Physiological Indices for Salt Tolerance of Lipo-Chitooligosaccharide Primed Maize

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Abstract
Salinity has a range of negative effects on germination and early seedling growth. Lipo-chitooligosaccharide are organic compounds, which are produced by *Rhizobium* and play an important role in growth, development and yield of crops and are becoming popular in the field of agriculture. In order to study the effect of priming with Lipo-chitooligosaccharide (LCO) on germination and growth of corn under saline conditions, a completely randomized design experiment in factorial arrangement was conducted. Treatments comprised of 5 levels of salinity (0, 2, 4, 6 and 8 dSm^{-1}) and two priming (priming with LCO and non priming). Results showed that the salinity and priming had significant effects ($p<0.05$) on stress tolerance indices of shoot length, root length stress, root volume, root dry weight and fresh leaves of maize. The increase in salinity up to 8 dSm^{-1} negatively influenced all physiological indices and the amounts of reduction for the mentioned traits were 31, 46, 83 and 49 %, respectively, as compared with the control. Seed priming with LCO compensated the negative effects of salinity on stress indices and all the physiological indices were positively responded to the treatment of LCO priming. Results showed that seed priming with LCO can be considered as a reliable method to increase the maize tolerance to salinity.

Keywords: Germination, Lipo-chitooligosaccharide, Physiological indices, Salt tolerance and Salinity
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Introduction

Soil salinity is an increasing issue in the world and is a main obstacle to agricultural productivity especially in arid to semi-arid zones of the world. Seed germination is the fundamental process which is adversely affected by salinity. Kausar *et al.* (2012) have shown that salinity reduces all the physiological indices. Pre- sowing seed treatments have been shown to enhance stand establishment in non-saline areas and have potential in saline areas as well. The priming is done with materials of inorganic, biological and organic origin which has a unique compound to alleviate stress. One among such compound is nod factor.

Legume-rhizobia symbiosis produces an organic compound called Lipo-Chitooligosaccarides (nod factor), an unique molecule that when present at that time of planting, enhances a root and shoot development immediately and independently of variety, soil environment conditions and thereby improving the plant health, which ultimately enables the plant to manage environmental pressures.

Maize is one of the most important cereals after rice and wheat, and is reported as salt sensitive species among the cereals. The salt susceptibility of young maize plants is one of the most important limiting factors for expanding the extent of maize production and the productivity which can be alleviated by seed priming. Hence, a laboratory study was attempted to investigate physiological indices of maize hybrid as a screening tool for salinity stress by the influence of LCO priming which may be useful for future research work on saline tolerance.

Materials and Methods

Seeds of maize hybrid (CoHM 6) were used for this study and were obtained from seed laboratory of the Department of Seed Sciences and Technology, Tamil Nadu agricultural University, Coimbatore. The seeds were primed by soaking with LCO at 4 ml/kg of seed for 12 h at room temperature. A factorial CRD was used with 2 factors which are salinity at 5 levels (0, 2, 4, 6, and 8 dSm^{-1}) and priming with 2 levels (LCO primed and non-primed seeds). The experiment was carried out in 48 petri dishes that are 24 for NaCl LCO primed seeds and 24 for unprimed (Control) seeds. The salinity levels were obtained by dissolving 1.28, 2.56, 3.84, 5.12, 6.4 g of NaCl in one litre distilled water respectively. Distilled water (0 dSm^{-1}) was used as a control. Seeds were sown on petridishes with 10 cm diameter which was lined with whatman No1 filter paper and these were supplied with 10 ml of each treatment solution daily. After 14 days of the experiment, shoot and root lengths and fresh weights were evaluated. The plants were dried at 70^{0}C for two days and their dry weight was also recorded. Physiological indices were

calculated according to the formula adopted by Kausar *et al.* (2012).

PHSI = (Plant height of stressed plants / Plant height of control plants) x100

RLSI = (Root length of stressed plants / Root length of control plants) x100

RDSI = (Root dry weights of stressed plants / Root dry weights of control plants) x 100

RVSI = (Root volume of stressed plants / Root volume of control plants) x 100

FLSI = (Fresh leaves of stressed plants / Fresh leaves of control plants) x 100

Results and Discussion

The results indicated that priming and salinity levels affected physiological indices. Physiological indices decreased with the increase in salinity as compared to the control (Table 1).

Plant height stress tolerance index (PHSI)

Maize showed sensitive behavior towards higher level of salinity (8 dSm^{-1}). Under non-primed seeds higher PHSI (100) was recorded under control and minimum PHSI was observed under 10 dSm^{-1}. The data regarding PHSI indicated that the LCO primed seeds are relatively salt tolerant. These differences might be due to the enhanced germination and seedling growth, along with the mitogenic nature of LCOs, suggesting accelerated meristem activity, which induced growth (Souleimanov *et al.*, 2002).

Root length stress tolerance index (RLSI)

At all levels of NaCl, LCO primed seeds attained higher root length compared to non primed seeds. In the present experiment, RLSI showed that LCO primed seeds could be grown as salt tolerant up to 6 dS m^{-1} of salinity because they produced the maximum biomass under saline environment than non-primed seeds. However higher levels of salinity exhibited greater decrease in root growth. This result was in accordance with the finding of Udhaya Nandhini *et al.* (2015).

Root dry weight (RDSI *and root volume stress tolerance* RVSI) *indices*

Root dry weight significantly decreased with progressive increase in salinity level. Root dry weight and root volume stress tolerance indices were highest in control, while they were lowest at 8 dSm^{-1}. Roots, the first developing organ in seed germination is sensitive to increasing levels of salinity (Akram *et al.*, 2007). In fact, lower availability of O_2 under saline conditions deprives the plants from energy source and accumulation of high level of ethylene inhibits root growth. Based on root dry weight and root volume stress tolerance index, it was clear that all concentrations of salinity decreased growth of roots. However, LCO primed seeds produced higher root biomass than non-primed seeds, which showed sensitive behavior towards salinity.

Table 1: Effect of lipo- chitooligosaccharide (LCO) on physiological indices of maize under different levels of salinity

Salinity (dSm^{-1})	Shoot length stress tolerance index (SLSI)			Root length stress tolerance index(RLSI)			Root volume stress tolerance index (RVSI)			Root dry weight stress tolerance index (RDSI)			Fresh leaves stress tolerance index (FLSI)		
	P	NP	Mean	P	NP	Mean	P	NP	Mean	P	NP	Mean	P	NP	Mean
0	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**	100.0	100.0	**100.0**
2	90.9	81.9	**86.4**	94.8	73.9	**84.4**	82.7	81.3	**82.0**	81.2	78.4	**79.8**	97.7	95.1	**96.4**
4	88.7	76.8	**82.8**	87.5	65.4	**76.5**	65.4	56.3	**60.8**	54.7	47.8	**51.3**	72.7	68.3	**70.5**
6	76.4	71.3	**73.9**	79.7	59.0	**69.4**	44.2	33.3	**38.8**	35.1	29.6	**32.4**	70.0	51.2	**60.6**
8	71.3	66.2	**68.7**	64.1	43.6	**53.8**	23.1	14.6	**18.8**	17.6	16.2	**16.9**	59.1	43.9	**51.5**
Mean	**85.5**	**79.3**		**85.2**	**68.4**		**63.1**	**57.1**		**57.7**	**54.4**		**79.9**	**71.7**	
	P	S	P x S	P	S	P x S	P	S	P x S	P	S	P x S	P	S	P x S
SE	0.5	0.8	1.1	0.4	0.6	0.9	0.4	0.6	0.8	0.3	0.5	0.8	0.3	0.5	0.8
CD (P=0.05)	1.0	1.6	2.3	0.8	1.3	1.8	0.7	1.1	1.6	0.7	1.1	1.5	0.7	1.1	1.5

Fresh leaves stress tolerance index (FLSI)

Maize showed better results for up to 6 dSm^{-1}, while 8 dSm^{-1}remained at the lowest level for tolerance. It is well known that salinity changes the membrane permeability by the accumulation of sodium ions which inhibits photosynthesis and reduces leaf area and productivity of most crops, whereas, LCO promotes the leaf growth by acting as a growth enhancer.

Conclusion

It is concluded that seed priming with LCO enhances the early growth and establishment of maize under salinity stress. Further studies are needed to find the physiology behind the seed establishment.

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