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Influence of P & K with and without *Rhizobium japonicum* and Phosphorous Solubilizing Bacteria on Growth and Yield Sustainability of Soybean in Black Soil

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ABSTRACT

An experiment was conducted to study during kharif season of 2016 and 2017 at Sehore (M.P). The experiment was laid out in Randomized block design with three replication having Ten treatments viz. Control (T1), Bradyrhizobium japonicum alone(T_2), Local check (KRIBHICO–rhizobium culture(T3), T_2+ P $_{60}$ kg/ha through SSP(T4), T_2 + K $_{30}$ kg through MOP(T5), T_2 + PSB 10 g/kg seed treatment(T6), T_2 + P $_{30}$ kg/ ha + PSB 10 g/kg seed treatment(T7), T_2 + K 15kg /ha + PSB 10 g/kg seed treatment(T8), T_2 + T_8 (T9) and P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}). On the basis of results obtained on various parameters as per approved synopsis following summary and conclusions have been drawnout: Growth characters such as no. of branches/plant, dry weight/plant, number and dry weight of root nodules attained significantly higher values with the application of P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6).Yield and yield attributing characters such as no. of pods/plant, seed index and seed yield attained significantly higher values with the application of P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6). Number of pods per plant was noted higher in the treatment P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6). Appreciably higher seed index was noted under P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6). Application of P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6) gave significantly higher N, P, K, Zn, B & Mo in straw and seed as compared to other treatments and control. Application of P $_{60}$ kg/ ha+ K $_{30}$ kg/ha (T_{10}) as compared to other treatments followed by (T_5 and T_6).also improved the content of N, P, K , Zn, B and Mo in soil at harvest of soybean.

Key words: *Soybean, Rhizobium, Kharif, FYM*

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INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is one of the important grain legume crop of India, which not only helps in maintaining soil fertility but it is also a rich source of protein (38 to 42%) and oil (18-20%). Its cultivation has become popular in Madhya Pradesh due to the establishment of processing units and high remunerative prices. Singh and Kumar reported that the treatment have FYM @ 5 t per ha+V.C. @ 2.5 t per ha+V.W. @ 10 per cent+50 per cent NPK gave maximum nodule number (49 and 53/plant), highest nodule dry weight (384 and 372 mg/plant) and plant dry weights (30.33 and 40.33 g/plant). Konthoujam *et al.*, reported that the application of 75% RDF + vermicompost a @ 1 t ha-1 + PSB recorded the highest plant height, number of nodules per plant and dry weight of nodules per plant over control.

Soybean, being a Leguminous crop has got capacity of fixing N_2 through Rhizobium bacteria which forms nodules on the roots of this crop. Nodule rhizobia can fix nitrogen actively only if the plant is adequately supplied with all the mineral elements essential for active growth. In this respect elements like P, Ca, Mo, Fe, Zn and Co play an important role. Hence, supplementation of micronutrients along with Rhizobium + PSB inoculation in soybean cultivation may increase biological nitrogen fixation and P availability in soybean crop and there by its productivity.

Seeds of legumes when inoculated with manganese and molybdenum mixed with rhizobium culture increased the yield and protein content[5]. The application of Zinc and molybdenum in Soybean increased the grain yield and seed index. They have also started that the nodule rhizoid can fix nitrogen only of the plant is adequately supplied with all the minerals elements essential for active growth. In this context, zinc molybdenum, boron and biofertilizers play an important role enhancing biological inoculation in Soybean. Recent investigations carried out by Jain and Thakur[5]. indicates that only 15-20% of the applied fertilizer phosphorus is utilized by the crop to which it is applied and rest gets chemically fixed in the soil and becomes unavailable to plants. *Rhizobium* is known to fix atmospheric N_2 in the root nodules of legume crops whereas phosphorus solubilizing bacteria solubilizes the fixed or unavailable form of phosphorus and make available to crops. Hence, there use may prove beneficial in increasing soybean production in the state.

RESULTS AND DISCUSSIONS

Growth character as affected by different treatments:

Number of nodules per plant at 40 & 60 DAS

Treatments influenced the number of nodules per plant significantly. Maximum number of nodules per plant was recorded under the treatment T_{10}, followed by T_6, T_5 and T_4 , respectively at both stages. However, number of nodules per plant under the treatments T_6, T_5 and T_4 were found at par. Number of nodules per plant under treatment T_{10} was significantly higher over the remaining treatments. Minimum number of nodules per plant was observed with control. The findings of, Ibrahim *et al.*[4], Anonymous[1] and Jain and Thakur[5] are in close agreement with these results

Dry weight of nodules per plant (mg) at 40 & 60 DAS

Treatments influenced the dry weight of nodules per plant significantly. Maximum dry weight of nodules per plant was noted under the treatment T_{10}. The other treatments in the decreasing order of dry weight of nodules per plant were T_6, T_5 , T_4 , T_9 , T_8 and T_7 per plant respectively at both the stages. However, dry weight of nodules per plant under the treatments T_{10} ,T_6, T_5, T_4, T_9, T_8 and T_7 were found at par. Minimum dry weight of nodules per plant was observed with control. The findings of, Ibrahim *et al.*[4], Anonymous[1] and Jain and Thakur[5] are in close agreement with these results.

Number of branches per plant

Treatments influenced the number of branches per plant significantly. At maturity stage, maximum number of branches per plant was

recorded under the treatment T_{10}, followed by T_6 , T_9 and T_4. However, number of branches per plant under treatments T_{10} and T_6 were found statistically same. Minimum number of branches per plant was observed with control. The findings of, Ibrahim *et al.*[4], Anonymous[1] and[5] are in close agreement with these results

Dry weight per plant at maturity

Treatments influenced the dry weight per plant significantly. At maturity stage, maximum dry weight per plant was recorded under the treatment T_{10}, followed by T_6, T_9 and T_4. However, dry weight per plant under the treatments T_{10}, T_6 and T_9 were found at par. Minimum dry weight per plant was observed with control.

Studies on growth character as affected by different treatments (mean values of two years)

Treatment		Number of nodules / plant		Dry weight of nodules / plant(mg)		Branches / plant	Dry weight / plant (g)
		40 DAS	60 DAS	40 DAS	60 DAS		
T_1	Control	62.51	61.46	35.95	41.18	3.17	8.21
T_2	*Bradyrhizobium japonicum* alone	70.62	69.22	44.66	49.71	3.71	11.55
T_3	Local check (KRIBHICO– rhizobium culture)	64.75	63.66	37.99	43.14	3.46	9.75
T_4	T_2+ P 60 kg/ha(SSP)	76.81	75.73	51.30	56.47	4.55	13.31
T_5	T_2 + K 30 kg (MOP)	78.66	77.75	52.28	54.46	4.25	13.33
T_6	T_2 + PSB 10 g/kg seed treatment	80.55	79.45	56.30	61.44	4.98	14.85
T_7	T_2 + P 30 kg/ ha + PSB 10 g/kg seed treatment	69.34	68.21	47.15	52.10	3.90	12.26
T_8	T_2 + K 15kg /ha + PSB 10 g/kg seed treatment	75.47	74.67	49.30	54.41	4.11	12.92
T_9	T_2 + T_8	76.28	75.24	50.70	55.80	4.70	14.11
T_{10}	P 60 kg/ ha+ K 30 kg/ha	90.55	89.47	60.46	65.55	5.24	15.25
	S.E(m) ±	0.37	1.37	2.78	4.78	0.40	0.55
	CD at 5%	1.11	3.97	8.38	13.84	1.22	8.21

Yield and yield attributing character as affected by different treatments:

Number of pods per plant

The treatment T_{10} gave the maximum number of pods per plant which was significantly higher to the rest of the treatments. It was followed by treatments T_6, T_9 and T_5. However, treatments T_{10} and T_6 were at par. The lowest significant number of pods per plant was noted with control.

This may be attributed to the fact that the plant of soybean generally tenders up to 70-80 DAS and therefore, the fair availability of nutrients including micronutrients in the soil and thus, the maximum translocation of nutrients might have been occurred from different parts of plant and get accumulated in the seed and thus, add towards the enhanced dry weight at harvest. The findings of, Ibrahim *et al.*[4], Anonymous[1] and[5].are in close agreement with these results.

Seed index (g)

Treatments T_{10} gave the maximum seed index. It was followed by the treatments T_6, T_9 and T_5. However, the treatments T_{10}, T_6, T_9 and T_5 gave the seed index statistically the same. The minimum seed index was produced by control.

Yield and yield attributing character as affected by different treatments (mean values of two years)

Treatment		No. of pods / plant	Seed index (g)	Seed yield (q ha^{-1})	Straw yield (qha^{-1})
T_1	Control	29.14	8.81	16.74	34.75
T_2	*Bradyrhizobium japonicum* alone	31.28	10.95	22.02	36.60
T_3	Local check (KRIBHICO–*rhizobium* culture)	31.13	10.44	22.20	31.91
T_4	T_2+ P 60 kg/ha(SSP)	33.86	11.24	22.64	37.60
T_5	T_2 + K 30 kg (MOP)	35.61	11.70	22.67	36.10

T_6	T_2 + PSB 10 g/kg seed treatment	41.30	12.14	25.80	38.21
T_7	T_2 + P 30 kg/ ha + PSB 10 g/kg seed treatment	33.60	12.32	23.29	35.75
T_8	T_2 + K 15kg /ha + PSB 10 g/kg seed treatment	33.61	11.31	23.77	36.41
T_9	T_2 + T_8	38.92	11.84	25.59	37.10
T_{10}	P 60 kg/ ha+ K 30 kg/ha	42.04	12.51	26.87	36.14
	S.E(m) ±	1.52	0.35	0.40	2.00
	CD at 5%	2.50	1.04	0.96	6.17

Seed yield (q ha^{-1})

Treatment T_{10} was approved significantly superior over rest of the treatments. The minimum seed yield was produced by control could be attributed because of better utilization of nutrients due to the fair availability of nutrients remained in the soil for plant uptake and better nitrogen fixation phenomenon and thereby increased uptake of nutrients specially N, P & K by soybean plant which accelerated the seed index hence the increased seed yield of soybean. The results obtained by Ibrahim *et al.*[4], (2000-2009) and[5]. Have also observed the similar results on straw yield of soybean.

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