Plant Archives Vol. 25, Supplement 2, 2025 pp. 269-276 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.033

IMPACT OF P, S AND Zn LEVELS WITH BIO-INOCULANTS ON GROWTH, YIELD AND NUTRIENTS UPTAKE IN MUNGBEAN (*VIGNA RADIATA* L.)

Pooja Goswami[1*], Pratibha Bisen[1], Shraddha Karcho[1] and Vinod Bharati[2]
[1]Department of Agronomy, College of Agriculture, Balaghat, Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India
[2]G.H. Raisoni University, Chhindwara, Madhya Pradesh India
*Corresponding author E-mail: agropooja17@gmil.com
(Date of Receiving : 26-02-2025; Date of Acceptance : 05-05-2025)

ABSTRACT

Among pulses mungbean (*Vigna radiata* L.) is one of the most important pulse crops of India ranks third after chickpea and pigeonpea. The experiment was carried out at the Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India) during *summer* seasons. Application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} significantly caused beneficial improvement in the values of growth attributes *viz*. plant height, branches $plant^{-1}$ and dry matter production $plant^{-1}$ (g), number of nodules $plant^{-1}$, at all the studied stages, yield attributes (pods $plant^{-1}$, grains pod^{-1} and 100-grain weight), yields (grain and stalk yield) and harvest index over other fertility levels. The higher N, P, K, S and Zn content and uptake by grain as well as stalk was recorded with dual seed inoculation of PSB + *Trichoderma* and which was significantly superior over seed inoculation of PSB or *Trichoderma.*
Keywords**:** Growth, Zinc, Nitrogen, Sulphur, Yield, Mungbean, Nutrient uptake.

Introduction

Among pulses mungbean (*vigna radiata* L.) is one of the most important pulse crop of India ranks third after chickpea and pigeonpea (Sathymoorthi *et al*., 2008). Consumption of pulses is highest in India where majority of the population is vegetarian. Pulses contain high amount of protein (18-32%), fat (1-5%), macro and micro nutrients (Ca, P, K, Fe, Zn). Pulses are rich in calcium as compared to cereals and contain about 100-200 mg of calcium per 100g seeds. They are also rich in vitamin, fibre and carbohydrates for balance nutrition. Pulses are the good source of crude fibre, protein and lipid components have shown hypocholestrolemic effect, which ability to reduce cholesterol in blood. Phosphorus is an important plant nutrient which is referred to as the “Master key” element in crop production. It is associated with several vital functions seed germination, cell division, flowering, fruiting, synthesis of fat, starch and infect every biochemical activity. It also induces root proliferation, nodulation and N fixation. About 20-25 percent of the phosphorus applied to the soils is only available to the crop in the year of its application and the remaining part is converted into insoluble unavailable forms (Yadav, 2004). Some species of phosphorus-solubilizing bacteria like *Bacillus polymyxa* and *pseudomonas striata* are known to have the ability to solubilize phosphorus from insoluble sources (Gupta and Verma, 2009).

Legumes require almost equal amount of phosphorus and sulphur. When phosphorus and sulphur are present below the critical level in the soil, plant growth and quality of produce are affected adversely (Dubey and Mishra, 1970). Sulphur application increased the total chlorophyll content in mungbean (Poorani, 1992). Sulphur plays a dominant role in improving the quality of pulses (Pasricha and Fox, 1993). Zinc plays an important role in biological system, such as maintenance of structural integrity of biological membranes and direct contributions to protein synthesis. In addition to nutrient mining and the increasing dependence on fertilizer imports at very high international prices underlined the need to explore and exploit the potential of alternative sources of plant nutrients. Of late, biofertilizer have shown a good promise and has emerged as an important component of integrated plant nutrient system.

Method and Materials

The experiment was carried out at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India). The experiment was conducted in spli-plot design having 9 treatments in main plots (levels of phosphorus, sulphur and zinc) and 3 treatments in subplot (seed inoculated by PSB, *Trichoderma,* PSB + *Trichoderma*). with three replications. All the bio-inoculants were prepared in Soil Microbiology Lab, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences BHU, Varanasi.

The whole field was divided into 3 blocks, each representing a replication. Each block was further divided in nine main plots; treatments were randomly allocated within them. Then each main plot was again divided into three equal sub plots in which treatments were allocated randomly. For each replication, fresh steps of randomization were followed. Different types of bio-inoculants *Viz., Rhizobium,* PSB (*Paevibacillus polymyxa*) and *Trichoderma (Trichoderma viridae*) were taken for seed inoculation. The observations on growth attributes were recorded at an interval of 15 days i.e. 15th, 30th, 45th days after sowing and at maturity. The significance of the treatment effect was judged with the help of 'F' test (Variance ratio). The difference of the treatments mean was tested using critical difference (C.D.) at 0.05% level of probability.

Result and Discussion

The maximum plant height was obtained with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} (42.8 & 43.12 cm) as compare to other fertility treatments and was found significantly superior over its lower levels *viz.,* 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}, amongst bio-inoculants, combination of PSB + *Trichoderma* recorded a tallest plant (42.64 & 42.88 cm) which was found significantly superior over seed inoculated with PSB and *Trichoderma* alone at all the stages of observation during both the years of study. There was a gradual increase in number of branches plant^{-1} with the advancement in the age of the crop in all the treatments upto harvest stage during both the years of experimentation. Maximum increment in number of branches plant^{-1} has been observed between 1st and 3rd observations during both the years of experimentation. Application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} recorded significantly more number of branches plant^{-1} (7.61 & 7.97) over other fertility treatments and was found significantly superior over its lower levels *viz*., 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. Data indicated that amongst bio-inoculants, dual seed inoculation of PSB + *Trichoderma* recorded maximum number of branches plant^{-1} (8.07 & 8.27) and this treatment was found significantly superior over seed inoculated with PSB and *Trichoderma* alone at all the observation of crop growth in respect to number of branches plant^{-1} during both the years of experimentation. Total dry matter accumulation in whole plant increases upto maturity with the advancement of the crop age. It is obvious from the data that total dry matter accumulation differ significantly with increasing levels of P (25 and 50) and application of sulphur and zinc at the rate of 25 and 3 kg ha^{-1} respectively. Higher dry matter accumulation plant^{-1} was recorded with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} (10.35 & 10.71 g) and was found significantly superior over 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. It was also observed that increasing levels of phosphorus upto 50 kg P_2O_5 ha^{-1} was found significantly superior (9.39 & 9.59 g) over 25 kg P_2O_5 ha^{-1} and control in respect of dry matter accumulation plant^{-1} all growth stages during both the years (Table 1).

The rate of increase in plant height was higher with application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} this may be attributed to increase in the proliferation of lateral and tap root system of the crop with advancement in time and showed unique superiority over other levels right from initial to later stage of crop growth in respect of dry matter assimilation due to positive effect on shoot elongation and number of branches. The number of branches plant^{-1} increased rapidly after completing the initial growth. At all the stages of observations, number of branches plant^{-1} increased under increasing levels of nutrients like N, P, K, S, Zn. Obviously, the plant supplied adequately phosphorus levels produced more leaves and recorded higher accumulation of photosynthates yielding higher dry matter production. Similar results were also confirmed by Shukla and Dixit 1996, Upadhyay et al. 1999, Yakadri*et al.* 2004 and Singh and Yadav 1997.

The data regarding to pods plant^{-1} as influenced by different fertility treatments and bio-inoculants during both the years of experimentation. Maximum number of pods plant^{-1} (13.31 & 13.71) was recorded with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} which was found significantly superior over 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}

(12.26 & 12.66). Maximum number of pods plant^{-1} was associated with dual seed inoculation of PSB + *Trichoderma* which was significantly superior to PSB and *Trichoderma* (13.51 & 14.01). Higher number of grains pod^{-1} recorded with application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} (11.05 & 11.21) as compare to other treatments which was found significantly superior to lower levels of phosphorus 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. In between both phosphorus levels 50 kg P_2O_5 ha^{-1} gave higher number of grains pod^{-1} (10.73 & 10.78) and was found significantly superior over 25 kg P_2O_5 ha^{-1} and control treatment during both the years of experimentation. Maximum value of 2.95 and 3.07 (g) 100 seed weight was observed at 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} over other treatments which was found significantly superior over 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. It was also observed from the data that phosphorus application at the rate 50 kg P_2O_5 ha^{-1} registered higher value of 100 seed weight (2.65 & 2.74) over 25 kg P_2O_5 ha^{-1} and control. Seed inoculation with PSB + *Trichoderma* was recorded higher 100 seed weight (2.88 & 3.05) and which was found significantly superior over seed inoculation of PSB and *Trichoderma* during both the years of study (Table 2).

It is evident from the data that grain yield of mungbean significantly varied from different levels of phosphorus, sulphur, zinc and bio-inoculants during both the years of experimentation. The highest grain yield (930.05 & 994.38 kg ha^{-1}) was obtained with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} and was found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. Increasing levels of phosphorus upto 50 kg P_2O_5 ha^{-1} was significantly influence grain yield (701.5 & 723.24 kg ha^{-1}) and was found significantly superior over 25 kg P_2O_5 ha^{-1} and control. Dual seed inoculation of PSB + *Trichoderma* was recorded significantly maximum grain yield (741.99 & 795.92 kg ha^{-1}) over seed inoculated with PSB and *Trichoderma.* It is obvious from the data that stalk yields significantly varied due to phosphorus, sulphur and zinc applications, stalk yield was maximum (2310.44 & 2496.86 kg ha^{-1}) with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} over other treatments and found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}.Among bio-inoculants, dual seed inoculation of PSB + *Trichoderma* gave maximum stalk yield (1976.67 & 2073.82 kg ha^{-1}) which was found significantly superior PSB and *Trichoderma* individual. Application of 50 kg P_2O_5 ha^{-1}+ 25 kg S ha^{-1} + 3 kg Zn ha^{-1} recorded maximum harvest index (28.47 & 28.90 %). It was also observed that 50 kg P_2O_5 ha^{-1} registered higher value of harvest index (26.88 & 27.58%) over 25 kg P_2O_5 ha^{-1} and control during both the years. Amongst bio-inoculants, dual seed inoculation of PSB + *Trichoderma* recorded maximum harvest index (27.37 & 27.88 %) and minimum harvest index was recorded with *Trichoderma* during both the years of study (Table 3)

Integrated fertility treatment brought about marked increase in the production of number of pods plant^{-1}, number of grains pod^{-1}, 100-grain weight and finally yields. Number of pods plant^{-1} largely governed by the number of branches increase with increasing nutrient levels; there was increased in number of pods plant^{-1} also. With higher application of fertilizers, the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have been enhanced causing greater number of flowers which later developed in pods. It is thus observed that improvement brought about due to application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. This could be attributed to better supply of nitrogen, phosphorus and potassium, sulphur and zinc resulting in higher branches and pods plant^{-1} and there by higher yield. It is an established fact that nitrogen and phosphorus play an important role in the formation of new shoots thereby; increase the number of branches plant^{-1}. In addition, it regulates the photosynthesis and carbohydrate metabolism which can be considered to be one of the major factors limiting growth particularly during the reproductive phase. the adequate supply of nitrogen, phosphorus, potassium along with sulphur and zinc application play a vital role in metabolic process of photosynthesis. The increase in above parameters with the application of nitrogen, phosphorus, potassium along with sulphur and zinc to its appropriate level might be due to its favorable effect on growth parameters. These findings are in agreement with the results reported by Mitra *et al*. 1999, and Kumar *et al.* 2012, Srivastava *et al.*, 2006; Banik and Sengupta 2012.

It is obvious from the data that different fertility treatments significantly increased nitrogen uptake by grain (35.73 & 38.75 kg ha^{-1}) and stalk (38.46 & 43.32kg ha^{-1}) in mungbean during course of study. Application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} exhaust maximum quantity of nitrogen as compare to other treatments and was found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. 50 kg P_2O_5 ha^{-1} was found significantly superior for nitrogen uptake by grain (25.86 & 27.18 kg ha^{-1}) and stalk (28.45 & 31.51 kg ha^{-1}) over 25 kg P_2O_5 ha^{-1} and control (without fertilizers) during both the year of experimentation.

Dual seed inoculation with PSB + *Trichoderma* recorded significantly higher nitrogen uptake by grain (28.83 & 31.11 kg ha^{-1}) and stalk (30.96 & 33.63 kg ha^{-1}) over PSB and *Trichoderma* (Table 4). Application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} uptakes maximum quantity of phosphorus by grain (35.04 & 38.16 kg ha^{-1}) and stalk (4.77 & 5.82 kg ha^{-1}) as compare to other treatments and was found significantly superior over its lower treatment levels. Dual seed inoculation with PSB + *Trichoderma* recorded significantly higher phosphorus uptake by grain (27.97 & 30.61 kg ha^{-1}) and stalk (3.95 & 4.67 kg ha^{-1}) over PSB and *Trichoderma* alone during both the years of study (Table 4).

Different fertility treatments significantly increased potassium uptake in mungbean during both the years, application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} recorded maximum value of potassium uptake by grain (11.58 & 12.67 kg ha^{-1}) and stalk (58.51 & 62.89 kg ha^{-1}) as compare to other treatments and was found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. Dual seed inoculation with PSB + *Trichoderma* recorded significantly higher potassium uptake by grain (9.59 & 9.97 kg ha^{-1}) and stalk (49.94 & 53.12 kg ha^{-1}) over PSB and *Trichoderma* (Table 5). The data of different fertility treatments significantly recorded increased sulphur uptake by grain (2.61 & 2.90 kg ha^{-1}) and stalk (3.08 & 3.43 kg ha^{-1}) in mungbean, 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} drain maximum quantity of sulphur as compare to other treatments and was found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. Application of higher levels of phosphorus up to 50 kg P_2O_5 ha^{-1} recorded significantly higher uptake of sulphur by grain (1.76 & 1.97 kg ha^{-1}) as well as stalk (2.19 & 2.29 kg ha^{-1}) over 25 kg P_2O_5 ha^{-1} and control (without fertilizers) during both the year of experimentation. seed inoculation with PSB + *Trichoderma* recorded significantly higher potassium uptake by grain (2.03 & 2.25 kg ha^{-1}) and stalk (2.74 & 3.04 kg ha^{-1}) over PSB and *Trichoderma* (Table 5).

Application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} exhaust maximum quantity of zinc as compare to other treatments and was found significantly superior over its lower levels 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. Application of 50 kg P_2O_5 ha^{-1} along with 25 kg S and 3 kg Zn ha^{-1} recorded higher zinc uptake by grain (56.77 & 60.42 kg ha^{-1}) as well as by stalk (275.5 & 297.4 kg ha^{-1}) of mungbean. Application of higher levels of phosphorus up to 50 kg P_2O_5 ha^{-1} recorded significantly higher uptake of zinc by grain (33.09 & 35.94 kg ha^{-1}) as well as stalk (187.2 & 198.8 kg ha^{-1}) over 25 kg P_2O_5 ha^{-1} and control treatment during both the year of experimentation. Application of PSB + *Trichoderma* exhausts maximum Zn from the soil by grain (38.73 & 42.30 kg ha^{-1}) and stalk(229.6 & 242.5 kg ha^{-1}) during both the years (Table 6).

The nutrient uptake is an integrated function of soil-crop environment, together with amounts and sources nutrient supply and cultivars of the crop. The term uptake denotes the net movement of mineral from the ambient to the plant and numerically is a product of nutrient concentration and yield. The nutrient uptake is a relative term depending upon the test plants, its duration as well as its population density and management. Nitrogen, phosphorus, potassium, sulphur and zinc uptake by grain and stalk of mungbean was influenced significantly due to adoption of integrated application of phosphorus, sulphur, zinc and bio-inoculants. Uptake was relatively higher with the application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} which was significantly superior over 25 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1}. This was mainly due to higher biological production and developed root system with enhanced root activity The above conformity by Khan *et al*., 2002; Sasode 2008, Patel *et al*., 2010.

Conclusion

Significant improvement in growth attributes, yield attributes and yields were observed with application of 50 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + 3 kg Zn ha^{-1} as compared to other fertility levels also In between phosphorus levels 50 kg P_2O_5 ha^{-1} gave better results over 25 kg P_2O_5 ha^{-1} and control. Amongst bio-inoculants, dual seed inoculation with PSB + *Trichoderma* had significant effect on growth attributes, yield attributes and yield, which was superior over seed inoculation of PSB or *Trichoderma* alone during both the years of study. Seed inoculated with PSB recorded significantly higher value of growth, yield attributes and yield over *Trichoderma* alone.

Table 1: Effect of phosphorus, sulphur, zinc and bio-inoculants on growth of mungbean

Treatment	Growth Observations at Harvest					
	Plant Height (cm)		Number of branches plant-1		Dry matter plant-1 (g)	
	2011	2012	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})						
Control	40.77	40.91	5.90	6.43	8.78	8.85
25 P_2O_5	40.91	41.61	6.20	6.62	9.07	9.18
25 P_2O_5 + 25 S	41.59	42.48	6.52	7.07	9.25	9.54
25 P_2O_5 + 3 Zn	41.32	42.19	6.97	7.31	9.11	9.39
25 P_2O_5 + 25 S + 3 Zn	41.89	42.36	7.03	7.51	9.31	9.49
50 P_2O_5	42.20	42.47	7.23	7.44	9.39	9.59
50 kg P_2O_5 + 25 S	42.54	42.90	7.58	7.88	9.55	9.96
50 P_2O_5 + 3 Zn	42.33	42.73	7.36	7.74	9.42	9.65
50 P_2O_5 + 25 S + 3 Zn	42.88	43.12	7.61	7.97	10.35	10.71
S.Em. ±	0.73	0.776	0.26	0.23	0.29	0.32
CD (P= 0.05)	NS	NS	0.79	0.70	0.88	0.97
Bio-Inoculants						
PSB	41.80	42.30	6.58	7.05	9.28	9.47
Trichoderma	41.04	41.74	6.15	6.67	8.54	8.87
PSB + Trichoderma	42.64	42.88	8.07	8.27	10.25	10.45
SEm. ±	0.454	0.372	0.11	0.09	0.19	0.18
CD (P= 0.05)	NS	NS	0.32	0.27	0.54	0.50
Interaction	NS	NS	6.58	7.05	NS	NS

Table 2: Effect of phosphorus, sulphur, zinc and bio-inoculants on yield attributes of mungbean

Treatment	Yield Observations					
	No of pods plant-1		No. of grains pods-1		100 seed weight (g)	
	2011	2012	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})						
Control	11.16	11.40	9.34	9.63	2.06	2.35
25 P_2O_5	11.41	11.81	9.84	9.85	2.24	2.41
25 P_2O_5 + 25 S	12.18	12.56	10.17	10.40	2.37	2.53
25 P_2O_5 + 3 Zn	12.13	12.40	10.26	10.09	2.30	2.48
25 P_2O_5 + 25 S + 3 Zn	12.26	12.66	10.33	10.45	2.48	2.59
50 P_2O_5	12.61	12.86	10.73	10.78	2.65	2.74
50 kg P_2O_5 + 25 S	13.02	13.32	10.81	11.08	2.85	2.89
50 P_2O_5 + 3 Zn	12.69	13.07	10.61	10.72	2.78	2.84
50 P_2O_5 + 25 S + 3 Zn	13.31	13.71	11.05	11.21	2.95	3.07
S.Em. ±	0.33	0.33	0.20	0.27	0.13	0.149
CD (P= 0.05)	1.00	0.98	0.60	0.82	0.40	0.44
Bio-Inoculants						
PSB	12.05	12.66	10.25	10.45	2.56	2.65
Trichoderma	11.37	11.25	9.50	9.54	2.12	2.29
PSB + Trichoderma	13.51	14.01	11.30	11.41	2.88	3.05
SEm. ±	0.18	0.17	0.11	0.12	0.09	0.09
CD (P= 0.05)	0.53	0.48	0.31	0.34	0.25	0.27
Interaction	NS	NS	NS	NS	NS	NS

Table 3: Effect of phosphorus, sulphur, zinc and bio-inoculants on yield attributes of mungbean

Treatment	Yield Observations					
	Grain yield (kg ha^{-1})		Stalk yield (kg ha^{-1})		Harvest index (%)	
	2011	2012	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})						
Control	528.25	553.45	1561.10	1635.75	25.32	25.58
25 P_2O_5	555.09	587.50	1581.19	1646.62	26.44	26.77
25 P_2O_5 + 25 S	605.42	655.84	1651.15	1763.16	25.87	26.98
25 P_2O_5 + 3 Zn	580.86	645.45	1567.60	1735.66	26.64	26.72
25 P_2O_5 + 25 S + 3 Zn	625.80	696.44	1630.53	1786.35	25.88	27.12
50 P_2O_5	701.50	723.24	1782.72	1837.17	26.88	27.58
50 kg P_2O_5 + 25 S	832.47	873.69	2076.61	2233.42	28.25	28.37
50 P_2O_5 + 3 Zn	770.80	824.77	1989.67	2166.05	27.13	27.53
50 P_2O_5 + 25 S + 3 Zn	930.05	994.38	2310.44	2496.86	28.47	28.90
S.Em. ±	21.00	35.54	77.34	85.59	0.89	1.06
CD (P= 0.05)	62.96	106.54	231.87	256.60	NS	NS
Bio-Inoculants						
PSB	658.97	727.29	1723.60	1904.09	26.54	27.68
Trichoderma	642.46	661.70	1683.40	1789.11	26.39	26.29
PSB + Trichoderma	741.99	795.92	1976.67	2073.82	27.37	27.88
SEm. ±	8.41	10.77	36.01	40.27	0.41	0.48
CD (P= 0.05)	24.13	30.90	103.28	115.51	NS	NS
Interaction	S	S	S	S	NS	NS

Table 4: Effect of phosphorus, sulphur, zinc and bio-inoculants on Nitrogen & Phosphorus uptake (kg ha^{-1}) by grain and stalk

Treatment	Nitrogen & Phosphorus uptake							
	N uptake by grain (kg ha^{-1})		N uptake by stalk (kg ha^{-1})		P uptake by grain (kg ha^{-1})		P uptake by stalk (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})								
Control	17.19	18.85	20.45	21.15	16.26	17.35	1.90	2.32
25 P_2O_5	19.17	20.59	21.48	23.85	18.36	19.55	2.20	2.73
25 P_2O_5 + 25 S	21.27	23.48	26.37	27.62	20.47	22.33	2.90	3.38
25 P_2O_5 + 3 Zn	20.04	22.64	23.45	25.75	19.50	21.25	2.62	3.09
25 P_2O_5 + 25 S + 3 Zn	22.70	25.61	26.67	30.57	22.37	25.05	3.20	3.83
50 P_2O_5	25.86	27.18	28.45	31.51	25.34	26.59	3.48	4.06
50 kg P_2O_5 + 25 S	31.46	33.71	34.51	39.05	30.59	33.11	4.23	5.06
50 P_2O_5 + 3 Zn	28.57	31.55	31.75	36.15	27.91	30.91	3.86	4.76
50 P_2O_5 + 25 S + 3 Zn	35.73	38.75	38.46	43.32	35.04	38.16	4.77	5.82
S.Em. ±	0.91	1.46	2.54	3.29	0.90	1.27	0.23	0.28
CD (P= 0.05)	2.71	4.38	7.62	9.86	2.68	3.79	0.69	0.85
Bio-Inoculants								
PSB	23.31	26.42	28.06	31.71	22.69	25.58	3.04	3.55
Trichoderma	21.86	23.26	24.84	27.64	21.28	21.91	2.73	3.46
PSB + Trichoderma	28.83	31.11	30.96	33.63	27.97	30.61	3.95	4.67
SEm. ±	0.51	0.50	1.08	1.21	0.51	0.55	0.10	0.15
CD (P= 0.05)	1.46	1.45	3.09	3.46	1.47	1.58	0.30	0.44
Interaction	NS	NS	NS	NS	S	S	NS	NS

Table 5: Effect of phosphorus, sulphur, zinc and bio-inoculants on Potassium & Sulphur uptake (kg ha^{-1}) by grain and stalk

Treatment	Potassium & Sulphur uptake							
	K uptake by grain (kg ha^{-1})		K uptake by stalk (kg ha^{-1})		S uptake by grain (kg ha^{-1})		S uptake by stalk (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})								
Control	5.36	5.40	35.36	37.80	1.12	1.24	1.30	1.51
25 P_2O_5	5.91	6.14	37.03	40.88	1.23	1.36	1.38	1.69
25 P_2O_5 + 25 S	7.17	7.76	44.38	45.08	1.56	1.74	1.85	2.16
25 P_2O_5 + 3 Zn	6.43	7.02	40.69	42.77	1.42	1.63	1.62	1.95
25 P_2O_5 + 25 S + 3 Zn	7.45	8.16	45.13	49.48	1.64	1.75	1.88	2.53
50 P_2O_5	8.35	8.52	46.63	51.36	1.76	1.97	2.19	2.29
50 kg P_2O_5 + 25 S	10.52	10.70	52.44	58.06	2.27	2.48	2.72	3.15
50 P_2O_5 + 3 Zn	9.38	9.92	50.01	56.24	2.03	2.27	2.40	2.64
50 P_2O_5 + 25 S + 3 Zn	11.58	12.67	58.51	62.89	2.61	2.90	3.08	3.43
S.Em. ±	0.94	1.05	2.21	3.35	0.06	0.13	0.20	0.17
CD (P= 0.05)	2.81	3.15	6.61	10.05	0.19	0.40	0.61	0.51
Bio-Inoculants								
PSB	7.71	8.38	44.62	48.78	1.68	1.91	1.89	2.31
Trichoderma	6.76	7.07	42.17	46.29	1.50	1.63	1.51	1.77
PSB + Trichoderma	9.59	9.97	49.94	53.12	2.03	2.25	2.74	3.04
SEm. ±	0.47	0.48	1.06	1.19	0.02	0.04	0.10	0.10
CD (P= 0.05)	1.34	1.39	3.04	3.41	0.07	0.10	0.30	0.29
Interaction	NS	NS	NS	NS	S	S	NS	NS

Table 6: Effect of phosphorus, sulphur, zinc and bio-inoculants on Zinc uptake (kg ha^{-1}) by grain and stalk

Treatment	Zinc uptake (kg ha^{-1})			
	Zn uptake by grain		Zn uptake by stalk	
	2011	2012	2011	2012
Fertility treatments (kg ha^{-1})				
Control	20.80	22.62	143.64	151.83
25 P_2O_5	22.05	24.15	160.40	174.76
25 P_2O_5 + 25 S	25.15	29.69	169.93	188.79
25 P_2O_5 + 3 Zn	25.99	28.90	171.22	192.11
25 P_2O_5 + 25 S + 3 Zn	27.70	32.65	184.49	211.06
50 P_2O_5	33.09	35.94	187.23	198.77
50 kg P_2O_5 + 25 S	41.79	45.73	234.66	254.47
50 P_2O_5 + 3 Zn	43.43	50.43	237.88	259.87
50 P_2O_5 + 25 S + 3 Zn	56.77	60.42	275.53	297.41
S.Em. ±	2.21	2.37	10.82	8.68
CD (P= 0.05)	6.63	7.11	32.45	26.03
Bio-Inoculants				
PSB	32.01	37.38	185.79	209.31
Trichoderma	28.18	30.50	172.92	191.16
PSB + Trichoderma	38.73	42.30	229.62	242.54
SEm. ±	0.67	0.71	4.84	5.10
CD (P= 0.05)	1.92	2.04	13.88	14.64
Interaction	S	S	NS	NS

References

Banik, N.C. and Sengupta K. (2012). Effect of sulphur on growth and yield of green gram (*Vigna radiata* (L.) Wilczk), *Journal of Crop and Weed,* **8**(1): 109-110.

Dube, S.D. and Mishra, P.H. (1970). Effect of S deficiency on growth, yield and quality of some important leguminous crops. *Journal Indian Social Soil Science*, **18**: 375-378.

Gupta, S.C. R.P. and Verma, R. (2009). Response of chickpea to P levels from different sources with various PSB species. *Legume Research*, **32** (3): 212-214.

Khan, M.A., Aslam, M., Tariq and Sultan Mahmood, I.A. (2002). Response of phosphorus application on growth and yield of inoculated and un-inoculated mungbean (Vigna radiata). *International Journal of Agriculture and Biology,* **4**(4): 523-524.

Kumar, R.R., Singh, Y. V., Singh, S., Latare, A.M., Mishra, P.K. and Supriya. (2012). Effect of phosphorus and sulphur nutrition on yield attributes, yield of mungbean, *Journal of Chemical and Pharmacutical Research*, **4**(5): 2571-2573.

Mitra, S., Bhattacharya, S.K., Datta, M. and Banik, S. (1999). Effect of variety, rock phosphate and phosphate solubilizing bacteria on growth and yield of green gram in acid soils of Tripura. *Environment and Ecology,* **17**(4): 926-930.

Pasricha, N.S. and Fox. R.L. (1993). Plant nutrient sulphur in the tropics and subtropics. *Advances in Agronomy*, **50**: 209-255.

Patel, P.M., Patel, J.S., Patel, J.J. and Patel, H.K. (2010). Effect of levels and sources of sulphur on seed yield and quality of summer greengram. *International Journal of Agricultural Sciences*, **6**(1): 169-171.

Poorani, B. (1992). Radiotracer studies on the interaction effects of application of P and S on available nutrients, yield and quality of greengram. M.Sc. (Ag.) Thesis Tamil Nadu Agricultural University, Coimbatore.

Sasode, D.S. (2008). Response of greengram [*Vigna radiata* (L.) Wilczek] to fertility levels and sulphur sources application. *Agriculture Science Digest*. **28**(1): 18-21.

Sathyamoorthi, K., Mohamed, A.M., Somasundaram, E. and Vaiyapuri, K. (2008). Yield attributes and yield of greengram [*Vigna radiata* (L.) Wilczek] as influenced by plant density and nutrient management. *Indian Journal of Agricultural Sciences,* **4**(2): 719-724.

Shukla, S.K. and Dixit, R.S. (1996). Nutrient and plant-population management in summer greengram (*Phaseolus radiatus*). *Indian Journal of Agronomy,* **41**(1): 78-83.

Singh U. and Yadav D.S. (1997). Studies on sulphur and zinc nutrition on greengram in relation to growth attributes, seed protein yield and S, Zn uptake. *Legume Research*, **20**(3/4): 224-226.

Srivastava, A.K., Tripathi, P.N., Singh, A.K. and Singh, R. (2006). Effect of Rhizobium inoculation, sulphur and zinc levels on growth yield, nutrient uptake and quality of summer greengram (*Phaseolus radiatus* L.). *International Journal of Agricultural Sciences*, **2**(1): 190-192.

Upadhyay, R.G., Sharma S., and Darmwal N.S. (1999). Effect of *Rhizobium* inoculation and graded levels of phosphorus on the growth and yield of summer mungbean (*Phaseolus mungo*). *Legume Research,* **22** (4):277-279.

Yadav, S.S. (2004). Growth and yield of green gram (*Vigna radiata* L.) as influenced by phosphorus and sulphur fertilization. *Haryana Journal of Agronomy,* **20**(1/2): 10-12.

Yakadri, M., Tahatikuta, R. and Latchanna, A. (2004). Dry matter production and nutrient uptake of green gram (*Vigna radiata* L,) as influenced by nitrogen and phosphorus application during wet season. *Legume Research,* **27**(1): 58-61