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Effect of microbial consortia on soil enzymatic activities of sorghum [*Sorghum bicolor* (L.) Moench] rhizosphere under glass house conditions

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ABSTRACT

A pot experiment was conducted under green house conditions to study the influence of microbial consortia on rhizospheric soil enzymatic activities at different intervals of sorghum growth. Microbial consortia along with different doses of chemical fertilizers and FYM were added to sorghum (CSV-27). Different soil enzymes *viz*., acid phosphatase, alkaline phosphatase, dehydrogenase enzyme and urease enzyme activity were monitored at zero DAS, 45 DAS, 90DAS and 120DAS in potculture. Treatment T_{10} (75% RDF + Microbial consortium-2 +FYM) showed significantly highest enzymatic activity of all the enzymes at all intervals of crop growth compared to other treatments. While, except urease all the other three soil enzymes like dehydrogenase, acid phosphatase and alkaline phosphatase activities were significantly lowest in T_{11} (100% RDF). Microbial consortium-2 showed maximum enzymatic activity compared to microbial consortium-1.

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INTRODUCTION

A diverse group of bacteria, including different species of *Azospirillum, Azotobacter, Rhizobium, Bacillus, Pseudomonas, Klebsiella, Enterobacter,* and many others, facilitate plant growth by various mechanisms. These micro-organisms are the important tools for sustainable environment and agriculture because they not increase the availability of essential nutrients to plants but also helps to enhance the nutrient use efficiency. Several researchers have reported improved growth and yield of agricultural crops in response to microbial inoculants both under pot experiment and field conditions (Naiman *et al*., 2009).

Micro-organisms are important source of soil enzymes and play an important role in plant growth,

macro and micro nutrient cycling in soil. Higher C into the soil in the form of root exudates enhances the microbial activity. Enzyme activities varies with the microbial load, microbial activity which is directly or indirectly dependent on the crop growth and stage. Further the externally applied microbial inoculants and chemical inputs can also alter the soil enzymatic activities.

The present study has been taken upto find out the relationship between the externally applied microbial consortia and chemical inputs on soil enzyme activity in the presence of host crop.

MATERIAL AND METHODS

Soil preparation and sowing:

In this experiment we used black soil and sand mixture in the ratio of 2:1 as potting mixture. Soil mixture was weighed and 7 kg was filled in each pot. CSV-27 of sorghum was selected for the experiment and only 2 plants per pot was maintained.

Microbial inoculats:

Microbial consortia were prepared and mixed with the carrier material in 1:3 ratio (consortial broth: carrier material).

– Peat + Microbial consortium 1 (*Azospirillium*, P-solubilizer, K-releaser, Zn-solubilizer and PGP isolate)

– Lignite +Microbial consortium 2 (*Azotobacter*, *Azospirillium*, P-solubilizer, K-releaser, Zn-solubilizer and PGP isolate)

The following treatments were imposed in the present study:

– T_1 : Microbial consortium 1
– T_2 : Microbial consortium 2
– T_3 : 50% RDF + Microbial consortium 1
– T_4 : 50% RDF + Microbial consortium 2
– T_5 : 50% RDF+ FYM + Microbial consortium 1
– T_6 : 50% RDF+ FYM + Microbial consortium 2
– T_7 : 75% RDF + Microbial consortium 1
– T_8 : 75% RDF + Microbial consortium 2
– T_9 : 75% RDF+ FYM + Microbial consortium 1
– T_{10} : 75% RDF+ FYM +Microbial consortium 2
– T_{11} : 100% RDF
– T_{12} : 100% RDF + FYM

Dehydrogenase enzyme activity estimated as given by Casida *et al*. (1964). Phosphatase enzyme activity estimated as given by Tabatabai and Bremner (1969). Urease enzyme activity estimated as given by Tabatabai and Bremner (1972).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Effect of carrier based microbial consortia on enzymatic activities:

Dehydrogenase enzyme activity:

Dehydrogenase enzyme activity was 80.74 µg TPF g^{-1} day^{-1} in the initial potting mixture at zero day. At 45 DAS all the treatments showed increased dehydrogenase enzyme activity compared to initial. Significantly highest dehydrogenase enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 152.27 µg TPF g^{-1} day^{-1}, which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 150.38 µg TPF g^{-1} day^{-1}. At 90 DAS all the treatments showed increased dehydrogenase enzyme activity compared to initial and 45 DAS. Significantly highest dehydrogenase enzyme activity was observed in T_{10} (75%RDF + microbial consortium-2+ FYM) 191.94 µg TPF g^{1} day^{-1} which was significantly higher than T_9 (75%RDF + microbial consortium-1+ FYM) 188.69 µg TPF g^{-1} day^{-1}. At 120 DAS dehydrogenase enzyme decreased in all treatments compared to 90 DAS but comparitively more than activity at 45 DAS. Significantly highest dehydrogenase enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 141.75 µg TPF g^{1} day^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 140.70 µg TPF g^{-1} day^{-1} (Table 1).

Microbial enzyme activity increased from zero day to 45 DAS in all the treatments and comparitively highest enzymatic activity was observed at 90 DAS and then decreased by 120 DAS.

The dehydrogenase enzyme in the soil observed to be highest at 90 DAS and the reason might be due to root mass accumulated as higher C inputs in the soil that enhanced the microbial activity which helped in increased dehydrogenase activity. Fertilization also improved dehydrogenase activity. Dehydrogenase enzyme activity improved with of N fertilizer application as reported by Serra-Wittling *et al*. (1995). The dehydrogenase activity and microbial population were observed to be correlated significantly with soil organic Chander *et al*. (1977) studied the biological oxidation of

Table 1 : Effect of microbial consortia on dehydrogenase enzyme activity at different stages of sorghum crop growth

Treatments	Dehydrogenase enzyme activity (µg TPF g^{-1} day^{-1})		
	45 DAS	90 DAS	120 DAS
T_1	116.38	150.38	122.86
T_2	120.43	156.32	126.91
T_3	126.91	161.18	129.07
T_4	129.34	164.41	130.69
T_5	135.27	170.35	132.84
T_6	139.05	172.24	135.27
T_7	142.83	179.80	138.51
T_8	148.49	184.38	139.32
T_9	150.38	188.69	140.70
T_{10}	152.27	191.94	141.75
T_{11}	95.61	123.67	111.86
T_{12}	101.27	129.60	116.38
S.E. ±	0.246	0.258	0.279
C.D. (P=0.05)	0.723	0.756	0.818
CV	0.328	0.271	0.370

soil organic compounds as a dehydrogenation process and concluded that soil dehydrogenase activity is a measure of microbial metabolism in soils. More organic compounds addition led to increased microbial population which leads to more dehydrogenase enzyme activity in soil. The studies showed a positive correlation between soil dehydrogenase activity and microbial biomass.

Acid phosphatase enzyme activity:

Activity of acid phosphatase enzyme was 21.81 µg PNP g^{-1} h^{-1} in the initial soil sample at zero day. At 45 DAS all the treatments showed increased activity of acid phosphatase enzyme compared to initial soil. Significantly highest activity of acid phosphatase enzyme was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 63.59 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75%RDF + microbial consortium-1+ FYM) 61.11 µg PNP g^{-1} h^{-1}. At 90 DAS all the treatments showed increased acid phosphatase enzyme activity compared to initial and 45 DAS. Significantly highest acid phosphatase enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 84.11 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 80.75 µg PNP g^{-1} h^{-1}. At 120 DAS activity of acid phosphatase enzyme decreased in all treatments compared to 90 DAS while it was more than at 45 DAS. Significantly highest activity of acid phosphatase enzyme was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 75.26 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75%RDF + microbial consortium-1+ FYM) 71.55 µg PNP g^{-1} h^{-1}. (Table 2).

Table 2 : Effect of microbial consortia on acid phosphatase enzyme activity at different stages of sorghum crop growth

Treatments	Acid phosphatase enzyme activity (µg pNP g^{-1} h^{-1})		
	45 DAS	90 DAS	120 DAS
T_1	37.59	56.34	45.73
T_2	39.36	58.99	48.38
T_3	43.43	63.77	52.45
T_4	46.08	66.95	55.63
T_5	47.67	69.07	58.29
T_6	52.10	70.31	61.65
T_7	55.81	75.26	64.48
T_8	57.75	78.62	67.30
T_9	61.11	80.75	71.55
T_{10}	63.59	84.11	75.26
T_{11}	30.70	50.50	41.48
T_{12}	33.53	53.51	44.49
S.E. ±	0.198	0.161	0.169
C.D. (P=0.05)	0.581	0.474	0.497
CV	0.724	0.415	0.512

The results were similar to experiments conducted by Goyal *et al.* (1999). Intense activity of phosphatase was observed when low available P was detected in soil to meet the demand of P by plant and microbes. Application of inorganic fertilizers and high activity of microbial population in the soil stimulated soil acid phosphatase activities.

Alkaline phosphatase enzyme activity:

Activity Alkaline phosphatase enzyme was 18.59 µg PNP g^{-1} h^{-1} in the initial soil sample at zero day. At 45 DAS all the treatments showed increased acid phosphatase enzyme activity compared to initial. Significantly highest acid phosphatase enzyme activity was observed in T_{10} (75%RDF + microbial consortium-2+ FYM) 52.10 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75%RDF + microbial consortium-1+ FYM) 50.33 µg PNP g^{-1} h^{-1}. At 90 DAS all the treatments showed increased acid phosphatase enzyme activity

compared to initial and 45 DAS. Significantly highest acid phosphatase enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 71.55 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 69.43 µg PNP g^{-1} h^{-1}. At 120 DAS acid phosphatase enzyme activity decreased in all treatments compared to 90 DAS while comparitively more that at 45 DAS. Significantly highest acid phosphatase enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 56.87 µg PNP g^{-1} h^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 54.75 µg PNP g^{-1} h^{-1} (Table 3).

Table 3 : Effect of microbial consortia on alkaline phosphatase enzyme activity at different stages of sorghum crop growth

Treatments	Alkaline phosphatase enzyme activity (µg pNP g^{-1} h^{-1})		
	45 DAS	90 DAS	120 DAS
T_1	24.15	43.43	31.05
T_2	25.57	45.73	31.58
T_3	33.35	52.27	39.19
T_4	35.47	53.69	40.25
T_5	39.36	60.41	44.49
T_6	40.60	62.71	45.91
T_7	43.96	63.41	49.27
T_8	45.55	64.83	50.33
T_9	50.33	69.43	54.75
T_{10}	52.10	71.55	56.87
T_{11}	20.62	40.78	29.81
T_{12}	23.45	42.55	30.87
S.E. ±	0.184	0.184	0.217
C.D. (P=0.05)	0.542	0.540	0.636
CV	0.882	0.570	0.893

The treatments having both microbial consortium and inorganic fertilizers showed higher activity of alkaline phosphatase as compared to the treatments added with inorganic fertilizers alone. This might be due to continuous production and secretion of the enzymes by microbes which are necessary for degradation of their substrate (food). At 90 DAS, roots may secret organic acids and carbohydrate, which stimulate higher soil enzyme activities. Soil alkaline phosphatase activities found to be positively correlated with PSB population in soil at all time intervals. Similar results were reported by Frankenberger and Dick (1983).

Soil alkaline phosphatase activity reportedly decreased at 120 DAS compared to other stages. The reason might be due to the crop attained maturity stage, so there was no production of root exudates which lead to lowering in alkaline phosphatase activity. Decline in the soil alkaline phosphatase activity at 120 DAS is due to decline in PSB population as the alkaline phosphatase is positively correlated with PSB population. These results were similar to the studies conducted by Goyal *et al*. (1999).

Urease enzyme activity:

Urease enzyme activity was 45.15 µg NH_4^--N g^{-1} h^{-1} in the initial soil sample. At 45 DAS all the treatments showed increased urease enzyme activity compared to initial. Significantly highest urease enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 92.26 µg NH_4^--N g^{-1} h^{-1} which was significantly higher than T_9 (75%RDF + microbial consortium-1+ FYM) 88.71 µg NH_4^--N g^{-1} h^{-1}. At 90 DAS all the treatments showed increased urease enzyme activity compared to initial and 45DAS. Significantly highest urease enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 123.83 µg NH_4^--N g^{-1} h^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 117.44 µg NH_4^--N g^{-1} h^{-1} (Table 4).

The treatments with microbial consortium along with added inorganic fertilizers showed higher urease activity

Table 4 : Effect of microbial consortia on Urease enzyme activity at different stages of sorghum crop growth

Treatments	Urease enzyme activity (µg NH_4^--N g^{-1} h^{-1})		
	45 DAS	90 DAS	At harvest
T_1	51.47	67.43	59.98
T_2	57.15	72.75	65.30
T_3	62.82	82.33	72.04
T_4	65.30	85.52	76.30
T_5	75.23	97.23	81.27
T_6	81.27	99.35	84.46
T_7	83.39	105.74	92.61
T_8	86.59	111.06	94.74
T_9	88.71	117.44	100.77
T_{10}	92.26	123.83	110.00
T_{11}	66.37	80.56	72.75
T_{12}	69.91	84.46	74.88
S.E. ±	0.340	0.355	0.324
C.D. (P=0.05)	0.997	1.041	0.951
CV	0.802	0.654	0.683

as compared to all the other treatments. Significantly higher urease activity was observed at 90 DAS compared to all time intervals. The results were similar with the research conducted by Frankenberger and Dick (1983). Urease enzyme activity was positively related to soil organic matter content and also microbial activity of the soil. The urease activity was observed to be positively correlated with bacterial population and available nitrogen in soil. The reason might be that the urease enzyme was involved in the hydrolysis of urea fertilizer this resulted in increased activity with increase in the level of N-fertilizer in the form of urea.

At 120 DAS urease enzyme activity decreased in all treatments compared to 90 DAS while comparitively more activity that at 45 DAS and initial. Significantly highest urease enzyme activity was observed in T_{10} (75% RDF + microbial consortium-2+ FYM) 110.00 µg NH_4^--N g^{-1} h^{-1} which was significantly higher than T_9 (75% RDF + microbial consortium-1+ FYM) 100.77 µg NH_4^--N g^{-1} h^{-1} (Table 4). The treatments having integrated application of microbial consortium and inorganic fertilizers were observed with higher urease activity as compared to treatments having application of inorganic fertilizers alone. Decrease in urease activity was reported at 120 DAS due to less available N in soil. The results were found to be in agreement with the findings of Frankenberger and Dick (1983).

Conclusion:

Soil enzymatic activity was significantly highest in treatment where there was an integrated use of microbial consortia, reduced dose of chemical fertilizers and FYM compared to the treatments with 100% RDF. Also the enzymatic activity was significantly highest during flowering stage in all the treatments which shows that root exudates and other secretions from the roots influence the enzymatic activities in the soil. Thus from the present study it was explained that the enzymatic activity in the soil can be improved by integrated use of microbial consortia, reduced dose of chemical fertilizers and FYM which indirectly leads to increase in crop growth attributes. Also the reduced use of chemical fertilizers substituted with microbial inoculants improves the soil health and it is also environmental friendly activity.

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