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The influences of different salinity levels on germination performance of golden berry, (*Physalis peruviana* L.) seeds

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Research Paper

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ABSTRACT

Salinity is one of the major limitations for plant growth and productivity nearly in all over the world. Although a lot of researchers have reported that, plants are sensitive to high salinity during germination and the seedling stage a few studies have compared the effects of various salinity sources on the germination of plants. This study was conducted to investigate the effects of different NaCl and $CaCl_2$ levels on germination of some golden berry genotypes from Turkey. Seeds of four advanced golden berry lines were used. The concentrations of salt solutions were 50, 100, 150, 200, 250 mM (millimolar) and distilled water served as control. Germination percentage (%), time to reach 50% germination (days), shoot length (cm) and seedling fresh weights (mg) were measured on 25th. day after sowing. The lines showed different responses to NaCl and $CaCl_2$ levels. The 12.67% of Line 1 seeds germinated in the 250 mM $CaCl_2$ but any germination has not been observed in the 250 mM NaCl. Increased salinity levels resulted in decreased germination, inhibition of seedling growth and increased mean germination time. The 50% of the Line 4 seeds were germinated at 4th. days after sowing in the control treatment whereas 12 days were needed for the same ratio of germination in the 250 mM $CaCl_2$ treatment. According to all results of experiments, 'Line 4' and 'Line 7' appeared more tolerant to salt stress than the other two lines.

Key words: Salinity, golden berry, tolerance, NaCl, $CaCl_2$

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INTRODUCTION

Nowadays golden berry (*Physalis peruviana* L.) is the most popular fruit in Turkey. The botanical name of the plant is *P. peruviana* Linneaus, belonging to the family Solanaceae and genus *Physalis,* there are more than 80 varieties can be found in wilderness (Cedeno and Montenegro, 2004). Golden berry plants not only spreads naturally in Peru and Chile but also it is cultivated in South Africa, Kenya, India, Egypt, New Zealand, the Caribbean, South East Asia, California, Columbia, and Hawaii (Legge, 1974; Chattopadhyay, 1996) and now in Turkey.

P. peruviana L. is a herbaceous, semi-shrub, upright, and perennial in subtropical zones plant, it can grows until reach 0.6 to 0.9 m and in some cases can grow up to 1.8 m. The flower can be easily pollinated by insects, wind and also by auto-pollination. The fruit is a juicy berry with ovoid shape and a diameter between 1.25 to 2.50 cm, 4 and 10 g weight, containing inside around 100 to 200 small seeds, also fruit is protected by the calyx or fruit basket which completely covers the fruit along their development and ripening, protecting it against insects, birds, diseases and adverse climatic situations (Tapia and Fries, 2007).

Salinity is one of the major limitations for plant growth and productivity nearly in all over the world. Soil salinity occurred long before humans and agriculture; however, the problem is increasing at a rate of 10% annually (Flowers, 2004 and Foolad, 2004). Many researchers have reported that plants are sensitive to high salinity during germination and the seedling stage (Ghoulam and

Fares, 2001). But only a few studies (Egan et al., 1997; Agboola, 1998; Pujol et al., 2000; Tobe et al., 2002; Joshi et al., 2005) have compared the effects of various salts on the germination of plants. Many important crops are glycophytes that show susceptibility to soil salinity. Seed germination and emergence are critical to the survival of plants in salt-affected areas (Khan, 2002).

The purpose of this study was to determine salt tolerance differences among some local golden berry lines using germination percentage (GP, %), time to reach 50% germination ($T_{50,}$ days), shoot length (SL, cm) and seedling fresh weight (FW, mg) during the germination stages of golden berry seed.

MATERIALS AND METHOD

The germination of local golden berry lines in Turkey was tested at different NaCl and $CaCl_2$ concentrations. 'Line 1, Line 4, Line 5, and Line 7' seeds were obtained from the Ataturk Central Horticultural Research Institute in Yalova city.

Ten salinity treatments and a control were used. For the salinity treatments, NaCl and $CaCl_2$ were added to distilled water. The germination potential of seeds was estimated in accordance with the International Seed Testing Association procedures (ISTA, 1985). Salinity levels of the solutions were adjusted to 50 mM, 100 mM, 150 mM, 200 mM and 250 mM by using NaCl and $CaCl_2$. Distilled water served as the control. Three replicates of 50 seeds were evenly spaced in 90 mm petri dishes on Whatman no. 1 filter papers moistened with salt solutions. Petri dishes were placed in an incubator maintained at 23 ± 2˚C in darkness. For determination of salt tolerance differences among the four lines, GP (%), T_{50} (days), SL (cm) and FW (mg) were used as the parameters during the germination stages.

The experiment was conducted in the laboratory of the Department of Vegetable Breeding and Tissue Culture at the Ataturk Central Horticultural Research Institute. Research has been designed according to "factorial randomized parcel experimental design" with three replications. For comparison of multiple means, two-way ANOVA and the Duncan test were used. Percentage values were arcsine transformed prior to statistical analysis. Significant difference in statistical tests was set at $P < 0.01$.

RESULTS AND DISCUSSION

The GP (%), T_{50} (days), SL (cm) and FW (mg) were significant for three factors (lines, salinity and their interaction) (Table 1).

Generally, GP (%) value was reduced by increased salt concentration. That effect was more distinctive in 'Line 1'.

Table 1. A two-way analysis of variance.

		F Ratio			
Source	**DF**	**GP**	**SL**	**Weigh**	**T_{50}**
Salinity	10	151.74*	321.53*	163.27*	23.86*
Lines	3	31.58*	8.62*	9.57*	6.39*
Salinity x Lines	30	4.73*	5.78*	12.43*	7.37*
C. Total	131				
Error	88				

*significant ($p < 0.01$), ns: Not significant F: Freedom, DF: Degree of freedom, GP: Germination percentage, SL: Shoot Lenght, T_{50}: time to reach 50% germination, C. Total: Corrected Total.

Table 2. Germination percentage of golden berry lines seeds in saline solutions (%).

Salinity (mM)		**Line 1**	**Line 4**	**Line 5**	**Line 7**	**Average %**
NaCl	0	92.67A*b	98.67Aa*	100Aa	100Aa	97.84
	50	96.00Ab	100Aa	98.67Aab	98.67Aab	98.34
	100	94.67Ab	100Aa	98.00Aab	98.67Aab	97.84
	150	66.00Ba	67.33ABa	91.33Aa	95.33ABa	80.00
	200	20.00Cb	67.33ABa	74.00Aa	85.33ABa	61.67
$CaCl_2$	250	12.67DEb	45.33Ba	18.67Bb	52.00Ba	32.17
	50	99.33Aa	100Aa	100Aa	100Aa	99.83
	100	92.67Ab	100Aa	98.00Aa	98.67Aa	97.34
	150	16.00CDc	63.33ABab	33.33Bbc	77.33ABa	47.50
	200	8.67Eab	22.67Cab	6,00Cb	15.33Cab	13.17
	250	0.00Fb	4.67Da	1.33Db	8.00Da	3.50
Average %		54.43	69.94	65.39	75.39	

means within a column that have a different capital letter are significantly different from each other and means within a row that have different small letter are significantly different from each other ($P < 0.01$).

For example, in the 250 mM (millimolar) NaCl salt treatment, only 12.67% of 'Line 1' seeds had germinated after 25-days incubation (Table 2). When seeds were incubated with 150 mM, 200 mM and 250 mM $CaCl_{2,}$ germination percentage was more adversely affected than for the equivalent NaCl treatments, for all lines. For example, in the 250 mM $CaCl_2$, 12.67% of Line 1 seeds germinated but any germination would not have been observed in the 250 mM NaCl.

The T_{50} (days) value was also significantly affected by salinity concentration (Table 3). When seeds were incubated with $CaCl_2$, especially at 200 mM and 250 mM salinity, for all cultivars, the mean time to germination was lower than for NaCl.

The 50% of sowing in the control treatment whereas 12 days were needed for the same ratio of germination in the 250 mM $CaCl_2$ treatment. The longest SL (cm) value was in the control treatments for 'Line 1, Line 4 and Line 7', whereas 'Line 5' had it in the control, 50 mM NaCl and $CaCl_2$ treatments (Table 4). Generally, FW (mg) value was reduced by increased salt concentration (Table 5). When seeds were incubated with NaCl, especially at 250 mM salinity, for all cultivars the FW (mg) value was lower than for other treatments.

Table 3. The time to reach 50% germination (T_{50}) of golden berry lines seeds (days).

Salinity (mM)		Line 1	Line 4	Line 5	Line 7	Average %
NaCl	0	5.00G**a***	4.00Gb	4.33Cb	4.00Db	4.33
	50	6.00FGa	4.67FGb	5.00Cab	4.67CDb	5.09
	100	7.00EFa	4.67FGb	5.00Cb	4.67CDb	5,34
	150	7.00EFa	5.00EFGb	6.33BCab	5.33Cab	5.92
	200	8.00DEa	6.67CDEa	8.00BCa	7.00Ba	7.42
$CaCl_2$	250	9.00CDa	8.00BCDab	9.00Ba	7.33Bb	8.33
	50	8.33DEa	5.67EFGb	6.67BCb	5.67Cb	6.59
	100	10.33BCa	6.33DEFb	9.00Ba	7.00Bb	8.17
	150	11.33Ba	8.67Bb	9.67AB	8.00Bb	9.42
	200	13.33**A***a	8.33BCb	13.33Aa	7.67Bb	10.67
	250	-	12.00Aa	12.00Aa	11.33Aa	10.44
Average%		8.53	6.73	7.67	6.61	

means within a column that have a different capital letter are significantly different from each other and means within a row that have different small letter are significantly different from each other ($P < 0.01$).

Table 4. Shoot length of seeds of golden berry lines in saline solutions (cm).

Salinity (mM)		Line 1	Line 2	Line 3	Line 4	Average %
NaCl	0	7.07**A*a***	6.97Aa	6.80Aa	6.63Aa	6.87
	50	5.57Ba	5.97Ba	6.20Aa	5.53Ba	5.82
	100	3.60Cb	4.73Ca	4.80Ba	4.90BCa	4.51
	150	1.73Db	4.13CDa	2.20Cb	2.00Eb	2.52
	200	3.63Ca	1.27Eb	1.03Db	1.43EFb	1.84
$CaCl_2$	250	0.53Eb	0.83EFa	0.83Da	0.90Fa	0.77
	50	5.93Bab	6.33ABa	6.00Aab	4.30Cb	5.64
	100	1.93Dc	3.83Da	2.50Cbc	3.33Dab	2.90
	150	0.50Ec	1.20EFa	-	1.00Fb	0.90
	200	-	0.40FG	-	-	0.40
	250	-	-	-	-	-
Average%		3.39	3.57	3.80	3.34	

means within a column that have a different capital letter are significantly different from each other and means within a row that have different small letter are significantly different from each other ($P < 0.01$).

Table 5. Weights of golden berry lines in saline solutions of NaCl and $CaCl_2$ (mg).

Salinity (mM)		Line 1	Line 2	Line 3	Line 4	Average %
NaCl	0	3.94Aa	2.80Ac	3.53Ab	2.60Bc	3.22
	50	3.80Aa	2.55Ab	2.28BCb	2.58Bb	2.80
	100	1.80Ca	2.03BCa	2.15BCDa	1.49Ea	1.87
	150	1.30DEc	1.77CDb	2.08CDa	1.10Gc	1.56
	200	0.90Ec	1.37Db	1.90DEa	0.93Hc	1.28
$CaCl_2$	250	0.90Ea	0.88Ea	0.05Gb	0.10Ib	0.48
	50	2.26Bc	2.88Aa	2.46Bb	2.77Aa	2.59
	100	1.42CDc	2.46ABa	1.66Ec	1.97Cb	1.88
	150	1.44CDc	1.96Ca	1.67Eb	1.91Ca	1.75
	200	1.42CDc	1.40Dc	1.58Eb	1.78Da	1.55
	250	1.36Da	1.40Da	0.86Fb	1.25Fa	1.22
Average%		1.87	1.95	1.84	1.68	

means within a column that have a different capital letter are significantly different from each other and means within a row that have different small letter are significantly different from each other ($P < 0.01$).

Significant differences were obtained for the two salts regarding seed germination at higher salt levels. Reduction in germination caused by increased salinity has been described by numerous authors (Sivritepe and

Demirkaya, 2002; Yildirim et al., 2011). In the present study, significant differences were obtained for salinity regarding all observations. Similar results were earlier noted for several cultivars of golden berry (Yildirim et al., 2011, Miranda et al., 2010). High $CaCl_2$ levels had a greater effect than high NaCl levels. NaCl affects the permeability of the plasma membrane and increases influx of external ions and efflux of cytosolic solutes (Cramer et al., 1985) in plant cells. These effects of NaCl on cellular function are alleviated by the addition of Ca^{2+} to the external medium (Cramer et al., 1985; Cramer, 1992).

The current study reports a greater reduction in germination due to $CaCl_2$ than NaCl in all cultivars. This result supports that of Tavili and Biniaz (2009) report. In their study, $CaCl_2$ had a greater effect than NaCl and KCl salts on germination percentage of *Hordeum vulgare* and *H. bulbosum*. Also this result supports other research (Hanci et al., 2012). In their study $CaCl_2$ had a greater effect than NaCl salts on germination parameters of different local onion (*Allium cepa* L.) cultivars currently using in Turkey. The current study reports that high levels of Ca^{2+} had a negative effect on germination. Considerable variation was observed between the four lines for germination percentage, especially at higher salinity levels. In the present study, the 'Line 4 and Line 7' were more salt-tolerant than other lines at the high NaCl and $CaCl_2$ concentrations. Although maximum germination was obtained under non-saline conditions, it still had the ability to germinate at high levels of both NaCl and $CaCl_2$.

CONCLUSIONS

In conclusion, $CaCl_2$ had a greater effect on germination parameters than NaCl. Increased salinity levels resulted in decreased germination, inhibition of seedling growth and increased time to reach 50% germination ($T_{50,}$ days). Responses of golden berry lines were different for different parameters. 'Line 4' and 'Line 7' appeared more tolerant to salt stress than the other two lines.

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