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Influence of nutrient management practices on soil enzyme activity in finger millet

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Abstract
A field experiment was conducted during *Kharif*, 2022 on sandy loams soils at Indian Institute of Oilseed Research, Hyderabad to study the effect of nutrient management practices in finger millet crop. The results indicated that at panicle initiation and harvest stages of finger millet, the activity of urease, dehydrogenase and phosphatase enzymes was found highest in the treatment (T_8) which had received NPK + 0.2% B as foliar spray at flowering + FYM @ 2t ha^{-1} (N was applied in 3 splits) and this was on par with treatment (T_6) which received Soil Test Based (NPK) + FYM @ 2t ha^{-1} (N was applied in 3 splits), (T_7) NPK + 0.2% B as foliar spray at flowering (N was applied in 2 splits), (T_5) Soil Test Based (NPK) (N was applied in 2 splits) and (T_4) RDF (N was applied 3 splits).

Keywords: Finger millet, soil, nutrient management, urease, dehydrogenase and phosphatase

Introduction
Finger millet (*Eleusine coracana* L. Gaertn) commonly called as *Ragi*, is an important millet crop grown in India. It is the third most important millet after sorghum and pearl millet with a cultivated area of 1.014 million hectares and production of 1.52 million tonnes, having a productivity of 1747 kg ha^{-1}. In Telangana, area under Finger millet crop is 1012 hectares, with production of 1200 tonnes and productivity of 1220 kg ha^{-1} (www.indiastat.com., 2020-2021) [9]. It can be recommended as a contingent crop due to its short duration and ability to withstand harsh weather conditions. Being a C4 crop, it has higher water use efficiency and low input requirements. As this crop shows adapting ability to various ecological conditions, it can be integrated to different cropping systems.

Indiscriminate use of fertilizers and continuous application of chemical fertilizers pertaining to N and P only has resulted in stagnant yields due to declined response to blanket fertilizer application. Hence, balanced nutrient management is key in achieving higher yield and to maintain soil fertility. Further, high cost of chemical fertilizers and their negative impacts on soil health have led to growing interest in the organic nutrient management and conjunctive use of organic and chemical sources of nutrients. The enzymes in soil originate from animal, plant and microbial sources and are very much influenced by the addition of organic manures. Soil enzymes are biologically significant as they participate in the nutrient transformation, cycling of mineral elements and influence their availability to plant. Soil enzyme activities are 'sensors or indicators' of soil degradation since they exhibit information about microbial status and physico-chemical conditions of soil in relation to nutrients availability. Keeping these points in view the present study was conducted to know the changes of enzyme activities in response to different nutrient management practices in finger millet.

Materials and Methods
A Field experiment was carried during *Kharif*, 2022 at Indian Institute of Oilseed Research, Hyderabad. The experiment was laid out in randomized complete block design with 9 treatments, replicated thrice. The treatments included were T_1: Control, T_2: Farmers practice, T_3: RDF (N applied in 2 splits), T_4: RDF (N applied in 3 splits), T_5: Soil Test Based (NPK) (N applied in 2 splits), T_6: Soil Test Based (NPK) + FYM (farm yard manure) @ 2t ha^{-1} (N applied in 3 splits), T_7: NPK + 0.2% B foliar spray at flowering (N applied in 2 splits), T_8: NPK + 0.2% B foliar spray at flowering + FYM @ 2t ha^{-1} (N applied in 3 splits), T_9: FYM

+ GM (Goat manure) + *Azospirillum* + PSB (Phosphate solubilizing bacteria) + KSB (Potassium solubilizing bacteria) + ZnSB (Zinc solubilizing bacteria). The recommended dose of fertilizers for finger millet was 50-40-20 kg N, P_2O_5 and K_2O ha^{-1}. Nitrogen was applied in 2 splits *i.e* half @ sowing and remaining half @ 30 DAS, when applied in 3 splits 1/3 was applied @ sowing, 1/3 @ 30 DAS remaining as foliar N during panicle initiation stage of finger millet at 45 DAS. Soil Test based recommended dose of fertilizers (65-40-20 N, P_2O_5, K_2O kg ha^{-1} were applied to treatments T_5, T_6 and in T_7 and T_8, limiting micronutrient (Boron), respectively based on initial soil test values. Liquid Biofertilizers (*Azospirillum*, PSB, KSB and ZnSB each @ 1.25 L ha^{-1}) was applied to soil in T_9 treatment. Soil samples were collected at panicle initiation and harvest stages from each treatment in between the plants and were analysed for activity of urease, dehydrogenase, Acid phosphatase and Alkaline phosphatase by following the procedures as described by Bremner and Douglas (1971), [2] Casida *et al*. (1964) [3], Evazi and Batabai (1979) [5] and Tabatabai and Bremner (1972) [16], respectively.

Results and Discussion

The data pertaining to the activities of urease, dehydrogenase, acid and alkaline phosphatases enzymes in soil due to nutrient management practices in finger millet at panicle initiation and harvest stage are presented in Table 1, 2, 3 and 4.

Urease activity

The urease activity in soil at panicle initiation stage varied from 18.60 to 34.40 µg NH4+-N g^{-1} 2hr^{-1} and at harvest stage it was ranged between 14.20 to 30.80 µg NH4+-N g^{-1} 2hr^{-1}. At both the stages, significantly highest urease activity in soil was recorded in treatment T_8 (34.40 and 30.80 µg NH4+-N g^{-1} 2hr^{-1}, respectively) which had received recommend dose of NPK + 0.2% B + FYM @ 2t ha^{-1}, but the total N requirement of the crop was applied in 3 splits *i.e*., at sowing, 30 DAS and at 45-50 DAS. The effect of this treatment was on noticed to be at par with treatments T_6, T_7, T_5 and T_4 (Table1). At panicle initiation and harvest stage significantly lower urease activity was recorded in organics alone (22.30 and 18.20 µg NH4+-N g^{-1} 2hr^{-1}, respectively) and control (18.60 and 14.20 µg NH4+-N g^{-1} 2hr^{-1}, respectively). Highest urease activity was found in treatments receiving both inorganic source and organic source (T_8, T_6, T_4). This may be attributed to sufficient supply of energy source *i.e.* carbon from the organics and readily available nutrients from inorganic fertilizers for the growth of microbes responsible for releasing urease enzyme. Further, application of organic matter provides proper aeration, moisture content and nutrients which resulted in better proliferation of microorganisms. Singaram and Kamala Kumari (2000) [15] reported the enhanced levels of soil enzyme activity due to addition of FYM and Inorganic source. The higher organic matter levels in the farmyard manure treatments might have provided a more favourable environment for the accumulation of enzymes in soil matrix, since soil organic constituents were thought to be important in forming stables complexes with free enzymes (Ramalakshmi *et al*., 2011 and Vandana *et al*., 2012) [12, 17]. Similarly it was also reported by Yadav *et al*. (2013) [18] and Reddy *et al*. (2016) [14]. The urease enzyme activity at harvest was lower than at panicle initiation stage which could be due to lower moisture in soil affecting microbial activity.

Levels of soil enzyme activity due to addition of FYM. The higher organic matter levels in the farmyard manure treatments might have provided a more favourable environment for the accumulation of enzymes in soil matrix, since soil organic constituents were thought to be important in forming stables complexes with free enzymes (Ramalakshmi *et al*., 2011 and Vandana *et al*., 2012) [12, 16]. These results were in consonance with Yadav *et al*. (2013) [17] and Reddy *et al*. (2016) [13]. The enzymes activity at harvest was lower than at PI stage which could be due to lower moisture in soil affecting microbial activity.

Dehydrogenase activity

Dehydrogenase activity (DHA) indicates the overall microbial activity in the soil and the data pertaining to it at two growth stages of finger millet is presented in Table 2. At panicle initiation stage, it ranged from 32.41 to 54.21 µg TPF formed g^{-1} soil day^{-1}, while at harvest stage it ranged from 25.26 to 42.76 µg TPF formed g^{-1} soil day^{-1}. The highest dehydrogenase activity at panicle initiation (54.21 µg TPF formed g^{-1} soil day^{-}1) and harvest stage (42.76 µg TPF formed g^{-1} soil day^{-1}) was observed in the treatment receiving balanced nutrition in treatment T_8. The lowest values for both the stages was observed in control (32.41 and 25.26 µg TPF formed g^{-1} soil day^{-1}, respectively). Balanced application of nutrients included combined use of organics and inorganics based on actual soil test values in T_8 which recorded 44.13, 44.65 per cent increase over application of organic sources alone (T_9) at both the stages, respectively. This might be due to the addition of organic sources which might have created environment conducive for formation of soluble organic carbon pools which might have helped in stimulating the activity of soil microorganisms resulting in an increased DHA in the soil. These results were coincided with the findings of Prasad *et al*. (2010) [11] and Lee *et al*. (2004) [7] also reported that soil treated with organic manure showed higher level of dehydrogenase activity as compared to mineral fertilizers applied soil. Build-up of dehydrogenase activity in organics and inorganics treated plots may be due to increased organic carbon content and other nutrient sources that have contributed to the increased soil microorganisms which increased the dehydrogenase activity. These results were coincided with the findings of Mali *et al*. (2015) [8] and Mounika *et al*. (2021) [10].

Acid Phosphatase activity

Soil phosphatase activity are the most important in plant nutrition, these are involved in mineralization of organically bound phosphorus to inorganic phosphorus compounds in soil. The acid phosphatase (AcP) in the soil was significantly affected by nutrient management practices at both the stages of finger millet (Table 3). The highest acid phosphatase activity 27.3, 23.6 µg PNP g^{-1} soil h^{-1}at panicle initiation and harvest, respectively) was observed in the treatment (T_8) which received balanced nutrition *i.e* NPK + 0.2% B + FYM @ 2t ha^{-1} (N applied in 3 splits) and this was on par with T_6, T_7 and T_4 and lowest was recorded in control (15.6 and 12.50). Higher acid phosphatase activity might be ascribed to the increased population of microorganisms due to availability of substrate. Futher, the organic acids produced during the decomposition of FYM might have resulted in enhanced enzyme activity. These findings are in agreement with the studies of Ramakrishnaiah and Vijaya (2013) [13].

Alkaline phosphatase activity

The activity of alkaline phosphatase (AlP) followed the same trend of acid phosphatase activity. Significantly highest alkaline phosphatase over control were obtained in balanced nutrition where maximum 38.29, 24.21 µg PNP g^{-1} soil h^{-1} was shown by (T_8) NPK + 0.2% B + FYM @ 2t ha^{-1} (N applied in 3 splits) at both the stages of finger millet crop, respectively and it was on par with (T_6) Soil Test Based (NPK) + FYM @ 2t ha^{-1} (N applied in 3 splits), (T7) NPK + 0.2% B foliar spray at flowering (N applied in 2 splits), (T_5) Soil Test Based (NPK) (N was applied in 2 splits) and (T_4) RDF (N was applied 3 splits). Higher alkaline activity in soil might be due to the reason that microbes continuously produce and secrete the enzyme necessary for degradation of their substrate (food). Roots might have secreted organic acids and carbohydrates, which stimulate higher soil enzyme activities. In all the treatments the acid and alkaline phosphatase activity exhibited highest activity at panicle initiation and thereafter the activity gradually decreased at harvest. The sharp increase in the enzyme activities at panicle initiation stage which coincides with the active growth stage of the crop, enhanced root activity and the release of extracellular enzymes like urease and phosphatase into soil solutions during the active growth phase which resulted in higher rate of mineralization of nutrients in the soil. The results were in conformity with the findings of Jagadeesh (2000) [6], Datt *et al*., (2013) [4] and Aher *et al*., (2015) [1]. Further, the treatments receiving only organics (T_9) showed decrease in phosphatase activity might be due to non-availability of phosphorous source for microbial growth which might have affected the enzyme activity as the P in organic sources gets released slowly.

Table 1: Effect of nutrient management practices on soil urease activity

Treatments	Urease (µg NH4+-N g^{-1} $2hr^{-1}$)	
	Panicle Initiation	Harvest
T_1 - Control	18.60	14.20
T_2 - Farmers practice	26.10	22.20
T_3 - RDF (N applied in 2 splits)	29.80	26.20
T_4 - RDF (N applied in 3 splits)	30.90	27.20
T_5 - STB (NPK)(N applied in 2 splits)	31.40	28.00
T_6 - STB (NPK) + FYM @ 2 t ha^{-1} (N applied in 3 splits)	33.40	29.80
T_7 - (NPK) + 0.2% B (N applied in 2 splits)	32.40	29.00
T_8 - (NPK) + 0.2% B + FYM @ 2 t ha^{-1} (N applied in 3 splits)	34.40	30.80
T_9 - FYM + GM + *Azospirillum* + PSB + KSB + ZnSB	22.30	18.20
S.Em (±)	1.19	1.28
CD (P=0.05)	3.58	3.84
CV (%)	7.18	8.19

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Table 2: Effect of nutrient management practices on soil dehydrogenase activity

Treatments	Dehydrogenase (µg TPF g^{-1} day^{-1})	
	Panicle Initiation	Harvest
T_1 - Control	32.41	25.26
T_2 - Farmers practice	43.01	33.96
T_3 - RDF (N applied in 2 splits)	48.31	38.16
T_4 - RDF (N applied in 3 splits)	49.41	38.96
T_5 - STB (NPK)(N applied in 2 splits)	50.41	39.76
T_6 - STB (NPK) + FYM @ 2 t ha^{-1} (N applied in 3 splits)	53.01	41.66
T_7 - (NPK) + 0.2% B (N applied in 2 splits)	51.71	40.76
T_8 - (NPK) + 0.2% B + FYM @ 2 t ha^{-1} (N applied in 3 splits)	54.21	42.76
T_9 - FYM + GM + *Azospirillum* + PSB + KSB + ZnSB	37.61	29.56
S.Em (±)	1.68	1.36
CD (P=0.05)	5.05	4.09
CV (%)	6.25	6.42

Table 3: Effect of nutrient management practices on soil acid phosphatase activity

Treatments	Acid phosphatase (µg PNP g^{-1} hr^{-1})	
	Panicle Initiation	Harvest
T_1 - Control	15.6	12.5
T_2 - Farmers practice	21.4	17.8
T_3 - RDF (N applied in 2 splits)	24.2	20.6
T_4 - RDF (N applied in 3 splits)	25.2	21.3
T_5 - STB (NPK)(N applied in 2 splits)	25.9	21.8
T_6 - STB (NPK) + FYM @ 2 t ha^{-1} (N applied in 3 splits)	26.6	22.9
T_7 - (NPK) + 0.2% B (N applied in 2 splits)	26	22.2
T_8 - (NPK) + 0.2% B + FYM @ 2 t ha^{-1} (N applied in 3 splits)	27.3	23.6
T_9 - FYM + GM + *Azospirillum* + PSB + KSB + ZnSB	18.5	15.2
S.Em (±)	0.88	0.84
CD (P=0.05)	2.65	2.51
CV (%)	6.54	6.64

Table 4: Effect of nutrient management practices on soil alkaline phosphatase activity

Treatments	Alkaline phosphatase (µg PNP g^{-1} hr^{-1})	
	Panicle Initiation	Harvest
T_1 - Control	19.29	12.51
T_2 - Farmers practice	25.29	18.21
T_3 - RDF (N applied in 2 splits)	28.19	21.01
T_4 - RDF (N applied in 3 splits)	29.19	21.81
T_5 - STB (NPK)(N applied in 2 splits)	29.69	22.21
T_6 - STB (NPK) + FYM @ 2 t ha^{-1} (N applied in 3 splits)	30.99	23.41
T_7 - (NPK) + 0.2% B (N applied in 2 splits)	30.49	22.51
T_8 - (NPK) + 0.2% B + FYM @ 2 t ha^{-1} (N applied in 3 splits)	31.89	24.21
T_9 - FYM + GM + *Azospirillum* + PSB + KSB + ZnSB	22.29	15.41
S.Em (±)	0.90	0.88
CD (P=0.05)	2.70	2.64
CV (%)	5.68	7.58

Conclusion

From the foregoing discussion, it is clear that in all the treatments soil enzymes (urease, dehydrogenase and phosphatases) exhibited more activity at panicle initiation, there after activity was reduced at harvest of finger millet crop. Balanced application of nutrients based on actual soil test values utilising both organic and inorganic sources (NPK + 0.2% B + FYM @ 2t ha^{-1}) registered significantly highest urease, dehydrogenase and phosphatase activity at panicle initiation and harvest stages of finger millet crop, which in turn can enhance nutrient availability to plants through faster mineralization processes.

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