RESEARCH PAPER Asian Journal of Bio Science Vol. 6 Issue 1 (April, 2011) : 69-73

Inducting salt tolerance and its effect on growth and germination of maize (*Zea mays* L.) genotypes

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(Received: December, 2010; Accepted: January, 2011)

Maize (*Zea mays* L.) is one of the most important cereal crop of worlds agricultural economy. It ranks third in production in the world being suppressed only by rice and wheat. It is proudly called as 'Queen of Cereals' and 'King of Fodder' and miracle crop. It is called as a moderately sensitive to salinity and considered as the most salt sensitive of the cereals. Hence, the evaluation of NaCl tolerance was considered of interest to determine the possibility of using these germplasms in corn tolerance improvement. The present work was conducted to determine whether salt tolerance could be induced in maize at germination stage. All seed samples were used for further experiments. At the end of work tolerant, moderately tolerant and sensitive genotype were found for salt stress.

Key words : Germination, Maize, Salinity, Salt tolerance

Rajurkar, A.B., Shende, S.S. and Gadge, P.J. (2011). Inducting salt tolerance and its effect on growth and germination of maize (*Zea mays* L.) genotypes. *Asian J. Bio. Sci.*, **6** (1) : 69-73.

INTRODUCTION

The problem of salinity becomes more and more serious in the world limiting crop production (Munns, 2002), more non productive land and affecting 20% of agricultural cultivated land and 50 % of the crop plant through out world suffers from excess salinity or salt stressed (Szabolcs, 1994; Flowers and Yeo, 1995). High salt concentrations in soils negatively affect corn growth and consequently produce a large drop in yield (Ashraf and Mcneilly, 1989).

The effect of saline stress on corn has been well studied. It has been shown to affect water relations (Cramer *et al.,* 1992), permeability of root cortex (Hasegawa *et al.*, 2000) and many physiological parameters *viz.*, cell wall rheological properties (Cramer *et al.,* 1992), leaf bioelectrical activity and ionic balance (Ashraf and Mcneilly, 1989; Shobala *et al.,* 1998).

It was also reported that high concentration of soluble salts in soil and salt stress unfortunately affect plant growth and productivity during all developmental stages. Greenway and Munns (1980) and Khan (1993) reported that high concentration of salts cause reduction in germination percentage and delay in germination of seeds of many species. Epstein *et al.* (1980) reported that salinity decreases seed germination, retards plant development and reduces crop yield. Shokohifard *et al.* (1989) reported that salt stress negatively affects seed germination either through osmotically or through the accumulation of Na and Cl ions.

The physical parameter studied has no much correlation to that of salinity (Pesqueira *et al.,*2003) and therefore change in plant growth or yield compared with a control is the most reliable indicator of the tolerance to the saline stress (Cramer *et al.,* 1992). Most of reports are based on experiments with NaCl and hence studies to examine salinity effects on the initial growth of plants have usually carried out with individual salt (especially NaCl) (Tavili and Biniaz, 2009; Grant, 2003) but little information exits concerning the effect of other salt on the seed germination.

In present study the objective is to screen the maize genotype, a crop known for its highest salt sensitivity (Ashraf, 1994; Fortmeier and Schubert, 1995) by studying the effect of salt (especially NaCl) on seed germination and growth.

RESEARCH METHODOLOGY

Zea mays L. belongs to graminae family and third most important cereal in the world after rice and wheat. It is also called as queen of cereals and miracle crop. Seed of salt sensitive genotypes of *Zea mays viz.,* EC558620, EC 558622, EC 558706, EC 558707, EC558711, EC558715, EC 558717, EC558719, IC 326865 and IC 274556 were obtained from National Agriculture Research Program (NARP) Aurangabad, Maharashtra, India.

Before start of experiment seeds were surface sterilized with 10% sodium hypochlorite for 10 min, then rinsed 3-4 times with sterile distilled water and air dried. The sterilized seeds were then soaked for 8 hrs in different NaCl concentrations *viz*., 0.5% (85mM), 1% (171mM), 1.5% (225mM) and 2% (340mM). After 8 hrs pre sowing treatment, all seed samples were rinsed with sterile distilled water for 2-3 times. Salt treated seeds together with untreated seeds (control) were placed in sterile Petri dishes containing a layer of filter paper moistened with 5ml of different concentrations of NaCl solution. Three seeds were placed in each Petri dish and incubated at room temperature (26± 2^0C).

The experiment was performed with completely randomized designs with three replicates. The data for seed germination and germination canopy recorded daily up to 14 days. A seed was considered germinated when the radical emerged from seed. The water level was adjusted at 2 day interval with sterile water to avoid changes in salinity due to evaporation. After 14 days the parameters *viz.,* days to 50% germination, germination percentage, germination velocity, shoot length, root length, fresh weight, dry weight were calculated with following formulae:

Germination percentage:

$$\textbf{Final germination \%} = \frac{\textbf{No. of germinated seeds}}{\textbf{Total no. of seeds planted}}$$

Germination velocity:

$$\textbf{Germination velocity} = \sum \frac{\textbf{No. of germinated seeds}}{\textbf{Day of count}}$$

Seed vigour:

$$\textbf{Seed vigour} = \frac{\textbf{(Length of shoot + Length of root) x Germination \%}}{\textbf{100}}$$

RESULTS AND ANALYSIS

The days to 50% germination, germination percentage, germination velocity were calculated on 7^{th} day while the seed vigour, shoot length, root length, fresh weight, dry weight were calculated on 14^{th} day.

Effect of salinity on seed germination:

Significant differences were obtained for two considered factors *i.e.* genotypes, salt concentrations and their effect on seed germination. The germination of seed was calculated with days to 50% germination and 100% germination value. The days required for 50% germination and 100% germination value count are given in Table 1. Seeds treated with 0.5% salt concentration required 2-3 days for 50% germination on the other hand seeds treated with 2% salt required maximum 13 days for 50% germination followed by control in all genotypes.

The germination velocity was also affected with increasing salt concentrations. The germination velocity was found same at control and 0.5% salt, but it was found to be decreasing with increase in salt concentration while in 2% salt some genotypes *viz*., EC 558707 and EC 558717 showed 0 germination velocity (Table 1).

Effect of salinity on length of shoot and root length:

Salinity adversely affect shoot and root length. It was found that increasing concentration of salt decreased shoot and root length (Fig. 1 and 2). The result showed

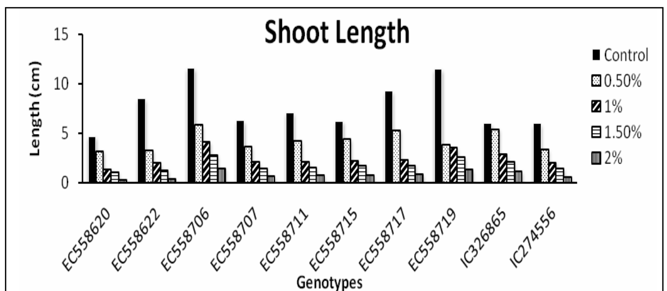

Fig. 1: Effect of salt stress on shoot length

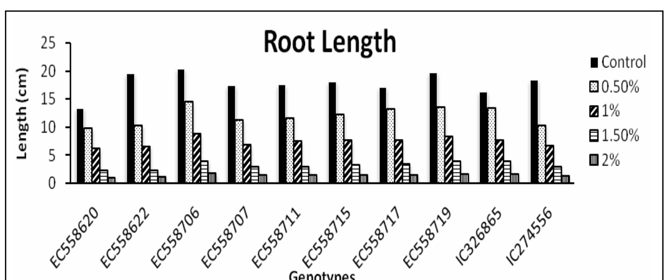

Fig. 2: Effect of salt stress on root length

that in 2% concentration of NaCl less shoot length was observed in genotype EC558620, on the other hand higher length was observed in genotype EC558706 as compared

Table 1 : Effect of salinity on days to 50% germination, germination percentage, germination velocity and seed vigour (Mean ± S.D)

NaCl Conc.	Parameters / Genotype	G558620	G558622	G558706	G558707	G558711	G558715	G558717	G558719	G326885	G277558
	Days to 50% germination	1st Day	1st Day	1st Day	1st Day	1st Day	1st Day	1st Day	1st Day	1st Day	1st Day
	Germination percentage	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Control	Germination velocity	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.50 ± 0	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09
	Seed vigour	43.81 ± 2.11	65.93 ± 0.76	75.73 ± 1.58	57.70 ± 3.70	57.46 ± 5.11	57.08 ± 1.31	61.94 ± 3.55	71.70 ± 1.96	51.32 ± 1.38	57.60 ± 3.52
	Days to 50% germination	2nd Day	4th Day	3rd Day	3rd Day	6th Day	3rd Day	3rd Day	3rd Day	4th Day	2nd Day
	Germination percentage	100 ± 0	88.88 ± 19.24	100 ± 0	91.66 ± 14.43	66.66 ± 28.86	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
0.5%	Germination velocity	0.55 ± 0.09	0.49 ± 0.16	0.55 ± 0.09	0.50 ± 0	0.27 ± 0.19	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09	0.55 ± 0.09
	Seed vigour	32.46 ± 2.81	26.05 ± 3.17	48.86 ± 2.20	33.75 ± 3.00	21.36 ± 4.12	40.57 ± 2.07	43.08 ± 1.36	45.16 ± 0.18	43.77 ± 1.80	33.17 ± 1.71
	Days to 50% germination	3rd Day	5th Day	4th Day	3rd Day	7th Day	12th Day	6th Day	10th Day	5th Day	5th day
1%	Germination percentage	80.55 ± 17.34	77.77 ± 19.24	77.77 ± 19.24	72.22 ± 25.45	66.66 ± 28.86	36.11 ± 37.57	80.55 ± 17.34	66.66 ± 57.73	72.22 ± 25.45	100 ± 0
	Germination velocity	0.44 ± 0.09	0.44 ± 0.19	0.44 ± 0.19	0.38 ± 0.09	0.21 ± 0.09	0.22 ± 0.25	0.44 ± 0.09	0.38 ± 0.09	0.38 ± 0.09	0.49 ± 0.16
	Seed vigour	15.27 ± 1.69	14.98 ± 0.62	22.29 ± 2.27	13.94 ± 0.91	15.66 ± 2.04	4.83 ± 4.22	20.06 ± 2.19	15.97 ± 6.17	17.38 ± 1.60	20.60 ± 5.00
	Days to 50% germination	9th day	6th Day	4th Day	9th Day	10th Day	7th Day	11th Day	6th Day	8th Day	6th Day
1.5%	Germination percentage	47.22 ± 41.10	61.10 ± 09.61	72.22 ± 25.45	49.99 ± 16.66	33.33 ± 28.86	49.99 ± 16.66	49.99 ± 16.66	69.44 ± 4.81	52.77 ± 41.10	61.10 ± 9.61
	Germination velocity	0.27 ± 0.25	0.33 ± 0	0.38 ± 0.09	0.27 ± 0.09	0.10 ± 0.09	0.27 ± 0.09	0.27 ± 0.09	0.38 ± 0.09	0.27 ± 0.19	0.33 ± 0
	Seed vigour	3.10 ± 1.59	5.76 ± 0.74	12.29 ± 1.59	5.63 ± 1.37	4.34 ± 1.30	6.86 ± 1.67	8.65 ± 1.27	10.05 ± 0.86	8.86 ± 2.83	6.36 ± 0.22
	Days to 50% germination	9th Day	11th Day	13th Day	13th Day	10th Day	11th Day	12th Day	9th Day	10th Day	11th Day
	Germination percentage	30.55 ± 04.80	19.44 ± 17.34	11.11 ± 19.24	0	16.66 ± 28.88	22.22 ± 19.24	0	33.33 ± 19.24	19.44 ± 17.34	0
2%	Germination velocity	0.16 ± 0	0.10 ± 0.09	0.05 ± 0.09	0	0.05 ± 0.09	0.10 ± 0.09	0	0.16 ± 0.16	0.10 ± 0.09	0
	Seed vigour	1.14 ± 0.32	0.72 ± 0.30	1.08 ± 0.62	0	1.25 ± 0.72	1.57 ± 0.45	0	3.46 ± 1.32	0.95 ± 0.40	0

to the control.

The less root length was also observed in genotype EC558620 and higher in EC558706 at 2% salt concentration as compared to control.

Seed vigour:

The principal object of a seed vigour test was to differentiate a range of quality levels for example high, medium and low vigour seed. Seed vigour is obtained by germination percentage and length of stem and radical, therefore the result of seed vigour is largely similar to them. However, as shown in Table 1, a significant difference was observed among genotypes with respect to salinity treatments.

The seed vigour of EC 558719 was higher while it was lowest (0) in EC 558707, EC 558717, IC 274556 genotypes at 2% salt concentration.

Fresh weight and dry weight:

Saline growth medium had adverse effect on fresh and dry weights of plumule and radicle containing seed. There were not much more differences were observed in fresh weight but when observed graphically (Fig. 3 and 4), it was found that the fresh weight decreased with increase in salt concentrations. But in all genotypes, the fresh weight in 0.5% salt concentration was observed to be increased than that of control. The highest fresh weight was observed in EC 558706 while lowest was observed in EC 558620 at 2% salt concentration as compared to control.

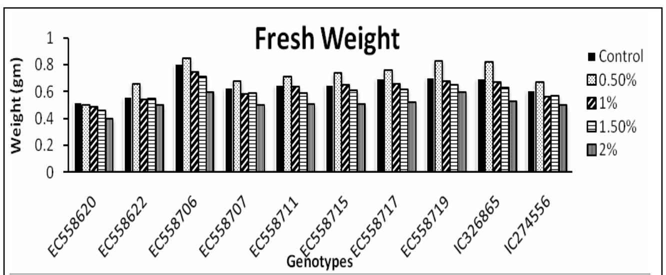

Fig. 3: Effect of salt stress on fresh weight

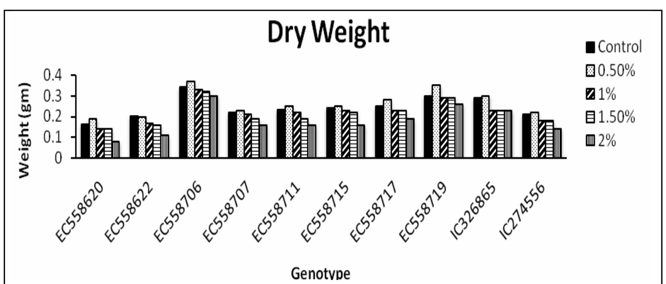

Fig. 4 Effect of salt stress on dry weight

While in case of dry weight similar trend was observed. The dry weight was found to be decreasing with increasing salt concentrations. The highest dry weight was observed in EC 558706 while lowest was observed in EC 558620 at 2% salt concentration as compared to control.

Screening of genotypes for salt tolerance:

The parameters studied germination percentage, germination velocity, days to 50% germination, seed vigour, shoot length, root length, fresh weight and dry weight showed clear idea about effect of salt concentrations on the growth parameters of genotypes. In most of the cases the parameter *viz*., germination percentage, days to 50% germination, germination velocity were found to be same or nearly same, so these parameter were not considered for screening of the genotypes.

Out of total 10 genotypes 3 were screened as sensitive, tolerant and moderately tolerant genotypes to that of salt stress.

The genotype EC 558620 showed lowest values in most of the parameters studied at 1.5% salt concentration, *viz*., seed vigour, shoot length, root length, fresh weight and dry weight at all concentration of salt stress. While genotype EC 558706 showed highest value for many parameters studied at 1.5%, *viz.,* seed vigour, shoot length, root length, fresh weight and dry weight.

Therefore, the EC 558620 genotype was termed as a salt sensitive genotype whereas EC 558706 genotype termed as a salt tolerant genotype. The middle of the both, EC 558719 was termed as a moderately tolerant showing seed vigour, shoot length, root length, fresh weight and dry weight at 1.5% salt concentration. Afterwards only these three genotypes EC 558620 (salt sensitive), EC 558706 (salt tolerant), EC 558719 (moderately salt tolerant) were used for further experimentation.

From the result of present studies for final germination percentage, germination velocity, fresh and dry weight of 14 days old seedlings of maize, it is evident that presoaking treatment of seeds with NaCl solution proved to be effective in inducing salt tolerance at the germination stage in maize genotypes. The results for germination percentage can be related to the earlier findings in which Black and El-Hadi (1992) found an improvement in germination of *Acacie senegal* in water compared with untreated control, when the seeds were primed with $CaCl_2.2H_2O$ and the same results were also reported by Ashraf and Rauf (2001) in maize with chloride salts like NaCl, KCl, $CaCl_2.2H_2O$.

According to present results germination percentage, germination velocity, seed vigour, shoot length, root length, fresh weight, dry weight were decreased with increase in salt concentration. Decrease and delay in germination in saline medium has also been reported by Rahman and Kayani (1988) in *Zea mays*. The results are also in conformity with results of Othman *et al.*(2006) who reported diminished effect of increasing salt concentrations in barley and also observed by Tavili and Biniaz (2009) in fodder maize (*Hordeum vulgare* and *Hordeum bulbosum*).

Idris and Aslam (1975) found the stimulatory effect of inducing treatments on germination processes so that rate of germination was higher in treated than untreated seeds under both non saline and saline conditions.

Acknowledgement:

We are indebted to Dr. Satpute Sir, Breeder. NRCS, Aurangabad for providing us maize genotypes repeatedly for many times and we are also thankful to Mr. Sachin Sadawarte, Lecturer, MGM College of CS and IT, Parbhani.

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