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ASSESSMENT OF SOIL ENZYME ACTIVITIES UNDER RICE-WHEAT CROPPING SYSTEM IN GUGRAPUR BLOCK OF KANNAUJ DISTRICT, UTTAR PRADESH, INDIA

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ABSTRACT

A study was conducted to assess the soil enzyme activities under the rice-wheat cropping system in Gugrapur Block of Kannauj District, Uttar Pradesh. Soil samples were collected from the 0-15 cm soil depth from representative rice and wheat growing fields in 25 villages. The soil samples were analyzed for five important soil enzymes, namely dehydrogenase, urease, acid phosphatase, alkaline phosphatase and arylsulphatase using standard laboratory methods. The pooled results of two years revealed considerable variation in enzyme activities between the rice and wheat cropping phases. Under rice, dehydrogenase activity ranged from 50.57 to 63.31 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, with a mean of 56.82 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, while under wheat it ranged from 50.06 to 62.68 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, with a mean of 56.25 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$. Urease activity recorded mean values of 10.03 and 9.93 $\mu\text{g NH}_4^+ \text{-N g}^{-1} \text{h}^{-1}$, under rice and wheat, respectively. Acid phosphatase showed almost identical mean activities of 120.86 and 120.82 $\mu\text{g PNP g}^{-1} \text{h}^{-1}$, in rice and wheat, respectively. Alkaline phosphatase recorded the highest mean activity among the enzymes, with values of 139.30 $\mu\text{g PNP g}^{-1} \text{h}^{-1}$, in rice and 136.52 $\mu\text{g PNP g}^{-1} \text{h}^{-1}$, in wheat. Arylsulphatase activity averaged 16.25 and 15.77 $\mu\text{g PNP g}^{-1} \text{h}^{-1}$, under rice and wheat, respectively. The coefficient of variation was generally low for most enzymes, whereas arylsulphatase showed comparatively greater variability. Overall, the findings demonstrate active microbial and biochemical processes associated with nitrogen, phosphorus and sulphur transformation in the rice-wheat soils of Gugrapur Block.

Key words : Rice-wheat cropping system, Soil enzyme activity, Dehydrogenase, Urease, Phosphatase, Arylsulphatase, Soil biological health, Nutrient cycling.

Introduction

Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) is the largest cropping system practised in South Asian countries (Nawaz *et al.*, 2019). Rice is the staple food of eastern and southern parts of India (Singh *et al.*, 2013; Deogam *et al.*, 2020). Wheat is a good supplement for nutritional requirement of human body as it contains 8.0-15.0% protein, 60-68% starch, 1.5-2.0% fat, 2.0-2.5% cellulose and 1.5-2.0% minerals and vitamins (B complex and vitamin E), which is consumed as human as well as animal feed (Sharma, 2000 and Rueda-Ayala *et al.*, 2011).

Soil microorganisms are important participants in driving soil carbon and nitrogen cycles. Changes in

microbiological indicators such as soil microbial biomass and special enzyme activities (e.g., β -glucosidase and urease) under soil disturbances can apparently affect the biochemical transformations of soil carbon. Soil enzymes play an important role in the transformation of organic matter, nutrient cycling, nitrogen fixation, detoxification of pesticides etc. and thus regulate the ecosystem. Soil enzymes also help in reactions necessary for life processes of the microbial community in soils and in the formation of organic matter and soil structure (Dahm *et al.*, 2011). Soil enzymes are important for soil health and fertility management in different ecosystems (Makoi and Ndakidemi, 2008).

Among different soil enzymes, phosphatase plays an important role in organic phosphorus mineralization by hydrolytic cleavage of inorganic phosphate groups from organic phosphorus and thus helps in agriculture. Phosphatase enzymes are correlated to phosphorus stress and plant growth and in case of phosphorus deficiency, acid phosphatase secreted from roots will increase solubilization and mobilization of phosphate, which helps the plant to cope with P-stressed conditions (Versaw and Harrison, 2002).

Dehydrogenase activities in soil are biological indicators of the overall microbial respiratory activity of soils and are used by microorganisms in the soil to degrade organic matter. Urease enzyme plays an important role in hydrolysis of urea fertilizers applied to soil into NH_3 and CO_2 . Arylsulphatases are widespread in nature and soils which regulates the hydrolysis of aromatic sulphate esters to phenols and sulphate, or sulphate sulphur. Arylsulphatases help in sulphur mobilization in agricultural soils (Kertesz and Mirleau, 2004).

β -glucosidase enzyme is an important soil quality indicator and plays an important role in soils as it carries out hydrolysis and biodegradation of various β -glucosides present in plant debris during decomposition. Soil enzymes and microbial populations play a vital role in the decomposition of organic matter and helps in the maintenance of carbon and nitrogen stocks in the soil. Further, the information on soil carbon and nitrogen (Marinari *et al.*, 2006; Dick, 1997).

Materials and Methods

Study sites

Kannauj is located at 27.07°N 79.92°E. It has an average elevation of 139 metres (456 feet). The Ganges is the main river of the district at the North East border of the district. Kali river is at the northern border of the district while the Ishan River flows through the district. The climate of the district is characterized by a hot dry summer and a pleasant cold season according to Koppen and Geiger (1930). The average rainfall of the district is approximately 800 mm (KVK, Kannauj). The district is bounded by the districts of Farrukhabad to the north, Hardoi to the northeast, Kanpur Nagar to the east, Kanpur Dehat to the southeast, Auraiya to the south, Etawah to the southwest and Mainpuri to the west. The district is divided into three tehsils and eight development blocks. The district was split from Farrukhabad on 18 September 1997 and is part of Kanpur Division. The whole study was carried out in the 1 block (Gugrapur) of the district. Twenty-five villages were selected from Gugrapur Block and one representative

sampling site was selected in each village. The selection of villages and sites was based on rice wheat cropping system soil with help of GPS.

Collection of Soil samples and Laboratory analysis

Soil samples were taken at depths of 0-15 cm at the location. The soil samples were air-dried, crushed using a wooden pestle and mortar, sieved through a 2 mm mesh, labelled and stored at the Soil Laboratory of the Department of Soil Science and Agricultural Chemistry, C.S. Azad University of Agriculture and Technology, Kanpur - 208 002, U.P., India, in accordance with standard laboratory protocols. The soil samples were analysed for soil enzymes viz., Soil urease activity was determined by method described by Tabatabai and Bremner (1972). The acid and alkaline phosphatase activity was assayed by quantifying the amount of p-nitrophenol released after incubation of soil samples for one hour with p-nitrophenyl phosphate as described by Tabatabai and Bremner (1969). The Aryl Sulphatase activity was assayed by quantifying the amount of p nitrophenol released after incubation of soil samples for one hour with p nitrophenyl Sulphate as described by Tabatabai and Bremner (1970). Dehydrogenase activity was estimated by monitoring the rate of production of triphenyl formazon (TPF) from tri-phenyl tetrazolium chloride which is used as an electron acceptor. The method of Casida *et al.* (1964) was employed for the assay of dehydrogenase activity.

Data analysis

The data underwent descriptive statistical analysis, including minimum, maximum, mean and confidence interval and co-efficient of variation were calculated using R-Studio.

Results and Discussion

Soil Enzyme activities

The pooled results of two years revealed considerable variation in soil enzyme activities under rice-wheat cultivation in Gugrapur Block (Tables 1, 2 and Figs. 1, 2). Soil enzymes are sensitive indicators of soil biological activity because they participate in organic matter decomposition and nutrient cycling.

Dehydrogenase activity

Dehydrogenase activity in rice soils ranged from 50.57 to 63.31 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, with a mean value of 56.82 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, CI of 1.481 and CV of 0.063. In wheat soils, the activity ranged from 50.06 to 62.68 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, with a mean of 56.25 $\mu\text{g TPF g}^{-1} \text{h}^{-1}$, CI of 1.467 and CV of 0.063. Thus, dehydrogenase activity was slightly higher under rice than wheat, although the difference in mean activity was small. The identical CV values indicate similar

relative variability under both crops. Dehydrogenase activity is widely used as an indicator of overall microbial oxidative activity and soil biological functioning (Jat *et al.*, 2021).

Urease activity

Urease activity under rice ranged from 7.78 to 11.84 $\mu\text{g NH}_4^+\text{-N g}^{-1} \text{ h}^{-1}$, with a mean of 10.03 $\mu\text{g NH}_4^+\text{-N g}^{-1} \text{ h}^{-1}$, CI of 0.398 and CV of 0.096. Under wheat, it ranged from 7.70 to 11.72 $\mu\text{g NH}_4^+\text{-N g}^{-1} \text{ h}^{-1}$, with a mean of 9.93 $\mu\text{g NH}_4^+\text{-N g}^{-1} \text{ h}^{-1}$, CI of 0.395 and CV of 0.096. The mean urease activity was therefore slightly higher under rice than wheat. The similar CV values indicate comparable relative variability between the two cropping phases. Urease plays an important role in nitrogen transformation through the hydrolysis of urea in soil (Lakshmi *et al.*, 2014).

Acid phosphatase activity

Acid phosphatase activity in rice soils ranged from 99.66 to 139.17 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, with a mean value of 120.86 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, CI of 4.011 and CV of 0.080. In wheat soils, the activity ranged from 97.68 to 141.72 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, with a mean of 120.82 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, CI of 4.101 and CV of 0.082. The mean activities were almost

identical in rice and wheat, indicating very little difference in average acid phosphatase activity between the two crops. The slightly higher CV under wheat indicates marginally greater relative variability. Phosphatase enzymes are important in the mineralization of organic phosphorus and contribute to soil phosphorus cycling (Jat *et al.*, 2021).

Alkaline phosphatase activity

Alkaline phosphatase activity ranged from 122.36 to 157.09 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, under rice, with a mean value of 139.30 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, CI of 4.561 and CV of 0.079. Under wheat, it ranged from 119.93 to 153.96 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, with a mean of 136.52 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, CI of 4.470 and CV of 0.079. Rice therefore recorded a slightly higher mean alkaline phosphatase activity than wheat. The identical CV values indicate similar relative variability in both cropping phases. The higher alkaline phosphatase activity may indicate active biological phosphorus transformation in these soils (Gopal Ramdas *et al.*, 2017).

Arylsulphatase activity

Arylsulphatase activity in rice soils ranged from 9.17 to 22.12 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, with a mean value of 16.25 $\mu\text{g PNP g}^{-1} \text{ h}^{-1}$, CI of 1.514 and CV of 0.226. In wheat soils,

Table 1: Soil Enzyme Activities in rice crop of Gugrapur Block (pooled of 2 years).

Rice					
	Dehydrogenase ($\mu\text{g TPF g}^{-1} \text{ h}^{-1}$)	Urease ($\mu\text{g NH}_4^+\text{-N g}^{-1} \text{ h}^{-1}$)	Acid phosphatase ($\mu\text{g PNP g}^{-1} \text{ h}^{-1}$)	Alkaline phosphatase ($\mu\text{g PNP g}^{-1} \text{ h}^{-1}$)	Arylsulphatase ($\mu\text{g PNP g}^{-1} \text{ h}^{-1}$)
Minimum	50.57	7.78	99.66	122.36	9.17
Maximum	63.31	11.84	139.17	157.09	22.12
Mean	56.82	10.03	120.86	139.30	16.25
Confidence Interval	1.481	0.398	4.011	4.561	1.514
Co-efficient of variation	0.063	0.096	0.080	0.079	0.226

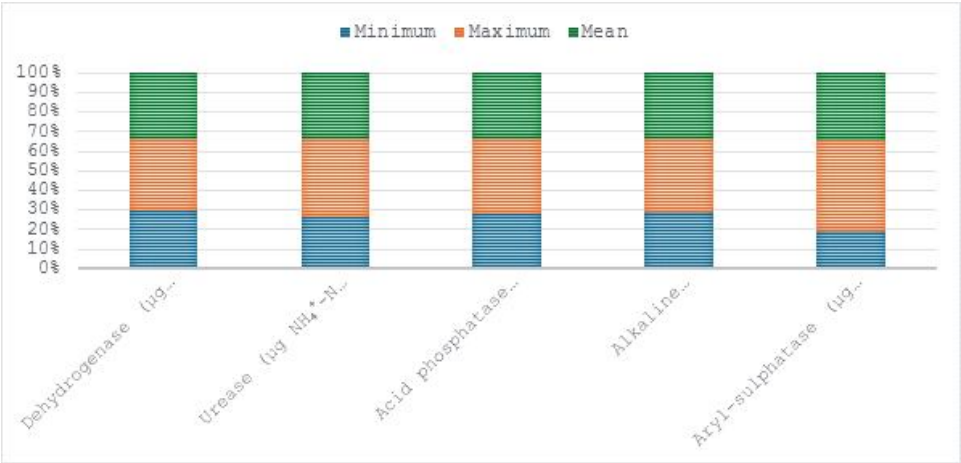


Fig. 1 : Soil Enzyme activities in rice crop of Gugrapur Block.

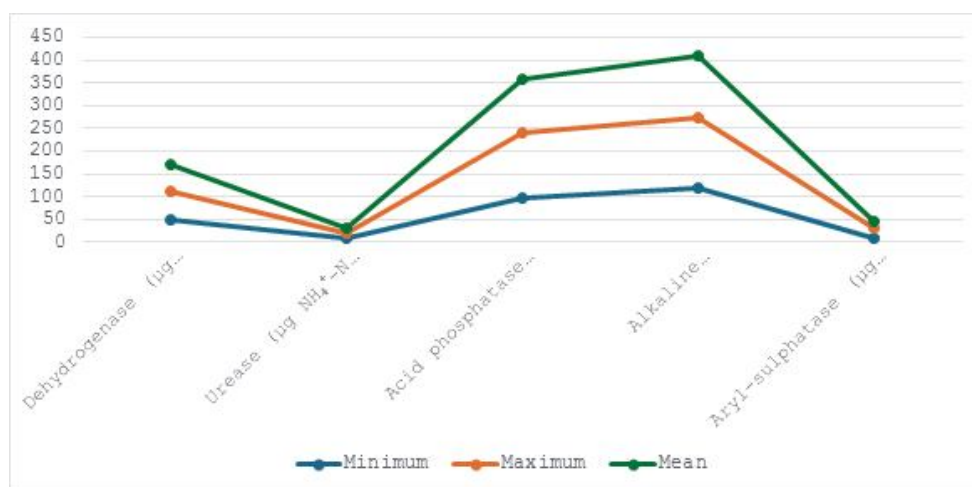


Fig. 2 : Soil Enzyme Activities in wheat crop of Gugrapur Block.

Table 2 : Soil Enzyme Activities in wheat crop of Gugrapur Block (pooled of 2 years).

Wheat					
	Dehydrogenase (µg TPF g ⁻¹ h ⁻¹)	Urease (µg NH ₄ ⁺ -N g ⁻¹ h ⁻¹)	Acid phosphatase (µg PNP g ⁻¹ h ⁻¹)	Alkaline phosphatase (µg PNP g ⁻¹ h ⁻¹)	Arylsulphatase (µg PNP g ⁻¹ h ⁻¹)
Minimum	50.06	7.70	97.68	119.93	8.72
Maximum	62.68	11.72	141.72	153.96	22.12
Mean	56.25	9.93	120.82	136.52	15.77
Confidence Interval	1.467	0.395	4.101	4.470	1.488
Co-efficient of variation	0.063	0.096	0.082	0.079	0.229

the activity ranged from 8.72 to 22.12 µg PNP g⁻¹ h⁻¹, with a mean of 15.77 µg PNP g⁻¹ h⁻¹, CI of 1.488 and CV of 0.229. The mean arylsulphatase activity was slightly higher under rice than wheat. The relatively higher CV in wheat indicates slightly greater variability in arylsulphatase activity. Arylsulphatase is associated with the mineralization of organic sulphur and therefore contributes to sulphur cycling in soil (Jat *et al.*, 2021).

Conclusion

The present study revealed appreciable soil enzyme activities under both rice and wheat cultivation in Gugrapur Block of Kannauj District. The pooled two-year results showed that rice soils generally recorded slightly higher mean activities of dehydrogenase, urease, alkaline phosphatase and arylsulphatase than wheat soils, whereas acid phosphatase activity was almost similar in both crops. Among the enzymes, alkaline phosphatase recorded the highest mean activity, indicating active biological phosphorus transformation in the studied soils. Dehydrogenase showed the lowest variability, while arylsulphatase exhibited comparatively greater variability across the sampling sites. Overall, the observed enzyme activities indicate active microbial functioning and nutrient

transformation, particularly related to nitrogen, phosphorus and sulphur cycling. Thus, soil enzyme activities can be useful biological indicators for assessing soil health and biological fertility under the rice-wheat cropping system.

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