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Effect of Different Sources of Phosphatic Fertilizers on Soybean (*Glycine max* L.) Growth and Yield

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ABSTRACT

A field experiment was conducted at Zonal Agricultural and Horticultural Research Station, University of Agricultural and Horticultural Sciences (UAHS), Navile, Shivamogga to know the effect of different sources of phosphatic fertilizers on soybean growth and yield during kharif 2014–15. The experiment comprised of eleven treatments consisting of combination of different phosphatic fertilizers. The plant height (15.50, 30.06 and 34.14 cm respectively), number of trifoliate leaves per plant (6.07, 23.61 and18.37 respectively), numbers of branches per plant (5.43, 10.42 and 10.32 respectively), number of pods per plant (50.67), number of seeds per pod (3.03) and test weight (13.15 g) was significantly high in the treatment T_7 receiving 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF at 30, 60 days after sowing and at harvest. Significantly higher seed yield and Stover yield (23.76 q ha^{-1} and 31.37 q ha^{-1}) was observed in the treatment T_7 compared to other treatments. Therefore, it was concluded that by supplying 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF helps in improvement in growth and yield of soybean.

Key words: *Soybean, Phosphatic Fertilizer, Nutriphos, geowth and yelled.*

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important oilseed crops in the world. It is termed as wonder crop as it contains 40% good quality protein and 20% oil high in essential unsaturated fatty acids[6]. Soybean being a potentially high yielding crop can play greater role in boosting oil seed production in the country. Soybean is an important nitrogen-fixing leguminous crop cultivated in several part of the world for food and feed[11]. Soybean oil, soymilk and soymeal are some of the important product of soybean. Owing to its multiplicity of use as food and industrial product, it is called as a "wonder crop". This legume is making straight way in Indian agriculture to meet protein and oil requirement.

Soybean stands third in area and production among the commercial oil seed crops and contributes to 33 per cent of commercial oil seeds and 21 per cent of total pulse production in the world.

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In India, it occupies an area of 9.96 million hectare with production of 11.90 million tons with an average productivity of 1195 kg per hectare[4]. 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 a 6% contribution. Andhra Pradesh, Karnataka, Chhattisgarh and other parts of India also produce the bean in small quantities[3]. In Karnataka, soybean is grown over an area of 2.47 lakh hectares with a production of 3.00 lakh metric tonnes and productivity of about 1215 kg per hectare[3]. World production of soybean is predicted to increase by 2.2 % annually to 371.3 million tons by 2030 using an exponential smoothing model with a damped trend[10].

Phosphorus is an essential nutrient for crop growth and high yield with good quality. Phosphorus is essential for root and shoots growth. It stimulates the setting of pods, decreases the number of unfilled pods and hastens the maturity of the crop. Presently, the chemical fertilizers are the major source of nutrients but escalating cost, coupled with increasing demand for chemical fertilizers and depleting soil health necessitates the safe and efficient use of bio-fertilzsers in crop production. Phosphorus is an important plant nutrient involved in several energy transformation and biochemical reactions including biological nitrogen fixation. Phosphorus fertilizers have low efficiency of utilization due to chemical fixation in soil and due to poor solubility of native soil phosphorus. Soil microorganisms play a key role in soil phosphorus dynamics and subsequent availability of phosphate to plants. Co-inoculation of phosphate-solubilizing microorganism (PSM) and *Arbuscular mycorrhizas* (AM) may enhance plant acquisition of phosphorus from insoluble phosphorus sources[9].

Materials and Methods

A field experiment was carried out at Zonal Agricultural and Horticultural Research Station, University of Agricultural and Horticultural Sciences (UAHS), Navile, Shivamogga and belongs to Southern Transition Zone (Zone-7) of Karnataka. It is situated at 14^{o}O' to 14^{o}1' North latitude and 75^{o} 40' to 75^{0} 42' East longitude with an altitude of 650 meters above mean sea level. The soil texture was sandy loam, soil reaction was acidic (5.23) low in available nitrogen (208.97 kg ha^{-1}), high in available phosphorus (161.81 kg ha^{-1}) and medium in available potassium status (181.10 kg ha^{-1}).

The experiment was laid out in Randomized Complete Block design (RCBD) with three replications using soybean v*ar*. JS – 335 as a test crop (*Glycine max* L.). The recommended dose of nitrogen and potassium nutrients (25:60:25 kg NPK ha^{-1}) was applied in the form of urea and murate of potash respectively to all the treatments except control and phosphorus was applied by using two sources *viz*., single super phosphate and Nutriphos was applied 25, 50 and 75 per cent of phosphorus through single super phosphate and Nutriphos. Treatments includes T_1- control, T_2- Recommended dose of P_2O_5 as SSP, T_3- Recommended dose of P_2O_5 as Nutriphos, T_4- Recommended dose of P_2O_5 as SSP + PSF, T_5- Recommended dose P_2O_5 as Nutriphos + PSF, T_6- 50 % of P_2O_5 through SSP + 50 % of P_2O_5 through Nutriphos, T_7- 50 % of P_2O_5 through SSP + 50 % of P_2O_5 through Nutriphos + PSF, T_8- 25 % of P_2O_5 through SSP + 75 % of P_2O_5 through Nutriphos , T_9- 75 % of P_2O_5 through SSP + 25 % of P_2O_5 through Nutriphos, T_{10}- 25 % of P_2O_5 through SSP + 75 % of P_2O_5 through Nutriphos + PSF, T_{11}- 75 % of P_2O_5 through SSP + 25 % of P_2O_5 through Nutriphos + PSF. The soybean seeds are treated with or without phosphorus solubilizing fungus (*Aspergillus awamori*) before sowing. The soybean seeds are shade dried and sown. A spacing of 30 X 10 cm was followed and inter-cultural operations, weeding and plant protection measures were taken.

Biometric observations

The crop was harvested as per treatment details when the pods were picked from the net plot and hand threshing was done separately. Representative samples were drawn for laboratory analysis after processing by following standard procedures

Biometric observations were recorded on five randomly selected tagged plants from each plot at 30, 60 days after sowing (DAS) and at harvest stage of the crop. Plant height was recorded from the ground level to the tip of the main shoot. Measurements were taken from five tagged plants in each treatment and the average height was calculated and expressed in centimeter. The number branches per plant from five plants were counted and the average was worked out and expressed as number of branches per plant. Numbers of trifoliate leaves per plant from five plants were counted and the average was worked out and expressed as number of trifoliate leaves per plant.

Yield and yield components

The plants selected for growth studies were also utilized for recording the observations on the yield components such as number of pods per plant, number of seeds per pod and test weight of seeds.

The numbers of pods from five random plants were counted and average was worked out. The numbers of seeds per pod from five random plants were recorded and number of seeds per pod was calculated by dividing the total number of seeds by total number of pods. For test weight hundred seeds were counted from the sample drawn from seed yield of each net plot and the weight of 100 seeds was recorded and expressed in grams.

Seed yield was recorded after threshing and winnowing the pods from the net plot area. Seed yield per plot was converted to quintal per hectare factor. Stover yield of soybean was recorded from each net plot and used for calculating the stover yield per hectare.

Hectare factor (HF) = 10,000m^2/size of the net plot.

The data collected from the experimental field was analyzed statistically The level of significance used in ‘F’ and ‘t’ test was P = 0.05. Critical differences were calculated wherever ‘F’ test was significant.

RESULTS

Influence of different sources of phosphorus fertilizers on growth attributes of soybean at different growth stages

The data recorded with respect to plant height, number of leaves per plant and number of branches per plant of soybean at different growth stages as influenced by the application of two sources of phosphorus is presented in Table 1. Results of the field experiment indicated that plant height, numbers of trifoliate leaves per plant and numbers of branches per plant were significantly increased with different sources of phosphorus fertilizers.

The yield attributing characters of crops were greatly affected by sulphur application[6].

It is involved in several important physiological functions in soybean including oil synthesis and acts as precursor for many amino acids,namely cysteine (26%S), cystine (27%S) and methionine (21%S)which act as building blocks for the synthesis of protein (Patel et al., 2013b).

Application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment has recorded significantly higher plant height (15.50, 30.06 and 34.14 cm respectively), number of trifoliate leaves per plant (6.07, 23.61 and18.37 respectively) and numbers of branches per plant (5.43, 10.42 and 10.32 respectively) at 30, 60 days after sowing and at harvest compared to other treatments. Lowest plant height (10.51, 17.33 and 21.92 cm respectively), number of trifoliate leaves per plant (2.17, 10.07 and 5.57 respectively) and numbers of branches per plant (1.67, 3.57 and 3.40 respectively) at 30, 60 days after sowing and at harvest was recorded in control.

Yield attributes of soybean as influenced by different sources of phosphorus

The data on yield attributes of soybean *viz.*, number of pods per plant, number of seeds per pod and test weight (g) as influenced by different sources of phosphorus are presented in Table 2.

Results indicated that there was significant increase in the number of pods per plant over the control due to the application of different sources of phosphorus. Among the different treatments, treatment (T_7) that received 50 per cent of P_2O_5 applied through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF was recorded maximum number of pods per plant (50.67) which is on par with treatments (T_{10}) where 25 per cent of P_2O_5 applied through SSP+ 75 per cent of P_2O_5 through Nutriphos + PSF (47.33) was applied,(T_4) which received recommended dose of P_2O_5 as SSP + PSF (46.33), (T_5) where recommended dose of P_2O_5 as SSP and Nutriphos (47.67) was applied and (T_6) which received 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos (42.67). Whereas lowest number of pods per plant were recorded in control (29.00).

There was no significant variation among the treatments on number of seeds per pod due to the application of different sources of phosphorus fertilizers to soil. The higher number of seeds per pod (3.03) was recorded in treatment (T_7) that received 50 per cent of P_2O_5 applied through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF and which was superior over other treatments. Lowest numbers of pods per plant (2.67) were recorded in control.

Significantly higher test weight (13.15 g) was noticed in the treatment (T_7) that received 50 per cent of P_2O_5 applied through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF. The lowest test weight (9.21 g) was recorded in control as compared to other treatment combinations of phosphorus.

Effect of different sources of phosphorus on seed yield and stover yield of soybean crop

The seed yield and stover yield of soybean were varied significantly due to the application of different sources of phosphorus. Application of 50 per cent of P_2O_5 through SSP + 50 percent of P_2O_5 through Nutriphos + PSF treatment recorded significantly higher seed yield and stover yield (23.76 q ha^{-1} and 31.37 q ha^{-1}) compared to other treatments. Lowest seed yield and stover yield was recorded in control (10.86 q ha^{-1} and 16.86 q ha^{-1}).

Table 1: Influence of different sources of phosphorus fertilizers on growth attributes of soybean at different growth stages

Treatments	Plant height (cm)			Number of trifoliate leaves $plant^{-1}$			Number of branches $plant^{-1}$		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1 : Control	10.51	17.33	21.92	2.17	10.07	5.57	1.67	3.57	3.40
T_2 : Recommended dose of P_2O_5 as SSP	11.30	21.54	24.56	2.57	11.46	7.25	2.63	5.04	4.52
T_3 : Recommended dose of P_2O_5 as Nutriphos	11.73	22.19	25.56	2.90	12.24	7.91	2.90	5.46	5.24
T_4 : Recommended dose of P_2O_5 as SSP + PSF	13.94	26.49	30.14	5.36	21.27	16.32	4.66	9.93	9.78
T_5 : Recommended dose of P_2O_5 as Nutriphos + PSF	13.93	26.50	30.19	5.33	21.17	16.32	4.37	9.93	9.80
T_6 : 50 % of P_2O_5 through SSP +50 % of P_2O_5 through Nutriphos	13.00	24.39	27.40	3.30	15.71	11.16	3.53	6.77	6.57
T_7 : 50 % of P_2O_5 through SSP +50 % of P_2O_5 through Nutriphos + PSF	15.50	30.06	34.14	6.07	23.61	18.37	5.43	10.42	10.32
T_8 : 25 % of P_2O_5 through SSP +75 % of P_2O_5 through Nutriphos	13.24	25.18	28.72	4.20	19.52	14.85	3.87	6.98	6.86
T_9 : 75 % of P_2O_5 through SSP +25 % of P_2O_5 through Nutriphos	12.62	23.68	25.62	3.00	14.20	9.59	3.17	6.24	6.12
T_{10} : 25 % of P_2O_5 through SSP +75 % of P_2O_5 through Nutriphos + PSF	13.93	26.51	30.17	5.37	21.25	16.31	4.63	9.91	9.81
T_{11} : 75 % of P_2O_5 through SSP +25 % of P_2O_5 through Nutriphos + PSF	11.40	20.42	23.46	2.93	11.52	6.07	2.37	4.78	4.66
S.Em ±	0.20	0.94	0.82	0.10	0.76	0.36	0.18	0.35	0.11
CD at 5%	0.58	2.76	2.43	0.29	2.24	1.05	0.54	1.03	0.31

Table 2: Influence of different sources of phosphorus fertilizers on yield attributes of soybean

Treatments	No. pods plant^{-1}	No. seeds pod^{-1}	Test weight (g)
T_1 : Control	29.00	2.67	9.21
T_2 : Recommended dose of P_2O_5 as SSP	37.67	3.00	12.99
T_3 : Recommended dose of P_2O_5 as Nutriphos	39.00	3.03	13.00
T_4 : Recommended dose of P_2O_5 as SSP + PSF	46.33	3.00	13.13
T_5 : Recommended dose of P_2O_5 as Nutriphos + PSF	47.67	3.00	13.13
T_6 : 50 % of P_2O_5 through SSP + 50 % of P_2O_5 through Nutriphos	42.67	3.00	13.00
T_7 : 50 % of P_2O_5 through SSP + 50 % of P_2O_5 through Nutriphos + PSF	50.67	3.03	13.15
T_8 : 25 % of P_2O_5 through SSP + 50 % of P_2O_5 through Nutriphos	45.00	3.00	13.10
T_9 : 75 % of P_2O_5 through SSP + 25 % of P_2O_5 through Nutriphos	40.67	3.00	12.21
T_{10} : 25 % of P_2O_5 through SSP + 75 % of P_2O_5 through Nutriphos + PSF	47.33	3.00	13.13
T_{11} : 75 % of P_2O_5 through SSP + 25 % of P_2O_5 through Nutriphos + PSF	36.33	3.00	12.17
S.Em ±	0.74	0.10	0.28
CD at 5%	9.19	NS	0.81

NOTE: SSP: Single super phosphate, PSF: Phosphorus solubilizing fungus

Table 3: Influence of different sources of phosphorus fertilizers on seed yield and stover yield of soybean

Treatments	Seed yield	Stover yield
	← (q ha^{-1}) →	
T_1 : Control	10.86	16.86
T_2 : Recommended dose of P_2O_5 as SSP	15.66	23.07
T_3 : Recommended dose of P_2O_5 as nutriphos	17.35	24.76
T_4 : Recommended dose of P_2O_5 as SSP + PSF	22.11	29.61
T_5 : Recommended dose of P_2O_5 as nutriphos + PSF	22.13	29.67
T_6 : 50 % of P_2O_5 through SSP +50 % of P_2O_5 through nutriphos	20.03	26.40
T_7 : 50 % of P_2O_5 through SSP +50 % of P_2O_5 through nutriphos + PSF	23.76	31.37
T_8 : 25 % of P_2O_5 through SSP +75 % of P_2O_5 through nutriphos	21.02	28.42
T_9 : 75 % of P_2O_5 through SSP +25 % of P_2O_5 through nutriphos	19.59	27.07
T_{10} : 25 % of P_2O_5 through SSP +75 % of P_2O_5 through nutriphos + PSF	23.04	30.85
T_{11} : 75 % of P_2O_5 through SSP +25 % of P_2O_5 through nutriphos + PSF	16.13	23.71
S.Em ±	0.64	0.84
CD at 5%	1.90	2.49

DISCUSSION

Among the treatments, application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment (15.50, 30.06 and 34.14 cm respectively) has recorded significantly higher plant height compared to other treatments and lowest plant height was recorded in the control. This might be due to application of rock phosphate had higher total phosphorus and citric acid soluble-phosphorus content. This citric acid soluble-phosphorus solubilises the nutrient from the soil and helps in plant nutrition, also growth and development. These results are in agreement with that of Andy Wijanarko and Abdullah Taufiq[2].

Application of different sources of phosphorus fertilizers significantly increased the number of trifoliate leaves per plant at 30, 60 days after sowing and harvest of the crop. Among the treatments, application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment (6.07, 23.61 and 18.37 trifoliate leaves plant^{-1} respectively) has recorded significantly higher number of trifoliate leaves per plant compare to other treatments and lowest number of trifoliate leaves per plant was recorded in the control. This might be due to phosphorus present in single super phosphate increases leaf appearance rate and also stomatal resistance in soybean and keep water from leaving the plant and there by maintaining plant water status. These results are in conformity with the findings of Jaidee *et al*[8].

Application of different sources of phosphorus fertilizers significantly increased the number of branches per plant at 30, 60 days after sowing and harvest of the crop. Among the treatments, application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment (5.43, 10.42 and 10.32 branches plant^{-1} respectively) has recorded significantly higher number of branches per plant compare to other treatments and lowest number of branches per plant was recorded in the control. This might be due to high and continuous availability of phosphorus and because of its role in role in growth, development and photosynthesis might have reflected in higher values for number of branches per plant. This is in accordance with the findings by El-Habbasha *et al*[7]. Significantly higher growth, prolonged crop period and yield performance of soybean crop at each incremental phosphorus level and SSP can be ascribed to more phosphorus availability and resultant higher crop phosphorus mining under these treatments. In fact effect of phosphorus nutrition on growth and productivity performance of legume oil seeds is gave that ultimately links to key role of this nutrients in plants (photosynthesis regulations, root and shoot growth, nitrogen fixation, partitioning of photosynthates, constituent of plasma membrane, nucleic acid, many coenzymes, organic molecules and quality parameters etc.) This is in accordance with the findings by Adelson and Marcelo[1], and Ramaswamy *et al*[12].

Number of pods per plant, number of seeds per pod and test weight of seeds varied due to the different sources of phosphorus fertilizers. Among the treatments application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment has recorded significantly higher number of pods per plant (50.67), number of seeds per pod (3.00) and test weight (13.15 g). Lowest Number of pods per plant (29.00), number of seeds per plant (2.60) and test weight (7.21 g) has recorded in control. This may be due to the combined application of phosphorus fertilizers increased the nutrient supply which enhanced vegetative growth, affecting pod and seed formation and also test weight of soybean seeds. These findings are in agreement with that of Verde *et al*[14]. Also might be due to phosphorus solubilizing microbe inoculation increased uptake of nitrogen and phosphorus by plants. In addition, the microbes involved in phosphorus solubilization and production of plant growth promoting hormones which increased plant growth, development, number of pods, number of seeds and test weight of soybean crop. This is accordance with the findings by Athul *et al*[5].

Seed yield and stover yield of soybean differed significantly due to the application of different sources of phosphorus fertilizers in soybean. Among the treatments, application of 50 per cent of P_2O_5 through SSP + 50 per cent of P_2O_5 through Nutriphos + PSF (T_7) treatment has recorded significantly highest seed yield (23.76 q ha^{-1}) and stover yield (31.37 q ha^{-1}). Lowest seed yield (10.86 q ha^{-1}) and stover yield (16.86 q ha^{-1}) has recorded in control. The superiority of the combination of single super phosphate and rock phosphate nutrition over either single super phosphate or rock phosphate alone may be due to the priming action of water soluble phosphorus in the dissolution of rock phosphate. The results are in agreement with Sahu and Pal[13].

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