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Effect of Microbial Inoculation and Sulphur on Soybean Growth and Yield

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ABSTRACT

Field experiment was conducted at Instructional Farm of Rajasthan College of Agriculture, Udaipur during kharif 2015 to assess the response of soybean [Glycine max (L.) Merrill] to microbial inoculation and sulphur. The experiment was laid out in factorial randomized block design with three replications and consisted treatments viz. microbial inoculation (Control, Rhizobium, Phosphate solubilizing bacteria, Rhizobium + Phosphate solubilizing bacteria) and four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}). The results revealed that microbial inoculation and sulphur significantly increased the growth attributes viz., plant height, dry matter accumulation, LAI, primary branches plant^{-1}, number of pods plant^{-1} and yield attributes number seeds pod^{-1}, seed index, grain and haulm yield over the control.

Key words: *Microbial inoculation, Sulphur, Soybean, Growth, Yield*

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is an important protein and oil seed crop belongs to family Leguminosae. It contains 40-42 % high quality protein, 18-20% oil and several other nutrients like calcium, iron etc. It is also rich in polyunsaturated fatty acids like linoleic and oleic acid. It is a good source of is flavones and therefore it helps in preventing heart diseases, cancer and HIVs[7]. Soybean oil is the leading vegetable oil in the world and is used in many industrial applications including biodiesel. Because of its high nutritional value, it is recognized as 'Golden Bean'. The annual soybean production in India was 11.64mt[5] with an area of 10.02 m ha and productivity of 1062 kg ha^{-1}. Madhya Pradesh is known as the soybean bowl of India, contributing 59% of the country's soybean production followed by Maharashtra with 29% contribution and Rajasthan with 6% contribution. Area, production and productivity of soybean in Rajasthan 0.92 m ha, 0.95 mt and 1036 kg ha^{-1} (Government of Rajasthan 2014).In the recent years, continous hike in prices and scarcity of chemical fertilizers had led to search alternative sources for chemical fertilizers. Microbial fertilization like *Rhizobium* and phosphate solubilizers have shown tremendous potentials as these are eco-friendly, low cost, non bulky bio-fertilizers.

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Use of bio-fertilizers as a source of N and P can minimize dependence on chemical fertilizers. *Rhizobium* have an enormous potential to fix atmospheric N_2 while, PSB have capacity to solubilize and mobilize P and micro nutrients present in the soil under soybean cultivation. Sulphur fertilization in legume and oilseed is of prime importance in exploiting genetic potential of oilseed crops. The sulphur deficiency caused 12-15% reduction in seed yield of soybean as reported by Chandel *et al*.[1]. Sulphur is essential for chlorophyll formation and plays an important role in the formation of sulphur containing essential amino acids (cysteine, methionine and cystine), biosynthesis of protein and oil, formation of nodulation in legumes and synthesis of several enzymes that regulate the growth of plants. Looking to paucity of work on biofertilizer and sulphur nutrition in soybean were southern Rajasthan present investigation was planned.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* 2015 at the Instructional Farm Rajasthan College of Agriculture, Udaipur (Rajasthan). The experimental soil was sandy clay loam in texture, having pH 8.1,organic carbon (0.84 %) and medium with respect to available nitrogen, phosphorus and high in potassium (276.3, 19.41 and 378.6 kg ha^{-1},respectively). The sulphur content in the soil was 8.90 mg kg^{-1}. The treatments consisted of microbial inoculation (Control, *Rhizobium*, Phosphate solubilizing bacteria, *Rhizobium* + Phosphate solubilizing bacteria) and four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) tested in a factorial randomized block design with three replication. A promising variety of soybean, JS-9560 was sown manually in furrows maintaining optimum plant spacing of 30 x10 cm. N, P and S were applied through urea, di-ammonium phosphate and gypsum respectively. The crop was sown on 16 July 2015 and receive 636 mm rainfall in 42 rainy days.

RESULTS AND DISCUSSION

Growth parameters:

Microbial inoculation with Rhizobium + PSB recorded the maximum plant height (45.9 cm), dry matter accumulation (29.97 g $plant^{-1}$), LAI at 50 DAS (4.42) and primary branches $plant^{-1}$ (6.03) (Table 1) which was significantly superior over control, *rhizobium* and PSB inoculation. *Rhizobioum* + PSB inoculation gave significantly 10.6, 3.2 and 5.6 per cent higher plant height, 8.2, 2.6 and 5.5 per cent dry matter, 15.7, 12.2 and 12.8 per cent higher LAI and 80.54, 18.70 and 28.29 per cent higher primary branches $plant^{-1}$ over control, *rhizobium* and PSB, respectively. Further *rhizobium* and PSB inoculation were also found significantly superior over control with respect to all growth parameters. Significant improvement in overall growth of soybean plants due to inoculation of *rhizobium* + PSB was closed agreement with finding of Vasumathi and Jayanthi[11] and Jaga and Sharma[6]. Application of 40 kg S ha^{-1} recorded the maximum plant height (44.70 cm) and dry matter accumulation (29.19 g) at harvest which was significantly superior over control and 20 kg S ha^{-1}. Plant height and dry matter accumulation under 40 kg S ha^{-1}were increased by 5.30 and 5.77 per cent, respectively over control and 3.26 and 3.10 per cent over 20 kg S ha^{-1}.Application of 60 kg S ha^{-1} recorded maximum LAI at 50 DAS (4.12) and primary branches $plant^{-1}$ (5.29) which was significantly superior over control, 20 and 40 kg S $ha^{-1.}$ Application of 60 kg S ha^{-1} gave significantly higher LAI by 3.6, 3.3 and 1.5 per cent and primary branches $plant^{-1}$ 26.3, 10.4 and 8.4 per cent over control, 20 and 40 kg S ha^{-1}, respectively. Further 20 and 40 kg S ha^{-1} were also found significantly superior over control with respect growth parameter. Similar results were reported by Farhad *et al*.[3], Thenua *et al*.[10] and Lakshman *et al*[8].

Interaction effect:

It is evident from data presented in Table 2 that interaction effect of microbial inoculation and sulphur on primary branches $plant^{-1}$ was recorded significantly maximum primary branches $plant^{-1}$ (20.10) under the treatment

combination I_3S_3 over rest of the treatments combination. Minimum primary branches plant^{-1} (9.07) was recorded under treatment combination I_0S_0.

Yield attributes:

Microbial inoculation and application of sulphur brought about significant variations in several yield attributes viz. number of pods plant^{-1}, number of seeds pod^{-1}, seed index and seed yield plant^{-1} (Table 3). Microbial inoculation with *rhizobium* + PSB recorded maximum number of pods plant^{-1} (28.43), number of seeds pod^{-1} (3.30), seed yield (9.92 g plant^{-1}) and seed index (13.65) which was significantly superior over control, *rhizobium* and PSB inoculation by 13.3, 19.1, 32.7 and 26.5 per cent, respectively over control. Microbial inoculation with *rhizobium* + PSB also gave significantly higher number of pods plant^{-1} by 3.6 and 7.2 per cent, higher number of seeds pod^{-1} by 10.7 and 15.8 per cent, higher seed yield (g plant^{-1}) by 9.0 and 19.5 per cent and higher seed index by 9.5 and 17.5 per cent over *rhizobium* and PSB inoculation respectively. Further *rhizobium* and PSB inoculation were also found significantly superior over control with respect to all yield attributes. The finding of present investigation were in close agreement with results reported by several researcher Janagard *et al.* Government of India 2014, Farniya and Gudiny[4], Vasumathi and Jayanthi[11] and Jaga and Sharma[6]. Application of 60 kg S ha^{-1}recorded the maximum number of pods plant^{-1} (28.02), number of seeds pod^{-1} (3.10), seed yield (9.13 g plant^{-1}) and seed index (12.47), which was significantly superior over control, 20 and 40 kg S ha^{-1}by 9.5, 12.7, 11.6 and 7.0 per cent, respectively over control. Application of 60 kg S ha^{-1}gave significantly higher number of pods plant^{-1} by 5.3 and 2.8 per cent, higher number of seeds pod^{-1} by 4.4 and 0.97 per cent, seed yield (g plant^{-1}) by 6.0 and 3.0 per cent and higher seed index by 3.6 and 0.8 per cent over 20 and 40 kg S ha^{-1}, respectively. Further 20 and 40 kg S ha^{-1}were also found significantly superior over control with respect to all yield attributes. These results are in agreement with the finding of Serker *et al.*[9], Dhage *et al.*[2] and Lakshman *et al.*[8]

Yield:

Results presented in Table 4 reveal that inoculation with *Rhizobium* + PSB recorded maximum seed yield(1442.79 kg ha^{-1}), haulm yield (3409.65 kg ha^{-1}),biological yield (4852.62 kg ha^{-1}) and harvest index (30.10 %), which was significantly superior over control, *rhizobium* and PSB inoculation. Microbial inoculation with *rhizobium*+ PSB recorded significantly higher seed yield over control, *rhizobium* and PSB by 66.7, 4.4 and 25.5 per cent, respectively. Further, rhizobium alone and PSB alone also proved significantly superior over control by 59.76 and 32.83 per cent, respectively. Similar trends were noted with respect to haulm and biological yield. Haulm yield was significantly superior over control by 54.8, 29.2 and 60.8per cent under *rhizobium*, PSB and *rhizobium* + PSB. Similarly biological yield was also significantly improved under *rhizobium*, PSB and *rhizobium* + PSB by 56.2, 29.5 and 62.5 per cent over control. With respect to harvest index, the maximum harvest index was recorded under *rhizobium* + PSB which was significantly superior over control, *rhizobium*, PSB by 4.0, 1.0 and 2.1 per cent, respectively. The finding of present investigation were in close agreement with results reported by several researcher Janagard et al. (2013), Farniya and Gudiny[4], Vasumathi and Jayanthi[11] and Jaga and Sharma[6]. Maximum seed yield kg ha^{-1}(1330.70 kg ha^{-1}), haulm yield (3076.60 kg ha^{-1}) and biological yield (4405.20 kg ha^{-1}) was observed with the application of 60 kg S ha^{-1}, which was significantly superior over control, 20 and 40 kg S ha^{-1} by 26.54, 14.30 and 18.40 per cent respectively over control. Maximum harvest index (30.50 %) was noticed with the application of 20 kg S ha^{-1}. The application of 20 kg S ha^{-1} increased harvest index by 8.15 per cent over control. Application of 60 kg S ha^{-1}also gave significantly11.8 and 4.8 per cent higher seed yield, 11.19 and 1.94 per cent higher haulm yield, 11.31 and 2.79 per cent higher biological yield over 20 and 40 kg S ha^{-1}, respectively. Further 20 and 40 kg S ha^{-1}were also found significantly superior over

control with respect to seed, haulm and biological yield. These results are in agreement with the finding of Serker *et al.*[9], Dhage *et al.*[2] and Lakshman *et al*[8].

Table 1: Effect of microbial inoculation and sulphur levels on the growth parameters of soybean

Treatments	Plant height (cm)	Dry matter accumulation (g plant^{-1})	LAI (at 50 DAS)	Primary branches Plant^{-1}
Inoculation				
Control	41.57	27.71	3.82	3.34
Rhizobium	44.57	29.21	3.94	5.08
PSB	43.55	28.41	3.92	4.70
Rhizobium + PSB	45.98	29.97	4.42	6.03
SEm ±	0.269	0.241	0.034	0.051
CD (P = 0.05)	0.778	0.0696	0.097	0.148
Sulphur levels (kg ha^{-1})				
0	42.62	27.92	3.92	4.19
20	43.46	28.64	3.99	4.79
40	44.88	29.53	4.06	4.88
60	44.70	29.19	4.12	5.29
SEm ±	0.269	0.241	0.034	0.051
CD (P = 0.05)	0.778	0.696	NS	0.148

Table: 2: Interaction effect of microbial inoculation and sulphur levels on primary branches plant^{-1}

Treatments		Microbial inoculation		
Sulphur levels	**I_0**	**I_1**	**I_2**	**I_3**
S_0	9.07	10.60	15.58	15.10
S_1	9.37	16.22	13.72	18.18
S_2	10.36	16.53	12.67	18.98
S_3	11.33	17.65	14.47	20.10
SEm±	0.039			
CD (P= 0.05)	0.111			

Table 3: Effect of microbial inoculation and sulphur levels on yield attributes and yield of soybean

Treatments	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed yield (gplant^{-1})	Seed index
Inoculation				
Control	25.10	2.77	7.48	10.79
Rhizobium	27.43	2.98	9.10	12.47
PSB	26.53	2.85	8.30	11.62
Rhizobium + PSB	28.43	3.30	9.92	13.65
SEm ±	0.226	0.026	0.077	0.104
CD (P = 0.05)	0.654	0.075	0.224	0.299
Sulphur levels (kg ha^{-1})				
0	25.60	2.75	8.18	11.65
20	26.60	2.97	8.61	12.04
40	27.27	3.07	8.86	12.37
60	28.02	3.10	9.13	12.47
SEm ±	0.226	0.026	0.077	0.104
CD (P = 0.05)	0.654	0.075	0.224	0.299

Table 4: Effect of microbial inoculation and sulphur levels on yield attributes and yield of soybean

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Inoculation				
Control	865.4	2120.8	2986.0	28.9
Rhizobium	1382.6	3282.8	4664.0	29.8
PSB	1149.7	2739.6	3865.9	29.5
Rhizobium + PSB	1442.8	3409.7	4852.6	30.1
SEm ±	9.86	27.8	35.38	0.16
CD (P = 0.05)	28.46	78.8	102.19	0.48
Sulphur levels (kg ha^{-1})				
0	1051.6	2691.5	3720.3	28.2
20	1190.6	2766.9	3957.4	30.5
40	1267.6	3017.9	4285.5	29.4
60	1330.7	3076.6	4405.2	30.2
SEm ±	9.86	27.78	35.38	0.16
CD (P = 0.05)	28.46	78.78	102.19	0.48

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