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INFLUENCE OF INM ON NODULATION, YIELD, QUALITY AND ECONOMICS OF GREENGRAM IN COASTAL SALINE SANDY SOIL

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Abstract

A field experiment was carried out during January-April, 2019 to study the influence of integrated nutrient management on nodulation, yield, quality and economics of greengram *Vigna radiata* (L.) in a coastal saline sandy soil. The field experiment was conducted at Mandabam coastal village, near Chidambaram. The texture of the soil was sandy loam with pH-8.37 and EC-4.05 dS m^{-1}. The available nitrogen, phosphorus and potassium status were low, low and medium, respectively. The treatments consisted of T_1–Control (RDF alone/100% NPK), T_2–RDF + FYM @ 12.5 t ha^{-1}, T_3–RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_4–RDF + FYM @ 12.5 t ha^{-1} + Rhizobium @ 2.0 kg ha^{-1}(BF), T_5–RDF + CCP @ 12.5 t ha^{-1}+ Rhizobium (BF), T_6–RDF + FYM @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}, T_7–RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}, T_8–RDF + ZnEFYM @ 6.25 t ha^{-1} + BF + Pink Pigmented Facultative Methylotrophs (PPFM) @ 1.0 % Foliar spray and T_9–RDF + ZnECCP @ 6.25 t ha^{-1} + BF + PPFM @ 1.0 % Foliar spray twice at pre flowering stage and flowering stage. The experiment was laid out in a randomized block design with three replications using greengram var. ADT-5. The results revealed that the integrated application of recommended dose of NPK + Zn enriched composted coir pith (ZnECCP) @ 6.25 t ha^{-1} along with Rhizobium @ 2.0 kg ha^{-1} through soil and foliar spray of pink pigmented facultative methylotrophs (PPFM) 1.0 per cent twice at pre flowering and flowering stage superior in increasing the nodulation, yield, quality and economics of greengram. The increased seed and haulm yield recorded was 982 and 2079 kg ha^{-1} as compared to 566 and 1103 kg ha^{-1} of seed and haulm yield in control.

Key words : coastal saline sandy soil, enriched organics, nodulation, yield, quality, economics, greengram.

Introduction

In saline soils of coastal areas of Tamil Nadu, rice-pulses cropping system especially greengram is the dominant crop. Due to low organic matter, poor nutrient status and loss of applied nutrients through leaching, there is a need to test the response of greengram to application of increasing levels or recommended dose of both macro and micro nutrients in coastal saline sandy soils. Even the applied nutrients are leached to the lower layers due to poor physical properties, poor nutrient retention and low organic carbon content, which further aggravates the problem of nutrient deficiency. The coastal farmers are cultivating the lands by adopting traditional management practices and realizing very low yield of crops as compared to other regions. Now a day's use of enriched organic manure to restore the soil fertility status has now been recognized. Additional inorganic nutrient especially micronutrients like Zinc along with organics in sandy soil not only full fill the nutrients demand but also helps in preventing loss of applied nutrients and steady release of them. Therefore, integrated use of Zn enriched organic manure and inorganic NPK fertilizer along with biofertilizer as best option for maintaining soil fertility and to achieve higher growth, yield and quality of greengram production (Shankar *et al*., 2013 and Patel *et al*., 2016). Hence an attempt was made in the present study to find out the effect of integrated nutrient management on nodulation, yield, quality and economics of greengram in

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coastal saline sandy soils.

Materials and Methods

A field experiment was carried out in a farmer's field during January-April 2019 at Mandabam coastal village to find out the effect of integrated nutrient management on the nodulation, yield, quality and economics of greengram in coastal saline sandy soil. The treatments involving like T_1-Control (RDF alone), T_2–RDF + FYM @ 12.5 t ha^{-1}, T_3–RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_4–RDF + FYM @ 12.5 t ha^{-1} + Rhizobium @ 2.0 kg ha^{-1}(BF), T_5–RDF + CCP @ 12.5 t ha^{-1}+ Rhizobium (BF), T_6–RDF + FYM @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}, T_7–RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}, T_8–RDF + ZnEFYM @ 6.25 t ha^{-1} + BF + Pink Pigmented Facultative Methylotrophs (PPFM) @ 1.0 % Foliar spray and T_9–RDF + ZnECCP @ 6.25 t ha^{-1} + BF + PPFM @ 1.0 % Foliar spray twice at pre flowering stage and flowering stage. The experiment was carried out in a Randomized Block Design (RBD), with three replications, using greengram variety ADT-5. The experimental soil had sandy loam texture with pH- 8.37; EC-4.05 dSm^{-1} and organic carbon- 2.31 g kg^{-1}. The available DTPA-Zn content of 0.71 mg kg^{-1} in soil. The alkaline $KMnO_4$–N; Olsen-P and NH_4OAc-K, were low, low and medium status, respectively. Calculated amount of inorganic fertilizer doses of Nitrogen (25 kg N ha^{-1}), Phosphorus (50 kg P_2O_5 ha^{-1}) and Potassium (25 kg K_2O ha^{-1}) were applied through Urea, DAP and MOP, respectively. Required quantities of Zinc Sulphate and Zn enriched organics like farm yard manure (ZnEFYM) and composted coir pith (ZnECCP) as per the treatment schedule were incorporated. The biofertilizer namely *Rhizobium* @ 2 kg ha^{-1} was also applied to as per the treatment schedules plots. Nodule growth characters like number of nodules palnt^{-1} and nodule weight were recorded at critical stages of greengram viz., pre flowering, and flowering stages. Quality parameters like Methionine and protein content were estimated using the standard procedure as outlined by Jackson (1973) and computing the protein yield of greengram seeds. At harvest seed and haulm yield were recorded as separately and economics was also worked out.

Results and Discussion

Nodules growth characters

The application of various INM treatments significantly and positively influenced by the nodules growth characters like number of nodules plant^{-1}, nodule fresh weight and dry weight was well evidenced in the present study (Table 1).

Among the various INM treatments, combined application of recommended dose of NPK + ZnECCP @ 6.25 t ha^{-1} + BF @ 2 kg ha^{-1} through soil application as well as foliar spray of PPEM @ 0.5 per cent twice at pre flowering and flowering stage (T_9) recorded the highest number of nodules plant^{-1} (13.68 and 16.82), nodules fresh weight (186.45 and 263.40) and nodule dry weight (62.08 and 84.50), respectively. This was followed by the treatment $T_{8,}$ application of RDF + BF and ZnEFYM @ 6.25 t ha^{-1} through soil application along with foliar spray of PPFM @ 0.5 per cent which recorded a number of nodules plant^{-1} (12.94 and 13.11), nodules fresh weight (177.17 and 250.16) and nodule dry weight (58.87 and 79.80), respectively. This was followed by the treatment $T_{7,}$ supplied with RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1} and treatment $T_{6,}$ supplied with RDF + FYM @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1} which recorded the lowest number of nodules plant^{-1} (12.8 and 11.32), nodules fresh weight (236.83 and 223.62) and nodule dry weight (75.58 and 71.31) at flowering stage, respectively as compared to above said treatments. This was followed by the treatments arranged in the descending order like $T_{5>}$ T_4 > T_3 and T_2. These treatments were also statistically significant. The lowest number of nodules plant^{-1} (7.47 and 9.73), number of nodules fresh weight (111.83 and 157.53 g) and nodule dry weight (36.51 and 49.56 g) was recorded in the treatment T_1 (RDF alone).

In coastal saline soil, greengram responded well to the integrated nutrient application. Among the various INM treatments, combined application of recommended dose of NPK + ZnECCP @ 6.25 t ha^{-1} + *Rhizobium* @ 2 kg ha^{-1} through soil and foliar application of PPFM @ 1.0% twice at pre flowering stage (PFS) and at harvest stage (HS) was established as the best treatment in increasing nodules count, nodules fresh and dry weight. The present results clearly indicated that the integrated application of recommended dose of NPK fertilizers + *Rhizobium* along with ZnECCP @ 6.25 t ha^{-1} and foliar spray of PPFM @ 1.0% twice recommended dose of NPK fertilizers were better than NPK alone. Higher number of root nodules and nodules weight in greengram might be due to more root proliferation under adequate supply of N and P from Zn enriched organic manures. The result of the present investigation is in conformity with the earlier findings of Saravanan *et al*., (2013) and Patel *et al*., (2016) in greengram. Further, increase in number and size of nodules might be due to increased nitrogenase activity by *Rhizobium* responsible to produce growth hormones, *i.e.* IAA, auxins, gibberellins and

Table 1: Effect of INM on the nodules growth characters of green gram.

Treatments	Number of nodules Plant^{-1}		Nodules weight plant^{-1} (g)			
			Flowering stage		Pod formation stgae	
	Flowering stage	Pod formation stage	Fresh weight	Dry weight	Fresh weight	Dry weight
T_1	7.47	9.73	111.83	36.51	157.53	49.56
T_2	8.24	10.71	121.17	39.77	170.84	54.03
T_3	9.05	11.64	130.45	42.93	184.05	58.38
T_4	9.73	12.53	139.69	46.07	197.16	62.59
T_5	10.61	13.39	149.06	49.22	210.27	66.95
T_6	11.32	14.18	158.51	52.50	223.62	71.31
T_7	12.18	15.06	167.85	55.71	236.83	75.58
T_8	12.94	15.97	177.17	58.87	250.16	79.80
T_9	13.68	16.82	186.45	62.08	263.40	84.50
SE_D	0.28	0.36	4.30	1.43	6.10	1.95
CD (p=0.05)	0.61	0.77	9.21	3.07	13.07	4.18

Table 2: Effect of INM on the quality parameters and yield green gram.

Treatments	Quality characters			Yield	
	Methionine content (%)	Protein content (%)	Protein yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	0.81	22.14	125.31	566	1103
T_2	0.88	22.48	139.15	619	1236
T_3	0.95	22.93	154.08	672	1345
T_4	1.01	23.15	166.91	721	1460
T_5	1.08	23.46	181.34	773	1603
T_6	1.14	23.87	196.68	824	1721
T_7	1.22	24.09	211.00	875	1858
T_8	1.29	24.52	227.79	929	1972
T_9	1.36	24.70	242.55	982	2079
SE_D	0.02	0.54	5.63	22.47	47.54
CD (p=0.05)	0.06	NS	12.06	48.10	101.75

vitamins which are conductive to better nodulation was observed by Amruta *et al.*(2015). The application of recommended dose of NPK + biofertilizer along with Zn enriched organic manures significantly increased number and weight of nodules in greengram as compared to application of RDF alone. This might be due to the growth enzymes, present in organic sources, which favoured rapid cell division and multiplication. Similar finding was reported by Singh *et al*., (2006).

Yield of greengram

The greengram responded well for the integrated plant nutrients application. The significant influence of recommended NPK, biofertilizer along with Zn enriched organics in increasing the grain and haulm yield of greengram was well documented in the present study (Table 2). The yield realized under the nutrient deficient coastal saline soil, the highest seed yield (982 kg ha^{-1}) and haulm yield (2079 kg ha^{-1}) was recorded with combined application of recommended dose of fertilizer (RDF) + *Rhizobium* @ 2 kg ha^{-1} + ZnECCP @ 6.25 t ha^{-1} through soil along with foliar spray of PPFM @ 1.0 per cent twice at pre flowering and flowering stage (T_9). This was followed by the treatments T_8, (RDF + BF + ZnEFYM @ 6.25 t ha^{-1} through soil application and foliar application of PPFM @ 1.0%), T_7 (RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}) and T_6 (RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1}) which recorded the seed (929,875 and 824 kg ha^{-1}) and haulm (1972,1858 and 1721kg ha^{-1}) yield of greengram, respectively. This was followed by the application of organics and bio fertilizer alone or without micronutrient treatments T_5, (RDF + CCP @ 12.5 t ha^{-1} + BF), T_4 (RDF+FYM @ 12.5 t ha^{-1} + BF), T_3 (RDF + CCP @ 12.5 t ha^{-1}) and T_2 (RDF +FYM @ 12.5 t ha^{-1}) which recorded the lowest seed and haulm yield as compared to above said INM treatments (organic, inorganic and BF). The control treatment T_1, 100 per cent NPK alone recorded a lower seed (566 kg ha^{-1}) and haulm (1103 kg ha^{-1}) yield of greengram, respectively.

Higher yield in the INM treatment might also be due to the contribution of Zinc nutrient released from enriched organic manures attributed to involvement in many enzyme system, recycling functions and auxin production (Veeranagappa *et al.,* 2010) and enhanced synthesis of carbon hydrates and their transport to the site of seeds formation (Arulrajasekaran, 2019). Associated with improved growth and yield characters, the greengram yield also increased with the application of recommended dose of NPK + Rhizobium + ZnECCP @ 6.25 t ha^{-1} through soil application and foliar application of PPFM @ 1.0 per cent twice at pre flowering and flowering stage. Application of NPK + biofertilizer and Zn enriched organic manures helped in the slow and steady rate of nutrient release into soil solution to match the absorption pattern of greengram thereby

Table 3: Economic analysis of greengram.

Treatments	Cost of cultivation (Rs.)	Gross income (Rs.)	Net return (Rs.)	Benefit cost ratio (Rs.)
T_1	25963	68399	42436	2.63
T_2	19121	62536	43415	3.27
T_3	23413	74256	50843	3.17
T_4	26953	91070	64117	3.38
T_5	24403	96715	72312	3.96
T_6	26771	79675	52904	2.98
T_7	24221	85431	61210	3.53
T_8	27408	102683	75275	3.75
T_9	24857	108540	83688	4.37

increased the yield. Further, the favourable effect of Zn and NPK nutrients on seed and haulm yield was also could be attributed to their effect in maintaining soil available nutrients in balanced proportions for better growth and higher seed yield of greengram. This corroborates the earlier reported by Aloway, (2008).

Quality parameters of greengram

Protein content

The influence of different INM treatments in altering the protein content of greengram seeds was not statistically significant (Table 2).

Methionine content and protein yield

The influence of various INM treatments in significantly increasing the quality parameters viz., methionine content and protein yield of greengram seeds was well evidenced in the present study (Table 2). Among the various INM treatments, the integrated application of recommended dose of NPK fertilizer + Rhizobium + ZnECCP @ 6.25 t ha^{-1} along with foliar application of PPFM @ 1.0 per cent twice (T_9) registered a significantly higher methionine (1.36 g 100g^{-1}protein) content and protein yield (242.55 kg ha^{-1}) of greengram seed. This was followed by the application of RDF RDF + Rhizobium + ZnEFYM @ 6.25 t ha^{-1} through soil and PPFM @ 1.0% foliar spray (T_8), application of RDF + CCP @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1} (T_7), application of RDF + FYM @ 12.5 t ha^{-1} + BF + $ZnSO_4$ @ 25 kg ha^{-1} (T_6), application of RDF + CCP @ 12.5 t ha^{-1} + BF (T_5) and application of RDF + FYM @ 12.5 t ha^{-1} + BF (T_4) recorded the significantly decreased the methionine (1.29,1.22,1.14,1.08 and 1.01 g 100g^{-1}protein) content and protein (227.79, 211.00, 196.68, 181.34 and 166.91 kg ha^{-1}) yield of greengram seeds, respectively. This was followed by the treatment T_3, application of RDF along with CCP and treatment T_2, application of RDF along with FYM (without BF and micronutrient). The lowest quality parameters *viz*., methionine content (0.81 g 100g^{-1}protein) and protein yield (125.31 kg ha^{-1}) was recorded in the control or 100% RDF alone (without micronutrient and organics) as compared to all other treatments.

The improvement in quality of greengram seeds with the integrated nutrient application of 100 per cent recommended dose of NPK + Rhizobium @ 2.0 kg ha^{-1} along with ZnECCP @ 6.25 t ha^{-1} through soil + foliar spray of PPFM @ 1.0% twice was well evidenced. Application of inorganic NPK nutrients along with organics enriched with zinc increased the seed yield and nutrient availability which resulted in better accumulation of N and hence the protein and methionine content in seeds (Kalkute Rakesh *et al.,* 2019). Besides the addition of zinc as $ZnSO_4$ through enrichment of organics promoted better quality through synthesis of sulphur containing amino acids through its effect on protein metabolism in plants. Similar results were earlier made by Ram *et al*., (2002). Further, higher protein yield might be due to the increased nitrogen content in seed which intern helped to increase the protein yield of geengram seeds. These results confirm the findings of Chhatrapathi Mahilane and Vikrama Singh (2018). The impact of NPK along with Zn-enriched organics addition would have stimulated the metabolism and synthesis of amino acids thus resulting in higher methionine content in the greengram seeds. In line with the present study, Ashan *et al*., (2018) also reported similar results.

Economics of the green gram production

The benefit cost ratio was worked out to realize beneficial influence of various INM treatments through recommended dose of NPK, biofertilizer and Zn enriched organics application in increasing the net profit over the conventional methods of greengrsm production and/or farmers practice (Table 3). The net income per ha (gross income- cost of cultivation) and the benefit cost ratio was greatly increased with the Zn enriched organics (ZnECCP/ZnEFYM) application through soil + foliar spray of PPFM along with recommended NPK and Rhizobium. Among the various treatments, the highest net income (Rs. 83,688 ha^{-1}) and benefit cost ratio (Rs. 4.37) were obtained with the soil application of Zn enriched composted coir pith (ZnECCP) @ 6.25 t ha^{-1} and foliar application of PPFM @ 1.0 per cent twice at pre flowering stage (PFS) and flowering stage (FS) along with recommended dose of NPK and Rhizobium (T_9). This was followed by application of RDF + BF + ZnEFYM @ 6.25 t ha^{-1} through soil along with 1.0% foliar spray of PPFM (T_8). The lowest net income (Rs. 42,436 ha^{-1}) and benefit cost ratio (Rs.2.63) was observed in the control treatment (without micronutrients and organics).

The economics worked out in the field experiment revealed the beneficial role of INM treatments, application of organics, inorganic fertilizer along with biofertilizer increasing the net returns and benefit cost ratio. The highest net income (Rs. 83,688) and BCR (4.37) was recorded with the integrated application of 100 per cent recommended dose of NPK + Rhizobium @ 2.0 kg ha^{-1} + ZnECCP @ 6.25 t ha^{-1} through soil + PPFM foliar spray twice @ 1.0% as compared to all other treatments. The increase in the economic yields of greengram and hence the economic values of the yield support the cost of cultivation and ultimately resulted in higher net return and also the benefit: cost ratio. The earlier reports of Marimuthu and Surendran (2015) and Mohana Keerthi *et al*., (2015) also support the present findings.

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