.* (2016), who stated that increased plant height and growth characters might be due to improved atmospheric N fixation and enhanced insoluble phosphorus availability in available form.

During both the growth stages, T7 treated plants showed improved plant height (9.53% and 10.07%) and DMA (17.84% and 17.89%), as compared to T4. In comparison to carrier-based inoculants, liquid biofertilisers showed significantly positive result in groundnut, chick pea and soybean (Hegde, 2002). Trimurtulu *et al.* (2014) also reported similar improvement in growth of maize, red gram and some other leguminous crops with application of 75% RDF along with liquid bioinoculants. There was no significant difference in plant height, DMA and CGR of green gram plants treated with T2, T3, T5, T6, T8 and T9 treatments. Biofertilisers secrete organic substances, such as auxins, gibberellins, cytokinins, ethylene and abscisic acid and these bio-active compounds play a stimulating role to influence physiological process resulting in better growth and higher dry matter accumulation (Muley *et al.,* 2016).

It was evident from the experimental findings that LAI, number of leaves per plant of green gram improved with

Table 1: Effect of biofertilisers on growth attributes (Pooled data of 2018 and 2019).

Treatments	Plant Height		Dry matter accumulation (g/m^2)		Crop growth rate (g/m^2/day)		Leaf Area Index		Number of leaves per plant		Nodule
	40 DAS	80 DAS	40 DAS	80 DAS	40-60 DAS	60-80 DAS	40 DAS	60 DAS	40 DAS	60 DAS	Number
T1	37.93	46.52	52.32	160.84	4.52	0.89	0.92	1.41	17.2	14.85	15.33
T2	41.07	48.95	60.96	187.33	5.26	1.04	1.12	1.62	19.9	16.94	33.00
T3	39.83	47.14	59.18	184.44	5.22	1.02	1.10	1.64	19.23	16.78	31.00
T4	42.43	54.27	73.67	227.51	6.41	1.26	1.26	1.72	21.73	19.39	39.00
T5	39.53	49.29	63.44	194.86	5.48	1.06	1.20	1.67	21.4	18.17	31.67
T6	40.37	53.05	61.89	189.97	5.33	1.05	1.14	1.68	20.27	17.38	32.33
T7	46.90	60.35	89.67	277.10	7.80	1.54	1.33	1.89	22.53	19.69	51.33
T8	40.10	48.05	54.45	176.03	5.08	0.98	1.08	1.57	16.97	15.23	26.33
T9	41.20	49.07	56.47	180.30	5.17	1.00	1.11	1.62	17.13	15.34	34.00
T10	36.18	42.79	36.33	110.99	3.10	0.62	0.66	1.25	12.9	11.87	12.00
S.Em (±)	**1.69**	**2.69**	**5.43**	**9.27**	**0.21**	**0.05**	**0.1**	**0.07**	**0.75**	**0.8**	**3.2**
C.D (p=0.05)	**5.04**	**8.00**	**16.13**	**27.55**	**0.63**	**0.14**	**0.31**	**0.2**	**2.22**	**2.36**	**9.5**

seed treatment by Rhizobium and PSB at 40 and 60 DAS with significant highest values recorded in T7 treated plants. Overall improvement in the crop growth under the influence of bio inoculants i.e.; Rhizobium, PSB and Rhizobium + PSB seems to be on account of their impact on nutritional availability in soil and improvement in various physiological processes in the plant system which are considered to be pre-requisites for growth of the crop (Nadeem *et al.,* 2018). Nodulation of green gram improved effectively in all the treated plants, with highest nodule number (51.33) in T7 treated plants at 40 DAS (Table 1). This may be because of increased P availability due to PSB and better atmospheric N fixation due to rhizobium. Synergism in Rhizobium and PSB might be the outcome of better nodulation and dual inoculation was reported to be more effective single inoculation (Amit *et al.,* 2010).

Yield attributes and yield

The effects of liquid and carrier based inoculants applied along with RDF had beneficial effect on yield attributes and yield of green gram over T1. Number of seeds per pod (10.11), seed yield (1276.98 kg/ha), stalk yield (2737.51 Kg/ha) and husk yield (483.37 kg/ha) was superior in T7, biofertiliser treated plants, but was at par with T4 plants (Table 2). Seed and stalk yield of green gram were increased by 35.64% and 39.04% with the T7 application as compared to T1. The increase in yield due to application of bio inoculants may be due to increased availability of N and P in soil for better plant uptake and their growth promoting activities. Crops which received T8 and T9 recorded significantly higher yield than RDF treated plants. The harvest index was superior in crop applied with T7 but was statistically at par with all other treatments.

Increment of seed yield by using liquid inoculants was also observed by Biswas and Bhowmick (2007) in black gram and Trimurtulu and Rao, (2014) in maize. Application of microbial inoculants like Rhizobium + PSB was reported to be beneficial in improving nodule number, yield and yield attributes in chick pea and summer green gram (Tagore *et al.*, 2013); Dongare *et al.*, 2016).

Nutrient dynamics

Application of T7 in crops, have led to higher nutrient uptake compared to all other treatments (125.09 kg/ha, 14.83 kg/ha and 54.81 kg/ha of N, P and K respectively) (Fig 1). The higher uptake of NPK in plants treated with dual liquid inoculants might be due to good establishment of crop rhizosphere and ample supply of native soil nutrients (Trimurtulu and Rao, 2014). In green gram, the association between the PSB and Rhizobium culture along with inorganic fertiliser improved plant growth due to synergistic effect and the dual inoculation increased the uptake of N and P content in plant (Amit *et al.,* 2010). It was also noticed that T9 treatment showed significantly better uptake than crops treated with T1. Dual inoculation helped in better absorption of N, P and K in plant and utilization of all the plant nutrients due to more availability of nutrient in soil (Nadeem *et al.*, 2018).

Protein content

The significantly higher protein content in green gram seed (24.83%) was observed from the plants which received, T7 (Table 2). Singh *et al.* (2006) and Murugan *et al.* (2011) also observed significant positive changes in seed protein content on biofertiliser application in chickpea and black gram, respectively.

Post-harvest soil characteristics

Dual application of rhizobium and PSB enhances soil N and P content. Seed treatment with liquid biofertilisers, T7, improved soil physio-chemical properties, organic carbon (0.46%), available N (285 kg/ha), available P (46.63 kg/ha), over other treatments (Table 3). These results were in close conformity with the findings of Virendra and Shivay (2010) who revealed that integrated use of biofertilisers and chemical fertilisers significantly improved the available N, P and K contents compared to sole application of chemical

Table 2: Effect of biofertilisers on yield attributes and yield (Pooled data of 2018 and 2019).

Treatments	Number of seeds per pod	Test weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Husk Yield (kg/ha)	Harvest Index	Protein %
T1	9.77	31.20	821.63	1668.62	310.75	29.38	21.70
T2	9.90	31.83	992.19	2282.97	368.91	27.25	22.77
T3	9.47	31.50	977.57	2111.50	338.12	28.87	22.06
T4	9.80	31.93	1145.89	2561.06	465.81	27.45	24.67
T5	9.17	31.47	1095.57	2460.12	409.07	27.61	23.48
T6	9.57	31.43	1038.40	2382.87	391.37	27.22	23.10
T7	10.11	32.97	1276.98	2737.51	483.37	28.36	24.83
T8	9.57	31.53	968.83	2094.80	349.96	28.40	21.10
T9	9.63	31.73	987.36	2202.50	362.43	27.78	21.56
T10	9.13	30.37	594.68	1334.16	209.26	27.82	20.65
S.Em (±)	**0.24**	**0.58**	**47.85**	**152.17**	**34.7**	**0.65**	**0.68**
C.D (p=0.05)	**0.71**	**NS**	**142.18**	**452.13**	**103.11**	**NS**	**2.02**

Abbreviation: NS: Non significant.

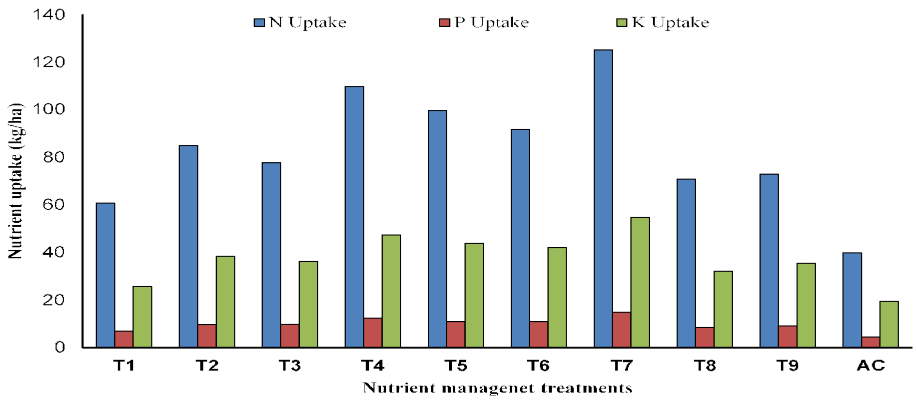

Fig 1: Effect of biofertilisers on nutrient dynamics (based on pooled data of 2018 and 2019).

Abbreviation: T1: Recommended doses of fertilisers, T2: RDF + Carrier-based Rhizobium, T3: RDF + Carrier-based PSB, T4: RDF + Carrier-based (Rhizobium + PSB), T5: RDF + Liquid-based Rhizobium, T6: RDF + Liquid-based PSB, T7: RDF + Liquid-based (Rhizobium + PSB), T8: 75% RDF + Carrier-based (Rhizobium + PSB), T9: 75% RDF + Liquid-based (Rhizobium + PSB), T10: Absolute Control-No fertiliser and bio-fertilisers.

Table 3: Effect of biofertilisers on Post-harvest soil characteristics (after completion of two year cropping cycle).

Treatments	Organic Carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T1	0.40	261.10	35.25	92.60
T2	0.44	271.90	39.98	98.78
T3	0.44	269.10	40.26	95.96
T4	0.45	280.11	43.94	87.49
T5	0.44	277.10	41.62	84.94
T6	0.42	273.12	42.92	65.59
T7	0.46	285.06	46.63	99.63
T8	0.41	232.92	39.12	99.05
T9	0.42	241.97	39.45	100.5
T10	0.39	229.03	31.27	83.87
S.Em (±)	0.02	9.67	1.48	3.82
C.D (p=0.05)	NS	28.73	4.41	11.34

Abbreviations: NS: Non significant.

Table 4: Effect of biofertilisers on economics (Pooled data of 2018 and 2019).

Treatments	Cost of Production (` /ha)	Gross Return (` /ha)	Net Return (` /ha)	Return Per Rupees Invest (`)
T1	25554	58310	32756	1.28
T2	25614	70575	44960	1.76
T3	25629	69452	43823	1.71
T4	25689	81463	55773	2.17
T5	25602	77892	52290	2.04
T6	25602	73858	48256	1.88
T7	25650	90712	65061	2.54
T8	24811	68832	44022	1.77
T9	24772	70190	45418	1.83
T10	22040	42279	20239	0.92
S.Em (±)	-	3382	3382	0.13
C.D (p=0.05)	-	10050	10050	0.4

Price of green gram seeds - ` 69.75/kg and stover - ` 0.60/kg.

fertilisers. The soil application of PSB, solubilised inorganic phosphates in soil (Barroso *et al*., 2006) while rhizosphere rhizobium colonies helped in nodule development, energy transformation during nitrogen fixation in root nodules (O'hara *et al.,* 1988).

Economics

The crop which received treatment, T7 recorded the highest gross return (` 90712.00), net return (` 65061.00) and return per rupees invested (2.54), on the other hand minimum economic return was recorded from the T10 treated crop (Table 4). Net return of T7 treated plots was 49.65% higher than RDF (T1) and 14.27% greater than carrier based biofertiliser (T4) plot. These results are in conformity with Patel *et al.* (2016). Return per rupee invested for plants treated with T9 was found statistically at par with T4, T5 and T6 treated crops.

CONCLUSION

All nutrient management practices consisting of seed treatment with liquid or carrier based Rhizobium with or without PSB increased the growth and yield components of green gram as compared to the crop which received only RDF. The superiority in respect to yield, net return and return per rupee invested was obtained from the T7 treated crop. But, T9 treated plants showed at par results for return per rupee invested when compared to plants treated with T4, T5 and T6 nutrient management treatment. Hence, application of 75% RDF and seed treatment with liquid biofertilisers, Rhizobium and PSB (T9) in summer green gram of red laterite soil can be an alternative for realizing better productivity and profitability.

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