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SALT TOLERANCE OF *PHYSALIS* DURING GERMINATION AND SEEDLING GROWTH

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Abstract

The study was conducted to evaluate the effect of NaCl salinity on germination and emergence of *Physalis ixocarpa* and *Physalis peruviana*. Seeds of *P. ixocarpa* and *P. peruviana* were germinated by the use of 0, 30, 60, 90, 120 and 180 mM NaCl solutions in petri dishes. Final germination percentage (FGP) decreased with the increase in NaCl concentration. Both species germinated at the ranges of salinity. *P. peruviana* gave the greater germination percentages under salt stress than *P. ixocarpa*. NaCl salinity at different concentrations adversely affected germination rates. For seedling growth, seeds of both species were sown at 10 mm depth in plastic trays filled with peat to determine final emergence percentage (FEP). The trays were irrigated manually to saturation every day with 0, 30, 60, 90, 120, 150 or 180 mM NaCl solutions to maintain the level of salinity. Salinity affected seed emergence and seedlings growth more than seed germination. The study showed that no emergence of *Physalis* was observed at 90, 120 and 180 mM NaCl salinity. Fresh and dry weights of normal seedlings were also evaluated. Salt stress significantly decreased the plant fresh and dry weight of both species. Based on the results of the experiment, it can be concluded that seedling emergence and growth is more sensitive to salt stress than seed germination in *Physalis*.

Introduction

Salinity in soil or water is one of the major stresses especially in arid and semi-arid regions and can severely limit plant growth and productivity (Ashraf & Foolad, 2007). Saline environments are widespread with approximately 1.0 billion ha of the 14.0 billion ha of worldwide agricultural land affected by excess salt (Christiansen, 1982) and 100 million ha or 5% of the arable land is adversely affected by high salt concentration which reduces crop growth and yield (Ghassemi et al., 1995). Excess salt in the soil solution may adversely affect plant growth either through osmotic inhibition of water uptake by roots or specific ion effect. In many crop plants, seed germination and early seedling growth are the most sensitive stages to environmental stresses such as salinity (Sivritepe *et al*., 2003).

Salinity may cause significant reductions in the rate and final percentage of germination, which in turn may lead to uneven stand establishment and reduce crop yields (Foolad *et al*., 1999). Rapid, uniform and complete germination is a prerequisite for successful transplant production and stand establishment in vegetable crops (Demir & Ermis, 2003).

One of the most effective ways to overcome salinity problems is the introduction of salt tolerant crops. It has been reported that differences in salt tolerance exist not only among different species, but also within certain species (Foolad & Lin, 1997; Achakzai *et al*., 2010). The success of selection depends on the amount of genetic variation distinguishable from environmental variation in the screening process. Evidence collected from many crop genera suggests that salt tolerance is a developmentally regulated, stage-specific phenomenon such that tolerance at one stage of plant development may not be correlated with tolerance at other developmental stages. Therefore, specific stages throughout the ontogeny of the plant, such as germination and emergence, seedling survival and growth, and vegetative and reproductive growth, should be evaluated separately during the assessment of germplasm for salt tolerance. Such assessments may facilitate development of cultivars with salt-tolerance characteristics throughout the ontogeny of the plant (Foolad & Lin, 1997; Akram *et al.,* 2010). Screening and selection for any characters are desired at the earliest developmental stage possible (Murillo-Amador *et al*., 2001).

Physalis belongs to the Solanaceae family and includes 100 known species that are annual or perennials. Four of these species are grown for their fruits. They are grown for sauce and ketchup (*Physalis peruviana* L.) as an ornamental plant (*Physalis alkekengi* L.) and as a vegetable (*Physalis ixocarpa* Brot.) (Quiros, 1984). Solanaceae family is considered to be moderately sensitive to salinity. Yield reduction starts when plant is irrigated with water having EC>2.5 dS m-1, while 50% yield reduction occurs when EC of irrigation water is 8-9.0 dS m-1(Mass, 1986; Cuartero & Fernandez-Munoz, 1999). However, to the best of our knowledge, literature concerning the effect of salinity on germination and emergence of *Physalis* is not abundant. Therefore, this study was aimed to evaluate the effect of NaCl salinity on germination and emergence of *Physalis* and to establish genetic potential for salt tolerance during germination and seedling growth of two *Physalis* species.

Materials and Methods

This study was carried out at Atatürk University, in Turkey in 2007 and 2008. Seed of *Physalis ixocarpa* and *Physalis peruviana* used as plant material, were obtained from Saatzcucht Quedlinburg Seed Company, Germany.

Germination assays: Seeds were disinfected with 0.5% Sodium hypochlorite solution for 10 min, then they were rinsed with sterile distilled water several times, and briefly blotted using sterile paper towels. Fifty disinfected seeds of *P. ixocarpa* and *P. peruviana* were germinated in two folds of Whatman number 1 filter paper (sterilized) placed in Petri dishes (9cm diameter). Each dish was moistened with 5mL of distilled water or one of the saline solutions of 0 (control), 30, 60, 90, 120 and 180 mM NaCl. NaCl was used since it is a common salt that adversely affects plant growth under natural conditions (Levitt, 1980). The electrical conductivities of these solutions were determined with a conductivity meter, Model 470 (Jenway Limited); 0.002, 3.41, 6.31, 9.23, 12.44, 15.05 and 17.96

dS m-1, respectively. Petri dishes were tightly sealed using parafilm to prevent evaporation. The NaCl solutions were changed in three days intervals after the onset of the experiment to maintain a constant osmotic potential. Petri dishes were arranged in a completely randomised design in an incubator maintained in dark at 25±0.5°C.

Radicle protrusion to 1mm was scored as germination. Germination was recorded daily until the numbers stabilized (for 28 days) and germinated seeds were removed from the Petri dishes (Anon., 1996). From the total number of seeds germinated, final germination percentage (FGP), its angular transformation (arcsine√FGP) and mean germination time (MGT) were calculated. MGT was calculated according to the following formula (Cantliffe, 1991):

$$MGT = (A_1D_1+A_2D_2+\ldots A_nD_n) / (A_1+A_2+\ldots A_n)$$

where: A = number of seeds germinating per day, D = time corresponding to A in days, and n = number of days to final count

Seedling growth: For seedling growth, 40 seeds of two species were sown at 10 mm depth in 40-cell plastic trays filled with peat. The trays were randomized on the benches in the greenhouse, and watered with appropriate solutions of NaCl mentioned above with four replicates (40 seeds per replication). Trays were covered with plastic to reduce evaporation until emergence beginning. After emergence plants were irrigated manually to saturation every day with 0 (Control), 30, 60, 90, 120, 150 or 180 mM NaCl solutions to maintain the level of salinity. Plants were harvested 40 days after sowing, and FEP and their fresh weights determined. Normal seedlings were counted and cleaned, or abnormal seedlings (Anon., 2004) were not evaluated. Dry weights of seedling were determined 24 hours after plants were maintained in an oven at 70°C. Temperature ranged between 19 and 34°C for the first experiment, 18 and 35°C for the second for a period of 40 days (Table 1).

Table 1. Effect of salinity on plant fresh and dry weight of *Physalis ixocarpa* and *Physalis peruviana*.

NaCl conc. (mM)	0	30	60
Species		**Fresh weight (g)**	
P. peruviana	4.34	1.09	-
P. ixocarpa	14.63	5.79	2.65
LSD (int.) : 0.38			
		Dry weight (g)	
P. peruviana	0.28	0.08	-
P. ixocarpa	1.69	0.41	0.17
LSD (int.) : 0.01			

Statistical analysis: Experimental design was hierarchical with respect to two factors arranged in a completely randomized design with four replications. The first factor had seven levels (0, 30, 60, 90, 120, 150, 180 mM NaCl) and the second one had two levels (species). Data were analysed with two way analysis of variance (ANOVA) using the GLIM procedure of SAS (Anon., 1985) for FGP, MGT, FEP, plant fresh and dry matter. Percentage data were transformed using arcsine prior to statistical analysis (Montgomery, 2001). The differences between the means were compared using LSD test ($p<0.05$). All experiments were conducted two times (i.e. two replicates in time), and thus, a total of eight replicates.

Results and Discussion

Effect of salinity on FGP of *Physalis* species is presented in Fig. 1. Germination percentages of both species significantly ($p<0.05$) decreased with increasing salt stress. Both species germinated at the ranges of salinity of NaCl concentration. On the other hand, *P. peruviana* had greater FEP values than those of *P. ixocarpa* in all NaCl concentrations. The greatest FGP at 180 mM NaCl was obtained from *P. peruviana* with 72%. Elevated NaCl concentrations from 0 mM to 180 mM increased the MGT in both species (Fig. 2). Similar to the FEP values *P. peruviana* gave the fastest germination rate values compared to those of *P. ixocarpa* in all NaCl concentrations (Fig. 3).

In successive two experiments both species did not show emergence at 90, 120, 150 and 180 mM NaCl levels. In addition no emergence of *P. peruviana* was observed any at 60 mM. FEP values of *P. peruviana* and *P. ixocarpa* were reduced by 59% - 47% at 30 mM and 100% - 62% at 60 mM, respectively. In salt stress presence, *P. ixocarpa* gave the higher FEP values with 82, 44 and 17% respectively than *P. peruviana*.

Salt stress significantly ($p<0.05$) affected fresh weight and dry weight of both species seedling. These parameters were adversely affected with increasing salt stress. Plant fresh weight of *P. peruviana* and *P. ixocarpa* were reduced by 75% - 60% at 30 mM and 100% - 72% at 60 mM, respectively.

The present study demonstrated salt stress adversely affected germination, emergence and growth of *Physalis*. Salinity, as an abiotic hazard, induces numerous disorders in seeds and propagules during germination. Salinity either completely inhibits germination at higher levels or induces a state of dormancy at lower levels (Khan & Ungar, 1997). Salinity can also affect germination by facilitating the intake of toxic ions, which can cause change of certain enzymatic or hormonal activities of the seed. Salinity has been reported to cause significant reductions in the rate and final percentage of germination and emergence of many vegetable crops, which in turn may lead to uneven stand establishment and reduced crop yields (Yildirim *et al*., 2002; Yildirim & Guvenc, 2006). Salinity had a more adverse effect on seed emergence and seedlings growth than seed germination. Both species germinated in all NaCl concentrations while no emergence of *Physalis* species was observed at the high level salt stress conditions (90, 120, 150 and 180 mM). Similarly, Chartzoulakis & Klapaki (2000) reported that seedling emergence and growth of pepper is more sensitive to salt stress than seed germination. Foolad & Lin (1997) suggested that salt tolerance is a developmentally regulated, stage-specific phenomenon such that tolerance at one stage of plant development may not be related with tolerance at other developmental stages.

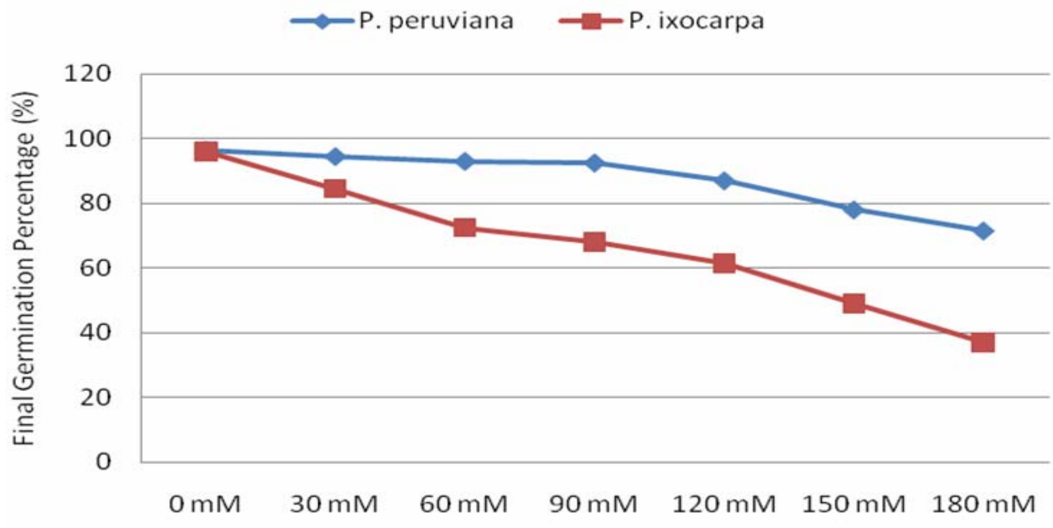

Fig. 1. Effect of salinity on final germination percentage (FGP) of *Physalis ixocarpa* and *Physalis peruviana*.

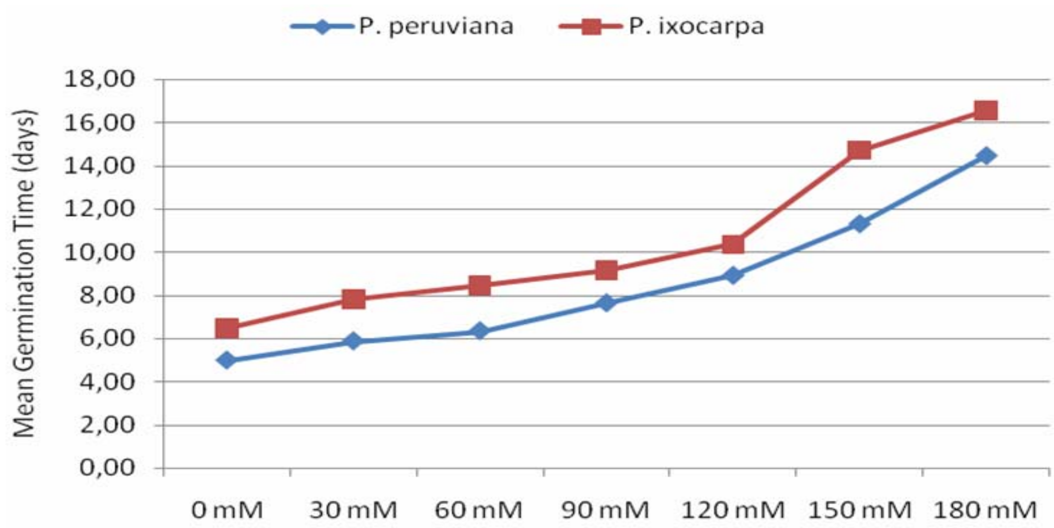

Fig. 2. Effect of salinity on mean germination time (MGT) of *Physalis ixocarpa* and *Physalis peruviana*.

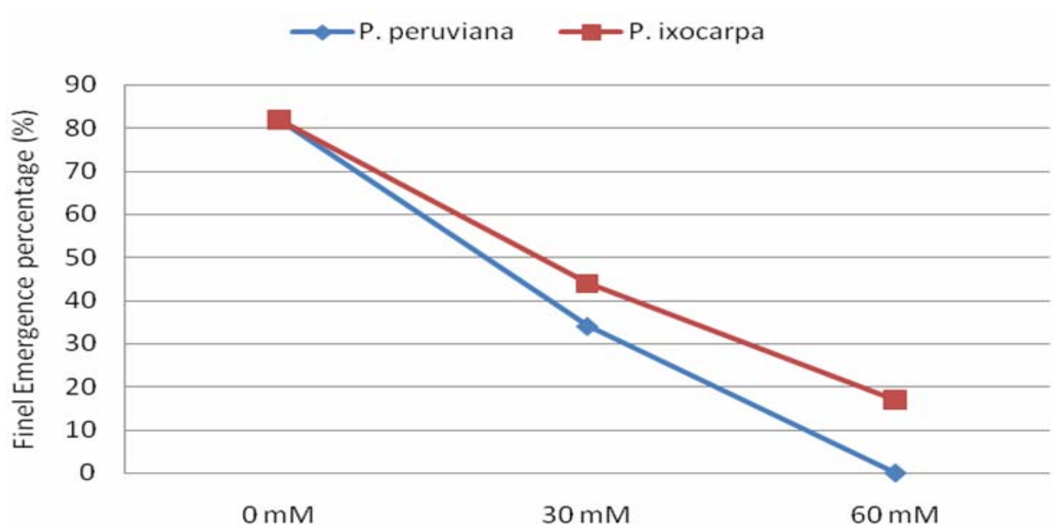

Fig. 3. Effect of salinity on final emergence percentage (FEP) of *Physalis ixocarpa* and *Physalis peruviana*.

The differences in germination between the two species were greater in the presence than in the absence of salinity in regard to FGP and FEP. This difference can be attributed that genotypic variation in germination response is expressed to a greater degree under stress than under non-stress conditions. Certain genes may be stress inducible and expressed only under salt-stress conditions (Foolad & Lin, 1997). Furthermore, ***P. peruviana*** had greater FGP values than ***P. ixocarpa*** whereas ***P. ixocarpa*** showed better emergence than ***P. peruviana***. To conclude ***P. peruviana*** is tolerant to salt stress during germination, but become more sensitive during emergence and early seedling stages. However, ***P. ixocarpa*** is more tolerant to salt stress than ***P. peruviana*** during emergence and early seedling stages.

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