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EFFECTS OF THE INOCULATION WITH SOIL MICROBIOTA ON MAIZE GROWN IN SALINE SOILS

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Introduction

According to the UN 2010 predictions, the human population will reach 10 billion by 2080. The food and energetic needs will thus increase dramatically, while conventional agriculture is, even actually, facing drastic reductions in production yields and/or severe increases in cost to compensate losses in productivity due to lower soil fertility.

Soil salinity is a serious problem worldwide causing potential loss of fertility, as plants facing salt stress suffer alterations that adversely affect its growth (Parida and Das, 2005).

Although a possible strategy of coping with salinity may be the use of crops that are able to survive under the installed saline conditions, this would be very limiting and the growth of particular crops with high economic valorisation in such soils would be disabled. Therefore, amelioration of the growth of plants with high yield, biomass and economical value such as maize (*Zea mays* L.) should be explored. Therefore, this work aimed evaluating the effectiveness of combinations of microorganisms for the recovery of maize productivity in saline soils.

Material and Methods

In this study a strategy was set that we relied on the culture in greenhouse conditions of a high value food and energetic crop (maize) inoculated with soil plant growth promoting microbiota – an arbuscular mychorrizal fungi (*Rhizophagus irregularis*), and a rizospheric (*Pseudomonas reactans*) and an endophitic (*Pantoea alli*) plant growth promoting bacteria (PGPB), exposed to soil swith different salinity levels (0, 2.5 and 5 mg NaCl kg^{-1}). A randomized design of 5 treatments for each tested concentration was conducted as follows: 0) non-inoculated control soil with maize ; B) soil with maize inoculated with *P. reactans*; F) soil with maize inoculated with *R. irregularis*; E) soil with maize inoculated with *P. alli;* and MIX) soil with maize inoculated with *R. irregularis, P. reactans* and *P.alli*.

Roots and shoots of maize plants were harvested 60 days after seeding, washed with deionized water, followed by HCl 0.1 M and again with deionized water. Samples were placed in an oven at 70 ºC for 48 h to determine their dry weights. As the work also aimed at relating the effects of bioinoculation with alterations in plant response to salt stress tissue, root and shoot's samples were then grinded and sieved to <1 mm and digested in a PerkinElmer Microwave 3000 (Waltham, USA) following the 3052 USEPA method. Sodium content was determined using Inducted Couple Plasma by Optic Emission Spectrometry (ICP-OES) of the digests (Wallinga et al., 1989).

Results and Discussion

It was possible to conclude that increases in salt concentration decreased plant biomass production (Table 1). However, all microbial treatments induced increases in maize shoots and roots biomass, with the mixed inocula (MIX) including all tested microbiota generally outperforming the other treatments.

Table 1: Effects of microbial inoculation and salt concentration on maize biomass (g) (n=4).

SHOOT	sample	biomass (g)			sample	biomass (g)			sample	biomass (g)		
	0C	2,06	±	0,02 ^{c}	2.5C	1,55	±	0,16 ^{c}	5C	0,92	±	0,05 ^{c}
	0B	2,68	±	0,28 ^{b}	2.5B	1,74	±	0,09 ^{b}	5B	1,39	±	0,12 ^{b}
	0F	2,40	±	0,36 ^{b}	2.5F	2,41	±	0,06 ^{a}	5F	1,50	±	0,08 ^{b}
	0E	2,65	±	0,23 ^{b}	2.5E	1,90	±	0,08 ^{b}	5E	1,40	±	0,15 ^{b}
	0MIX	3,00	±	0,11 ^{a}	2.5MIX	2,32	±	0,08 ^{a}	5MIX	1,86	±	0,13 ^{a}
	F=11,158 (sig=0)				F=69,501 (sig=0)				F=45,943 (sig=0)			
ROOT	sample	biomass (g)			sample	biomass (g)			sample	biomass (g)		
	0C	0,75	±	0,09 ^{d}	2.5C	0,44	±	0,11 ^{d}	5C	0,37	±	0,02 ^{e}
	0B	1,14	±	0,09 ^{b}	2.5B	0,54	±	0,08 ^{c}	5B	0,46	±	0,01 ^{c}
	0F	1,27	±	0,14 ^{a}	2.5F	0,75	±	0,08 ^{b}	5F	0,57	±	0,02 ^{b}
	0E	0,90	±	0,09 ^{c}	2.5E	0,42	±	0,03 ^{d}	5E	0,40	±	0,01 ^{d}
	0MIX	1,08	±	0,08 ^{b}	2.5MIX	0,99	±	0,02 ^{a}	5MIX	0,61	±	0,04 ^{a}
	F=20,891(sig=0);				F=54,606(sig=0)				F=120,565(sig=0)			

Concerning sodium uptake by maize, as expected it increased with increasing soil concentrations, being the accumulations in roots and shoots generally of the similar order. Generally microbial inoculation avoided Na uptake in either maize roots or shoots, and again the treatment with the mixture of all tested organisms (MIX) showed significantly ($P<0.05$) best performance, although in some cases treatment with *Rhizophagus irregularis* (F) showed similar effect.

Table 2: Effects of microbial inoculation and salt concentration in sodium uptake (g/kg plant fry weight) by maize (n=4).

SHOOT	sample	Na (g/kg)			sample	Na (g/kg)			sample	Na (g/kg)		
	0C	0,018	±	0,004 ^{ab}	2.5C	7,4	±	0,2 ^{a}	5C	13,2	±	1,1 ^{a}
	0B	0,021	±	0,001 ^{a}	2.5B	7,2	±	1,2 ^{a}	5B	11,1	±	0,8 ^{b}
	0F	0,007	±	0,005 ^{c}	2.5F	4,6	±	0,3 ^{b}	5F	4,7	±	0,4 ^{d}
	0E	0,015	±	0,001 ^{b}	2.5E	7,2	±	0,1 ^{a}	5E	9,2	±	0,7 ^{c}
	0MIX	0,009	±	0,002 ^{c}	2.5MIX	5,2	±	0,8 ^{b}	5MIX	3,9	±	0,2 ^{d}
	F=13,395 (sig=0)				F=11,873 (sig=0)				F=92,763 (sig=0)			
ROOT	sample	Na (g/kg)			sample	Na (g/kg)			sample	Na (g/kg)		
	0C	1,17	±	0,14 ^{a}	2.5C	7,6	±	0,9 ^{a}	5C	11,5	±	1,9 ^{a}
	0B	1,06	±	0,1 ^{ab}	2.5B	7,3	±	0,7 ^{a}	5B	10	±	0,9 ^{ab}
	0F	0,93	±	0,04 ^{bc}	2.5F	5,8	±	0,8 ^{b}	5F	10,1	±	1,3 ^{ab}
	0E	1,06	±	0,11 ^{ab}	2.5E	5,5	±	0,5 ^{b}	5E	9,06	±	0,7 ^{bc}
	0MIX	0,76	±	0,08 ^{c}	2.5MIX	5,5	±	0,3 ^{b}	5MIX	7,4	±	0,6 ^{c}
	F=7,785(sig=0,001)				F=6,703 (sig=0,003)				F=4,975 (sig=0,009)			

This study strongly supports that adequate inoculation is determinant for the recovery of saline soils, and that a combination of soil microbiota including rhizospheric, endophytic bacteria and mychorrizal fungi can allow even a glycophyte as maize to proliferate in such land, rendering it prone to economic valorisation. The adequate combination of AMF, PGPR and host plants, such as energy maize, is determinant for the result of their interaction under stress and consequently for their potential use in management of saline soils.

References

Parida AK, Das AB 2005. Salt tolerance and salinity effects on plants: a review. Ecotoxicology and Environmental Safety 60: 324-349.

Wallinga I, Vark W, Houba VJG, Lee JJ 1989. Plant Analysis Procedures. Department of Soil Science and Plant Nutrition, Wageningen: Wageningen Agricultural University, Syllabus.

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