

Rhizosphere Effect of *Kharif* Crops on Phosphatases and Dehydrogenase Activities in a *Typic Haplustert*

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Abstract In recent years phosphorus crisis is emerging at global level, every country in the world searching for alternative sources and management options for increasing its supply and use efficiency. Increasing cost of cultivation due to phosphatic fertilizers, attracting our mind towards it. In this experiment it was focused on effect of major kharif crops (maize, soybean, sorghum, pearl millet, finger millet and rice) on phosphatases and dehydrogenase activities in soil at different crop growth periods (30, 50, 75, 90 days after sowing and at crop harvest). Acid phosphatase activity varied crop wise and also at different crop growth periods. The maximum acid phosphatase activities were observed at 75 DAT in rice (0.206 mg PNP/g h), 90 DAS in sorghum (0.194 mg PNP/g h) and pearl millet (0.201 mg PNP/g h), 50 DAS in soybean (0.127 mg PNP/g h), and 30 DAS in maize (0.154 mg PNP/g h) and, 50 DAS as well as 75 DAS in finger millet (0.180 mg PNP/g h), respectively. But alkaline phosphatase activities were maximum at 75 days after sowing in all the crops i.e. sorghum (0.533 mg PNP/g h), soybean (0.465 mg PNP/g h), rice (0.440 mg PNP/g h), maize (0.538 mg PNP/g h), pearl millet (0.546 mg PNP/g h) and finger millet (0.530 mg PNP/g h), respectively. The dehydrogenase activities were also higher in 75 days after sowing in all the crops. These

enzyme activities associated with higher availability and uptake of phosphorus.

Keywords Acid phosphatase activity · Alkaline phosphatase activity · Dehydrogenase activity

Introduction

Phosphorus (P) is an important plant nutrient for crop growth and crop yield [1, 2]. It maintains biochemical, metabolic functions in plants; maintains soil fertility and soil health [3]. But lower phosphorus use efficiency limits crop yield and economic return [4]. Phosphorus fertilizers are totally imported in India and indigenous rock phosphate having low P concentration, increasing crop production cost. Plants exudate various type organic substances [5], which convert immobilize P into more plant available P [6]. Different phosphatases enzyme activities speed up the conversion process of immobile P to plant available P in soil solution, and indirectly enhance plant P uptake [7]. In rhizosphere region many microorganisms play a crucial role to enhance enzyme activities and P solubilization process. But it varies accordingly crop wise, species wise and under different crop cultivation practices [8]. Bacteria are more effective in phosphorus solubilization than fungi [9]. Among the whole microbial population in soil, phosphate solubilizing bacteria constitute 1–50 %, while phosphorus solubilizing fungi are only 0.1–0.5 % in P solubilization potential [10]. Hence the effect of different crops on phosphatase enzyme activities and dehydrogenase activity (DHA) should be studied and understood. Keeping all the above in mind, the pot culture experiment was conducted to understand the rhizosphere effect of maize, soybean, sorghum, pearl millet, finger millet and rice on these enzyme activities.

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Materials and Methods

A pot culture experiment was conducted at Indian Institute of Soil Science (IISS), Bhopal, India during *kharif* season of 2011. Geographically, Bhopal is situated at 23°18'N, 77°24'E and 485 m above mean sea level. It has semi-arid and sub-tropical dry summer and the cold winter climate with a mean annual air temperature of 25 °C and annual rainfall of 1,208 mm. Soil for the pot experiment was collected from the field of IISS, Bhopal. The collected soil was air dried and ground, and passed through a 2 mm sieve. The experimental soil belongs to Vertisols i.e. Hypothermic family of *Typic Haplusterts* popularly known as “black cotton soil”. The soil had the following properties : texture clay loam; pH(1:2.5) 8.06; EC (dSm⁻¹) 0.57; organic carbon 0.44 %; available N 115 kg ha⁻¹; available P 7.53 kg ha⁻¹, available K 185 kg ha⁻¹ and available S 9.1 kg ha⁻¹. The processed soil was filled in 90 plastic pots @ 10 kg/pot. In this experiment six crops were grown viz. maize, soybean, sorghum, pearl millet, finger millet and rice; the details of crop varieties and their characteristic features were depicted in Table 1. The crops were grown and rice seedlings were transplanted and replicated thrice. Recommended dose of N, P₂O₅ and K₂O (kg/ha) were applied i.e. 100:60:60 for sorghum, rice, maize and pearl millet; 30:60:40 for soybean and 60:40:40 for finger millet through urea, diammonium phosphate and muriate of potash. Half dose (50 %) of N and full doses of P₂O₅ and K₂O were applied as basal at the time of sowing in all the crops but in soybean all the nutrients were applied at the time of sowing. The remaining N was applied as two equal splits at 30 and 60 DAS. Zinc sulphate was applied @ 10 kg/ha for rice and 7 kg/ha other crops at the time of sowing. Soil samples were collected during the crop growth period at different time interval (30, 50, 75, 90 days after sowing/transplanting (DAS/DAT), and at crop maturity) and, the DHA [11], acid and alkaline phosphatase activities were

measured [12]. Statistical analysis was done for complete randomized design using WASP 2 [13].

Results and Discussion

Acid Phosphatase Activity

Data pertaining to acid phosphatase activities of soil was presented in Table 2. Variation in acid phosphatase enzyme activities was observed crop wise and at different crop growth periods. Among the crops, rice showed the highest mean acid phosphatase activity (0.173 mg PNP/g h) followed by finger millet (0.165 mg PNP/g h), pearl millet (0.154 mg PNP/g h), sorghum(0.140 mg PNP/g h), maize (0.140 mg PNP/g h) and soybean (0.107 mg PNP/g h). The acid phosphatase activity of soil varied in all the crops at different crop growth period. The maximum acid phosphatase activity was observed at 75 DAT for rice (0.206 mg PNP/g h), 90 DAS for sorghum (0.194 mg PNP/g h) and pearl millet (0.201 mg PNP/g h), 50 DAS for soybean (0.127 mg PNP/g h), and 30 DAS for maize (0.154 mg PNP/g h) and, 50 DAS as well as 75 DAS for finger millet (0.180 mg PNP/g h), respectively. Similar observations about the effect of different micro-organism on acid phosphates were observed in maize [9, 14]. Different crop growth stages showed different amount of acid phosphatase activity, it might be due to secretion of root exudates and biochemical changes in plant system [15]. Rice crop produce higher amount of root exudation in initial stages of crop growth which enhanced microbial activity in crop and modify nutrient concentrations in soil solution [16].

Alkaline Phosphatase Activity

The alkaline phosphatase activity of soil determined at different crop growth periods was presented in Table 3.

Table 1 Varietal characteristics of crop cultivars used in the experiment

Crop	Varieties	Characteristics
Sorghum	NJH-21	High yielding, drought tolerance, fatty acid composition 2.1–5.3 %, total saturated fatty acid 10.52 %
Soybean	JS-335	High yielding and early maturity; resistant to bacterial pastule, bacterial blight and susceptible to yellow mosaic virus
Rice	Kranti	Also known as R-2022, having short bold grain with white colour. It is best suited for irrigated areas
Maize	P-3540	Higher production, insect and acid resistant and suitable for rainfed cultivation
Pearl millet	VBBH-3115	Highly resistant to downy mildew; more number of synchronous tillers, long and very compact heads
Finger millet	V-10	Blast resistant, high production and total sugar reducing in reducing form

Table 2 Effect of different crops on acid phosphatase activity (mg PNP/g h) in soil

Crop	Crop growth period (DAS)					Mean
	30	50	75	90	At harvest	
Sorghum	0.138	0.118	0.145	0.194	0.106	0.140
Soybean	0.108	0.127	0.101	0.097	0.103	0.107
Rice	0.183	0.148	0.206	0.132	0.194	0.173
Maize	0.154	0.132	0.140	0.133	0.143	0.140
Pearl millet	0.139	0.159	0.159	0.201	0.110	0.154
Finger millet	0.143	0.180	0.180	0.171	0.151	0.165
CD ($P = 0.05$)	0.037	0.029	0.025	0.016	0.020	

Table 3 Effect of different crops on alkaline phosphatase activity (mg PNP/g h) in soil

Crop	Crop growth period (DAS)					Mean
	30	50	75	90	At harvest	
Sorghum	0.269	0.357	0.533	0.396	0.353	0.382
Soybean	0.276	0.351	0.465	0.357	0.239	0.338
Rice	0.214	0.370	0.440	0.309	0.294	0.325
Maize	0.237	0.353	0.538	0.368	0.241	0.347
Pearl millet	0.256	0.345	0.546	0.332	0.259	0.348
Finger millet	0.245	0.264	0.530	0.450	0.235	0.345
CD ($P = 0.05$)	0.024	0.062	0.060	0.056	0.051	

Table 4 Effect of different crops on DHA ($\mu\text{g TPF/g/24 h}$) in soil

Crop	Crop growth period (DAS)					Mean
	30	50	75	90	At harvest	
Sorghum	34.11	34.46	38.35	37.56	34.27	35.75
Soybean	31.40	30.47	35.63	32.05	35.03	32.92
Rice	37.14	34.07	40.47	35.53	38.41	37.12
Maize	31.62	26.35	33.62	30.20	29.11	30.18
Pearl Millet	37.10	32.98	37.48	37.46	30.11	35.03
Finger Millet	28.55	33.26	37.42	34.56	29.83	32.72
CD ($P = 0.05$)	2.27	2.76	2.73	0.84	1.25	

From the values it was clear that alkaline phosphatase activity of soil increased up to 75 DAS and afterwards it declined in all the crops. In respect to crops, alkaline phosphatase activity in soil was maximum at 75 DAS in all the crops i.e. sorghum (0.533 mg PNP/g h), soybean (0.465 mg PNP/g h), rice (0.440 mg PNP/g h), maize (0.538 mg PNP/g h), pearl millet (0.546 mg PNP/g h) and finger millet (0.530 mg PNP/g h), respectively. The mean alkaline phosphatase activity of soil was highest in sorghum (0.382 mg PNP/g h) followed by pearl millet (0.348 mg PNP/g h), maize (0.347 mg PNP/g h), finger millet (0.345 mg PNP/g h), soybean (0.338 mg PNP/g h) and rice (0.325 mg PNP/g h) respectively. Vigorous crop

growth enhanced the root exudation in soil and it enhanced the biological activities in the rhizosphere, which directly and indirectly enhanced the enzyme activity in soil [8].

Dehydrogenase Activity

Effect of different crops on DHA in soil was enlisted in Table 4. Among the enzymes DHA showed the little bit different path during the study. It varied from 34.11 to 38.35 $\mu\text{g TPF/g/24 h}$, 30.47–35.63 $\mu\text{g TPF/g/24 h}$, 34.07–40.47 $\mu\text{g TPF/g/24 h}$, 26.35–33.62 $\mu\text{g TPF/g/24 h}$, 30.11–37.48 $\mu\text{g TPF/g/24 h}$ and 28.55–37.42 $\mu\text{g TPF/g/24 h}$ in sorghum, soybean, rice, maize, pearl millet and

finger millet, respectively. But DHA activity varied crop wise and different crop growth period, the maximum activity was found at 75 DAS in all the crops, sorghum (38.35 $\mu\text{g TPF/g/24 h}$), soybean (35.63 $\mu\text{g TPF/g/24 h}$), rice (40.47 $\mu\text{g TPF/g/24 h}$), maize (33.62 $\mu\text{g TPF/g/24 h}$), pearl millet (37.48 $\mu\text{g TPF/g/24 h}$), and finger millet (37.42 $\mu\text{g TPF/g/24 h}$). It might be due to vigorous growth of the crops at 75 DAS, and the root exudation also more in this period. More microbial activities increased the DHA in the rhizosphere, due to more availability of food materials for its growth [17]. Variation in DHA activity in the rhizosphere due to plant genetic as well microbial species associated with it [18].

Conclusion

It was concluded that the *kharif* crops play a vital role in Indian food grain production but the cost of production is increasing due to fertilizers especially phosphorus. It reduces the profit of farmers. Different crops having rhizosphere effect on nutrient availability. Experimental data showed that various crops rhizosphere produced a different level of acid phosphatase activity. The highest acid phosphatase activity was observed at different stages for different crops, but alkaline phosphatase and dehydrogenase activities were maximum at 75 DAS in all the crops. These enzyme activities associated with higher availability and uptake of nutrients particularly phosphorus in plants.

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