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Soil Functional Diversity in Selected Rainfed Groundnut Production Systems of India

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ABSTRACT: Soil microorganisms are key drivers of various functions in agroecosystem. Soil dehydrogenase, alkaline and acid phosphatase enzymes are regarded as good indicators of microbiological activity of soils. The aim of the study was to assess the status of microbial activity in selected rainfed groundnut growing regions. Soil samples were collected from Bengaluru (Karnataka), Ananthapuramu (Andhra Pradesh), Sardar Krishinagar (Gujarat) and Rajkot (Gujarat) representing semi-arid (hot moist), arid (hot), semi-arid (hot dry), and semi-arid (hot dry) climatic conditions respectively. Microbial activities were estimated in terms of soil enzymes such as dehydrogenase, acid and alkaline phosphatase. The differences in microbial parameters across different regions were observed. Significant difference in dehydrogenase activity was observed between Sardar Krishinagar and Ananthapuramu soil samples. Higher soil functional diversity index was observed in Rajkot and Sardar Krishinagar. The results of the study suggest that, application of organic sources of nutrients like farm yard manure is essential to maintain soil microbial activity, functional diversity and soil health in rainfed groundnut production systems.

Keywords: Groundnut, microorganisms, rainfed, soil enzymes, soil health

Introduction

Soil microorganisms are indispensable part of agroecosystem as they perform multiple functions viz., organic matter decomposition, biogeochemical cycling of plant nutrients, mobilization, solubilization and transformation of nutrients, pest and disease management (Suman *et al.,*2022; Manjunath *et al.,* 2016 and 2017; Pratibha *et al.,* 2023). Soil enzymes are largely produced by microorganisms. They are vital for mineralization of soil organic matter, nutrient recycling and removal of toxic pollutants (Sainju *et al.,* 2022). They are largely used as indicators of microbial activity and soil health. Soil dehydrogenase, alkaline and acid phosphatase enzymes are regarded as good indicators of soil microbiological activity (Garcia *et al.,* 1997; Symanowicz *et al.,* 2022). Activities of soil micro-organisms are influenced by regional differences in climate, soil type and hydrothermal situations Srinivasarao *et al.,* 2018; Rampant use of inorganic fertilizers affects the diversity of soil microorganisms (Bharathi *et al.,* 2024). Decrease in soil microbial diversity would negatively impact the fertility and productivity of soil (Onet *et al.,* 2016). Groundnut is a major oilseed crop largely grown under rainfed conditions in India. Limited information is available on the status of soil microbial activity in different rainfed groundnut growing regions of India. Hence, the aim of the present study was to assess the status of microbial activity in selected rainfed groundnut growing regions viz., Bengaluru (Karnataka), Ananthapuramu (Andhra Pradesh), Rajkot (Gujarat) and Sardar Krishinagar (SK Nagar, Gujarat) representing semi-arid (hot moist), arid (hot), semi-arid (hot dry) and semi-arid (hot dry) climatic conditions respectively.

Materials and methods

Study area and collection of soil samples

The study area consisted of major rainfed groundnut growing regions viz., Ananthapuramu, Bengaluru, Sardar Krishinagar and Rajkot. The climatic and edaphic features of the studied rainfed groundnut growing locations have been presented in Table 1. Soil samples were collected from five farmer's field each from nearby areas of Ananthapuramu, Bengaluru, Sardar Krishinagar and Rajkot AICRPDA centers. At each farmer's field, after harvest of crop, four random samples (0-15 cm depth) were collected and pooled. The soil samples were immediately kept in cool boxes after removal of root pieces and gravel. The soil samples were brought to laboratory and stored at 4°C for further analysis.

Table 1: Climatic and edaphic characteristics of the studied locations

AICRPDA Centre	Agroclimatic Zone	Climate	Soil type	Rainfall (mm)
Ananthapu-ramu	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	Alfisols	544
Rajkot	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	Vertisols	590
SK Nagar	Northern Gujarat in Gujarat (2.3)	Semiarid/ Arid (Hot dry)	Entisols	670
Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	Alfisols	926

Analysis of microbial parameters

Soil dehydrogenase activity was measured spectrophotometrically using 2, 3, 5 triphenyl tetrazolium chloride (TTC) as substrate (Casida *et al.,* 1964). Alkaline and acid phosphatase enzyme activities were determined (Tabatabai and Bremner, 1969). Soil functional diversity was determined as per the procedure described by Rodriguez-Loinaz *et al.* (2008) and Kompała Bąba *et al.* (2021) with the following formula;

$$\text{Soil H}' = \sum_{i=1}^{s} pi \ \ln pi$$

where pi is the ratio of the activity of a specific enzyme to the sum of all the measured enzyme activities.

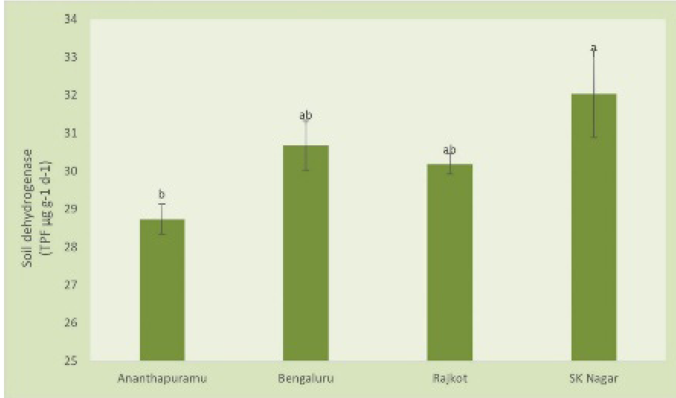
Statistical analysis

One way analysis of variance (ANOVA) of the data was done using SPSS 16.0 (SPSS Inc., Chicago, IL, USA) for windows. Comparison of means was made using the least significant difference at $p \leq 0.05$.

Results and Discussion

Soil dehydrogenase activity

Soil dehydrogenase activity ranged from 28.73 to 32.03 TPF µg/g/d in the studied rainfed groundnut growing regions viz., Ananthapuramu, Bengaluru, Sardar Krishinagar and Rajkot. Significantly ($p \leq 0.05$) higher dehydrogenase activity was recorded in SK Nagar (32.03 TPF µg/g/d), however it was at par with Bengaluru and Rajkot soil samples. Lowest dehydrogenase activity was observed in Ananthapuramu soil samples (Fig. 1).

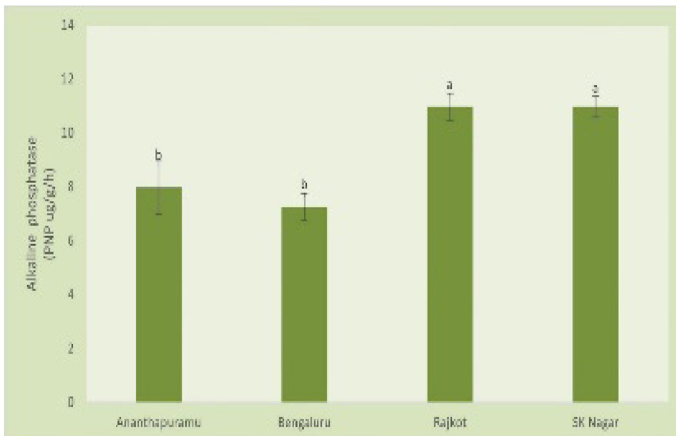


(Note: Data presented is means ±SE. Different alphabets at each column indicates significant difference ($p \leq 0.05$))

Fig. 1: Soil dehydrogenase enzyme activity (TPF µg/g/d) at selected rainfed groundnut growing locations

Alkaline phosphatase activity

Relatively higher and statistically ($p \leq 0.05$) at par values of alkaline phosphatase activity was observed in SK Nagar and Rajkot soil samples. Lowest alkaline phosphatase activity (7.25 PNP ug/g/h) was observed in Bengaluru soil samples (Fig.2).

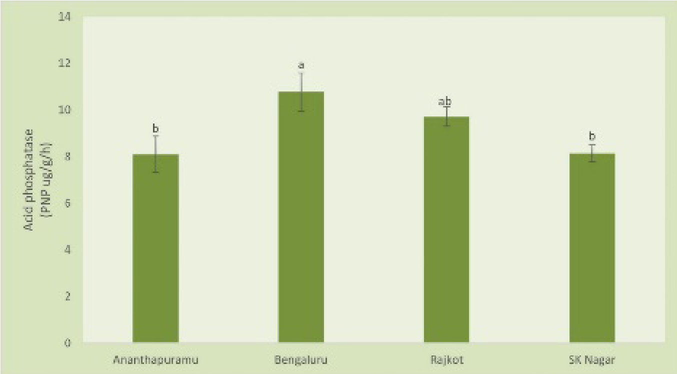


(Note: Data presented is means±SE. Different alphabets at each column indicates significant difference ($p \leq 0.05$))

Fig. 2: Alkaline phosphatase enzyme activity (PNP ug/g/h) at selected rainfed groundnut growing locations

Acid phosphatase activity

Maximum acid phosphatase activity (10.76 PNP ug/g/h) was recorded in Bengaluru soil samples followed by Rajkot. Lowest acid phosphatase activity (8.09 PNP ug/g/h) was noticed in Ananthapuramu soil samples, however it was statistically at par with SK Nagar and Rajkot soil samples (Fig. 3).

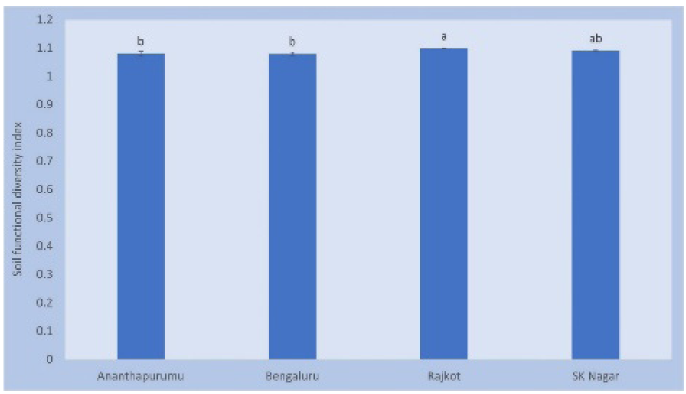


(Note: Data presented is means ±SE. Different alphabets at each column indicates significant difference (p≤0.05))

Fig. 3: Acid phosphatase enzyme activity at (PNP ug/g/h) selected rainfed groundnut growing locations

Soil functional diversity

Rajkot samples recorded significantly higher soil functional diversity index (H'=1.099) as compared to Ananthapuramu and Bengaluru soil samples. No significant difference in soil functional diversity index was observed between Bengaluru and Ananthapuramu soil samples (Fig. 4).



(Note: Data presented is means ±SE. Different alphabets at each column indicates significant difference (p≤0.05))

Fig. 4: Soil functional diversity index of selected rainfed groundnut growing locations

Soil microorganisms are the major source of soil enzymes (Bandick and Dick, 1999). Soil enzymes are very important for organic matter decomposition and cycling of various nutrients (Uwituze *et al.,* 2022). They act as early indicators of soil health (Sainju *et al.,* 2022) and have been widely used to monitor the soil health (Lee *et al.,* 2020). Dehydrogenase is an intracellular enzyme that functions only in living microorganisms hence, it is estimated to know the activity of living or viable microorganisms in the soil. In the present study, statistically at par values for dehydrogenase activity was observed in SK Nagar, Bengaluru and Rajkot soil samples. It could be due to regular use of FYM in the fields. Addition of FYM stimulates soil microorganisms due to the provision of organic carbon and other nutrients in easily available form (Kumar *et al.,* 2021). Soil treated with FYM and organic manure showed higher levels of dehydrogenase activity as compared to soil treated with mineral fertilizers (Lee *et al.,* 2004), reported that, incorporation of FYM enhanced the soil dehydrogenase activity. Acid and alkaline phosphatase enzymes convert organic phosphorus into inorganic phosphorus and improve fertility of soil (Kalayu, 2019; Chaudhary *et al.,* 2022). In the present investigation, maximum alkaline phosphatase activity was noticed in SK Nagar and Rajkot soil samples. Whereas Bengaluru soil samples recorded higher acid phosphatase activity as compared to other centers. Soil microbial functional diversity is important for organic matter decomposition and cycling of nutrients (JezierskaTys *et al.,* 2020). Organic sources of nutrients improved the soil microbial diversity (Manjunath *et al.,* 2018). In the present study, relatively maximum soil functional diversity index was observed in Rajkot followed SK Nagar soil samples. Higher functional diversity implies greater capability of utilization of different substrates by the microorganisms and participation in various transformation processes in soil.

Conclusion

Overall, higher soil microbial activity and functional diversity was recorded in Rajkot and SK Nagar soil samples. Inclusion of organic sources of nutrients such as farmyard manure in rainfed groundnut production is important for improving soil microbial activity, functional diversity and soil health.

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