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Osmopriming of Tomato Genotypes with Polyethylene Glycol 6000 Induces Tolerance to Salinity Stress

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ABSTRACT

The present investigation was carried out to evaluate the five tomato genotypes under salt stress using osmopriming with Poly ethylene glycol (PEG 6000) as priming media on plant height and dry matter of five tomato genotypes *viz.*, Kashi Amrit , Kashi Anupam, Kashi Hemant, Kashi Sarad, and Kashi Vishesh. Seeds were primed with four levels of PEG 6000 *viz.* -0.5, -1.0, -1.5 and -2.0 MPa, along with one hydropriming for 48 hours at 25°C. Dry tomato seeds considered as a control (non-primed). Treated seeds of all varieties were grown in pots with soils of different salt concentration *i.e.*, on 4, 8 and 12 dSm^{-1} along with control. Among genotypes Kashi Hemant primed with -5.0 Mpa was identified as salt tolerance among five tomato genotypes as it showed maximum plant height (55, 46 and 43 cm) and dry matter (8.0, 6.5 and 6.0 g) under both control and salt stress conditions of 4, 8, 12 dSm^{-1}. Results of variance analysis made clear that different osmotic potential and priming duration had significant effect on plant height and dry matter. The results revealed that Kashi Hemant performed better than other genotypes at high salt concentration and has immense potential for cultivation in the salinity areas. It was also observed that generally primed seeds exhibited better stress tolerance than non-primed seeds.

Key words *Tomato genotypes, osmopriming, seed priming, salinity stress, polyethylene glycol (PEG 6000), plant height, dry weight*

Tomato (*Solanum esculentum* L.) is one of the important remunerative vegetables in our country and in the world. It also ranks second in importance to potato in many countries. Tomato is sensitive to high salinity levels (Turhan, *et al.*, 2009), thus, salinity has become a great threat to tomato cultivation. However, previously; the tomato cultivation was mainly practices in soil but nowadays cultivation has switched to greenhouse (Chen, *et al.,* 2009). Salinity reduced tomato yield (Sonnenveld and Welles, 1988), but improved fruit quality traits *viz.,* total soluble solids, colour and acid contents (Martinez, *et al.*, 1987). However, most of the crops tolerate salinity up to a threshold level above which the yields decrease as salinity increases (Maas, 1986). Thus, salinity has become hazardous to agriculture in large areas across the globe. About 7% of arable lands of the world are under salinity stress. In India about 8.6 million hectares of land is salt affected (Ministry of Agriculture, 2004). High levels of soil salinity negatively affect productivity of most field crops. Salinity stress retards plant growth and development (Bliss, *et al.*, 1986 and Sairam and Tyagi, 2004), significant reductions in plant height, shoot weight, root length and number of lateral roots (Hajer, *et al.,* 2006 and Maggio, *et al.,* 2001), also affects plant morphology, anatomy and physiology (Greenway and Munns, 1980; Munns, 2002 and Ashraf and Harris, 2004). Development of salt tolerant genotypes would make possible for better exploitation of larger areas of saline soil for the cultivation of this crop but this strategy is difficult and time consuming. Thus, screening for salt tolerant genotypes is a prerequisite step to accomplish this target.

Therefore, seed priming is an alternative technique to alleviate salt stress though it is a common and cost effective method of seed treatment that can increase rate, percentage and uniformity of germination or rapid seedling emergence, seed vigor and yield, mainly under unfavorable environmental conditions. There are several reports that under diverse environmental stresses such as salinity, water deficiency and high and low temperatures osmopriming leads to cellular, sub-cellular and molecular changes in seeds and subsequently promotes seed vigor during germination and emergence in different plant species. There is evidence that seed osmopriming improved salinity tolerance of tomato (Khadri, *et al.*, 2007), bean (Jumsoon, *et al.*, 1996) and sunflower (Damirkaya, *et al.*, 2006). Seed priming can also alleviate the adverse effects of salt and drought stress (Ashraf and Foolad, 2005).

There are various osmoticums used for priming the seeds such as polyethylene glycol (PEG), mannitol, sugar and sodium chloride (osmopriming) and in water (hydropriming) has been reported to be a simple, economical and safe technique for enhancing potential

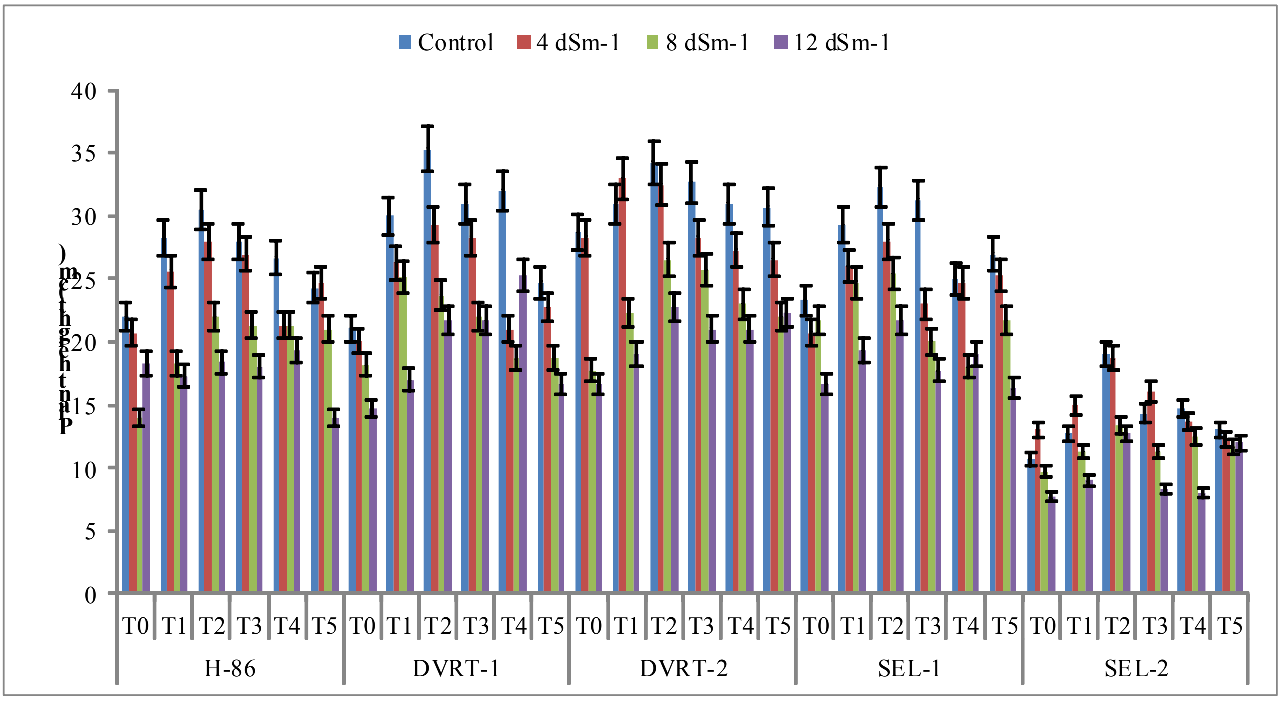

Fig. 1. Plant height (cm) of five tomato genotypes under different osmopriming treatments (PEG 6000) at different salinity levels, grown in pots at 20 days after transplanting.

Display error bar with 5% value. T_0=Dry control, T_1=Hydro primed, T_2= -0.5MPa, T_3= -1.0 MPa, T_4= -1.5 MPa, T_5= -2.0 MPa

of seeds to osmotic adjustment and improving seedling establishment and crop cultivation under stressed environment.

MATERIALS AND METHODS

Five tomato genotypes *viz.,* Kashi Amrit, Kashi Vishesh, Kashi Anupam, Kashi Sarad and Kashi Hemant were included for evaluation at Indian Institute of Vegetable Research (IIVR) Varanasi, Uttar Pradesh, India during *rabi* season as pot culture experiment. The seeds of five tomato genotypes were primed with four concentrations of PEG 6000 *viz*., -0.5, -1.0, -1.5 and -2.0 MPa along with one hydropriming for 48 hours at 25^0 C. Dry tomato seeds were considered as control (non-primed). Treated seeds were washed thoroughly with double distilled water and were sown in nursery after 2-3 days of treatment and these were allowed to grow into seedlings for 3-4 weeks. The seedlings were then transplanted into pots (25 cm x 25 cm) with varying electrical conductivity (EC) levels *viz.* 4, 8, 12 dSm^{-1} along with control with three replications containing well pulverized garden soil, sand and FYM, mixed in the ratio of 2.5:1.25:1.25 and observed for parameters such as plant height at 20, 40 and 60 days after transplanting (DAT) and dry weight at 60 DAT. Plant height were measured in (cm) with the help of scale as distance lying between the portion of the shoot just touching the soil surface and the tip of the plants. For the analysis of dry weight all the plant parts such as root, shoot and leaves were well washed and kept for drying in an electric oven, first at a temperature of 110 ^{0}C for an hour to kill the metabolic activities followed by constant temperature of 70 ^{0}C for a period of 72 hrs or until a constant weight was gained. All these experiments were conducted in factorial completely randomized block design (FCRD) with six treatments, three salinity level *viz*. 4, 8, 12 dSm^{-1} and also one control (C) and each treatment was replicated three times. Experimental data were analyzed using the analysis of variance as per standard statistical procedures as described by Panse and Sukhatme, 1967. Critical difference values were calculated at 5% probability level.

RESULTS AND DISCUSSION

Of the five tomato genotypes evaluated for salt tolerance using different osmopriming treatments with PEG 6000 on plant height and dry weight, Kashi Hemant showed highest plant height and dry weight at 60 DAT as compared to other genotypes.

Seed priming with PEG-6000 (-0.5MPa) resulted in increased plant height, number of branches and dry weight under both saline and non-saline conditions for all tomato genotypes. Khalil, *et al.,* 1997, reported that

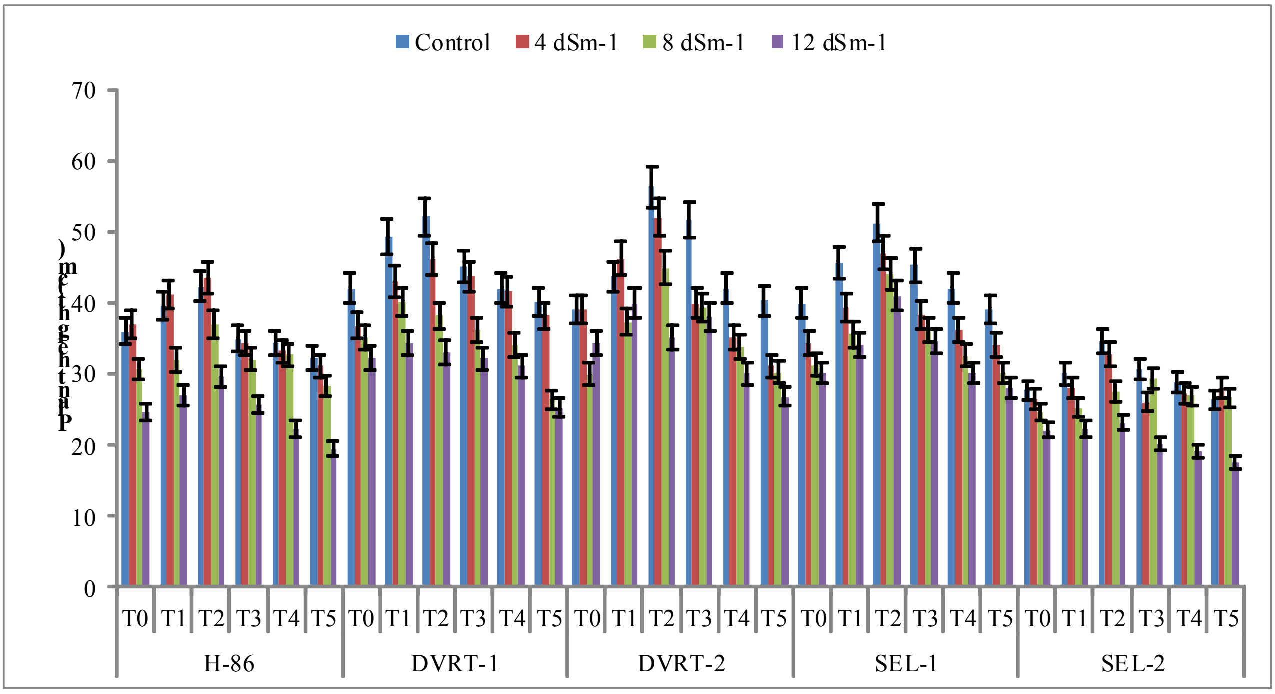

Fig. 2. Plant height (cm) of five tomato genotypes under different osmopriming treatments (PEG 6000) at different salinity levels, grown in pots at 40 days after transplanting.

Display error bar with 5% value. T_0=Dry control, T_1=Hydro primed, T_2= -0.5MPa, T_3= -1.0 MPa, T_4= -1.5 MPa, T_5= -2.0 MPa

plant raised from seed preconditioned in PEG-8000 exhibited faster germination and higher shoot length and dry weight compared to plants raised from untreated seeds which supports our findings. The increased plant height, number of branches and dry weight due to osmopriming may be due to beneficial effects of osmopriming on seed structure, biochemistry, enzyme activities and organic substances in germinating seeds as reported by several workers.

The effect of salinity in all genotypes showed a decrease in plant height and dry weight with increasing salinity. Similar results have also been reported in many crop plants *viz*. rice (El-Shouny, 1976), wheat and barley (Bhardwaj, 1960 and Joshi, 1976). The salinity tolerance in primed seeds may be due to higher potential of these plants for osmosis regulation. It has been proposed that priming causes considerable invigoration of the dry seeds (Heydecker and Coolbear, 1978), which results from the initiation of metabolic processes that normally take place during imbibitions and are fixed by subsequent drying (Hanson, 1973). However, in tomato a space is developed in the primed seed that facilitates water uptake, there by accelerating the speed of germination (Argerich and Bradford, 1989).

The data indicated significant differences in plant height due to osmopriming treatments (Fig. 1). Priming with -0.5 MPa (PEG-6000) showed significantly higher plant height under control and at 4, 8 and 12 EC. The results are in agreement with Sallam, 1999, who reported the significant increased in growth parameters observed in seeds primed with KCl or NaCl in broad bean. The dry non-primed seed recorded the lowest plant height for all genotypes at all levels of salinity as compared to primed seeds. Sallam, 1999, demonstrated that water soaked seeds of *Vicia faba* exhibited significantly higher growth than those of non primed seed under saline conditions, similar results support our findings. Among genotypes, Kashi Hemant primed with -0.5 MPa showed highest plant height 55, 46 and 43 cm under salinity at 4, 8 and 12 EC respectively and was superior in performance under saline condition. Plant height showed a decreasing trend as the salinity levels increased in the experiment. Ashraf and Iram, 2002, who reported that NaCl primed seed of pearl millet showed adverse effect of salt stress on germination and later vegetative growth, are in agreement with our findings. The plant height increased from 20 days after transplanting (DAT) to 40 and 60 DAT (Figs. 2, 3). Similar trend for osmopriming treatment and

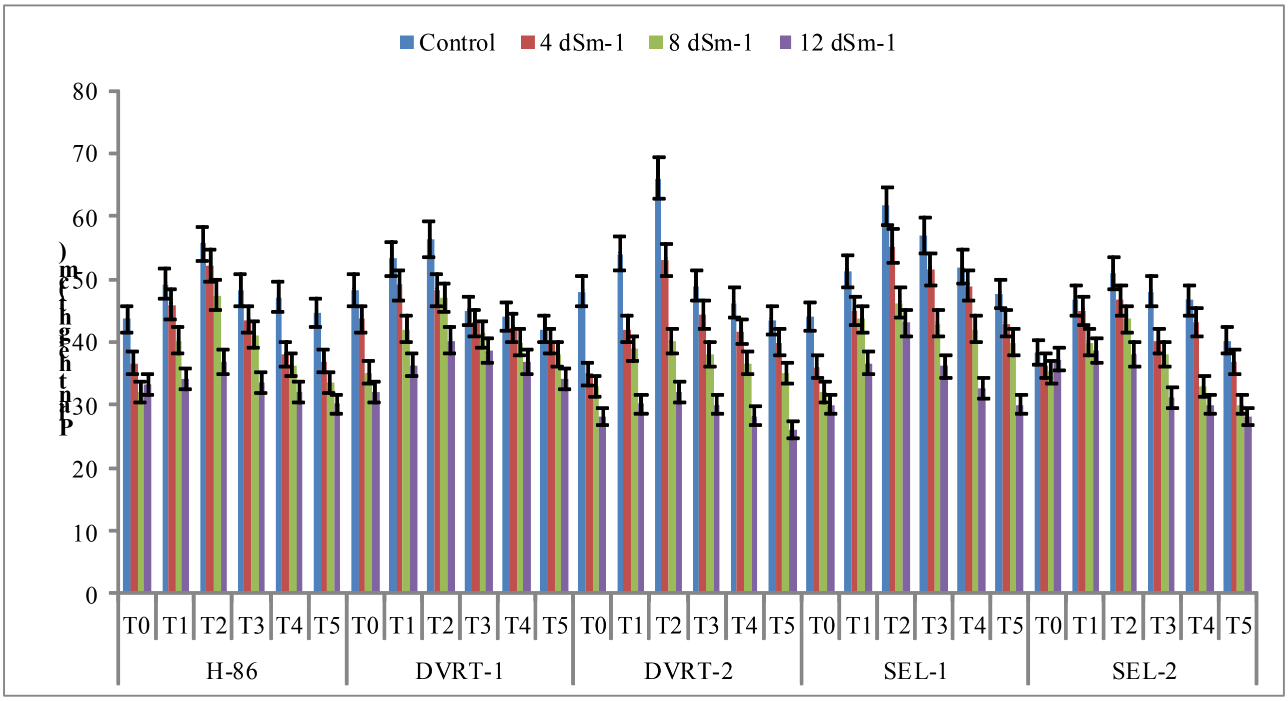

Fig. 3. Plant height (cm) of five tomato genotypes under different osmopriming treatments (PEG 6000) at different salinity levels, grown in pots at 60 days after transplanting.

Display error bar with 5% value. T_0=Dry control, T_1=Hydro primed, T_2= -0.5MPa, T_3= -1.0 MPa, T_4= -1.5 MPa, T_5= -2.0 MPa

performance of genotypes for plant height under different soil salinity was observed at 40 and 60 DAT.

Dry weight of vegetative parts of tomato decreased in all tomato genotypes as the salt concentration increased (Fig. 4). Among osmopriming treatments, priming with -0.5 MPa recorded the highest dry weight for all genotypes and also under high salt concentration. Pill, *et al.,* 1997 and Adiloglu, *et al.,* 2005, were reported that increased in shoot dry weight of seedlings treated with micronutrient, which was in similar pattern with the present study. Among all the treatments, priming with -2.0 MPa recorded the least dry weight. As priming increased beyond -0.5 MPa, there was observed decrease in dry weight. The second best results for dry weight was observed in priming with distill water. Among genotypes, Kashi Hemant primed with -0.5 MPa showed highest dry matter *i.e.*8.0, 6.5 and 6.0 g at 4, 8 and 12 EC respectively and performed better than other genotypes at high salt concentration. These findings are in agreement with Miraj, *et al.,* 2013, who reported that seed primed with SSP and KOH showed maximum fresh and dry weight in maize and also similar findings was observed in raya treated with $ZnSO_4$ (Ullah, *et al.,* 2002). Abraha and Yohannes, 2013, also reported that with the increase in salinity levels, roots, shoot dry weight of maize reduced significantly in unprimed seeds as compared to primed seeds which supports our findings.

It is evident from our experiment that considerable gain in terms of growth and dry matter has been achieved by PEG-6000 osmopriming with –0.5MPa. As consequences, Kashi Hemant primed with -0.5MPa showed better performance under salt conditions of 4, 8 and 12 EC and hence have potential for cultivation on saline soil after being seed treated with suitable osmoticums. Therefore, the osmopriming by PEG has positive response under stress conditions. It was also observed that generally primed seeds exhibited better stress tolerance than non-primed seeds.

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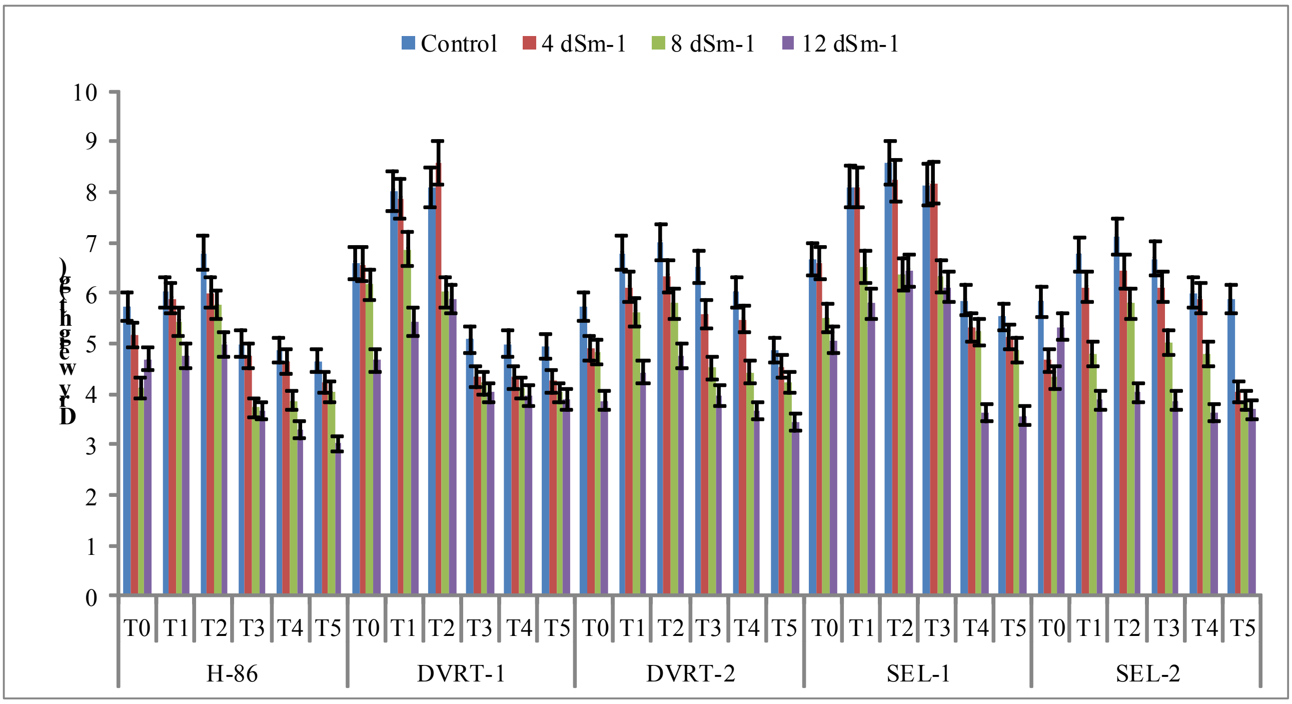

Fig. 4. Dry weight (g) per plant of five tomato genotypes under different osmopriming treatments (PEG 6000) at different salinity levels, grown in pots at 60 DAT.

Display error bar with 5% value. T_0=Dry control, T_1=Hydro primed, T_2= -0.5MPa, T_3= -1.0 MPa, T_4= -1.5 MPa, T_5= -2.0 MPa

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