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Influence of Exogenous Compounds and Maize Crop Residue on Biological Activities in Salt Affected Soil

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A B S T R A C T

Amelioration of salt-affected soils requires an integrated management approach, which not only improves their effectiveness for improving soil properties, but also increases the crop performance and stress tolerance ability of the crop. Hence, a green house experiment was conducted to determine the effect of integrated use of crop residue and inorganic source of fertilizers with exogenous foliar sprays on soil microbial population and DEH enzyme activity of maize grown saline soil (ECe 6.2 dS m^{-1}). Treatments included: 100 % RDFN (Recommended dose of nitrogen fertilizers) (T_1); 25 % extra nitrogen through inorganic fertilizers (T_2); 25% extra N through raw residue (T_3); 25% extra N through compost (T_4); and combination of T_2, T_3 and T_4 treatments with exogenous foliar sprays humic acid / proline / KNO_3 in a CRD layout. Result obtained at various stages of crop growth indicated a steady increase in bacterial, fungi, actinomycetes count and dehydrogenase enzyme activty startng from inital stage with more pronounced influence on fungal colonies as ther are more senstive to abotic stress with integrated application of crop residue and exogenous spray. Highest population of 21.33×10^5, 13.00×10^3, 20.67×10^4 bacteria, fungi, actinomycetes, respectively and the highest dehydrogenase activity of 36.67 µg g^{-1} of TPF g^{-1} day^{-1} was observed in compost amended treatment (T_{13}) along with KNO_3 foliar spray at tasseling.

Introduction

Soil salinity is a threat world-wide to agricultural production and ecosystems as it reduces plant growth through impaired nutrient uptake and microbial functioning. Soluble salts increase the osmotic potential of the soil water, draws water out of cells thereby kill microbes and roots through plasmolysis.

Plants and microbes can adapt to low osmotic potential by accumulating osmolytes, however; synthesis of osmolytes requires large amounts of energy and these results in reduced growth and activity. Crop residues hold great promise due to their local availability as a source of multiple nutrients and ability to improve soil characteristics. Application of organic matter alone to soil is not a complete substitute for inorganic fertilizer and their roles are complementary to each other. Supplementation of energy through crop residue as nutrient sources for microbes may be an important strategy to ameliorate saline soils.

Materials and Methods

Pot study and experimental arrangements

The experiment was conducted in a green house at the Department of Soil Science & Agricultural chemistry, Agricultural College Bapatla. Acharya N.G. Ranga Agriculture University during the Kharif season 2017-2018 using transported soil. The experimental soil characterized as clayey in texture, moderately alkaline with pH 8.20, ECe 6.2 dS m^{-1}, organic carbon 5.76 g kg^{-1}, available N, P, K, S of 220, 38.43, 432kg $ha^{-1}$and 59.94 mg kg^{-1}.Required quantity of stover was allowed to dry and latter chopped into pieces for further use.

The required quantity of compost was prepared by the aerobic decomposition of maize stalk. For microbial and enzymatic activity, soil samples were collected at sowing, knee high, tasseling and harvest stages from the rhizosphere region and were stored in polythene bags at 2 to 4 ° C for as short time as possible until examination**.**

Method adopted

Bacteria, fungi and actinomycetes were estimated as per the procedures outlined by Paroda (2007). The enumeration of total bacteria in fresh soil samples were carried out by following serial dilution plate count technique (Dhingra and Sinclair, 2000) using nutrient agar medium (agar agar-20g; beef extract -3g; peptone -5g solution; water -1 liter).

Total fungi using Martins rose bengal agar for fungi (Martin, 1950), actinomycetes with Khusters nutrient agar medium. Dehydrogenase activity in the soil sample was determined by following the procedure as described by Casida *et al*. (1964) using 2,3,5-Triphenyltetrazolium chloride (TTC).

Results and Discussion

Microbial population

Microbial enumeration carried out at knee high, tasseling and harvest stage of maize growth revealed that application of organics alone and in combination with exogenous compounds created a favorable environment for flourishing microbial communities as evident from the increased dehydrogenase enzyme activity recorded.

Bacteria

At knee high and tasseling stages, maximum bacterial count of 19.00× 10^5 and 21.33 × 10^5 CFU, respectively was recorded in treatment supplied with 25% extra nitrogen as compost + KNO_3 foliar spray (T_{13}) and it was at par with all treatments, which received compost (T_{12}, T_{11} and T_4) and significantly superior to remaining treatments except T_{10}, which received (25% extra nitrogen as raw residue + KNO_3 foliar spray @ 10g L^{-1}at 20 and 40 DAS) at tasseling stage.

All treatments supplied with raw residue recorded comparable values at knee high and tasseling stages. At harvest, among raw residue treatments, foliar spray of proline (T_9) and KNO_3 (T_{10}) were found to be significantly superior to others. The treatment supplied with 100% RDFN recorded the lowest population of 12.33, 14.00 and 10.00 × 10^5 CFU at knee high, tasseling and harvest, respectively.(Table 1)

Fungi

At knee high, tasseling and harvest the highest population of 10.33, 13.00 and 10.00 × 10^3 CFU was observed in treatment receiving 25% extra nitrogen through compost + KNO_3 foliar spray @ 10 g L^{-1}at 20 and 40 DAS (T_{13}) it was at par with T_{11} (25%

extra nitrogen through compost + humic acid @ 0.2% at 20 and 40 DAS) and T_{12} (25% extra nitrogen through compost + proline foliar spray @ 50 mM L^{-1}) at tasseling and comparable with T_{11} at harvest and significantly superior to remaining treatment at different stages, while the lowest count of 2.00× 10^3, 3.00 × 10^3, 1.00× 10^3 CFU) was observed in treatments supplied with 100% RDFN (Table 2).

Actinomycetes

Treatment supplied with 25% extra nitrogen through compost + KNO_3 foliar spray @ 10 g L^{-1}at 20 and 40 DAS T_{13} recorded the highest value of 19.67 and 20.67 × 10^4 CFU and was significantly superior to the remaining treatments except the treatments T_{12} and T_{11} at knee high and tasseling.

While At harvest maximum population was observed in compost treatments supplemented with exogenous foliar spray (T_{13}, T_{12}, and T11). The lowest (10.33, 11.67 and 9.67× 10^4 CFU) population was observed in T_1 (100% RDF) at knee high, tasseling and harvest stages, respectively as presented in table 3.

Dehydrogenase enzyme activity

At 30 and 60 DAS the highest dehydrogenase activity of 23.33 and 36.67 µg of TPF $g^{-1}day^{-1}$was recorded in treatments supplied with 25% extra nitrogen through compost + foliar spray of KNO_3 @ 10 g L^{-1}at 20 and 40 DAS.

At harvest the maximum activity of 17.28 µg of TPF g^{-1} day^{-1} was recorded in treatment $T_{12,}$ supplied with compost and foliar spray of proline 50 mM L^{-1} at 20 and 40 DAS. The lowest dehydrogenase activity of 8.20, 12.85 and 6.77 µg of TPF $g^{-1}day^{-1}$, was recorded in treatment supplied with recommended dose of fertilizers (T_1) at knee high, tasseling and harvest, respectively (Table 4).

Table. 1 Influence of exogenous compounds and crop residues on bacterial population in soil at different stages of crop growth

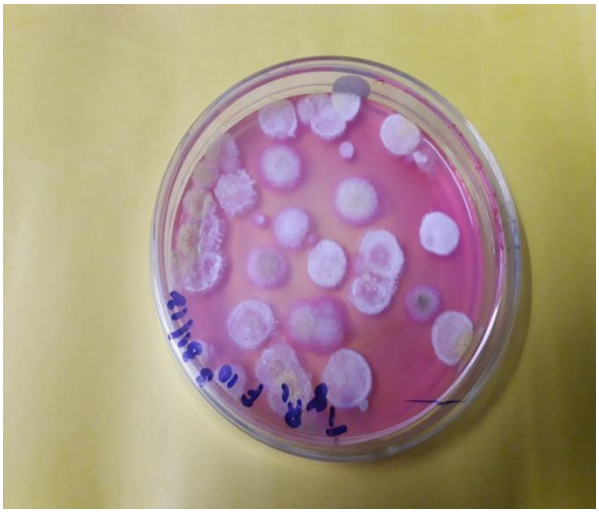
Treatment	Bacterial population (× 10^5 CFU g^{-1} soil)		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	12.33	14.00	10.00
T_2 : 125 % RDFN	13.33d	15.67	12.00
T_3 : 100% RDFN + 25% RDN as raw maize residue	16.00	18.67	14.33
T_4 : 100% RDFN + 25% RDN as maize compost	18.00	20.33	16.33
T_5 : T_2 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	13.67	16.00	12.33
T_6 : T_2 + Proline foliar spray @50 mM L^{-1} at 20 and 40 DAS	14.33	16.33	13.00
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	14.67	17.00	13.67
T_8 : T_3 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	16.00	19.33	14.67
T_9 : T_3 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	16.33	18.33	15.67
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	17.00	20.00	16.00
T_{11} : T_4 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	19.00	20.33	17.33
T_{12} : T_4 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	18.67	20.67	17.67
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	19.00	21.33	17.33
SEm±	0.40	0.48	0.39
CD @ 0.05	1.22	1.46	1.19
CV (%)	4.36	4.55	4.64

Table.2 Influence of exogenous compounds and crop residues on fungal population in soil at different stages of crop growth

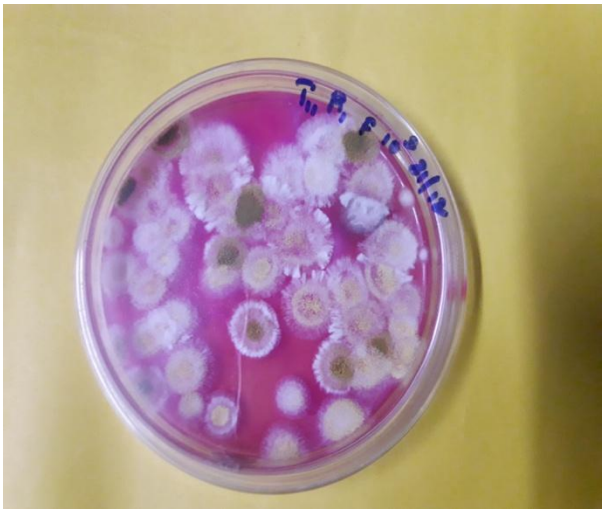
Treatment	Fungal population (× 10^3 CFU g^{-1} soil)		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	2.00	3.00	1.00
T_2 : 125 % RDFN	2.67	4.33	2.00
T_3 : 100% RDFN + 25% RDN as raw maize residue	4.00	8.00	3.67
T_4 : 100% RDFN + 25% RDN as maize compost	8.67	10.00	6.33
T_5 : T_2 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	2.67	5.00	1.67
T_6 : T_2 + Proline foliar spray @50 mM L^{-1} at 20 and 40 DAS	3.33	5.33	3.00
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	3.00	5.00	3.33
T_8 : T_3 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	6.67	8.67	4.00
T_9 : T_3 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	7.00	9.00	4.67
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	7.00	8.67	5.67
T_{11} : T_4 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	10.33	10.67	9.33
T_{12} : T_4 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	10.00	12.00	9.00
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	10.33	13.00	10.00
SEm±	0.23	0.23	0.25
CD @ 0.05	0.69	0.69	0.74
CV (%)	6.19	5.20	5.22

Table.3 Influence of exogenous compounds and crop residues on actinomycetes population in soil at different stages of crop growth

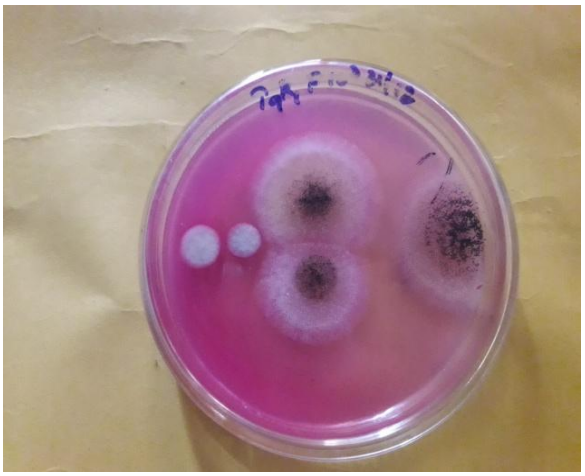
Treatment	Actinomycetes (× 10^4 CFU g^{-1} soil)		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	10.33	11.67	9.67
T_2 : 125 % RDFN	12.00	13.33	10.67
T_3 : 100% RDFN + 25% RDN as raw maize residue	15.00	17.00	12.33
T_4 : 100% RDFN + 25% RDN as maize compost	17.67	19.33	15.00
T_5 : T_2 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	12.00	13.67	11.33
T_6 : T_2 + Proline foliar spray @50 mM L^{-1} at 20 and 40 DAS	12.67	14.00	12.00
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	12.67	14.67	12.67
T_8 : T_3 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	14.00	17.33	13.00
T_9 : T_3 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	16.33	17.67	14.33
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	16.67	18.67	15.00
T_{11} : T_4 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	18.33	20.00	16.67
T_{12} : T_4 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	19.33	19.33	17.00
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	19.67	20.67	17.00
SEm±	0.42	0.40	0.37
CD @ 0.05	1.29	1.22	1.12
CV (%)	4.85	4.18	4.71



Compost



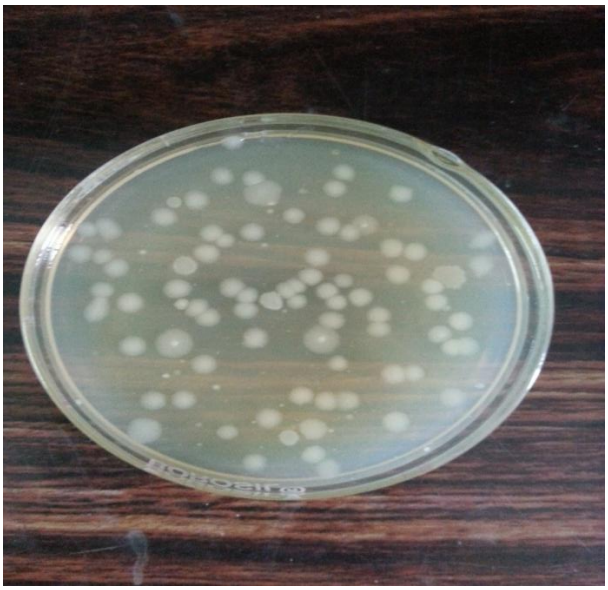
Raw residue



Inorganic

Control

Plate.1 Fungal colonies in different treatments at tasseling



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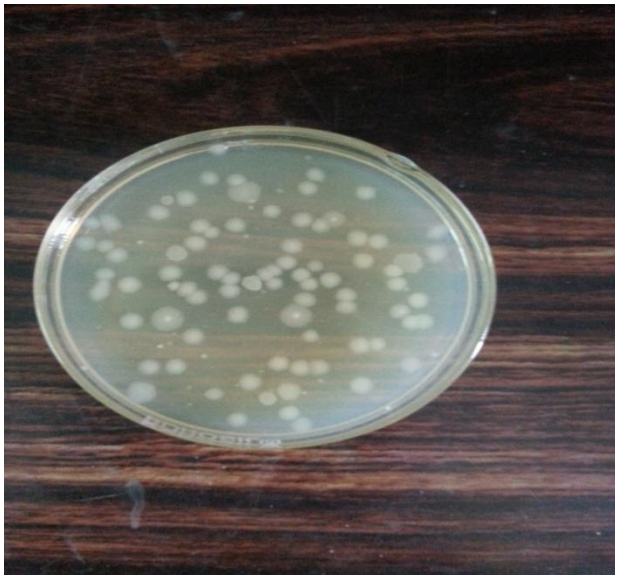
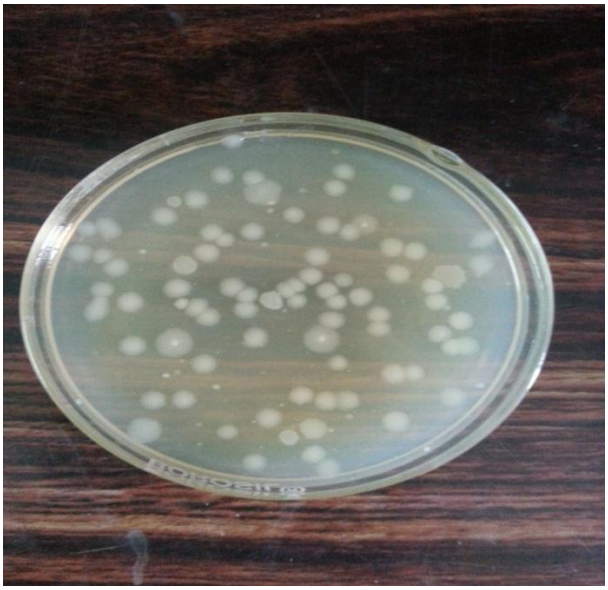


Raw residue



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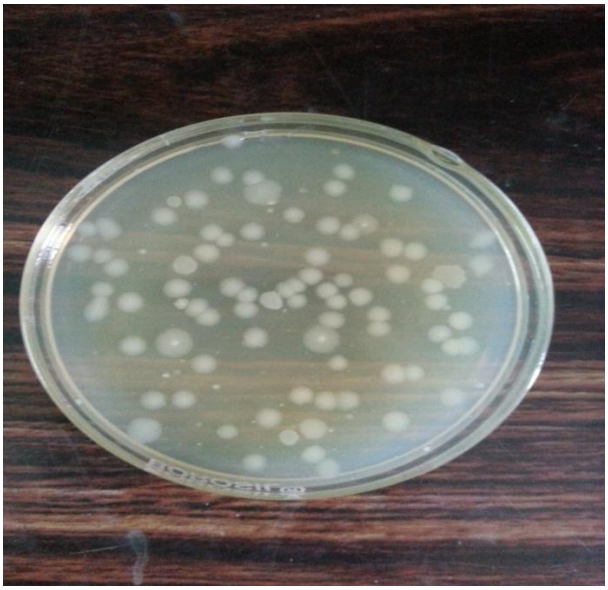
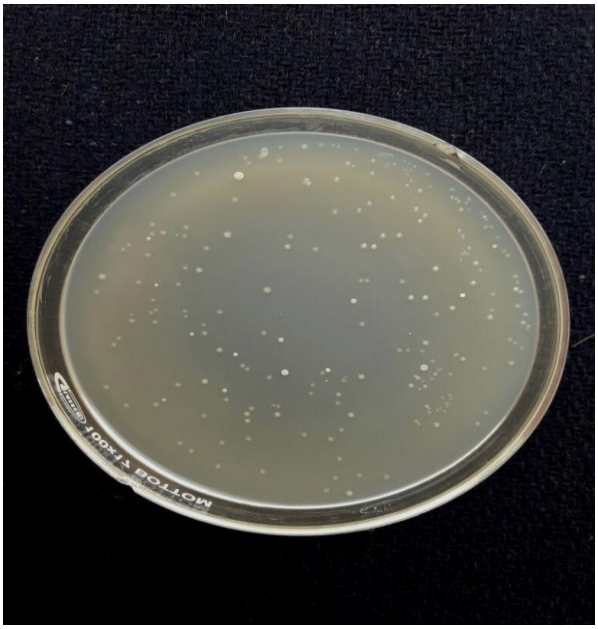
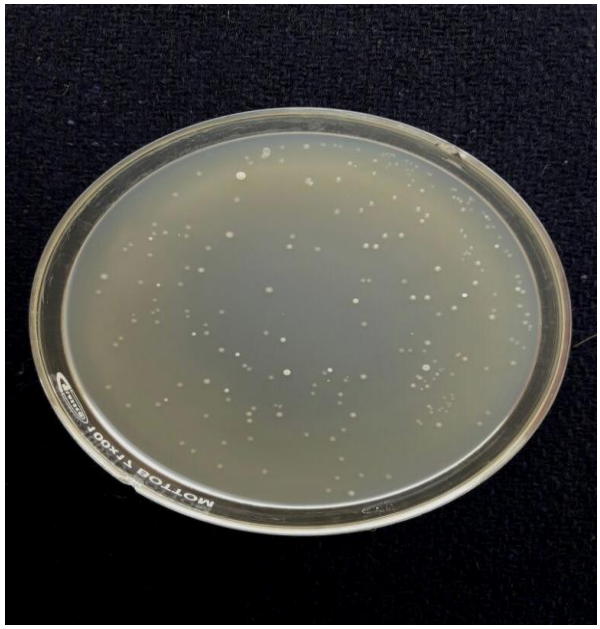


Control

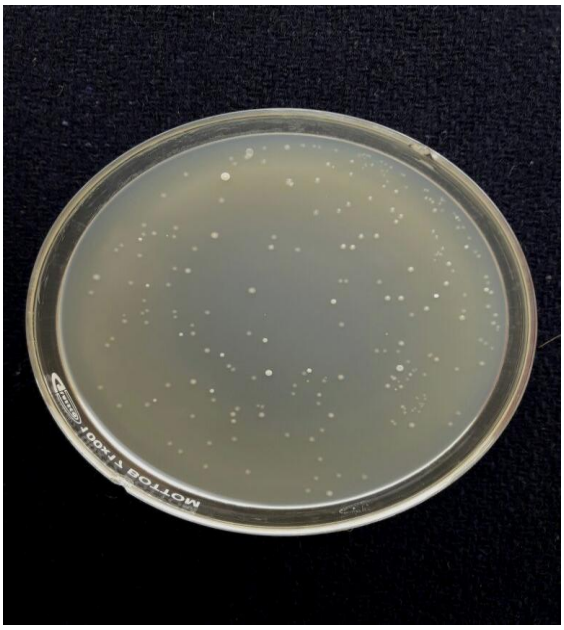
Plate.2 Bacterial colonies in different treatments at tasseling



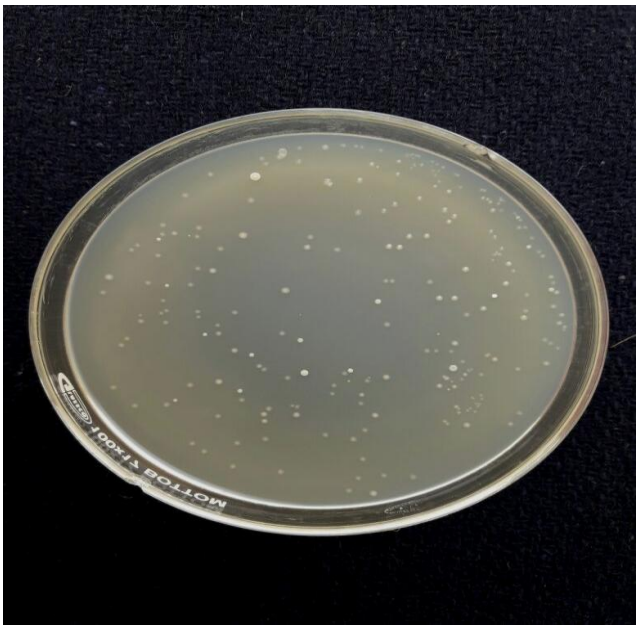
Compost



Raw residue



Inorganic



Control

Plate.3 Actinomycetes colonies in different treatments at lowering

Table.4 Influence of exogenous compounds and crop residues on dehydrogenase activity in soil at different stages of crop growth

Treatment	Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})		
	Knee high	Tasseling	Harvest
T_1 : 100% RDFN	8.20	12.85	6.77
T_2 : 125 % RDFN	9.34	15.84	10.80
T_3 : 100% RDFN + 25% RDN as raw maize residue	18.04	27.78	14.87
T_4 : 100% RDFN + 25% RDN as maize compost	22.22	35.45	16.18
T_5 : T_2 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	11.38	16.22	10.77
T_6 : T_2 + Proline foliar spray @50 mM L^{-1} at 20 and 40 DAS	11.41	16.00	10.89
T_7 : T_2 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	12.22	16.64	10.76
T_8 : T_3 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	18.17	27.22	14.89
T_9 : T_3 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	18.09	26.78	14.56
T_{10} : T_3 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	18.07	28.33	14.67
T_{11} : T_4 + Humic acid foliar spray @ 0.2% at 20 and 40 DAS	22.37	35.45	16.89
T_{12} : T_4 + Proline foliar spray @ 50 mM L^{-1} at 20 and 40 DAS	22.64	36.45	17.28
T_{13} : T_4 + KNO_3 foliar spray @ 10 g L^{-1} at 20 and 40 DAS	23.33	36.67	17.24
SEm±	0.37	0.57	0.39
CD @ 0.05	1.13	1.71	1.19
CV (%)	3.90	3.84	4.99

The critical observation of data indicated that application of organic residues especially in the form of compost was found to be favorable for the growth of microbes. Further use of exogenous compounds in general and KNO_3 in particular influenced the overall activity of microbes in the presence of crop residues. Fungi were found to be more effective as they are more sensitive to saline conditions.

Crop residues provide substrate (C and N) for growth and activity of soil microorganisms. Soil treated with crop residues inhabited 5 to10 times more aerobic bacteria and 1.5 to 11 times more fungi than in soils where residue is burnt or removed (Krishna *et al*., 2004). Addition of organic matter has been shown to increase microbial activity in saline soil (Yan and Marschner, 2012), which reduce the negative impact of salinity on microbes by providing energy for osmolytes synthesis. Addition of readily metabolizable C in organic materials is likely to have been the most influential factor contributing to increased microbial population (Tejada *et al*., 2006). According to Pathak and Rao (1996) and Liang *et al*. (2005), the incorporation of organic amendments to soil stimulates dehydrogenase activity because the added material may contain intra- and extracellular enzymes and may also stimulate microbial activity in the soil.The highest dehydrogenase activity at tasseling was due to increased root exudates, mucigel and sloughed- off cells, which stimulates the microbial proliferation (Pedrazini and Mckel, 1984; Gogel, 1992). Compared to the raw materials, compost was found to have less soluble salts, greater cation exchange capacity, increased humic acid content and microbial activity and thereby high enzyme activity (Atiyeh *et al*., 2002).

The microbial populations and dehydrogenase

activity of soils were significantly influenced by crop residues. Exogenous compounds in general and KNO_3 in particular irrespective of source of nitrogen showed higher population of all three organism. The dehydrogenase activity was found to be significantly higher in compost added treatments while, exogenous compounds did not show any significant effect.

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