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Effect of Natural, Organic and Inorganic Farming Methods on Microorganisms and Enzymes Activity of Maize Rhizosphere

G. Vinay[1*], B. Padmaja[1], M. Malla Reddy[1], G. Jayasree[1] and S. Triveni[1]

[1]Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author GV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BP and MMR managed the analyses of the study. Authors GJ and ST managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Continuous use of fertilizers decreasing the biological activity of the soil. Fertile soils teem with microorganisms, which directly contribute to the biological fertility of the soil. Microorganisms are responsible for the availability of nutrients to the plants which are already exist in the soil. Hence, the present study focused on to investigate the effect of natural farming on soil microorganisms and enzymes activity of maize rhizospherein comparison with inorganic and organic farming during the autumn season of 2016-17 at Agricultural College, Jagtial. The results of the investigation revealed that the population of microbes (bacteria and fungi) at 30, 60 Days After Sowing (DAS) and harvest was unaffected by variety (Aswini) or hybrid (DHM 117). But, among the different farming methods, organic farming recorded higher bacterial (19, 29 and 22.5 x 10^{-7} CFU{Colony Forming Unit} g^{-1} dry soil) and fungi (8.25, 14.67 and 10.25 x 10^{-5} CFU g^{-1} dry soil) population at 30, 60 DAS and harvest stage respectively and significantly superior to inorganic and natural methods. The microbial population in inorganic method was inferior to that in absolute control similar to microbial population, highest urease activity was recorded in organic method at 30, 60 DAS and harvest (52.92, 68.33 and 33.25 µg NH_4^+ g^{-1} 2 h^{-1}, respectively) and it was superior to inorganic and natural farming which were at a par with each other. Significantly higher activity of dehydrogenase was

**Corresponding author: E-mail: vinaygadipe6859@gmail.com, vinaygadipe68959@gmail.com;*

observed with organic farming at 30, 60 DAS and harvest (1.65, 2.29 and 1.72 µg TPF g^{-1} day^{-1}) compared to natural farming and inorganic farming. The activity of urease and dehydrogenase remained similar with DHM 117 or Aswini.

Keywords: Enzymes; microorganisms; organic farming and natural farming.

1. INTRODUCTION

Maize (*Zea mays* L.) is the world's third most important cereal crop after rice and wheat. Generally maize is called as "Queen of cereals" due to higher yield. Maize is grown primarily for grain, fodder, raw material for industries and for diversified products. Being a C_4 plant it is capable to utilize solar radiation more efficiently even at higher radiation intensity. As heavy feeder of nutrients maize productivity is largely dependent on nutrient management. Therefore it needs fertile soil to express its yield potential [1]. In India it is being cultivated in an area 9.38 M ha^{-1} (2017-18) with the production of 28.08 Mt (2018-19) and productivity of 3065 kg ha^{-1}(2017-18) (*Indiastat* 2020**)**. In Telangana State, maize is cultivated in an area of 8.02 lakh ha (2016-17)with a total production of 26.63 lakh tons (2016-17) and productivity of 3321 kg ha^{-1} (2016-17) (*Indiast at* 2020).

The advent of Green Revolution in the latter of 1960's indicated a new era in the history of Indian Agriculture. The green revolution technology aimed at stimulating agriculture production primarily by replacing traditional hardy varieties of crops by high responsive varieties and hybrids, increasing the use of fertilizers and plant protection chemicals. This high consumption of fertilizers and agrochemicals leads to the decreased the biological properties of the soil such as soil microorganisms and enzyme activities. Even crops also not responding for high dose of nourishments due to poor biological properties of the soil [2].

Soil enzymes (intracellular and extracellular) are the mediators and catalysts of biochemical processes important in soil functioning such as nutrient mineralization and cycling, decomposition and formation of soil organic matter. Specifically, the assessment of the activities of hydrolases can provide information on the status of key reactions that participate in rate of limiting steps of the decomposition of organic matter and transformation of nutrients in soil. Thus knowledge of several soil enzyme activities can provide information on the soil degradation potential. Further, it has been reported that any change in soil management and land use is reflected in the soil enzyme activities, and that they can anticipate changes in soil quality before they are detected by other soil analyses. The use of amendments is a factor affecting enzymatic activities in the soil, the inclusion of organic manure, such as Farm Yard Manure (FYM), increases soil microbial biomass by incorporating additional microorganisms into the system and stimulating growth of autochthonous micro biota through the incorporation of new carbon sources [3]. There is need to compare the different farming methods (Natural, organic and inorganic) so that may help to compare effect of different farming methods on microorganisms population and enzyme activities.

2. MATERIALS AND METHODS

A field experiment was carried out during autumn, 2016 at Agricultural College Farm, Jagtial. The experimental soil was sandy clay loam in texture with pH (7.65), organic carbon (0.47 per cent), available nitrogen (164 kg ha^{-1}), available phosphorous (43 kg ha^{-1}) and available potassium (277 kg ha^{-1}).The experiment was laid out in randomized block design with factorial concept replicated thrice. Eight treatment combinations were taken *viz.,* factor I: Variety vs Hybrid:2 (V_1: DHM-117, V_2: Aswini, factor II: Farming methods:4, F_1: Absolute control(no fertilizers, pesticides, herbicides and no hand weeding but only irrigation as and when required), F_2: Natural farming(Seed treatment with *Beejamrutha* + application of *Jeevamrutha* at fortnightlyintervals + mulching with organic residues + plant protection with natural pesticides/fungicides like *Neemasram, Agnasram* and *Pullatimajjiga*), F_3: Organic farming(FYM @ 20 t ha^{-1} (basal) + Vermicompost @ 5 t ha^{-1} each at knee high stage and tasseling stage (top dressing) + plant protection with organic products) and F_4: Inorganic farming.The gross and net plot size for each treatment are 7.2 m × 6.0 m and 4.8 × 5.2 mrespectively.

*Beejamrutha*was prepared as per YoganandaBabu [2] i.e., mixing 5 kg desi cow dung, 5 liters of desi cow urine, 50 g lime and

100 g antennae soil with 20 liters of water and keep it as such for an overnight. On the day of sowing maize seeds were soaked in the *Beejamrutha* solution and dried in the shade before sowing, of the crop. *Jeevamrutha* was prepared by placing 200 liters of water in a barrel and added 10 kg fresh desi cow dung, 10 liters of desi cow urine, 2 kg each of jaggery and chickpea flour and 100 g of antennae soil. The mixture was fermented for 3 days in shade condition. Mulching was done with the use of paddy straw (8 inch layer) when the crop was at 3-4 leaf stage. *Neemasram* was prepared by mixing of 10 liters of cow urine and neem (*Azardiracta indica*) leaves in 200 liters of water and fermented for 5 days in shade condition. This fermented solution was applied as anti-repellent in form of spray.

In control treatment, there was no weed management was done. While in Natural faming method, mulch act as weed suppresser. In organic farming method, the weeds were controlled by hand weeding at 10 days interval up to 50 DAS. Pre emergence application of atrazine 50% WP @ 2.0 $kgha^{-1}$ with hand weeding at 10 and 40 DAS was practiced in inorganic farming method.

Fertilizer management in natural farming through basal application of g*anajeevamrutha* @ 500 kg ha^{-1} was followed by *jeevamrutha* @ 500 L ha^{-1} along with irrigation water starting from 15 DAS to harvest at 15 days interval. When rainfall occurred, it was sprayed directly on the soil through knapsack sprayer. While in organic farming, FYM was applied basally @ 20 tonnes ha^{-1} and vermicompost was applied @ 10 tonnes ha^{-1} at knee high and tasseling stages and in inorganic farming, a recommended dose of 200:60:50 kg ha^{-1} of $N:P_2O_5:K_2O$ as urea, di ammonium phosphate and murate of potash was applied, respectively. Nitrogen was applied in three equal splits i.e., as basal dose, at knee high and flowering stage. The recommended dose of phosphorous was applied as basal dose.

Soil samples were collected at 30, 60 DAS and harvest stages from the respective treatments of rhizosphere for the analysis of totalmicrobial population (total bacteria [X 10^{-7} CFU g^{-1} dry soil] and total fungi [X 10^{-5} CFU g^{-1} dry soil] population separately) and enzyme activity (urease and dehydrogenase). Total microbial population analysis was done by using serial dilution method. The media used for analysis of total bacteria population was “nutrient agar media” and for total fungi population, “potato dextrose agar media”. Urease activity (μg NH_4^+ g^{-1} 2 h^{-1}) in soil was assayed by quantifying the ratio of release of NH_4^+ from the hydrolysis of urea [4]. Dehydrogenase activity dehydrogenase (μg TPF g^{-1} day^{-1}) of soil was measured with spectrophotometer at 485 nm [5].

The data were analysed statistically applying analysis of variance technique for randomized block design (RBD) with factorial concept as suggested by Gomez and Gomez [6]. Critical difference for examining the treatment means for their significance was calculated at 5 per cent level of probability.

3. RESULTS AND DISCUSSION

3.1 Total Microbial Population

The bacterial and fungi population were found to be unaffected by the variety or hybrid (Table 1). However, the farming method had influenced at all the stages. At 30 DAS, highest bacterial population was recorded with organic farming method which was superior to all the other methods. It was followed by natural farming method which was again superior to inorganic farming and absolute control. Inorganic farming was at par with absolute control. At 60 DAS and harvest also, similar trend was observed. However, the bacteria in inorganic farming was significantly lower than absolute control at 60 DAS. But the reverse was observed at harvest stage.

Similar to bacteria, the population of fungiwas also higher with organic farming at 30, 60 DAS and harvest (Table 1). It was superior to all other methods including absolute control. The second best treatment was natural farming which was again superior to inorganic farming method and absolute control. The inorganic method was the least with respect to fungal population significantly inferior to absolute control as well.The interaction effect of variety/hybrid and farming was not statistically significant for both bacterial and fungal population (Table 1).

The superiority of organic farming in microbial population (bacteria and fungi) might be due to the fact that addition of FYM and vermicompost might have served as source of carbon and energy for microorganisms [7]. Inorganic farming method recorded significantly less number of microbial counts. This suggests that addition of organic matter is must for maintaining microbial population. In natural farming, even though the

population was higher than inorganic method but inferior to organic method. This can be attributed to the fact that even though organic matter is added in the form of *Jeevamrutha* or *Beejamrutha* the quantity might not be sufficient to enhance the microbial population within one season. Basappa et al. [8] also quoted that the effect of Subhash Palekar method i.e, natural farming method could be realized only after long term practice of the method. Application of organic matter provides proper aeration, moisture content and nutrients which results in proliferation of microorganisms. Low microbial population count in control might be due to poor availability of substrate to sustain microbial biomass. Enhancement in microbial population in organic method, natural farming method and with *Jeevamrutha* was also reported by Amith and Sharanappa [9]; Vijaya et al. [7] and Sudhanshu et al. [10].

3.2 Enzyme Activity in Maize Rhizosphere

The perusal of the data indicates that the urease and dehydrogenase activity did not change due to cultivation of DHM 117 or Aswini in all the stages under observations whereas, farming method had significant effect on its activity (Table 2).

In general, the urease activity increased from 30 to 60 DAS but reduced at harvest. At all the stages of estimation, highest urease activity was recorded in organic method. It was superior to natural and inorganic methods at all the stages of observation. Inorganic and natural methods were at par with each other and superior to absolute control which recorded the lowest urease activity.Highest activity of urease enzyme recorded at 60 DAS which coincided with tasseling stage *i.e.,* active growth stage of the crop might be due to enhanced root activity and higher rate of mineralization of nutrients in the soil [11].

Urease (urea amidohydrolase) is an important extracellular enzyme which influences the availability of plant utilizable forms of nitrogen in soils. Urease is an unique enzyme because it catalyzes the hydrolysis of urea to ammonia (NH_3) which is subsequently transformed to ammonium (NH_4^+) and nitrate (NO_3^-) ions. Nitrate fertilizers use efficiency can be influenced by the activity of this enzyme. The increase in urease activity with organic manures might be due to increasing population of microorganisms like bacteria (Table 1) and increased availability of substrate through organic manures. The results are in close conformity with Reddy and Reddy [12]; Reddy et al. [13], Usha et al. [11], Geetha et al. [14].

Among all enzymes in the soil environment, dehydrogenase (DG) is the most important and extensively used indicator of overall soil microbial activity, because it occur intracellular in all living

Table 1. Bacterial and fungal population in the rhizosphere of maize as influenced by different farming methods

Treatment	Bacteria (X 10^{-7} CFU g^{-1} dry soil)			Fungi (X 10^{-5} CFU g^{-1} dry soil)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Variety *vs* hybrid						
DHM 117	12.71	20.42	14.79	5.88	10.08	7.38
Aswini	13.38	21.50	14.50	6.08	10.38	7.71
SEm±	0.35	0.57	0.54	0.16	0.29	0.20
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Farming method						
Absolute control	9.08	16.67	11.92	5.25	8.25	6.17
Natural farming	14.75	24.50	16.83	6.92	11.92	8.08
Organic farming	19.00	29.00	22.50	8.25	14.67	10.25
Inorganic farming	9.33	13.67	7.33	3.50	6.08	5.67
SEm±	0.50	0.81	0.54	0.23	0.41	0.28
CD (P = 0.05)	1.52	2.46	1.62	0.69	1.23	0.86
Interaction						
SEm±	0.71	1.15	0.76	0.32	0.58	0.40
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	9.40	9.46	8.96	9.37	9.75	9.19

Table 2. Urease and dehydrogenase activity in the rhizosphere of maize as influenced by different farming methods

Treatment	Urease activity ($\mu g\ NH_4^+\ g^{-1}\ 2\ h^{-1}$)			Dehydrogenase activity (μg TPF $g^{-1}\ day^{-1}$)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Variety *vs* hybrid						
DHM 117	41.88	54.50	25.92	1.33	1.95	1.43
Aswini	43.04	55.83	26.96	1.28	1.79	1.41
SEm±	1.03	1.45	0.76	0.02	0.06	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Farming method						
Absolute control	31.0	39.17	18.83	0.82	1.03	0.96
Natural farming	42.5	55.50	25.83	1.34	2.15	1.45
Organic farming	52.92	68.33	33.25	1.65	2.29	1.72
Inorganic farming	45.42	57.67	27.83	1.42	2.01	1.54
SEm±	1.46	2.05	1.07	0.03	0.08	0.05
CD (P = 0.05)	4.42	6.21	3.26	0.10	0.24	0.15
Interaction						
SEm±	2.06	2.90	1.52	0.05	0.11	0.07
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	8.41	9.09	9.94	6.31	10.26	8.53

microbial cells. Dehydrogenase play a significant role in the biological oxidation of soil organic matter.

In general, the dehydrogenase activity was gradually increased from 30 DAS and reached its peak at 60 DAS, then reduced thereafter and recorded lowest values at harvest (Table 2). Among the farming methods, highest activity of dehydrogenase enzyme was observed in organic farming at all the intervals of observation, which was superior to the other two methods and except with natural farming at 60 DAS. Lowest dehydrogenase activity was recorded with absolute control. At 30 DAS, the dehydrogenase activity was significantly superior in inorganic farming compared to natural farming. But at 60 DAS and harvest, the two methods were at par with each other. Several workers reported the improved dehydrogenase activity with the application of organic manures [15,3,16] The interaction effect of variety/hybrid and farming was not statistically significant for both urease and dehydrogenase activity (Table 2). The enzymes activity (both urease and dehydrogenase) at harvest was lower than at peak growth stage which could be due to lower moisture in soil affecting microbial activity.

4. CONCLUSION

Finally in can be concluded that, using of either variety or hybrid did not influenced the microbial and enzymatic activities of maize rhizosphere. However, among the different farming methods, organic farming recorded higher microbial and enzymatic activities than the other farming methods i.e., natural and inorganic.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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