

## PHOSPHATE USE EFFICIENCY IN GRAIN SORGHUM CULTIVARS

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A field experiment with 5 sorghum cultivars viz., CSH-5, CSH-6, Cs-3541, SPV-297 and PJ-8(K) was conducted to study the phosphate use efficiency in sorghum. Per cent P derived from fertilizer was increased with increasing levels of P at all the stages of growth. Amongst the sorghum cultivars, hybrid CSH-5 extracted maximum P (41.69%) from applied source. The per cent P removal by plant was low at second sampling (At 60 day plant growth stage). The genotypic ability for utilization of applied fertilizer P differed greatly. Hybrid CSH-5 utilized the largest amount of applied P (7.39 per cent) while PJ-8(K) utilized the lowest (3-10 per cent) during 60 days of plant growth. Significantly high P uptake in all the sorghum cultivars was observed at 90 kg  $P_2O_5$ /ha. Mean maximum P uptake (26.40 kg  $P_2O_5$ /ha) was recorded in hybrid CSH-5 and lowest (14.20 kg  $P_2O_5$ /ha) was observed in PJ-8(K). Even with applied fertilizer Phosphate, sorghum crop absorbed nearly 92 per cent of its total P uptake from native soil P source.

Grain sorghum *Sorghum bicolor* (L.) Moench is an important food crop particularly in arid and semi-arid tropical areas. Fertilizer use efficiency studies have attained greater importance in recent times to derive maximum utilization of applied fertilizer nutrients and thus save an investments on fertilizers. The utilization of fertilizer phosphorus by different crops has been shown to vary from 5 to 35 per cent (Larson, 1971).

The differential response of sorghum genotypes is an indication of differences that exist in the efficiency of phosphorus uptake. Selection of sorghum cultivars that can utilize most of applied phosphate for regional cultivation shall give an advantage for maximum utilization of applied phosphates and thus increase efficiency of P uptake.

Phosphate uptake or utilization of applied phosphate by sorghum also

varies during ontogenesis or developing stage of plant growth. It becomes therefore necessary to understand the stage of plant growth when phosphate uptake is maximum. This will greatly help to monitor phosphate availability in the soil during a particular plant growth stage. Plant absorb phosphates from soil and from applied phosphate source as well. By using labelled P source it is possible to measure the efficiency of plant use fertilizer. Per cent P derived from fertilizer and the percentage utilization of the applied fertilizer provide criteria for quantitative assessment of plant use efficiency of applied phosphate to the soil-plant system (Rennis and Fried 1971). It was therefore felt necessary to study the relative response of sorghum cultivars to varying levels of phosphate and to investigate by radiotracer technique the relative efficiency of sorghum cultivars in utilizing soil and fertilizer phosphorus.

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## MATERIAL AND METHODS

A field experiment was conducted at Agriculture College Farm, Parbhani during Monsoon Season of 1980 on medium black soil (pH 8.20, organic carbon 0.68 per cent, available phosphorus 14.06 Kg/ha and 7.5 per cent free  $\text{CaCO}_3$ ). Five sorghum cultivars viz., CSH-5; CSH-6; CS-3541; SPV-297 and PJ-8(K) were used. The experiment was laid out in factorial R.B.D. with four levels of phosphate, (i.e. 0, 30, 60, and 90, Kg  $\text{P}_2\text{O}_5$ /ha) replicated three times. Basal application of 50 Kg N/ha (through urea) and 60 Kg  $\text{K}_2\text{O}$ /ha (through muriate of potash) were made along with specified dose of P at the time of sowing. Additional 50 Kg N/ha as urea was applied 30 days after sowing. An area of 0.9 x 0.6 M<sup>2</sup> in two rows of each plot was marked for the application of labelled single super-phosphate. The specific activity of single super-phosphate was maintained at 0.4 mCi/g  $\text{P}_2\text{O}_5$  by use of carrier free <sup>32</sup>P procured from Bhabha Atomic Research Centre Trombay. Plant sampling was done on 30th and 60th day after sowing and the samples were analysed for radio-chemical phosphorus. Total P in triacid extract was determined colorimetrically by Vanadomolybdate method (Jackson, 1967). The radioassay of plant samples was done using G.M. counter.

$$\% \text{Pdff} = \frac{\text{Specific activity of sample}}{\text{Specific activity of fertilizer}} \times 100$$

% utilization of the applied fertilizer phosphorus

$$= \frac{\% \text{Pdff} \times \text{yield of p (Kg/ha) in plant}}{\text{Rate of fertilizer P application (Kg/ha)}}$$

The per cent P derived from fertilizer in 30 days of plant growth (Table-

## RESULTS AND DISCUSSION

## Grain and Fodder yield:

It is seen from the data on grain yield (Table 1) that amongst the five sorghum cultivars tested, hybrid CSH-5 give the highest grain yield (35.90 q/ha) and was followed by CSH-6, SPV-297, CS-3541 and PJ-8(K) yielded the lowest (20.37 q/ha). Phosphate application significantly increased the grain yield of all the sorghum cultivars over control. However, the dose effect was not significant. Sorghum cultivar PJ-8(K) responded significantly only upto 30 kg  $\text{P}_2\text{O}_5$ /ha, while other four cultivars showed response upto 60 kg  $\text{P}_2\text{O}_5$ /ha. It thus can be said that the optimum level of phosphorus for hybrids and improved varieties of sorghum is 60 kg  $\text{P}_2\text{O}_5$ /ha.

Fodder yield of four sorghum cultivars was increased significantly with increasing levels phosphorus, variety CS-3541 responded only upto 60 kg  $\text{P}_2\text{O}_5$ /ha. Increase in dry-matter in sorghum with increased levels of P was reported by Nagare (1969).

Per cent P derived from fertilizer (%Pdff) :

Efficiency of plant use of applied phosphate is assessed by determining per cent P derived from fertilizer (%Pdff) and percentage utilization of applied phosphate using the relationship.

2) by sorghum cultivars increased with increasing levels of fertilizers

phosphorus at all the stages of growth. Similar increase in uptake of added P was also reported by Simpson (1961). Hybrid CSH-5 extracted maximum P from applied source (41-69%), while lowest %Pdff was in case of PJ-8(K) (24.40%). Considerable higher amounts of fertilizer P was extracted by hybrid CSH-6 (35.54%) followed by improved varieties SPV-297 (34.63%) and CS 3541 (32.69%).

At second sampling (60 days after sowing) per cent P removed from fertilizer was reduced since plant developed massive root system and proportionately more nutrients are absorbed from the native soil source during later stage of growth. The average P derived from fertilizer by plants was low and varied from 19.09 to 36.39 per cent of total P in plants. However, the sequence of P removed from fertilizer was same as in the case of 30 days sampling.

Per cent utilization of applied fertilizer phosphate:

The utilization of applied fertilizer P was decreased with increasing P levels at all the stages of growth. This indicates that the application of higher doses of phosphorus are not properly utilized by sorghum plants. At higher rates of P application however, the plants were unable to utilize most of the applied nutrient resulting in lower recovery. Similar results were also reported by Sinha (1973),

The genotypic ability for utilization of applied fertilizer P differed greatly. Hybrid CSH-5 utilized the largest amount of applied P (7.39%) while PJ-8(K) utilized the lowest (3.10%),

during 60 days of plant growth. Hybrid CSH-6 was next followed by improved SPV-297 and CS-3541. It was interesting to notice that the per cent utilization of applied fertilizer is increased as the age of the plant advanced through the per cent P derived from fertilizer was reduced during later stages of growth. This may be on account of increased dry matter of Bio-mass production which required high P utilization.

Total P uptake:

Significantly high P uptake (Table 3) in all the sorghum cultivars was observed at 90 kg  $P_2O_5$ /ha. Mean highest P uptake (26.40 kg  $P_2O_5$ /ha) was recorded in hybrid CSH-5 and lowest was in PJ-8(K) (14.20 kg  $P_2O_5$ /ha). Relative higher P uptake was observed in SPV-297 (19.92 kg/ha) followed by CSH-6 (19.31 kg/ha) and CS 3541 (17.81 kg/ha).

Phosphorus derived from fertilizer was decreased at 90 kg  $P_2O_5$ /ha. It was 8.68 percent at 60 kg  $P_2O_5$ /ha but decreased at 6.54 per cent at 90 kg  $P_2O_5$ /ha level of P application. Irrespective of P levels highest P uptake from fertilizer was recorded in sorghum hybrid CSH-5 (14.56%), while it was lowest (3.71%) in PJ-8(K). There after the sequence appeared as CSH-6, SPV-297 and CS-3541. Such low uptake of applied fertilizer phosphate may be attributed to reduced availability of applied P due to high P fixing capacity of the soil (Ghonsikar & Musande, 1978). It is evident that though sorghum crop is supplied with fertilizer phosphate, native soil phosphate contri-

buted most to the total uptake of the phosphate in sorghum crop. Mean total P uptake of the sorghum crop (Average of total P uptake of five cultivars) was 19.52 kg P<sub>2</sub>O<sub>5</sub>/ha, nearly 92.05 per cent of this amount was a contribution of native soil phosphate.

Phosphate use efficiency of different sorghum cultivars under rainfed conditions seemed to be very low. Application of P beyond 60 kg P<sub>2</sub>O<sub>5</sub>/ha does not give any additional utilization of applied phosphates. Genotypic variability among sorghum cultivars in utilization of applied phosphate can be considered to make a selection for plant use efficiency of the fertilizer under a set of cultivation practices.

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Table 1 : Grain and fodder yield (q/ha) of sorghum cultivars as influenced by P application.

Cultivars	P <sub>2</sub> O <sub>5</sub> levels (kg/ha)				Mean
	0	30	60	90	
Grain yield					
CSH-5	29.8	35.6	38.9	39.1	35.9
CSH-6	29.8	30.6	34.6	34.6	31.5
CS-3541	25.5	27.7	30.2	30.2	28.4
SPV-297	26.6	28.4	34.0	34.1	30.8
PJ-8(K)	16.6	20.9	21.2	21.5	20.3
Mean	25.1	28.6	31.9	31.9	—
Cultivar Phosphate CXP					
C. D. at 5%		0.6	0.54	1.21	
Fodder yield					
CSH-5	87.9	82.7	89.3	93.1	86.0
CSH-6	63.8	65.8	70.9	71.5	68.0
CS-3541	65.2	68.0	72.5	72.6	69.6
SPV-297	68.4	72.9	76.5	78.3	74.0
PJ-8(K)	102.0	106.7	115.0	126.4	112.5
Mean	75.7	79.2	84.88	88.44	—
Cultivar Phosphate CXP					
C. D. at 5%		0.65	0.58	1.22	

Table 2: Per cent P derived from fertilizer (%Pdff).

Cultivar	P <sub>2</sub> O <sub>5</sub> levels (kg/ha)			Mean
	30	60	90	
1st Sampling (30 days of plant growth)				
CSH-5	35.4	42.4	47.1	41.6
CSH-6	30.3	34.0	42.2	35.5
CS-3541	26.1	33.2	38.6	32.6
SPV-297	27.8	35.8	40.1	34.6
PJ-8 (K)	20.0	22.2	24.9	24.4
Mean	27.9	33.5	38.6	
		Cultivar	Phosphate	C x P
C. D. at 5%		1.58	1.22	2.73
2nd Sampling (60 days of plant growth)				
CSH-5	31.7	37.6	39.7	36.3
CSH-6	26.9	28.6	35.6	30.3
CS-3541	21.2	25.0	27.9	24.7
SPV-297	23.5	29.4	30.6	27.8
PJ-8 (K)	16.4	20.2	20.6	19.0
Mean	23.9	28.1	30.90	
		Cultivar	Phosphate	C x P
C. D. at 5%		0.83	0.68	1.5

Table 3: Total P<sub>2</sub> O<sub>5</sub> uptake (kg/ha) by sorghum cultivars.

Cultivars	P <sub>2</sub> O <sub>5</sub> levels (kg/ha)				Mean
	0	30	60	90	
CSH-5	20.40	25.90	29.06	30.24	26.40
	-	(18.33)	(14.43)	(10.93)	(14.56)
CSH-6	16.17	18.58	21.73	22.46	19.31
	-	( 8.03)	( 9.20)	( 6.99)	(8.10)
CS-3541	15.08	16.94	19.51	19.83	17.81
	-	( 6.20)	( 7.22)	( 5.28)	(6.23)
SPV-297	16.52	18.58	21.67	22.89	19.92
	-	( 6.87)	( 8.58)	( 5.97)	(7.14)
PJ-8 (K)	12.35	13.47	14.68	16.31	14.20
	-	( 3.73)	( 3.88)	( 3.51)	(3.71)
Mean	16.10	18.70	21.30	22.34	19.52
	-	( 8.63)	( 8.68)	( 6.54)	(7.95)
			Cultivars	Phosphate	C x P
C. D. at 5%			0.315	0.282	0.663

Note: Figures in parenthesis indicate the percent P uptake from fertilizers.