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Influence of Different Sources of Phosphorus Acquisition and Utilization in Soybean Genotypes

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ABSTRACT: *A pot culture experiment was conducted to study the Phosphorus acquisition and utilization in soybean genotypes from different P sources applied to sand and soil mixture at college of agriculture, university of Agricultural sciences, Dharwad during* Kharif *2002. The experiment was laid out in completely randomized design with three genotypes and three different sources of phosphorus. The experiment consisted of 3 Main Treatments viz., V1: KHSb-2, V2: MAUS-2, V3: JS-335, and Sub TreatmentsT_1- Control, T_2- Rock Phosphate (RP), T_3- Rock Phosphate + mineral Phosphate solubilising bacteria (RP + MPSB), T_4- Single Super Phosphate (SSP). Interaction study was also done with main & sub treatments. In the present investigation also the acid phosphatase activity significantly increased in the treatment receiving no phosphorus source compared with phosphorus, supplemented in the form of RP, RP + MPSB and SSP. The plant height, total dry matter and leaf P uptake were strongly and positively correlated with total P uptake, whereas, ACPH activity and PUEF were negatively correlated. The most efficient genotype KHSb-2 responded well to the application of RP compared to the genotypes MAUS-2 and JS-335, in terms of P acquisition and seed yield.*

Key words: Phosphorus uptake, Single Super Phosphate, Rock Phosphate, Soybean

INTRODUCTION

Soybean being the world's leading oil seed crop stands next to ground nut and rape seed mustard in production in India. It is becoming increasingly popular among growers because of assured yield, remunerative prices and also due to its high oil and protein contents. Soybean can be grown in all type of soils having a PH 5.0 and above and is supplied with large quantity of fertilizer including P every year irrespective of the type of soil. Although total P content in soils of India is as high as 560 to 900 kg/ ha, only a very small portion of it (15 to25 kg/ha) is available to plant. Hence every time crops need heavy P fertilization. Phosphorous is one of the essential nutrients for plant growth. It occurs in soil as inorganic phosphate, produced by weathering of parent rock or as organic phosphate derived from decayed plant, animal or microorganism. Strategies to sustain agricultural production on P deficient soils have been focused on making the most efficient use of available soil P or cheaper source of P, so that crop production can be improved with minimum P application. A principle component of these strategies is the use mineral phosphate solubilising microbes, which acidify the substrate and possibly the rhizosphere. They have been used in unison with rock phosphate, so that the phosphorus in the rock phosphate can be made available in the soil for plant uptake. Increased dry matter yields of crop plants have been observed following inoculation with P solubilising micro organisms and application of phosphorus (1). Plants also have different statg\egies either increase efficiency or help extract more P from the soil to cope with restricted P supplies. In response to persisting low levels of available P in rhizosphere plants have developed highly specialized physiological (enhanced Pi uptake, reduced Pi efflux, increased Pi use efficiency, mobilization of Pi from

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vacuole to cytoplasm, secretion of organic acids, protons and chelates *etc*.) biochemical mechanisms (activation of enzymes, enhanced production of phosphatases and RNAses) along with morphological modifications (increased root: shoot ratio, changes in root morphology and architecture, increased root hair proliferation and root elongation) (2). Studies on the comparative efficiency of soybean genotypes in the absorption and utilization of P nutrient will help not only in identifying genotypes more efficient but also in understanding the rates of absorption, utilization, and the concentration of nutrient in the soil required for each genotype so that nutrient supply can be regulated according to their needs. Genotypic differences have also been observed in the internal utilization responses in dry matter production, biological yield and economic yield. Keeping this in view, the present investigation was taken up to find out the physiological and biochemical basis of phosphorus acquisition and utilization in soybean genotypes and compared with MPSB.

MATERIAL AND METHODS

The experiment was laid out in the Main Research Station, University of Agricultural sciences, Dharwad. A pot culture experiment was conducted to study the Phosphorus acquisition and utilization in soybean genotypes from different P sources applied to sand and soil mixture during *Kharif* 2002. The experiment was laid out in completely randomized design with three genotypes and three different sources of phosphorus. The experiment consisted of 3 Main Treatments viz., V1: KHSb-2, V2: MAUS-2, V3: JS-335, and Sub Treatments T_1- Control, T_2- Rock Phosphate (RP), T_3- Rock Phosphate + mineral Phosphate solubilising bacteria (RP + MPSB), T_4- Single Super Phosphate (SSP). The physiological and biochemical basis of mineral phosphate acquisition and utilization in the soybean genotypes (KHSb-2, MAUS-2, and JS-335) in vertisols mixed with sand (70:30) was studied in pot culture.The soil samples were collected from a depth of 0-15 cm. The collected soil samples were powdered and mixed thoroughly to obtain a homogenous mixture and mixed with sand in the ratio of 70:30. The mixture of soil and sand was sterilized by autoclaving at 121 degree Celsius and 15lb per sq. Inch for one hour (3) to make the soil free from native P Solubilising organisms. The sterilised soil was placed in black polyethene bags at the rate of 2.5 kg per bag. The recommended dose of nitrogen (37 kg/ ha) and potassium (37 kg/ha) was added to the poly bags before sowing.The seeds of all genotypes were surface sterilised with absolute alcohol and washed with sterile water. Then the seeds were commonly inoculated with *Bradyrhizobiumjaponicum*. The three treated seeds were sown in black polyetehene bags containing sterilized soil and sand mixture as per the treatments T1, T2 and T4. Similarly, the three rhizobium treated seeds were further inoculated with MPS bacteria (*Burkholderiacepacia*) as per the treatment T3 were immediately sown in the mixture of soil and sand. Once, the seedlings emerged, the plants were thinned down to one plant per bag.The polyetehene bags were kept in the house of the Department of crop physiology and maintained weed free. The moisture level in the soil was maintained at field capacity till the experiment was over and the care was taken that the water was not allowed to leak out of the polyethene bags. The plant protection measures were taken up as per the recommendation in the package of practices for soybean.Four sets of polyethene bags containing each genotype were maintained and replicated three times. Each of the four sets of three genotypes was used for sampling at 45, 60, 75 DAS and at harvest.At each sampling stage of 45, 60, and 75 and at harvest, the shoot portion was separated by cutting at collar region and root portion was kept in a plastic tray along with soil and separated carefully by washing it with jet of water without loosing the root in all the treatments.

The leaves were powdered in a pestle and mortar and 0.5 g sample was taken for wet digestion for the estimation of P. The sample was first pre-digested with 5 ml of concentrated nitric acid over night and then digested with 10 ml of triacid mixture containing concentrated nitric acid, sulphuric acid and perchloric acid in the ratio of 10:1:4. The digestion was continued till a colorless sticky liquid was left behind. The residue was cooled and dissolved in 6 N HCL and finally volume was made to 50 ml with distilled water.Determination of P in Plant samples: Phosphorus content in plant samples was determined by following the Vanadomolybdate yellow colour method as outlined by Jacson (4).Ten ml aliquot of the solution was taken in a 50 ml volumetric flask and some amount of distilled water was added to it. Ten ml of vanadomolybdate reagent was added and finally the volume was made up to 50 ml with distilled water. The reaction mixture was mixed well and allowed to react for 20 minutes which lead to the development of yellow colour. The intensity of yellow colour was measured using a spectrophotometer (Elico UV-VIS spectro-

photometer) at 420 nm. The phosphorus concentration of the sample was obtained from the standard graph.

RESULTS AND DISCUSSION

The data pertaining to phosphorus uptake efficiency (PUE) is presented in Table 1, and it varied significantly among the genotypes and treatments. At 45 DAS, the genotype MAUS-2 recorded significantly higher PUE (15.09) followed by JS-335 (14.73), however it was on par with MAUS-2 and the lowest was noticed in KHSb-2 (12.47). The treatment with the application of RP recorded significantly higher PUE (16.82) followed by RP + MPSB (14.48) and it was on par with SSP (14.01) and the lowest was noticed in control (11.14). At 60 DAS, the genotype JS-335 recorded significantly higher PUE (17.42) followed by KHSb-2 (15.16) and the lowest PUE was noticed in MAUS-2 (13.798). The treatment, combination of RP + MPSB recorded significantly higher PUE (19.26) followed by RP (16.422) and the lowest was noticed in control (11.68). At 75 DAS, the genotype KHSb-2 recorded significantly higher PUE (14.96) followed by JS-335 (13.74) and it was on par with MAUS-2 (13.38). Among the treatments, application of RP recorded significantly higher PUE (14.810) and it was on with RP + MPSB (14.47) and lowest PUE was noticed in control (13.40) and it was on par with SSP (13.43).
At harvest, the genotype JS-335 recorded significantly higher PUE (22.02) followed by MAUS-2 (20.74) and the lowest PUE was noticed in KHSb-2 (20.56). The control recorded significantly higher PUE (25.00) followed by RP + MPSB (21.38) and the lowest PUE was noticed in SSP (17.22). Mohod *et al*. (5) reported that the use of phosphate solubilising bacteria alone or in combination with P fertilizers in lateritic soil increased the root CEC, available P in soil and uptake by rice.The P utilization efficiency (PUEF) varied significantly among the genotypes and treatments at all the growth stages as represented in Table 2.

At 45 DAS, the genotype MAUS-2 recorded significantly higher PUEF (0.776) followed by KHSb-2 (0.651) and lowest was noticed in JS-335 (0.551). The control recorded significantly higher PUEF (0.830) followed by RP (0.645) and lowest was noticed in SSP (0.559). The interaction effects were not significant.At 60 DAS, the genotype MAUS-2 maintained significantly higher PUEF (0.620) followed by JS-335 (0.574) and the lowest was noticed in KHSb-2 (0.523). The interaction, JS-335 in control recorded significantly higher PUEF (0.763) followed by MAUS-2 in control (0.689) and lowest was noticed in KHSb-2 with the application of SSP (0.449).
At 75 DAS, the genotype JS-335 recorded significantly higher PUEF (0.618) followed by MAUS-2 (0.479) and it was on par with KHSb-2 (0.478). The interaction, JS-335 in control maintained the higher PUEF (0.725) followed by JS-335 with RP (0.601) and the lowest was noticed in MAUS-2 with the application of SSP (0.434).

At harvest, the genotype KHSb-2 recorded significantly higher PUEF (0.376) followed by MAUS-2 (0.371) and the lowest was noticed in JS-335 (0.369). The interaction MAUS-2 in control recorded significantly higher PUEF (0.444) followed by JS-335 in control (0.417) and the lowest was noticed in MAUS-2 with the application of RP + MPSB (0.332). The treatment effects at 60, 75 DAS and harvest followed the same trend as that of 45 DAS.

Helal (6) reported that root phosphatase activity is a significant factor in nutritional efficiency under

Table 1
Phosphorus uptake efficiency (PUE) (mg P / g root) of soybean genotypes as influenced by P-sources and P-solubilizer

Treatments	*45 DAS*				*60 DAS*				*75 DAS*				*At Harvest*			
	KHSb-2	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*
Control	7.73	15.42	10.28	11.14	10.48	12.50	12.05	11.68	12.38	13.01	14.82	13.40	22.32	25.32	27.36	25.00
RP	16.17	14.34	19.25	16.82	16.42	12.74	20.11	16.42	18.03	11.98	14.42	14.81	22.26	18.79	21.41	20.82
RP+MPSB	12.98	15.37	15.08	14.48	20.41	15.11	22.26	19.26	16.18	13.31	13.91	14.47	22.23	20.22	21.70	21.38
SSP	13.06	15.22	13.75	14.01	13.32	14.85	15.26	14.48	13.25	15.22	11.83	13.43	15.44	18.63	17.60	17.23
Mean	12.48	15.09	14.77		15.16	13.80	17.42		14.96	13.38	13.74		20.56	20.74	22.02	
For comparing means of	S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)	
Genotype	0.21		0.61		0.28		0.82		0.18		0.53		0.36		1.05	
Treatment	0.24		0.70		0.33		0.95		0.21		0.61		0.42		1.22	
Interaction	0.42		1.22		0.56		1.64		0.36		1.05		0.72		2.11	

RP=Rock Phosphate, MPSB=Mineral phosphate solubilising bacteria, SSP= Single superphosphate, DAS=Days after sowing

limited mineral phosphorus supply. The data pertaining to acid phosphatase activity in root extract presented in Table 3 indicated that it increased from 45 to 75 DAS. Acid phosphatase activity among the genotypes and treatments varied significantly.

At 45 DAS, the genotype JS-335 recorded significantly higher acid phosphatase activity (6.855) followed by MAUS-2 (5.740) and the lowest was recorded in KHSb-2 (4.308). Among the treatments, control recorded significantly higher acid phosphatase activity (6.980) followed by RP (5.963) and the lowest was recorded in SSP (4.429). The interaction effects were not significant. The same trend was followed by the genotypes and treatments at 60 DAS, but at the interaction the genotype JS-335 recorded significantly higher acid phosphatase activity in control (8.451) compared to any other treatment. The same trend was followed at 75 DAS as that of 45 and 60 DAS. Doris Fouse and Jungte (7) reported that in soils low in available P, contribution of P uptake by root hairs was up to 90 per cent of total uptake which was partially due to their surface area.

Table 2
Phosphorus utilization efficiency (PUEF) (g / mg P) of soybean genotypes as influenced by P-sources and P-solubilizer

Treatments	*45 DAS*				*60 DAS*				*75 DAS*				*At Harvest*			
	KHSb-2	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*
CControl	0.821	0.930	0.739	0.830	0.636	0.689	0.763	0.696	0.575	0.534	0.715	0.608	0.397	0.444	0.417	0.419
RP	0.647	0.787	0.500	0.645	0.525	0.675	0.570	0.590	0.457	0.485	0.601	0.514	0.375	0.364	0.375	0.371
RP+MPSB	0.572	0.739	0.502	0.604	0.483	0.552	0.494	0.510	0.443	0.463	0.572	0.493	0.370	0.332	0.340	0.347
SSP	0.563	0.649	0.464	0.559	0.449	0.563	0.470	0.494	0.439	0.434	0.584	0.486	0.364	0.343	0.343	0.350
Mean	0.651	0.776	0.551		0.523	0.620	0.574		0.478	0.479	0.618		0.376	0.371	0.369	
For comparing means of	S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)	
Genotype	0.015		0.046		0.004		0.008		0.003		0.008		0.009		NS	
Treatment	0.018		0.053		0.005		0.010		0.004		0.010		0.010		0.030	
Interaction	0.050		NS		0.008		0.016		0.005		0.016		0.018		NS	

RP=Rock Phosphate, MPSB=Mineral phosphate solubilising bacteria, SSP= Single superphosphate, DAS=Days after sowing

Table 3
Acid Phosphatase activity in root extract (ìmol P / g FW / min) of soybean genotypes as influenced by P-solubilizer

Treatments	*45 DAS*				*60 DAS*				*75 DAS*			
	KHSb-2	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*	*KHSb-2*	*MAUS-2*	*JS-335*	*Mean*
Control	5.446	7.371	8.122	6.980	8.310	7.841	8.451	8.201	8.686	7.981	8.780	8.482
RP	4.366	6.244	7.277	5.963	4.836	6.479	7.512	6.276	6.104	6.808	8.122	7.011
RP+MPSB	3.991	5.071	6.432	5.164	4.225	5.634	6.808	5.556	5.869	6.103	6.949	6.307
SSP	3.427	4.272	5.587	4.429	3.803	4.695	5.963	4.820	5.164	5.634	6.338	5.712
Mean	4.308	5.740	6.855		5.294	6.161	7.183		6.456	6.632	7.547	
For comparing means of	S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)		S. Em+/-		CD (0.05)	
Genotype	0.100		0.290		0.113		0.330		0.151		0.439	
Treatment	0.115		0.335		0.131		0.381		0.174		0.507	
Interaction	0.199		NS		0.227		0.661		0.301		NS	

RP=Rock Phosphate, MPSB=Mineral phosphate solubilising bacteria, SSP= Single superphosphate, DAS=Days after sowing

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