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Effect of phosphorus levels on comparison of soil test extractants for available soil phosphorus on soybean in vertisols

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Abstract
Phosphorus (P) fertilization is commonly based on soil testing, for which a variety of different soil P extraction methods are in use. The experiment was undertaken on medium black soil on the experimental field of Soil Science Department JNKVV Research Farm, Jabalpur. Five treatments based on targeted yield was laid in randomized block design consisted of T_1= control: T_2= GRD (20.60.20): T_3= Targeted Yield (2.5 t ha^{-1}): T_4= Targeted Yield (3.0 t ha^{-1}): T_5= Targeted Yield (3.5 t ha^{-1}), followed under optimum agronomic management practices. It was recorded that the Bray 2 method has extracted more available phosphorus than Troug, Mehlich 3 and Olsen having extracted lowest of all. The highest available phosphorus in the soil was noticed with the application of 118 kg ha^{-1} of phosphorus as obtained from the equation derived for targeted yield of soybean. The Olsen P is significantly small than the other three extractants. This indicates that other extracting agent extracted some forms of P that are not immediately available to 0.5M $NaHCO_3$ extractant. The methods of extraction for available Phosphorus, among the four extraction methods, the Bray 2 was found to extract high available P content followed by Troug, Mehlich 3 and Olsen in soils but it has not responded under field conditions as compared to olsen.

Keywords: Phosphorous, olsen, mehlich, troug, bray, fertilizers

Introduction

Soybean [*Glycine max* (L.) Merill] is protein and energy rich crop and have nutrient requirement especially the phosphorus in adequate amount. In India, soybean is cultivated in 10.88 million hectares with annual production of 10.44 million tones and the average productivity is 9.59 q ha^{-1} (The Soybean Processors Association of India, 2014) [10]. Madhya Pradesh contributes nearly 55.15% of the total area and 50.30% in total production of soybean in the country but the productivity of the crop is quite low (Agriculture Statistics, 2014) [2]. Phosphorus is the most important nutrient helps in biological nitrogen fixation in soybean and removes 28 kg P ha^{-1} from soil. The release of Phosphorus from soil is not markable it needs to be released completely from soil to nourish the crop. Targeted yield approach (Ramamoorthy *et al.*, 1967) [9] has been found beneficial which recommends balanced fertilization considering the soil available nutrient status and the crop need. The targeted yield approach is unique in developing fertilizer recommendation for desired targeted yield based on the farmers' resource availability and the farming community as this practices leads to balanced use of fertilizer for better crop yield and sustainable soil health. The most comprehensive approach of fertilizer application by incorporating soil test values at fixing yield-targets is possible only through Soil Test Crop Response approach. The available phosphorus supply of soils depends upon the amounts and forms of phosphorus present in soil. Various extractant have been developed to extract the soil phosphorus that plants would take up. In India, many researcher were used the ideal extractant sodium bicarbonate for measure phosphate availability in neutral to alkaline soils. The Olsen extractant, 0.5 M $NaHCO_3$ was developed for measuring labile P in calcareous soils (Olsen *et al.*, 1954) [8]. However, the method fails to predict growth responses when P fertility considered of the soils. Olsen's method sometimes underestimates P uptake from Vertisols which have been considered to have high P fixation capacity (Ae *et al.*, 1991) [1].

Material and Methods

Collection of soil samples

Soil samples were collected with the help of tube auger and screw auger from each plot of the experiment.

The samples were drawn from 0-15 cm depth at 30, 60, 90 DAS and at harvest stages of soybean crop 2015. Composite representative soil samples were obtained from each plot from different locations of each plot to insure representative sample of the plot adopting the quartering, technique. The soil samples were, processed through air-dried, crushed by wooden pestle and mortar and passed through 2 mm stainless steel sieve and stored in polythene bags at room temperature for further analysis.

Methods of soil analysis

Table : Available phosphorus estimation in soil by using different methods of extraction

S. No.	Method of extraction	Extractant	Soil: extractant ratio	Shaking time (mins.)	aliquot taken (ml)	Colour development
1	Olsen's	0.5 M $NaHCO_3$ at pH 8.5	1:20	30	5	Ascorbic acid
2	Bray 2	1 M NH_4F and 0.5 M HCL	1:20	1	5	
3	Troug	$(NH_4)_2SO_4$ and 1N H_2SO_4	1:200	30	5	
4	Mehlich 3	0.2 M CH_3COOH, 0.25 M NH_4NO_3, 0.015 M NH_4F, 0.013 M HNO_3, 0.001 M EDTA	1:10	5	5	

Olsen's

The phosphorus content of soil was estimated using procedure as described by Olsen *et al.* (1954) [8]. Soil available phosphorus was extracted with 0.5 M $NaHCO_3$ (pH 8.5) and colour developed by ascorbic acid as described by Miller and Keeney (1982). The absorbance of the blue colour was read on spectrophotometer at fixed wavelength (660 nm).

Bray 2

Phosphorus was extracted from the soil by Bray 2 extractant using 1 M ammonium fluoride and 0.5 M concentrated hydrochloric acid. Based on the reaction with ammonium molybdate and development of the 'Phospho Molybdenum Blue' colour complex was read on spectrophotometer at fixed wavelength of 882 nm.

Troug

Phosphorus is extracted from the soil using Ammonium Sulphate solution with 1 N Sulphuric acid as extractant. 1 gram soil sample was taken in 250 ml conical flask and 200 ml of extracting solution was added. The content was immediately kept on rotatary shaker for 30 minutes, after completing the shaking, the content was filtered through what man No. 1 filter papers and the solution was stored for Troug P analysis.

Mehlich 3

The phosphorus content in soil was estimated by using extraction procedure as described by Mehlich, 1984 [7]. The extracting solution was prepared of 0.2 M acetic acid (CH_3COOH), 0.25 M ammonium nitrate (NH_4NO_3), 0.015 M ammonium fluoride (NH_4F), 0.013 M HNO3 and 0.001 M ethylenediaminetetraacetic acid (EDTA) was taken in soil-to-solution ratio of 1:10. Two gram of soil as mixed with 20 ml of extracting solution and shaken for 5 minutes at room temperature, then filtered through what man No.1 filter paper and the solution was stored for Mehlich-3 P analysis.

Result and Discussion

Effect of phosphorus levels based on targeted yield on available P in soil with different extractant at 30 Das

The available phosphorus in soil at 0-15 cm soil depth as affected by different P levels. It is clear from data that available phosphorus content was significantly affected by different P levels by using different extraction methods of available phosphorus. The highest P level (118 kg P_2O_5 ha^{-1}) was recorded to be the best T.Y. having highest P-extracted by Bray 2 followed by Trough, Mehlich 3 and Olsen at both the surface and subsurface soils respectively against the initial values of available phosphorus. The highest phosphorus by different extraction methods are (14.81, 142.18, 87.53 and 21.87 kg ha^{-1}) at surface and subsurface (11.28, 100.17, 63.71 and 16.13) soils was obtain in higher P level in treatment (118 kg P_2O_5 ha^{-1}) targeted yield 35 q ha^{-1}.Similar finding were reported by Olsen *et al.* (1954) [8], Mamo *et al.* (2002) [5] and Dwivedi *et al.* (2014) [4].

Effect of phosphorus levels based on targeted yield on available P in soil with different extractant at 60 DAS

The available phosphorus in soil at 0-15 cm and 15-30 cm soil depth as affected by different P levels is clear from data that available phosphorus content was significantly affected by different P levels by using different extraction methods of available phosphorus. The highest P level (92 kg P_2O_5 ha^{-1}) was recorded to be the best T.Y. having highest P-extracted by Bray 2 followed by Trough, Mehlich 3 and Olsen at both the surface and subsurface soils respectively against the initial values. The highest phosphorus by different extraction methods are (24.67, 231.16, 106.85 and 31.13 kg ha^{-1}) at surface and at subsurface (14.85, 188.86, 73.91 and 24.75 kg ha^{-1}) soils was obtain in P level (92 kg P_2O_5 ha^{-1}) targeted yield 30 q ha^{-1}. Similar finding were reported by Olsen *et al.* (1954) [8], Mamo *et al.* (2002) [5] and Dwivedi *et al.* (2014) [4].

Effect of phosphorus levels based on targeted yield on available P in soil with different extractant at 90 DAS

The available phosphorus in soil at 0-15 cm and 15-30 cm soil depth as affected by different P levels is clear from data that available phosphorus content was significantly affected by different P levels by using different extraction methods of available phosphorus. The P level (92 kg P_2O_5 ha^{-1}) was recorded to be the best T.Y. having highest P-extracted by Bray 2 followed by Trough, Mehlich 3 and Olsen at both the surface and subsurface soils respectively against the initial values. The highest phosphorus by different extraction methods are (30.78, 235.93, 108.35 and 35.44 kg ha^{-1}) at surface and at subsurface (22.41, 217.23, 93.15 and 26.15 kg ha^{-1}) soils was obtain in P level (92 kg P_2O_5 ha^{-1}) targeted yield 30 q ha^{-1}. Olsen *et al.* (1954) [8], Mamo *et al.* (2002) [5] and Dwivedi *et al.* (2014) [4].

Effect of phosphorus levels based on targeted yield on available P with different extractant in soil at Harvest

Data on content of available phosphorus in soil at 0-15 cm and 15-30 cm soil depth as affected by different P levels is clear from data that available phosphorus content was significantly affected by different P levels by using different extraction methods of available phosphorus. The P level (60 kg P_2O_5 ha^{-1}) was recorded to be the best T.Y. having highest P-extracted by Bray 2 followed by Trough, Mehlich 3 and Olsen at both the surface and subsurface soils respectively against the initial values. The highest phosphorus by different extraction methods are (14.37, 141.54, 74.36 and 20.20 kg ha^{-1}) at surface and at subsurface (10.93, 111.81, 47.72 and 14.41 kg ha^{-1}) soils was obtain in P level (60 kg P_2O_5 ha^{-1}).Similar finding was reported by Olsen *et al.* (1954) [8], Mamo *et al.* (2002) [5], Steiner *et al.* (2010), Dwivedi *et al.* (2014) [4], Meetei *et al.* (2015) [6] and Wuenscher *et al.* (2015) [12].

Table 1: Effect of phosphorus levels based on targeted yield on available P in soil with different extractant at 30 DAS

P-levels	P-extraction in soil by different methods (kg ha^{-1})							
	Surface soil (0-15 cm depth)				Subsurface soil (15-30 cm depth)			
	Olsen	Bray 2	Troug	Mehlich 3	Olsen	Bray 2	Troug	Mehlich 3
T1: Control (0 kg P_2O_5 ha^{-1})	13.25	126.27	77.51	17.75	10.23	88.92	48.25	10.37
T2: GRD (60 kg P_2O_5 ha^{-1})	13.83	132.91	82.15	19.61	11.65	107.3	53.54	15.73
T3: T.Y. 25 q ha^{-1} (66 kg P_2O_5 ha^{-1})	14.17	135.89	83.32	20.36	12.17	109.27	66.33	14.6
T4: T.Y. 30 q ha^{-1} (92 kg P_2O_5 ha^{-1})	14.56	139.92	85.76	22.23	13.14	116.55	57.16	17.21
T5: T.Y. 35 q ha^{-1} (118 kg P_2O_5 ha^{-1})	14.81	142.18	87.53	21.87	11.28	100.17	63.71	16.13
SE m±	0.312	3.23	1.93	0.46	0.253	2.45	1.3	0.319
CD (p = 0.05)	0.962	9.94	5.94	1.42	0.78	7.55	3.99	0.983

Table 2: Effect of phosphorus levels based on targeted yield on available P with different extractant in soil at 60 DAS

P-levels	P-extraction in soil by different methods (kg ha^{-1})							
	Surface soil (0-15 cm depth)				Subsurface soil (15-30 cm depth)			
	Olsen	Bray 2	Troug	Mehlich 3	Olsen	Bray 2	Troug	Mehlich 3
T1: Control (0 kg P_2O_5 ha^{-1})	16.81	153.14	56.64	21.8	14.47	147.2	51.96	19.4
T2: GRD (60 kg P_2O_5 ha^{-1})	18.63	185.86	87.78	25.23	13.93	150.54	56.24	21.74
T3: T.Y. 25 q ha^{-1} (66 kg P_2O_5 ha^{-1})	21.95	228.63	98.27	24.42	14.31	167.47	58.17	20.73
T4: T.Y. 30 q ha^{-1} (92 kg P_2O_5 ha^{-1})	24.67	231.16	106.85	31.13	14.85	188.86	73.91	24.75
T5: T.Y. 35 q ha^{-1} (118 kg P_2O_5 ha^{-1})	22.7	209.54	98.93	26.13	13.73	156.11	65.27	19.54
SE m±	0.53	5.35	2.32	0.63	0.35	4.16	1.52	0.51
CD (p = 0.05)	1.63	16.48	7.15	1.95	1.07	12.82	4.67	1.57

Table 3: Effect of phosphorus levels based on targeted yield on available P with different extractant in soil at 90 DAS

P-levels	P-extraction in soil by different methods (kg ha^{-1})							
	Surface soil (0-15 cm depth)				Subsurface soil (15-30 cm depth)			
	Olsen	Bray 2	Troug	Mehlich 3	Olsen	Bray 2	Troug	Mehlich 3
T1: Control (0 kg P_2O_5 ha^{-1})	30.93	213.97	110.11	32.35	19.62	173.17	82.58	25.36
T2: GRD (60 kg P_2O_5 ha^{-1})	33.57	228.61	98.36	34.47	19.68	211.84	79.44	25.57
T3: T.Y. 25 q ha^{-1} (66 kg P_2O_5 ha^{-1})	32.75	221.72	105.13	36.53	20.78	207.19	85.15	28.66
T4: T.Y. 30 q ha^{-1} (92 kg P_2O_5 ha^{-1})	30.78	235.93	108.35	35.44	22.41	217.23	93.15	26.15
T5: T.Y. 35 q ha^{-1} (118 kg P_2O_5 ha^{-1})	30.41	200.15	87.29	31.63	21.47	186.93	71.72	23.85
SE m±	0.81	5.99	2.71	0.86	0.51	5.27	2.11	0.65
CD (p = 0.05)	2.48	18.46	8.36	2.63	1.57	16.22	6.49	1.99

Table 4: Effect of phosphorus levels based on targeted yield on available phosphorus with different extractant in soil at Harvest

P-levels	P-extraction in soil by different methods (kg ha^{-1})							
	Surface soil (0-15 cm depth)				Subsurface soil (15-30 cm depth)			
	Olsen	Bray 2	Troug	Mehlich 3	Olsen	Bray 2	Troug	Mehlich 3
T1: Control (0 kg P_2O_5 ha^{-1})	10.21	101.18	58.5	13.13	8.55	102.13	45.72	12.57
T2: GRD (60 kg P_2O_5 ha^{-1})	14.37	141.54	74.36	20.2	10.93	111.81	47.72	14.41
T3: T.Y. 25 q ha^{-1} (66 kg P_2O_5 ha^{-1})	13.53	132.73	66.7	16.32	9.85	101.86	49.15	13.19
T4: T.Y. 30 q ha^{-1} (92 kg P_2O_5 ha^{-1})	13.15	134.26	69.56	18.47	9.41	108.69	50.58	15.12
T5: T.Y. 35 q ha^{-1} (118 kg P_2O_5 ha^{-1})	11.37	115.63	61.97	15.12	8.77	103.47	44.86	12.38
SE m±	0.301	3.2	1.66	0.41	0.233	2.55	1.13	0.319
CD (p = 0.05)	0.928	9.86	5.12	1.26	0.718	7.87	3.49	0.981

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