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RESEARCH PAPER

Effect of *Rhizobium*, different levels of phosphorus and sulphur on growth and yield of *Vigna radiata* L. cv. PUSA BESAKHI

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Abstract : The experiment was laid out in a Factorial Randomized Block Design with twelve treatments and replicated thrice. Results indicate that the seed inoculation with *Rhizobium* showed some good results increasing numbers of nodules and uptake of nutrients due to inoculation. Significant effects were observed in plants growth attributes due to presence of phosphorus and uptake of phosphorus increased due to presence of sulphur @ 20kg ha^{-1} ultimately resulting in good yield. However, plant heights (66.00cm), Number of branches $plant^{-1}$ (4.82), Number of nodules $plant^{-1}$ (5.83), Number of grains pod^{-1} (12.56), test weight (51.03g) and grain yield (12.39 q/ha) were found significantly affected by the application of *Rhizobium* inoculation, application of 45kg phosphorus through DAP and 20kg sulphur through Gypsum ha^{-1}. Cost benefit ratio was also found (2.22) on higher side.

Key Words : Mungbean, RBD, *Rhizobium*, Sulphur, Plant parameter

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INTRODUCTION

India constitutes the single largest unit where plants make the major source of protein to more than half of its predominantly vegetarian population. Pulses by virtue of their high protein content (220-250g/kg) which is next to fish (dry) with (335g protein/kg) and easy digestibility provide an answer to the persisting problem of malnutrition. In food production nitrogen is the most limiting nutrient, the key element for increasing crop production. Hence, any technique which enhances N nutrition of crop will go a long way in increasing crop yields. Cultivation of legume crop is viewed more as a soil fertility improver than as an independent crop grown for their output. This is because legume crops are self-sufficient in N supply. Legume crops have the property of obtaining through symbiotic root nodule bacteria, combined nitrogen as an available nutrient. It is the fact that an inexhaustible store of N exists in the atmosphere and all the plant except legumes are not able to use it directly (Kanwar, 2000). Besides this, group of crops such as legumes help in maintaining soil fertility and thus,

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occupy a unique position in Indian Agriculture occupying an Area of around 23.63 million hectares with a production of 14.76 million tons securing the place highest pulse producing country of the world. Spring and summer pulses have recently gained popularity in India owing to availability of short duration cultivars, improvement in irrigation potential and favourable climatic conditions. Among the short duration pulse, mungbean [*Vigna radiata* (L.) Wilczeck] with an area of 34.4 lakh ha and production of 14 lakh ton with a productivity of 406.98kg/ha has emerged as full-fledged spring/summer pulses corps. The introduction of mungbean as an additional crop enable farmers to make the best use of their resources which otherwise would have remained idle during this period. Although large achievements have undoubtedly been made in the field of plant nutrition and fertilization in cereals like rice and wheat, comparatively much less attention has been devoted to the development of suitable agro-techniques of pulse production. The yield in pulses is governed by number of factors operating over the entire growing period. Since all pulses corps belongs to the family leguminoseae, inoculation with efficient *Rhizobium* strain and fertility management occupy an important place in the production technology of these crops. Nitrogen requirement of the developing pulse grain usually exceed the supply capacity of the roots and the deficit is made up by catabolism of nitrogen rich leaf protein. Basal application of N, P, K and S may thus satisfy a means of increasing total nitrogen import without involving roots during this critical period. There is paucity of information on the efficiency of nutrient uptake in pulses.

Rhizobium:

Rhizobium being one of the most important bio-fertilizer is used in modern agriculture. *Rhizobium* converts atmospheric nitrogen into ammonia, which is utilized by the plants, by symbiotic association. The process occurs within the root nodules, which are red or pink inside. This attributes to beneficial effects of *Rhizobium* inoculation, which has been primarily related to increase in the nitrogen uptake as a consequence of nitrogen fixation. *Rhizobium* is very much commonly used bio-fertilizer in legume crops which not only accelerates the nitrogen uptake of plants but also enhances the soil fertility. It is also seen that the crop of greengram, when inoculated with efficient *Rhizobium* strain shows favourable effect on growth attributes, physiological parameters and yield components of greengram (Sarkar and Pal, 2006).

Phosphorus:

Phosphorus application is essential for energy transfer in living cells enhancing root growth besides increasing the mobility of symbiotic bacteria in the root zone which ultimately results in more nitrogen fixation. Summer pulses in India usually respond favourably to phosphorus application indicating that this element is generally deficient in weathered soils of tropical regions. Phosphorus ensures uniform and directly ripening of crop and also involved in transformation of energy in higher value of growth and yield attributes and also that due to phosphorous early development translocation of food materials in plant body resulted in better uptake of nutrients and ultimately in better seeds and stover yield. (Parmar and Thanki, 2007), the yield attributes *viz.*, pods/plant, seed/pod and test wt., seed and straw yield increased significantly. Phosphorus application also resulted in significant increase in N and P uptake in seed and straw (Gupta *et al.*, 2006).

Sulphur :

Sulphur is increasingly being recognized as a fourth major plant nutrient, but the importance of sulphur (S) application has not been fully recognized in fertilizer recommendations. Soils which are deficient in S cannot on their own, provide adequate S to meet the crop demand resulting in S deficient crops and suboptimal yields (Malik, 1999). Use of gypsum is preferred because of its diverse roles in soil. On saline and alkaline soils, gypsum is used as an amendment also. The object is to bring soil pH, to a range favourable for nutrient availability and plant growth and development. Secondly, gypsum also improves the soil structure. This is in addition to its use as a source of sulphur and calcium. Gypsum has proved its Superiority on acid soils equally well, if not more. More effectiveness of gypsum as a source of sulphur is due to the reason that in addition to sulphur, it also carries calcium. In greengram calcium requirement is more as this is needed for the shell formation (Jaggi *et al*., 2000). However, the fate of applied phosphorus and sulphur in the presence of *Rhizobium* is not yet clearly understood. Therefore, there is need to study in detail the relationship between application of phosphorus and sulphur, the dry matter production and yield of greengram. Moreover, the residual effect of phosphorus, sulphur and *Rhizobium* inoculation in *Kharif* pulses being a highly exhaustive crop, and would exploit the residual effects of *Rhizobium* inoculation, nitrogen, phosphorus and sulphur very effectively and thus, needs through investigation. Keeping these points in view, the present investigation were planned and conducted with the following major objectives: To study the effect of *Rhizobium* and different levels of phosphorus and sulphur on growth and yield of mungbean, to study the interaction effect of phosphorus and sulphur with and without *Rhizobium* inoculation on growth and yield of *Kharif* mungbean and to evaluate the economics of different treatments.

MATERIAL AND METHODS

The materials used and methods adopted in the present experiment effect of *Rhizobium*, different levels of phosphorus and sulphur on growth and yield of mungbean (*Vigna radiata* L.) with a brief description of site of experiment, soil properties, climatic condition prevalent in the locality, cropping history, sampling techniques and statistical analysis adopted are dealt within this chapter.

Soil:

The soil of the experimental field constituting a part of Ajmer Agro climatic Zone is neutral and deep. Pre-sowing soil samples were taken from a depth of 15 cm with the help of an auger. The composite samples were used for the chemical and mechanical analysis. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus and low in potassium. The mechanical, chemical and physico-chemical properties of the soil of experimental field and the methods used, are presented in Table A.

Table A: Mechanical, chemical and physio-chemical field characteristics of the experimental field (0 – 15 cm)

Particulars	Result	Method	Reference
Mechanical analysis			
Sand (%)	60.50%	International	Piper, 1966
Silt (%)	24.10%	Pipette Method	
Clay (%)	17.20%		
Textural class	Sandy loam	USDA Triangle	Soil Survey Staff, 1975
Chemical analysis			
Organic carbon (%)	0.15%	Walkley and Black Method	Jackson, 1973
Available nitrogen (kg ha^{-1})	280kg ha^{-1}	Alkaline Permanganate Method	Subbaiah and Asija, 1956
Available phosphorus (kg ha^{-1})	22.50 kg ha^{-1}	Olsen's Colorimetric Method	Olsen *et al.*, 1954
Available potassium (kg ha^{-1})	110.00 kg ha^{-1}	NH_4OAc- leaching	Jackson, 1973
Soil pH	7.6	Glass electrode pH meter	Jackson, 1973

Experimental details:

The experiment was laid out in Randomized Block Design (2×3×2 factorial). The three factors are *Rhizobium*, phosphorus and sulphur levels. *Rhizobium* has two levels *i.e.* inoculated and uninoculated, three levels of phosphorous @ 40kg/ha, 45 kg/ha and 55kg/ha, and two levels of sulphur 25kg/ha and 40kg/ha, respectively comprising of twelve treatment combinations each replicated three times. Treatments were randomly arranged in each replication, divided into thirty six plots. The treatments tested, specifications of the layout, etc. are given below.

Details of treatment combinations:

Levels of Rhizobium:

Rh_1- inoculated and Rh_2-uninoculated.

Levels of phosphorus:

P_1-40kgha^{-1}, P_2- 45kgha^{-1} and P_3-55kgha^{-1}.

Levels of sulphur:

S_1 -25kgha^{-1} and S_2 -40kgha^{-1} .

Table B : Treatment combinations

Treatments number	Treatments combination	Treatment description
T_1	$Rh_0\ P_1\ S_1$	Rh_0 = non-treated P_1=30 × S_1=20
T_2	$Rh_0\ P_1\ S_2$	Rh_0 = non-treated P_1=30 × S_2=40
T_3	$Rh_0\ P_2\ S_1$	Rh_0 = non-treated P_2=45 × S_1=20
T_4	$Rh_0\ P_2\ S_2$	Rh_0 = non-treated P_2=45 × S_2=40
T_5	$Rh_0\ P_3\ S_1$	Rh_0 = non-treated P_3=60 × S_1=20
T_6	$Rh_0\ P_3\ S_2$	Rh_0 = non-treated P_3=60 × S_2=40
T_7	$Rh_1\ P_1\ S_1$	Rh_1 = treated P_1=30 × S_1=20
T_8	$Rh_1\ P_1\ S_2$	Rh_1 = treated P_1=30 × S_2=40
T_9	$Rh_1\ P_2\ S_1$	Rh_1 = treated P_2=45 × S_1=20
T_{10}	$Rh_1\ P_2\ S_2$	Rh_1 = treated P_2=45 × S_2=40
T_{11}	$Rh_1\ P_3\ S_1$	Rh_1 = treated P_3=60 × S_2=20
T_{12}	$Rh_1\ P_3\ S_2$	Rh_1 = treated P_3=60 × S_2=40

Pre-sowing operations:

Preparation of the field:

In order to facilitate sowing, the experimental field was thoroughly ploughed and harrowed and brought to fine tilth. Stubbles and weeds were picked up from the field and the land was leveled with the help of rake and the plots were demarcated according to layout.

Seed treatment:

Seed treatment was done with *Rhizobium* at the rate of 25g per kg seed to increase nodulation, growth and consequently yield of crop.

Seed inoculation:

The seeds were inoculated with *Rhizobium* by making slurry with jagerry (gur) solution. 120g of (gur) *i.e*. jagerry was dissolved in 1 litre of water and boiled for half an hour and then cooled. After cooling of the solution *Rhizobium* was added at the rate of 30g/kg seed and then kept for shade drying of the inoculated seeds.

Fertilizer application:

Fertilizers were applied as side placement, for which 4-5cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, diammonium phosphate (DAP) and muriate of potash (MOP) to fulfill the requirement of N, P_2O_5, K_2O and S/ha. The recommended dose of 15kg N and 25kg K_2O per ha was applied according to the treatment details through urea and MOP. Whole of nitrogen, phosphorus and potash was applied as basal at the time of sowing.

Sowing of seed:

Vigna radiata L. cv. PUSA BESAKHI variety was selected for sowing which takes around 60-65 days to mature. Seeds were sown in line manually on 30th of June 2016. Seeds were covered with soil immediately after sowing the seeds. The spacing adopted was was according to the treatment details and the seeds were drilled at 3-4cm depth.

Post planting operations:

Thinning and gap filling:

Thinning and gap filling was done at 12DAS to maintain the plant population according to treatment in order to attain recommended plant population for proper growth and yield of crop.

Weeding :

Weeding was done to remove all weeds from the field in order to check any form of initial crop-weed competition and also checks the spread of yellow mosaic virus disease thus helpful for crop nourishment. Hand weeding was done after 25DAS and 46DAS.

Irrigation:

Irrigation was not found mandatory due to heavy rain at frequent rainy days at all stages.

Plant protection:

To control the infestation of *Yellow mosaic virus* and *Anthraquinose* disease which are spread by virus with the help of insects. So for the control of insects 0.5 per cent Monomiliphos was sprayed at 33 DAS, 41DAS and 48DAS.

Post harvest observations:

Harvesting:

Picking was done only when pods were found turning blackish brown or black in colour. This colour started appearing at 65DAS onwards consecutively upto 71DAS and so the pickings were done in three slots, 1st at 67DAS, 2nd at 69DAS and finally 3rd at 71DAS.

Beating :

The pods were dried well and then beating was done by means of log or sticks which remove all seeds from the pods.

Post-sowing operations :

Various post-sowing operations carried out during the course of investigation which is summarized below in tabular form.

Pre-harvest observations :

During the experiment various observations were recorded which are as follows.

Plant heights (*cm*):

The average height of plants was recorded at an interval of 15DAS. The height of plant was measured from the base of the plant upto the tip. Height of the plants was recorded at 15, 30, 45 and 60 days after sowing and five plants were randomly selected from each plot which was tagged for observations. The height was measured in cm.

Number of branches plant:

Number of branches per plant was also recorded at regular intervals of 30, 45 and 60DAS from the tagged plants of each plot.

Number of nodules/plant:

After digging out two plants randomly from each plot the no of nodules were counted at regular intervals of 30, 45 and 60DAS.

Dry weight/plant:

Dry weight of plants was recorded without root at intervals of 30, 45 and 60DAS by uprooting two plants randomly in each plot. These plants were first air dried then wrapped with paper and then kept in oven for oven drying at 70°C for 24-48 hours. The dry weight of samples were recorded, averagely and expressed as g plant $^{-1}$.

Crop growth rate (*g* m^{-2} *day* $^{-1}$):

It represents dry weight gained by a unit area of crop in a unit time expressed as g m^{-2} day $^{-1}$ (Brown, 1984). The values of plant dry weight at 30, 45 and 60DAS intervals were used for calculating the CGR. It was calculated with the help of following formula:

$$\text{Crop growth rate} = \frac{W_2 - W_1}{t_2 - t_1} (\text{g m}^{-2}\text{day}^{-1})$$

where, W_1 = Dry matter production per unit area at time t_1, W_2 = Dry matter production per unit area at time t_2, t_1= Days to first sampling, t_2 = Days to second sampling.

Relative growth rate ($g^{-1}g^{-1}day^{-1}$):

It was described by Radford (1967) which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$$\text{Relative growth rate (RGR)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1} (\text{g g}^{-1}\ \text{day}^{-1})$$

where, W_1 = Initial dry weight of plant (g), W_2 = Final dry weight of plant (g), t_1= Initial time period, t_2= Final time period.

It is also called efficiency index (y) and can be expressed in g g^{-1} day $^{-1}$ this parameter was calculated for the time intervals, *i.e.*, 30, 45 and 60DAS intervals. Using the data obtained from dry weight of plants.

Post-harvest observations:

The post harvest observations are below.

Number of pods/plant:

For calculating no. of pods per plant, pods of tagged plants were picked separately and then counted.

Number of grain pod:

For calculating no. of grains per pod, some pods were randomly selected and then their seeds were counted.

Test weight (g):

Samples of thousand seeds were randomly collected from each plot and were weighed for further record by electronic balance, thus, test weight was finally estimated.

Grain yield in (q/ha):

The pods collected from each plot were beaten and grains were collected and weighed. Thus, the overall grain yield was calculated.

Stover yield (q/ha):

After picking the pods the crop was harvested from field as 1m separately harvested from each plot to fetch out total stover yield in (q/ha).

Harvest index (%):

The harvest index was worked out using feed and stover yield with the help of formulae given by Donald (1962).

$$\text{Harvest index (HI\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \text{x100}$$

Economics analysis:

Cost of cultivation, gross return, net return and benefit cost ratio were worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and output.

Cost of cultivation (A ha^{-1}):

The cost of cultivation for each treatment was worked out separately; taking into consideration all the cultural practices followed and costs of inputs used in the cultivation in A ha^{-1}.

Gross returns (A ha^{-1}):

The gross return from each treatment was calculated in R ha^{-1}.

Net returns (R ha^{-1}):

The net profit from each treatment was calculated separately, by using the following formula:

Net return = Gross return (A ha^{-1}) – Cost of cultivation (A ha^{-1})

RESULTS AND DISCUSSION

The results and discussion of the investigations on effect of *Rhizobium*, different levels of phosphorus and sulphur on growth and yield of mungbean (*Vigna radiata* L.) cv. PUSA BESAKHI are being presented under following heads.

Growth components:

Plant height:

The plant height of greengram as influenced by different treatments was taken at 15, 30, 45 and 60DAS. The period between 30 to 45DAS was found to be at maximum growth of all the treatments. Table 1a shows that the plant height was found highest with treatment $R_1P_2S_1$ (*Rhizobium* + phosphorus @ 45kg/ ha+ sulphur @ 25kg/ha) at all growth stages. At 15DAS the maximum plant height was found (10.97cm), at 30DAS the maximum plant height was (34.27cm), at 45DAS the maximum height (63.34cm), at 60DAS the maximum height (66.00cm). The statistical analysis of the table indicates that there was no significant effect of *Rhizobium*, phosphorus or sulphur on plant height at initial stages of growth, whereas at the later stages of growth, there was significant effect of *Rhizobium*, phosphorus and sulphur on plant height of crop. The response of *Rhizobium* and different levels of phosphorus and sulphur did not affect the plant height at early stages of growth. This may have been due to the slower rate of mineralization of nutrients, but at later stages the growth increase was may be due to the more mineralization and availability of nutrients.

Table 1a : Effect of *Rhizobium*, different levels of phosphorus and sulphur on plant height (cm) of greengram at different intervals

Treatments		Plant height (cm) 15 DAS	30 DAS	45 DAS	60 DAS
***Rhizobium* (R)**					
R_0	Uninoculated	9.49	25.79	50.53	54.80
R_1	Inoculated	10.36	30.67	57.06	62.11
F – test		NS	S	S	S
S.E.±		-	0.05	0.11	0.07
C.D. (P=0.05)		-	0.09	0.23	0.13
Phosphorus (P)					
P_1	40kg ha^{-1}	9.57	26.20	50.94	55.79
P_2	45kg ha^{-1}	10.26	30.27	57.25	60.97
P_3	55kg ha^{-1}	9.94	28.22	53.20	58.62
F – test		NS	S	S	S
S.E.±		-	0.06	0.14	0.08
C.D. (P=0.05)		-	0.11	0.29	0.17
Sulphur (S)					
S_1	25kg ha^{-1}	10.00	28.94	54.27	59.17
S_2	40kg ha^{-1}	9.84	27.51	53.32	57.74
F – test		NS	S	S	S
S.E.±		-	0.05	0.11	0.07
C.D. (P=0.05)		-	0.09	0.23	0.13
Interaction	F - test	NS	S	S	S
(R x P)	S.E. ±	-	0.08	0.20	0.11
	C.D.(P=0.05)	-	0.16	0.40	0.23
Interaction	F - test	NS	S	S	S
(P x S)	S.E.±	-	0.08	0.20	0.11
	C.D.(P=0.05)	-	0.16	0.40	0.23
Interaction	F - test	NS	S	S	S
(R x S)	S.E.±	-	0.06	0.16	0.09
	C.D.(P=0.05)	-	0.13	0.33	0.19

NS= Non-significant S= Significant

Number of branches $plant^{-1}$:

It is evident from Table 1b that the average numbers of branches/plant at all the successive stages of growth under various treatments did not show much difference. The statistical analysis of data indicates that the response of treatments on number of branches /plant did not show any significant effect at 30DAS, but later at 45DAS and 60DAS showed significant with (2.60) and (4.82) Number of branches /plant, respectively with treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha+ sulphur @ 25kg/ha) but at 45DAS T_{10} *i.e.* $R_1P_2S_2$ (*Rhizobium* + phosphorus @ 45kg/ha+ sulphur @ 40kg/ ha) and T_{11} *i.e.* $R_1P_3S_1$ (*Rhizobium* + phosphorus @ 55kg/ha+ sulphur @ 25kg/ha) was found at par with T_9.

Number of nodules $plant^{-1}$:

The mean data on the number of nodules $plant^{-1}$of greengram for 30, 45 and 60DAS are presented in the Table 1c. The number of nodules did not show any significant affect at 30DAS but at 45DAS and 60DAS was found significant in treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha+ sulphur @ 25kg/ ha) with (29.33) and (5.83) number of nodules/plant. So it can be inferred from the result that inoculation with *Rhizobium*, phosphorus @ 45kg/ha+ sulphur @ 25kg/ ha gives good result in terms of nodulation. Therefore, it is essential to go for inoculation with suitable *Rhizobium* strains application of optimum phosphorus and sulphur level so that highest crop yield may be obtained with an

Table 1b : Effect of *Rhizobium*, different levels of phosphorus and sulphur on number of branches/plant of greengram at different intervals

Treatments		Number of branches plant^{-1}		
		30DAS	45DAS	60DAS
***Rhizobium* (R)**				
R_0	Uninoculated	0.00	1.86	3.65
R_1	Inoculated	0.11	2.47	4.54
F - test		S	S	S
S.E.±		0.03	0.02	0.02
C.D.(P=0.05)		0.07	0.05	0.05
Phosphorus (P)				
P_1	40kg ha^{-1}	0.00	1.87	3.97
P_2	45kg ha^{-1}	0.10	2.43	4.43
P_3	55kg ha^{-1}	0.07	2.18	3.90
F - test		NS	S	S
S.E.±		-	0.03	0.03
C.D.(P=0.05)		-	0.06	0.06
Sulphur (S)				
S_1	25kg ha^{-1}	0.07	2.23	4.25
S_2	40kg ha^{-1}	0.04	2.09	3.95
F - test		NS	S	S
S.E.±		-	0.02	0.02
C.D.(P=0.05)		-	0.05	0.05
Interaction	F - test	NS	S	S
(R x P)	S.E.±	-	0.04	0.04
	C.D.(P=0.05)	-	0.08	0.08
Interaction	F - test	NS	S	S
(P x S)	S.E.±	-	0.04	0.04
	C.D.(P=0.05)	-	0.08	0.08
Interaction	F - test	NS	S	S
(R x S)	S.E.±	-	0.03	0.03
	C.D.(P=0.05)	-	0.07	0.07

NS=Non-significant S=Significant

Table 1c: Effect of *Rhizobium*, different levels of phosphorus and sulphur on number of nodules /plant of greengram at different intervals

Treatments		Number of nodules plant^{-1}		
		30DAS	45DAS	60DAS
***Rhizobium* (R)**				
R_0	Uninoculated	21.33	16.92	3.51
R_1	Inoculated	29.28	22.89	4.58
F – test		NS	S	S
S. E. ±		-	0.05	0.04
C.D.(P=0.05)		-	0.09	0.08
Phosphorus (P)				
P_1	40kg ha^{-1}	22.83	17.71	3.63
P_2	45kg ha^{-1}	27.75	22.83	4.58
P_3	55kg ha^{-1}	25.33	19.17	3.92
F – test		NS	S	S
S.E.±		-	0.06	0.05
C.D. (P=0.05)		-	0.11	0.10
Sulphur (S)				
S_1	25 kg ha^{-1}	26.14	20.64	4.23
S_2	40 kg ha^{-1}	24.47	19.17	3.86
	F - test	NS	S	S
	S.E.±	-	0.05	0.04
	C.D. (P=0.05)	-	0.09	0.08
Interaction	F - test	NS	S	S
(R x P)	S.E.±	-	0.08	0.07
	C.D. (P=0.05)	-	0.16	0.14
Interaction (P x	F - test	NS	S	S
S)	S.E.±	-	0.08	0.07
	C.D. (P=0.05)	-	0.16	0.14
Interaction	F - test	NS	S	NS
(R x S)	S.E. ±	-	0.06	-
	C.D.(P=0.05)	-	0.13	-

NS= Non-significant S= Significant

increased ratio of nitrogen by *Rhizobium* bacteria and increased uptake of phosphorus due to presence of sulphur.

Dry weight plant^{-1}:

It can be clearly seen from Table 1d that the dry weight of plant did not show any significant difference at 30DAS but showed significant difference between that of other treatments and (T_9), $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha + sulphur @ 25kg/ha) to that of other treatments with values (12.08g) and (27.58g) was found significant at 45 and 60DAS, respectively. The interaction effects were also not significant at 30DAS but at 45 and 60DAS the interaction of *Rhizobium* × phosphorus, phosphorus × sulphur and *Rhizobium* × sulphur were also found significant.

Crop growth rate (g m^{-2}day^{-1}):

The data on crop growth rate at different growth stages as influenced by *Rhizobium* and different levels of phosphorus and sulphur are presented in Table 1e. The crop growth rate was significantly not influenced by *Rhizobium* and different levels of phosphorus and sulphur at 30DAS and 45DAS but at 60DAS was found to be significant with (13.25g m^{-2}day^{-1}) at highest in comparison to other treatments. The probable reason

Table 1d : Effect of *Rhizobium*, different levels of phosphorus and sulphur on dry weight plant^{-1} (g) of greengram at different intervals

Treatments		Dry weight plant^{-1} (g)		
		30DAS	45DAS	60DAS
***Rhizobium* (R)**				
R_0	Uninoculated	3.67	8.87	15.28
R_1	Inoculated	4.75	11.09	22.33
F - test		NS	S	S
S. E.±		-	0.01	0.07
C.D. (P=0.05)		-	0.03	0.14
Phosphorus (P)				
P_1	40kg ha^{-1}	3.71	9.29	15.83
P_2	45kg ha^{-1}	4.71	10.78	21.75
P_3	55kg ha^{-1}	4.21	9.87	18.83
F - test		NS	S	S
S.E.±		-	0.02	0.08
C.D. (P=0.05)		-	0.03	0.17
Sulphur (S)				
S_1	25kg ha^{-1}	4.39	10.16	19.40
S_2	40kg ha^{-1}	4.03	9.80	18.21
F - test		NS	S	S
S.E.±		-	0.01	0.07
C.D. (P=0.05)		-	0.03	0.14
Interaction	F - test	NS	S	S
(R x P)	S.E.±	-	0.02	0.11
	C.D. (P=0.05)	-	0.05	0.24
Interaction	F - test	NS	S	S
(P x S)	S.E.±	-	0.02	0.11
	C.D. (P=0.05)	-	0.05	0.24
Interaction	F - test	NS	S	S
(R x S)	S.E.±	-	0.02	0.09
	C.D. (P=0.05)	-	0.04	0.19

NS= Non-significant S=Significant

Table 1e : Effect of *Rhizobium*, different levels of phosphorus and sulphur on crop growth rate (g m^{-2} day^{-1}) of greengram at different intervals

Treatments		Crop growth rate (g m^{-2} day^{-1})		
		30DAS	45DAS	60DAS
***Rhizobium* (R)**				
R_0	Uninoculated	1.56	4.45	5.50
R_1	Inoculated	2.02	5.42	9.63
F - test		NS	S	S
S.E.±		-	0.45	0.05
C.D. (P=0.05)		-	0.93	0.10
Phosphorus (P)				
P_1	40kg ha^{-1}	1.58	4.77	5.62
P_2	45kg ha^{-1}	2.00	5.19	9.39
P_3	55kg ha^{-1}	1.79	4.84	7.68
F - test		NS	NS	S
S.E.±		-	-	0.06
C.D. (P=0.05)		-	-	0.12
Sulphur (S)				
S_1	25kg ha^{-1}	1.87	4.93	7.92
S_2	40kg ha^{-1}	1.71	4.93	7.21
F - test		NS	NS	S
S.E.±		-	-	0.05
C.D. (P=0.05)		-	-	0.10
Interaction (R x P)	F - test	NS	NS	S
	S.E.±	-	-	0.08
	C.D. (P=0.05)	-	-	0.17
Interaction (P x S)	F - test	NS	NS	S
	S.E.±	-	-	0.08
	C.D.(P=0.05)	-	-	0.17
Interaction (R x S)	F-test	NS	NS	NS
	S.E.±	-	-	-
	C.D. (P=0.05)	-	-	-

NS= Non-significant S= Significant

for significant increase in crop growth rate was observed with successive increase in phosphorus doses upto 45kg P/ha and decrease in crop growth rate with decrease in nitrogen doses.

Relative growth rate (g g^{-1}day^{-1}):

The relative growth rate (g g^{-1}day^{-1}) at different growth stages as influenced by *Rhizobium* and different levels of phosphorus and sulphur are presented in Table 1f. The relative growth rate was significantly influenced by *Rhizobium* and different levels of phosphorus and sulphur at 60DAS with (T_{10}) $R_1P_2S_2$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 40kg ha^{-1}) but T_9 was at par with T_{10} where (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha+ sulphur @ 25kg ha^{-1}) with respect to relative growth rate. At 30DAS and 45DAS it was not found significant. The relative growth rate was significantly influenced by dry weight at 60 days in turn significantly lowest relative growth rate was observed in T_2 *i.e.* $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40kg /ha + sulphur @ 40kg ha^{-1}).

Yield components:

Number of pods plant^{-1}:

The Table 2a clearly shows that none of the treatments were found significant. Although *Rhizobium*

Table 1f : Effect of *Rhizobium*, different levels of phosphorus and sulphur on relative growth rate (g g^{-1} day^{-1}) of greengram at different intervals

Treatments		Relative growth rate (g g^{-1} day^{-1})		
		30DAS	45DAS	60DAS
***Rhizobium* (R)**				
R_0	Uninoculated	0.0411	0.0631	0.0361
R_1	Inoculated	0.0503	0.0597	0.0459
F - test		S	NS	S
S.E.±		0.0043	-	0.0002
C.D. (P=0.05)		0.0088	-	0.0004
Phosphorus (P)				
P_1	40kg ha^{-1}	0.0412	0.0657	0.0352
P_2	45kg ha^{-1}	0.0498	0.0586	0.0451
P_3	55kg ha^{-1}	0.0460	0.0600	0.0427
F - test		NS	NS	S
S.E.±		-	-	0.0002
C.D. (P=0.05)		-	-	0.0005
Sulphur (S)				
S_1	25kg ha^{-1}	0.0471	0.0597	0.0421
S_2	40kg ha^{-1}	0.0443	0.0632	0.0399
F - test		NS	NS	S
S.E.±		-	-	0.0002
C.D. (P=0.05)		-	-	0.0004
Interaction	F - test	NS	NS	S
(R x P)	S.E.±	-	-	0.0003
	C.D. (P=0.05)	-	-	0.0007
Interaction	F - test	NS	NS	S
(P x S)	S.E.±	-	-	0.0003
	C.D. (P=0.05)	-	-	0.0007
Interaction	F - test	NS	NS	S
(R x S)	S.E.±	-	-	0.0003
	C.D. (P=0.05)	-	-	0.0006

NS= Non-significant S= Significant

Table 2a : Effect of different levels of *Rhizobium*, phosphorus and sulphur on number of pods $plant^{-1}$ of greengram (*Vigna radiata* L.)

Treatments		Number of pods $plant^{-1}$
***Rhizobium* (R)**		
R_0	Uninoculated	9.53
R_1	Inoculated	12.90
F - test		S
S.E.±		0.55
C.D. (P=0.05)		1.13
Phosphorus (P)		
P_1	40kg ha^{-1}	10.15
P_2	45kg ha^{-1}	11.77
P_3	55kg ha^{-1}	11.73
F - test		S
S.E.±		0.67
C.D. (P=0.05)		1.39
Sulphur (S)		
S_1	25kg ha^{-1}	11.03
S_2	40kg ha^{-1}	11.40
F - test		NS
S.E.±		-
C.D. (P=0.05)		-
	F – test	NS
Interaction (R x P)	S.E.±	-
	C.D. (P=0.05)	-
	F - test	NS
Interaction (P x S)	S.E.±	-
	C.D. (P=0.05)	-
	F - test	NS
Interaction (R x S)	S.E.±	-
	C.D. (P=0.05)	-

NS= Non-significant S= Significant

and phosphorus was found to be significant but the effect of sulphur was again found non-significant. The interaction effects were also found non-significant. The highest number of pods/ plant was found to be (14.00) with treatment (T_{12}) $R_1P_3S_2$ *i.e.* (*Rhizobium* + phosphorus @ 55kg /ha+ sulphur @ 40kg/ha) and least no. of pods/plant was found to be with T_1 (8.60) $R_0P_1S_1$ *i.e.* (Uninoculated + phosphorus @ 40kg/ha + sulphur @ 25kg/ha).

Number of grains pods $^{-1}$:

The Table 2b clearly shows that treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg ha^{-1}) was found significant with a value of (12.56 grains pod^{-1}) highest. All the interaction effect was found to be significant. The highest number of grains pod^{-1} was found to be (12.56) with treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg ha^{-1}) and least number of grains pod^{-1} was found to be with T_2 (7.44 grains pod^{-1}) $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40kg /ha + sulphur @ 40kg ha^{-1}).

Test weight:

The Table 2c clearly shows that treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha + sulphur @ 25kg/ha) was found significant with a value

Table 2b: Effect of *Rhizobium*, different levels of phosphorus and sulphur on number of grains pod^{-1} of greengram

Treatments		Number of grains pod^{-1}
***Rhizobium* (R)**		
R_0	Uninoculated	9.02
R_1	Inoculated	11.18
F - test		S
S.E.±		0.05
C.D. (P=0.05)		0.10
Phosphorus (P)		
P_1	40kg ha^{-1}	9.25
P_2	45kg ha^{-1}	11.06
P_3	55kg ha^{-1}	10.00
F - test		S
S.E.±		0.06
C.D. (P=0.05)		0.12
Sulphur (S)		
S_1	25kg ha^{-1}	10.39
S_2	40kg ha^{-1}	9.81
F - test		S
S.E.±		0.05
C.D. (P=0.05)		0.10
Interaction (R x P)	F - test	S
	S.E.±	0.09
	C.D. (P=0.05)	0.18
Interaction (P x S)	F - test	S
	S.E.±	0.09
	C.D. (P=0.05)	0.18
Interaction (R x S)	F - test	S
	S.E.±	0.07
	C.D. (P=0.05)	0.14

S= Significant

Table 2c : Effect of *Rhizobium*, different levels of phosphorus and sulphur on test weight (g) of greengram

Treatments		Test weight (g)
***Rhizobium* (R)**		
R_0	Uninoculated	47.23
R_1	Inoculated	49.96
F - test		S
S.E.±		0.04
C.D. (P=0.05)		0.08
Phosphorus (P)		
P_1	40kg ha^{-1}	47.87
P_2	45kg ha^{-1}	49.43
P_3	55kg ha^{-1}	48.49
F - test		S
S.E.±		0.05
C.D. (P=0.05)		0.10
Sulphur (S)		
S_1	25kg ha^{-1}	48.78
S_2	40kg ha^{-1}	48.41
F - test		S
S.E.±		0.04
C.D. (P=0.05)		0.08
	F - test	S
Interaction (R x P)	S.E.±	0.07
	C.D. (P=0.05)	0.14
	F - test	S
Interaction (P x S)	S.E.±	0.07
	C.D. (P=0.05)	0.14
	F - test	NS
Interaction (R x S)	S.E.±	-
	C.D. (P=0.05)	-

NS= Non-significant S=Significant

of (51.03g) highest. All the interaction effect was found to be significant. The highest test weight was found to be (51.03) with treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha + sulphur @ 25kg/ha) and least number of grains/pod was found to be with T_2 (46.47g) $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40kg/ha + sulphur @ 40kg/ha).

Grain yield in (*q ha^{-1}*):

The Table 2d clearly shows that treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg/ha) was found significant with a value of (12.39q ha^{-1}) highest. All the interaction effect was found to be significant. The highest grain yield was found to be (12.39 q ha^{-1}) with treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45 kg /ha + sulphur @ 25kg/ha) and least grain yield in (q/ha) was found to be in close conformity with T_2 (7.35q ha^{-1}) $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40 kg/ha+ sulphur @ 40kg/ha).

Straw yield in (*q ha^{-1}*):

The Table 2e clearly shows that treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg ha^{-1}) was found significant with a value of (28.26q ha^{-1}) highest. All the interaction effect was found to be significant. The highest straw yield was found to be (28.26 q ha^{-1}) with treatment (T_9) $R_1P_2S_1$ *i.e.*

Table 2d : Effect of *Rhizobium*, different levels of phosphorus and sulphur on grain yield (q ha^{-1}) of greengram

Treatments		Grain yield (q ha^{-1})
***Rhizobium* (R)**		
R_0	Uninoculated	8.61
R_1	Inoculated	11.08
F - test		S
S.E.±		0.03
C.D. (P=0.05)		0.05
Phosphorus (P)		
P_1	40kg ha^{-1}	8.98
P_2	45kg ha^{-1}	10.74
P_3	55kg ha^{-1}	9.82
F - test		S
S.E.±		0.03
C.D.(P=0.05)		0.07
Sulphur (S)		
S_1	25kg ha^{-1}	10.13
S_2	40kg ha^{-1}	9.57
F - test		S
S.E.±		0.03
C.D.(P=0.05)		0.05
	F - test	S
Interaction (R x P)	S.E.±	0.05
	C.D. (P=0.05)	0.09
	F - test	S
Interaction (P x S)	S.E.±	0.05
	C.D. (P=0.05)	0.09
	F - test	S
Interaction (R x S)	S.E.±	0.04
	C.D. (P=0.05)	0.08

S=Significant

Table 2e: Effect of *Rhizobium*, different levels of phosphorus and sulphur on stover yield (q ha^{-1}) of greengram

Treatments		Stover yield (q ha^{-1})
***Rhizobium* (R)**		
R_0	Uninoculated	24.43
R_1	Inoculated	27.10
F - test		S
S.E.±		0.02
C.D. (P=0.05)		0.04
Phosphorus (P)		
P_1	40kg ha^{-1}	24.44
P_2	45kg ha^{-1}	26.87
P_3	55kg ha^{-1}	25.97
F - test		S
S.E.±		0.03
C.D. (P=0.05)		0.05
Sulphur (S)		
S_1	25kg ha^{-1}	26.01
S_2	40kg ha^{-1}	25.52
F - test		S
S.E. ±		0.02
C.D. (P=0.05)		0.04
	F - test	S
Interaction (R x P)	S.E.±	0.04
	C.D. (P=0.05)	0.07
	F - test	S
Interaction (P x S)	S.E.±	0.04
	C.D. (P=0.05)	0.07
	F-test	S
Interaction (R x S)	S.E.±	0.03
	C.D. (P=0.05)	0.06

S= Significant

(*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg ha^{-1}) and least straw yield in (q ha^{-1}) was found to be with T_2 (22.73q ha^{-1}) $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40kg /ha + sulphur@40kg/ ha).

Harvest index (%):

The Table 2f clearly shows that treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg /ha + sulphur @ 25kg ha^{-1}) was found significant with a value of (30.48%) highest. All the interaction effect was found to be significant. The highest harvest index was found to be (30.48 %) with treatment (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @ 45kg/ha + sulphur @ 25kg ha^{-1}) and least harvest index in (%) was found to be with T_2 (24.43%) $R_0P_1S_2$ *i.e.* (Uninoculated + phosphorus @ 40kg /ha + sulphur @ 40kg ha^{-1}).

Economics:

Data on economics of different treatment combination are presented in Table 3. The total gross return and net return obtained through mungbean production. The net return for different treatments was calculated by subtracting the total cost of cultivation from the gross return received on account of different treatments. The benefit cost ratio was calculated by dividing the gross return with the cost of cultivation and the data pertaining to this are presented in Table 3. The maximum gross return (52,386 R/ha) was recorded with

Table 2f : Effect of *Rhizobium*, different levels of phosphorus and sulphur on harvest index (%) of greengram

Treatments		Harvest index (%)
***Rhizobium* (R)**		
R_0	Uninoculated	26.03
R_1	Inoculated	28.98
F – test		S
S.E.±		0.04
C.D. (P=0.05)		0.08
Phosphorus (P)		
P_1	40kg ha^{-1}	26.76
P_2	45kg ha^{-1}	28.42
P_3	55kg ha^{-1}	27.34
F – test		S
S.E.±		0.05
C.D. (P=0.05)		0.10
Sulphur (S)		
S_1	25kg ha^{-1}	27.91
S_2	40kg ha^{-1}	27.10
F – test		S
S.E.±		0.04
C.D. (P=0.05)		0.08
	F - test	S
Interaction (R x P)	S.E.±	0.07
	C.D. (P=0.05)	0.15
	F - test	S
Interaction (P x S)	S.E. ±	0.07
	C.D.(P=0.05)	0.15
	F - test	S
Interaction (R x S)	S.E.±	0.06
	C.D. (P=0.05)	0.12

S= Significant

Table 3 : Economics of different treatment combinations and benefit cost ratio of mungbean

Treatments combination	Treatments			Cost of cultivation (Rha^{-1})	Gross return (Rha^{-1})	Net return (Rha^{-1})	Cost benefit ratio
	Rhizobium (R)	Phosphorus (P)	Sulphur (S)				
(T_1)-R_0 P_1 S_1	Uninoculated	30 kg ha^{-1}	20 kg ha^{-1}	23,074	35,803	12,729	1.55
(T_2)-R_0 P_1 S_2	Uninoculated	30 kg ha^{-1}	40 kg ha^{-1}	24,324	31,673	7,349	1.30
(T_3)-R_0 P_2 S_1	Uninoculated	45 kg ha^{-1}	20 kg ha^{-1}	23,569	42,335	18,766	1.80
(T_4)-R_0 P_2 S_2	Uninoculated	45 kg ha^{-1}	40 kg ha^{-1}	24,819	37,633	12,814	1.52
(T_5)-R_0 P_3 S_1	Uninoculated	60 kg ha^{-1}	20 kg ha^{-1}	24,049	37,205	13,156	1.55
(T_6)-R_0 P_3 S_2	Uninoculated	60 kg ha^{-1}	40 kg ha^{-1}	25,299	36,674	11,375	1.45
(T_7)-R_1 P_1 S_1	Inoculated	30 kg ha^{-1}	20 kg ha^{-1}	23,085	43,392	20,307	1.88
(T_8)-R_1 P_1 S_2	Inoculated	30 kg ha^{-1}	40 kg ha^{-1}	24,335	42,548	18,213	1.75
(T_9)-R_1 P_2 S_1	Inoculated	45 kg ha^{-1}	20 kg ha^{-1}	23,580	52,386	28,806	2.22
(T_{10})-R_1 P_2 S_2	Inoculated	45 kg ha^{-1}	40 kg ha^{-1}	24,830	50,235	25,405	2.02
(T_{11})-R_1 P_3 S_1	Inoculated	60 kg ha^{-1}	20 kg ha^{-1}	24,060	47,524	23,464	1.98
(T_{12})-R_1 P_3 S_2	Inoculated	60 kg ha^{-1}	40 kg ha^{-1}	25,310	46,092	20,782	1.82

Rhizobium inoculation, 45kg P/ha with 25kg S/ha. The maximum net return was (28,813 R/ha) and B: C (2.22) was recorded in (T_9) $R_1P_2S_1$ *i.e.* (*Rhizobium* + phosphorus @45kg/ha + sulphur @ 25kg/ha).

Conclusion :

It is concluded that *Rhizobium* inoculation, phosphorus application at the rate 45 kg/ha and sulphur at the rate 25kg/ha was found to be the best for obtaining highest grain yield and the interaction among *Rhizobium* × phosphorus, phosphorus × sulphur and *Rhizobium* × sulphur was found significant at almost all the stages of growth and yield of greengram. The benefit cost ratio in greengram was also found significant with highest value of (2.22). Since the findings are based on one year experiment, further trials are needed to substantiate the results on the research done in one season and it may be repeated for further confirmation.

REFERENCES

Donald, C.M. (1962). In search of yield. *J. Aust. Inst. Agric. Sci.,* **28**: 1971- 1978.

Gupta, A., Sharma, V. K., Sharma, G. D. and Chopra, P. (2006). Effect of biofertilizer and phosphorous levels on yield attributes, yield and quality of urdbean (*Vigna mungo*). *Indian J. Agron.,* **51**(2): 142-144 .

Heath, K.D. and Tiffin, P. (2009). Stabilizing mechanisms in a legume-*Rhizobium* mutualism. *Evolution,* **63** (3): 652-662.

Jackson, M.L. (1973). *Soil chemical analysis*, Prentice Hall of Indian Private Limited, NEW DELHI, INDIA.

Jaggi, R.C, Sharma, R.K. and Paliyal, S.S. (2000). Sulphur as second major nutrient in cruciferous oilseeds. *Indian Farm.,* **12** : 14-18.

Kanwar, K. (2000). Legumes – the soil fertility improver. *Indian Farm.,* **50** (5) : 9.

Malik, R.S. (1999). Crops in India need sulphur. *Indian Farm.,* **49** : 11-13.

Olsen, S.R., Cole, C.V., Watenabe, F.S. and Dean L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. United State Dept. of Agric. CIRC., Washinton, D.C., U.S.A.,939.

Parmar, P.P. and Thanki, J.D. (2007). Effect of irrigation, phosphorus and biofertilizer on growth and yield of *Rabi* greengram (*Vigna radiata* L.) under south Gujrat condition. *Crop Res.,* **34** (1, 2 & 3): 100-102.

Piper, C.S. (1966). Soil and plant analysis. Hans Publishers, Bombay (M.S.) INDIA, pp. 135-136.

Radford, P.J. (1967). Growth analysis formulae- their use and abuse. C*rop Science, Modison*,**7**: 171-175.

Sarkar, R.K. and Pal, P.K. (2006). Effect of pre-sowing seed treatment and foliar spray of nitrate salts on growth and yield of greengram (*Vigna radiata*). *Indian J. Agric. Sci.,* **76** (1) : 62 - 65.

Soil Survey Staff (1975). *Soil taxonomy. A basic key making and interpreting soil surveys*. USDA, Hard Book No. 436, US. Govt. Printing Press, Washington, D.C.

Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soil.*Curr. Sci.,* **25**: 259.