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THE EFFECT OF DIFFERENT TEMPERATURES AND SALT CONCENTRATIONS ON SOME POPCORN LANDRACES AND HYBRID CORN GENOTYPE GERMINATIONS

*LEYLA IDIKUT, ZIYA DUMLUPINAR, S. NESRIN KARA, CENGIZ YURURDURMAZ AND MUSTAFA ÇÖLKESEN

Department of Field Crops, Kahramanmaras Sutcu Imam University, 46100 Kahramanmaras, Turkey
**Corresponding author email: lcesurer@ksu.edu.tr) Phone: (344) 219 16 39 Fax: (344) 219 15 26*

Abstract

In this study, five popcorn, which belong to Adıyaman (Adıyaman-1 and Adıyaman-2) and Çanakkale provinces (Çanakkale-1, Çanakkale-2 and Çanakkale-3), and four hybrid corn genotypes (Progen Favorite, Progen 1550, HK Heroic and BC 566) were germinated at two different temperatures (13 and 22ºC) and at four different salt concentrations (0, 25, 50 and 100mM NaCl). The traits, such as germination speed, germination rate, vigor index, radicula length, coleoptile length and plumula length were investigated. The genotypes, different temperatures and salt concentrations were significantly different accordance to investigated traits. The interactions between genotype x salt concentration, genotype x different temperature and among genotype x salt concentration x different temperature were significant according to the some traits. It was recorded that increased temperatures caused an important positive effects on germination traits while increased salt concentrations caused negative effects. Popcorn landraces had higher values than hybrid types in according to investigated traits.

Introduction

Agriculture, which can be defined as obtaining vegetable and animal products using seeds and soil, mainly aims to increase living standards and food supply for human need. Thus, people always try to increase the productivity in unit area using all techniques. Corn can be shown as the best example of this situation. Corn is intensively cultivated in all regions where the necessarily temperature and humidity exist, especially in Mediterranean Region, however, water need is provided by irrigation. Since corn needs more water with the increase of temperature, it is usually irrigated in every 10-20 days, depends on conditions; however, frequent irrigation with high temperature causes salinity problems in soil.

Salinity is an environmental-stress factor for cop plants and is included in chemical stress group. Salinity problem in growing environment brings several problems together with it. These problems can be named as enzyme activation deformation, malnutrition, functional troubles in cell membrane, general troubles in metabolic process, out of equilibrium of water take unconformity of osmosis, oxidative stress and general growth problems (Orcutt & Nilsen, 1996). As for corn, which is sensitive against salinity, decrease in yield can reach to 50% when electricity permeability exceeds 5, 9ds/m (Orcutt & Nilsen, 1996). General growth problems which are affecting the value parameters are frequently seen in cultivated corn plant which is under salinity stress (Cicek & Cakirlar, 2002). Under salinity stress, the Na content of the corn leaves and roots increase, while K content decreases and especially for the genotypes which are more sensitive to salinity, water potential of leaves and transportation ability are destroyed (Azevedo Neto *et al*., 2004).

Salt damage has the most important effect during germination period, (Del'aquuila & Di- Turi, 1996). It was recorded that, salt had negative effect on growing by interrupting dissolution and transportation mechanism of germinating seed's stored material (Sheoran & Gar, 1978; Prakash & Prathapasenan, 1998; Yakıt & Tuna, 2006). Dumlupınar *et al*., (2007) has indicated that salt concentration has an important negative effect on germination and vigor index values and growth characters of seedling and the majority of the negative effect changes depending on the varieties. It has been pointed out salt-toleration can be defined as the ability of a plant to complete its life-span and compete against other plants under salt conditions (Jenning, 1968). As a result of previous studies, it has been indicated that, the damage caused by salt- stress on corn plant couldn't completely be tolerated with fertilizers and decreasing in yield was observed as a result of increasing of salt in irrigation water (Kaya & Tuna, 2005). It has been pointed out that temperature has an important effect on germination (Khan & Ungar, 1999), high temperatures increase the percentage of germination more than low temperatures (Khan *et al*., 2002), and too high and too low temperatures interrupt the germination (Dan & Brix, 2007).

Selection of salt tolerant plants and improvement studies are mostly done depending on agronomic characters (Noble & Rogers, 1992; Fatima *et al*., 2010), in salt toleration, genetic information has fallen behind the physiology (Tal, 1985), salt is a more prior factor with respect to temperature (Koch & Dawes, 1991). Soil and water are getting more and more important in the world where the global warming has been speeding up and water has been getting rare recently. Apart from being an important stress factor, salt in water and soil definitely limits growing agricultural crops (Shannon, 1998). Since corn has a wide range of use, as human, animal food and industrial product, it has an important share among agricultural products. Furthermore, that it can be grown in every place where necessary water and temperature are available easily and it has high yield in unit area increases the importance of corn. That pistil and anther of corn are in different places eases hybridization studies and has provided hybrid corns to spread all over the world.

This study was aimed to evaluate the germination and seedling traits under different temperatures and salt concentrations on nine corn genotypes, five of them were landraces and four of them were hybrid types.

Material and Methods

This study was carried out in the laboratory of Field Crops Department of Kahramanmaras Sutcu Imam

University. In this study 5 popcorns landraces (2 of them belong to Adıyaman province and 3 of them belong to Çanakkale province) and four hybrid corns (Progen Favorite, Progen 1550, HK Heroic and BC 566) were used as crop materials. We labeled the landraces as Adıyaman-1, Adıyaman-2, Çanakkale-1, Çanakkale-2 and Çanakkale-3 according to the province which they were derived from.

Some information about the genotypes is given as followings:

Adıyaman-1: The farmers in Adıyaman province use it for their local needs. They are round-shaped, with light yellow color, round-shaped in upper side and average weight of 100 seeds is 15g.

Adıyaman-2: The farmers in Adıyaman province use it for their local needs. They are strap-shaped, with dark yellow color, round-shaped in upper side and average weight of 100 seeds is 16g.

Çanakkale-1: The farmers in Çanakkale province use it for their local needs. They are strap-shaped, with yellow color, round-shaped in upper side and average weight of 100 seeds is 10g.

Çanakkale-2: The farmers in Çanakkale province use it for their local needs. They are strap-shaped, with purple color, round-shaped in upper side and average weight of 100 seeds is 14g.

Çanakkale-3: The farmers in Çanakkale province use it for their local needs. They are round like-shaped, with beige color, round-shaped in upper side and average weight of 100 seeds is 11g.

Progen favorite: They are produced by the companies and sold to farmers as F1 offspring. They are strap-shaped, cave shaped in upper side and average weight of 100 seeds is 33g.

Progen 1550: They are produced by the companies and sold to farmers as F1 offspring. They are round shaped, cave shaped in upper side and average weight of 100 seeds is 28g.

NK heroic: They are produced by the companies and sold to farmers as F1 offspring. They are round shaped, cave shaped in upper side and average weight of 100 seeds is 32g.

BC 566: They are produced by the companies and sold to farmers as F1 offspring. They are round shaped, cave shaped in upper side and average weight of 100 seeds is 34g.

The research was arranged in a randomized design with 3 replications. Filter papers were cut and placed to the petri dishes according to their size and then 25 seeds from each genotype were placed on the dishes and 30 ml water with 0, 25, 50 and 100mM NaCl concentration were added to the dishes and they were put into growth chamber (Munns & Termaat, 1986; Tort & Türkyılmaz, 2003; Dumlupınar *et al*., 2007). The corn germination temperatures is minimum 9 °C and optimum 18 °C (Kun 1985), and in our study, the temperatures of the growth chamber were 13°C and 22°C and it was 12-hours light and 12-hours dark. After the fourth day of the germination period, 40 ml extra water was added to the petri-dishes with 22°C temperature. Fourth day of the germination, germination speed and eighth day of the process; germination rate, vigor index, radicula length, coleoptile length and plumula length were measured.

Germination and seedling traits were determined according to the methods, Anonymous (1998); Şehrali (1989); Steiner *et al*., (1989); Kırtok *et al*., (1994), Killi (2004) and Dumlupınar *et al*., (2007).

Results

Five popcorn landraces and 4 hybrid corn genotypes were germinated at 2 different temperature (13 and 22°C) and 4 different salt concentrations (0, 25, 50 and 100mM NaCl). Germination speed, germination rate, vigor index, radicula length, coleoptile length and plumula length were determined and mean averages were obtained and their groupings according to LSD test are shown at Tables 1 and 2.

The results showed that, different temperatures had significant positive effects on all the traits, except germination rate (Table 1 and 2). The highest values for germination speed (100%), vigor index (2253), radicula length (11.53 cm), coleoptile length (4.03cm) and plumula length (2.35cm) were obtained from the seeds which germinated at 22°C. Salt concentrations had important negative effects on all traits. The lowest values for germinating speed (0.00%), germination rate (3.33%), vigor index (0.00), radicula length (0.07cm), coleoptile length (0.00cm) and plumula length (0.00cm) were obtained from the 100mM salt concentration, at 13°C temperature treatments.

Among the genotypes quite different results were obtained for all investigated traits. The highest germination speed values were obtained from Adıyaman-2 (100%), Adıyaman-1 and Çanakkale-2 (93.33%) genotypes at control salt and 22°C treatments (Table 1) and the lowest ones were obtained from BC 566 (0.00%), and Progen Favorite and Progen 1550 (1.67%) genotypes at 100 mM salt concentration, at 13 °C temperature treatments (Table 2). The highest values for the germinating rate, were obtained from Adıyaman-2 and Adıyaman-1 (100 and 95.00%) genotypes at control salt and 22°C treatments (Table 1) while the lowest ones were obtained from BC 566 and Progen 1550 (0.00 and 3.33%) genotypes (Table 2). Adıyaman-2 and Adıyaman-1 (1153.33 and 968.72) popcorn landraces had the highest values for vigor index at 0mM salt and 22°C temperature treatments, however, the hybrid types had the lower values at 100mM salt concentration and 13°C temperature treatments. BC 566 (0.00), Progen Favorite (0.67), Progen 1550 (0.75), HK Heroic (3.13) had lowest ones. According to Adıyaman-2 genotype had the highest values for radicula and coleoptile length (11.53 and 4.03cm), while Çanakkale-3 had the highest value for plumula length (3.62). In addition, the lowest radicula length values were obtained from BC 566 (0.07cm), Progen 1550, Progen Favorite (0.34cm) and Heroic (0.50cm), while the lowest coleoptile length values were obtained from BC 566 (0.00cm), Progen Favorite (0.10cm), Progen 1550 (0.20cm) and Heroic (0.37cm), (Table 2). Also plumula length of hybrid types were (0.00cm) at 100mM salt concentration and 13°C temperature treatments (Table 2).

In the study, for vigor index, radicula and plumula length; genotype x temperature, temperature x salt concentration and genotype x salt concentration interactions, for germination speed and coleoptile length; temperature x salt concentration interactions were determined to be important. Also interactions among genotype x temperature x salt concentration were significant for germination speed, radicula length, plumula length and vigor index.

Table 1. Mean values of germination speed (GS), germination rate (GR), radicula length (RL), coleoptile length (CL), plumula length (PL) and vigor index (VI), of five pop corn landraces seeds at two different temperatures (°C) and 4 different salt concentrations.

Temp.	Salinity	Genotypes	GS (%)	GR (%)	RL (cm)	CL (cm)	PL (cm)	VI
13°C	0 mM	Adıyaman-1	80.00	91.67	2.57	0.99	0.00	203.08
		Adıyaman-2	75.00	96.67	5.86	1.38	0.75	468.75
		Çanakkale-1	63.33	85.00	2.88	1.18	0.39	173.87
		Çanakkale-2	76.67	90.00	4.01	1.36	0.00	308.53
		Çanakkale-3	65.00	56.33	2.02	0.88	0.27	131.30
	25 mM	Adıyaman-1	68.33	88.33	1.55	0.98	0.32	105.88
		Adıyaman-2	66.67	88.33	3.72	1.37	0.93	248.12
		Çanakkale-1	71.67	86.67	1.42	0.84	0.48	106.00
		Çanakkale-2	65.00	76.67	2.54	1.16	0.80	204.63
		Çanakkale-3	48.33	70.00	1.96	0.87	0.65	102.62
	50 mM	Adıyaman-1	91.67	98.33	5.31	1.60	1.42	492.65
		Adıyaman-2	78.33	98.33	4.52	1.44	0.87	353.42
		Çanakkale-1	55.00	70.00	0.83	1.14	0.50	45.58
		Çanakkale-2	73.33	88.33	1.64	1.16	0.53	119.97
		Çanakkale-3	55.00	78.33	1.81	0.89	0.32	102.97
	100 mM	Adıyaman-1	30.00	76.67	0.99	0.38	0.00	33.88
		Adıyaman-2	30.00	85.00	1.09	0.54	0.00	41.10
		Çanakkale-1	28.33	63.33	0.35	0.64	0.00	8.08
		Çanakkale-2	36.67	65.00	0.62	0.76	0.22	25.50
		Çanakkale-3	3.33	60.00	0.56	0.37	0.00	1.90
22°C	0 mM	Adıyaman-1	93.33	95.00	10.44	3.38	2.35	968.72
		Adıyaman-2	100.00	100.00	11.53	4.03	2.22	1153.33
		Çanakkale-1	78.33	80.00	6.03	2.39	1.81	471.45
		Çanakkale-2	78.33	83.33	5.72	2.07	1.09	427.82
		Çanakkale-3	81.67	85.00	8.66	2.79	3.62	709.77
	25 mM	Adıyaman-1	95.00	95.00	8.95	3.44	2.09	845.73
		Adıyaman-2	93.33	95.00	8.72	3.45	1.75	807.30
		Çanakkale-1	66.67	70.00	2.63	1.95	1.33	170.65
		Çanakkale-2	93.33	93.33	7.00	3.04	2.08	667.58
		Çanakkale-3	73.33	78.33	4.49	1.88	1.37	341.00
	50 mM	Adıyaman-1	88.33	88.33	4.59	2.24	0.60	416.27
		Adıyaman-2	85.00	93.33	3.19	2.10	0.61	253.67
		Çanakkale-1	80.00	88.33	1.85	2.20	0.95	144.95
		Çanakkale-2	75.00	80.00	4.13	3.17	1.23	316.43
		Çanakkale-3	75.00	76.67	2.76	2.28	0.74	208.68
	100 mM	Adıyaman-1	96.67	96.67	2.30	2.29	0.39	222.88
		Adıyaman-2	91.67	91.67	3.36	2.41	0.38	310.47
		Çanakkale-1	46.67	50.00	0.45	1.19	0.21	33.33
		Çanakkale-2	78.33	85.00	1.88	2.71	0.98	147.95
		Çanakkale-3	40.00	43.33	1.09	1.41	0.40	67.60
Mean			69.29	82.03	3.65	1.76	0.87	299.09
LSD (%)			8.98	8.41	0.88	0.39	0.30	78.79

Table 2. Mean values of germination speed (GS), germination rate (GR), radicula length (RL), coleoptile length (CL), plumula length (PL) and vigor index (VI), of four hybrid corn seeds at two different temperatures and 4 different salt concentrations.

Temp.	Salinity	Genotypes	GS (%)	GR (%)	RL (cm)	CL (cm)	PL (cm)	VI
13°C	0 mM	Progen Favorite	8.33	35.00	0.47	0.37	0.00	4.48
		Progen 1550	6.67	38.33	0.49	0.46	0.00	2.80
		NK Heroic	25.00	48.33	0.82	0.52	0.00	20.50
		BC 566	0.00	5.00	0.25	0.00	0.00	0.00
	25 mM	Progen Favorite	26.67	43.33	0.59	0.66	0.00	13.65
		Progen 1550	31.67	48.33	0.74	1.14	0.53	24.82
		NK Heroic	40.00	51.67	1.23	1.17	0.33	68.80
		BC 566	8.33	8.33	0.38	0.45	0.00	6.17
	50 mM	Progen Favorite	20.00	43.33	0.89	1.33	0.73	22.53
		Progen 1550	3.33	21.67	0.34	0.42	0.00	1.60
		NK Heroic	40.00	61.67	0.63	0.99	0.14	29.17
		BC 566	0.00	5.00	0.13	0.00	0.00	0.00
	100 mM	Progen Favorite	1.67	21.67	0.34	0.10	0.00	0.67
		Progen 1550	1.67	5.00	0.42	0.20	0.00	0.75
		NK Heroic	6.67	18.33	0.50	0.37	0.00	3.13
		BC 566	0.00	3.33	0.07	0.00	0.00	0.00
22°C	0 mM	Progen Favorite	58.33	60.00	2.16	3.76	0.33	130.02
		Progen 1550	33.33	43.33	1.17	2.89	1.24	38.20
		NK Heroic	50.00	55.00	1.88	3.12	0.53	94.50
		BC 566	18.33	28.33	1.01	1.52	0.27	19.87
	25 mM	Progen Favorite	36.67	45.00	1.47	2.86	0.88	53.77
		Progen 1550	20.00	28.33	0.91	1.75	0.75	21.73
		NK Heroic	30.00	35.00	2.39	3.01	0.73	67.80
		BC 566	6.67	8.33	0.70	2.20	0.00	5.17
	50 mM	Progen Favorite	36.67	41.67	1.59	1.81	0.00	62.12
		Progen 1550	36.67	41.67	1.12	1.34	0.33	41.93
		NK Heroic	35.00	38.33	1.91	2.55	0.00	70.73
		BC 566	6.67	11.67	0.77	1.77	0.23	5.07
	100 mM	Progen Favorite	20.00	31.67	0.98	0.95	0.00	19.07
		Progen 1550	11.67	25.00	0.65	0.93	0.00	9.75
		NK Heroic	21.67	23.33	1.01	1.18	0.00	34.00
		BC 566	10.00	11.67	0.42	0.83	0.00	10.60
Mean			20.37	30.83	0.89	1.27	0.22	27.61
LSD (%)			8.98	8.41	0.88	0.39	0.30	78.79

Discussion

Germination speed, vigor index, radicula length, coleoptile length and plumula length were affected from temperature. Rising of the temperature increased the speed of germination characters. Vigor index, radicula, coleoptile and plumula lengths increased with the raise of temperature from 13 to 22^{o}C, while raise in temperature not caused a significant increase on germination rate. Khan *et al*., (2002) have indicated that when compared to high temperatures had more positive effect on germination rate with respect to low temperatures. Increases in the salt concentrations, especially at 100mM NaCl concentration level caused significant decreases in investigated traits (Khan *et al*., 2000 and Dumlupınar *et al*., 2007). Increase in salt concentration up to 50mM NaCl didn't have any significant effects on germination speed, germination rate and coleoptile length but when the concentration increased to 100mM NaCl level, it caused decrease in germination speed, germination rate, vigor index, radicula length, coleoptile length and plumula length. Ashraf & Orooj (2006), Irshad *et al*., (2002), Ghoulam *et al*., (2002), Daşgan *et al*., (2002) and Shahba *et al*., (2008) pointed out that salt stress had a negative effect on plant growth. In addition to this, temperature x salt concentration interactions was observed to be important for germination speed, vigor index, radicula, coleoptile and plumula lengths. Zia & Khan (2004) pointed out the same effect as well. As we can see from Figs. 1, 3, 7, 8 and 12; while salt rates increased, germination values decreased at both temperatures (Khan *et al*., 2001; Ungar, 1997).

Increased temperature had positive effect on all salt concentrations for germination speed (Fig. 1). The highest values were obtained from control treatment at 22^{o}C. 100mM NaCl concentration level caused the lowest germination speed at both temperatures. These situation points out that the negative effects of salt concentration continues even in case of increased temperature and low germination speed is caused by the negative effect of salt concentration (Khan *et al*., 2004).

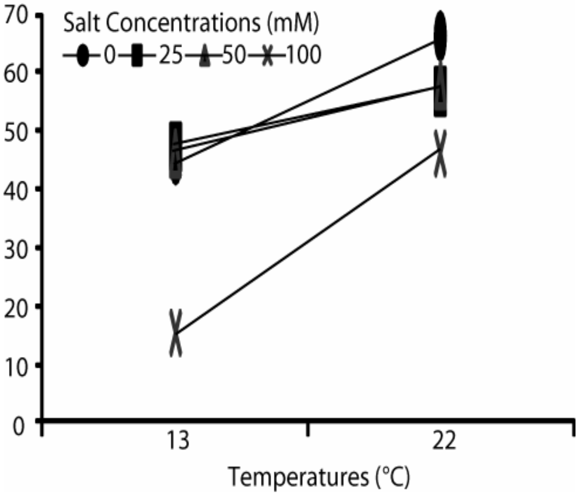

Fig. 1. Temperature x salt concentration interaction related to germination speed.

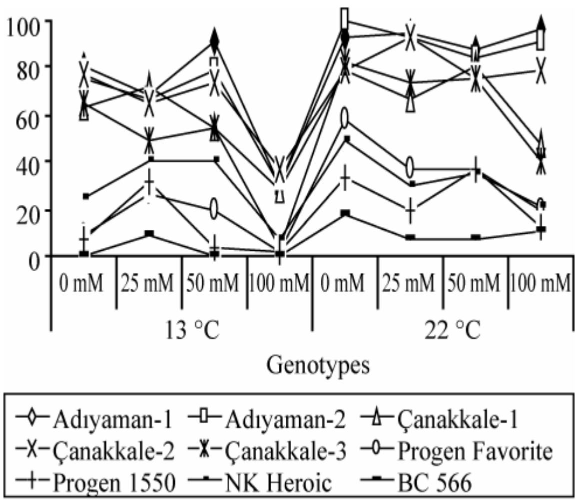

Fig. 2. Temperature x salt concentration x genotype interaction related to germination speed.

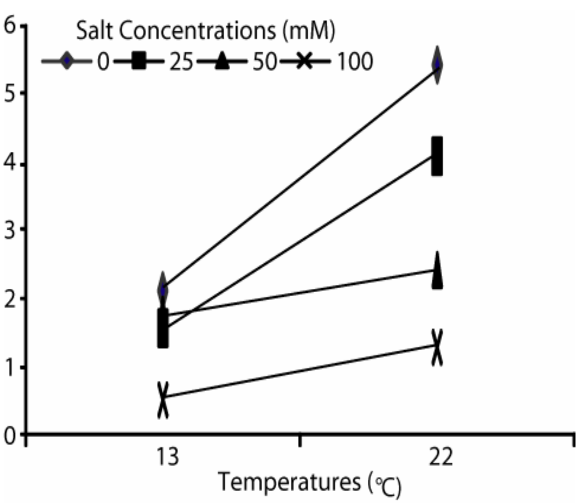

Fig. 3. Temperature x salt concentration interactions related to radicula length.

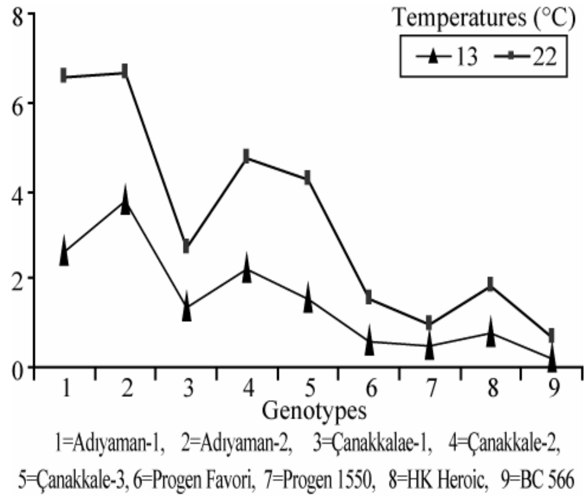

Fig. 4. Temperature x genotype interaction related to radicula length.

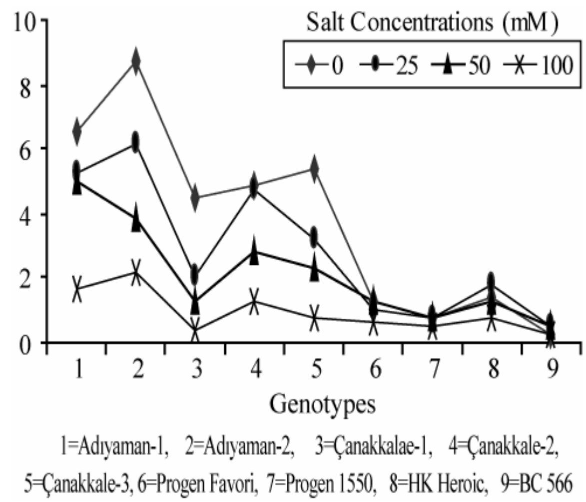

Fig. 5. Genotype x salt concentration interaction related to radicula length.

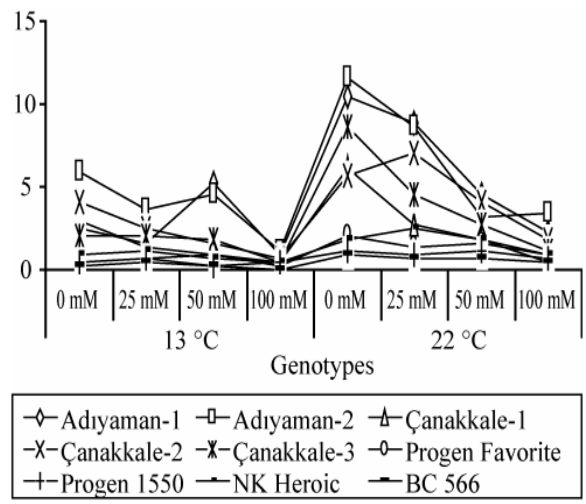

Fig. 6. Temperature x salt concentration x genotype interaction related to radicula length.

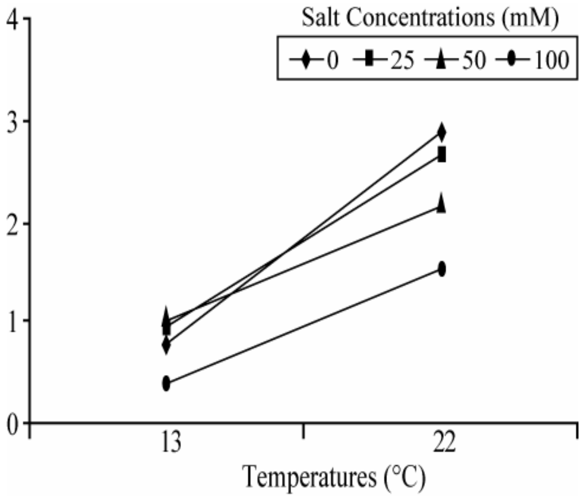

Fig. 7. Temperature x salt concentration interaction related to coleoptile length.

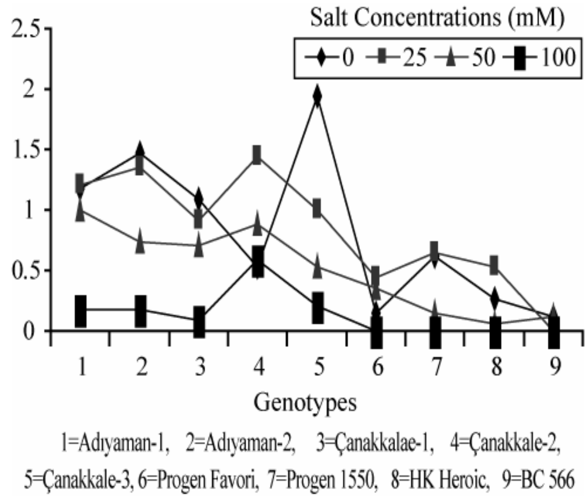

Fig. 10. Genotype-salt concentration interactions related to plumula length.

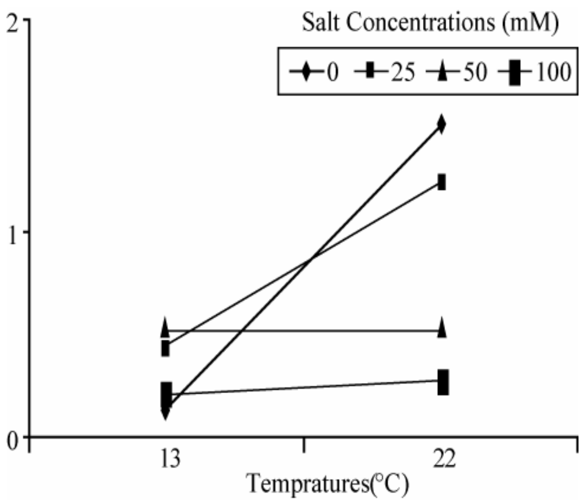

Fig. 8. Temperature x salt concentration interaction related to plumula length.

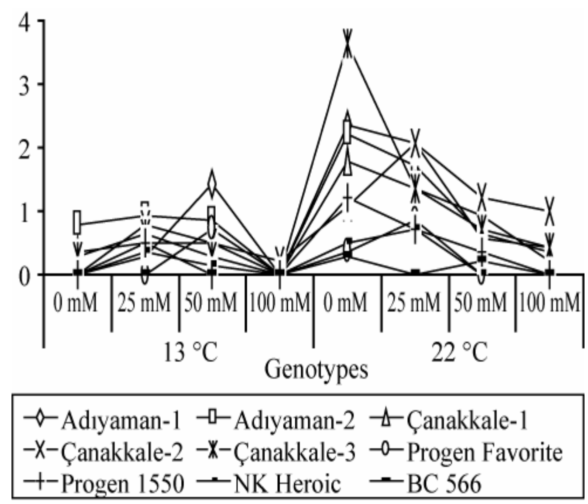

Fig. 11. Temperature x salt concentration x genotype interaction related to plumula length

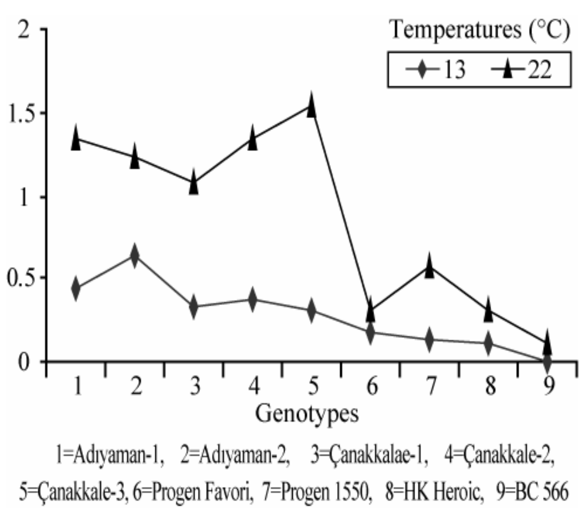

Fig. 9. Temperature x genotype interaction related to plumula length.

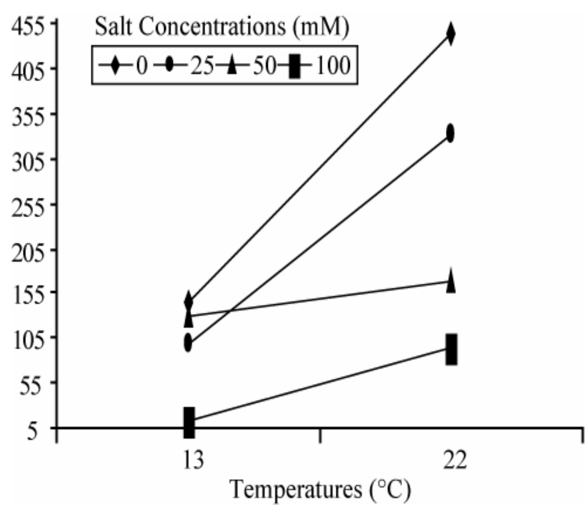

Fig. 12. Temperature x salt concentration interaction related to vigor index.

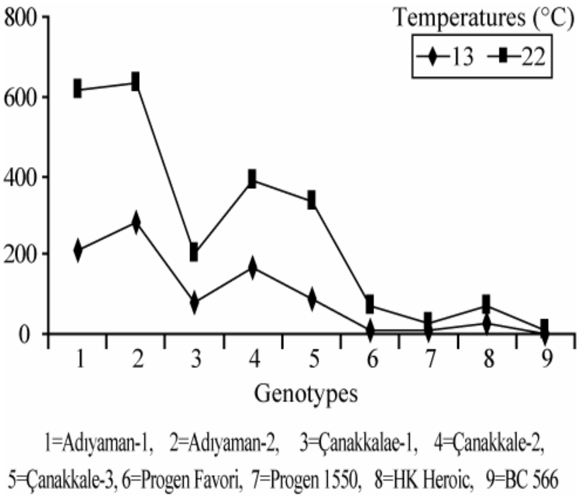

Fig. 13. Temperature x genotype interaction related to vigor index.

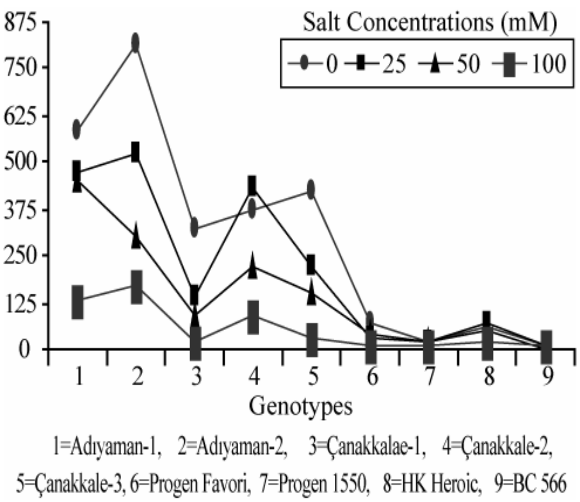

Fig. 14. Genotype x salt concentration interaction related to vigor index.

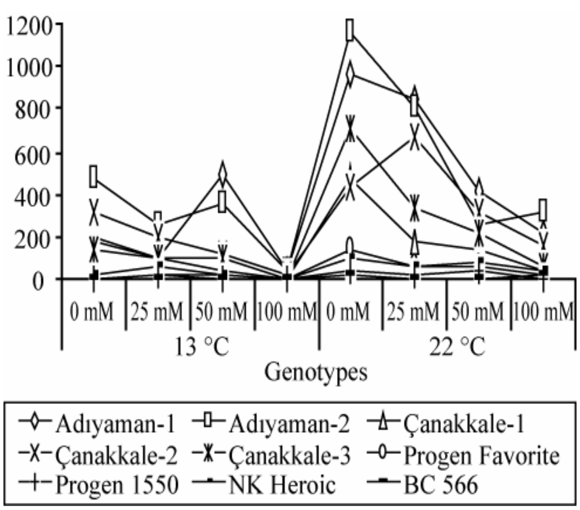

Fig. 15. Genotype x salt concentration Genotype interaction related to vigor index.

Radicula length increased in significant level at all salt concentrations depending on increased temperature. The increasing was limited at 50 and 100mM NaCl concentration levels, while it was obvious in control and 25mM treatments. Increasing of temperature from 13 to 22°C caused 2 to 3cm increasing in radicula length in control and 25mM NaCl concentration treatments (Fig. 3). Raising of the temperature increases the radicula length has also been indicated by Dan & Brix (2007).

The effect of salt concentration levels at different temperatures on coleoptile length was various. At low temperature, 100mM NaCl concentration level extended the coleoptile length about 1 cm, while, increasing of temperature to 22°C caused coleoptile length to increase in a significant extent. The highest coleoptile length at 22°C was obtained from the control treatment. This was followed by 25 and 50mM NaCl concentration treatments respectively and the lowest value was obtained from 100mM NaCl treatment (Fig. 7).

While both temperatures had similar effects on plumula length at 50 and 100mM treatments (Fig. 8), the increasing of temperature had positive effects on plumula length in control and 25mM NaCl treatments. Increasing in plumula length was 0.4 cm in control treatment, 0.2cm in 25mM NaCl treatment at 13°C, but it was 1.2-1.4cm at 22°C. Likewise, salt concentration treatments at low temperatures caused low vigor index values (Fig. 12) but it increased with the increasing of temperature to 22°C. Although this increase was not so much in 50mM and 100mM NaCl treatments, it was 3-4 times higher in control and 25mM NaCl treatments. The interactions of corn genotypes to temperature and salt concentrations were quite important in terms of investigated traits (Figs. 4, 5, 9, 10, 13 and 14). The interactions among genotype x temperature and salt concentrations were also significantly important for germination speed, radicula length, plumula length and vigor index. Genotypes had the lowest values at 100mM NaCl concentration at 13°C for germination speed, radicula length, plumula length and vigor index (Figs. 2, 6, 11 and 15). Khan & Gulzar, (2003) stated that genotypes and interactions among them and the reactions of genotypes against temperature and salt during germination are quite important.

Corn genotypes showed significant differences according to germination characters. Adıyaman-1 and Adıyaman-2 genotypes had higher values related with all the investigated traits than the other genotypes. Dumlupınar *et al*., (2007) also indicated that the genotypes showed significant differences among the germinations characters. The reaction to the salt concentration levels and different temperatures was different among the genotypes, except for Adıyaman-1 and Adıyaman-2 genotypes; however, all genotypes had quite low radicula length at 13°C. With the increasing of temperature to 22°C, radicula lengths of Adıyaman-1 and Adıyaman-2 genotypes increased significantly. Among the other genotypes, Çanakkale-1, 2 and 3 genotypes had positive effect to increased temperature while, Progen Favorite, Progen 1550, HK Heroic and BC 566 genotypes didn't have significant effect to increased temperature (Fig. 4).

The reactions of genotypes to salt concentrations were different at low concentrations (0 and 25mM NaCl) but they were similar at high concentrations (50 and 100mM NaCl). 100mM NaCl concentration treatment caused low radicula length for all genotypes. Adıyaman-2 of the all genotypes had the highest radicula length in control and 25mM NaCl treatment (Fig. 5). In a previous work, reported that, increase in salt concentrations, decreased radicula length (Qu *et al*., 2008). Increased temperature (22^{o}C), caused significant increase of plumula length for Adıyaman-1, Adıyaman-2, Çanakkale-1, Çanakkale-2 and Çanakkale-3 genotypes while, others were almost similar to that of at 13^{o}C (Fig. 9). The reactions of genotypes to salt concentrations for plumula length were quite different (Fig. 10). All the genotypes had the lowest plumula length at 100mM NaCl treatment, but the reactions started to be different with the decreases in the salt concentrations. Adıyaman-1 in 50mM NaCl, Çanakkale-2 in 25mM NaCl, Çanakkale-3 genotypes in control treatments had the highest plumula lengths.

As for, vigor index, genotypes had different reactions to different temperatures (Fig. 13). Adıyaman-1 (22^{o}C) and Adıyaman-2 (13 and 22^{o}C) genotypes positive affected due to increased temperature. The rising of temperature caused increase in vigor index for Çanakkale-2 and Çanakkale-3 genotypes but not as high as that of in Adıyaman-1 and Adıyaman-2 genotypes.

Vigor index values of the genotypes were different to salt concentrations. The highest vigor index (1153.33) was determined in Adıyaman-2 genotype in control salt concentration and at 22 ^{o}C treatments. The lowest vigor index values were found at 100mM NaCl treatment and at 13^{o}C for all genotypes. Al-Sherif (2007) stated that, increase in salt concentration decreased the vigor index values. At different salt concentration landraces (Adıyaman-1, Adıyaman-2, Çanakkale-1, Çanakkale-2, and Çanakkale-3) had higher vigor index values at different salt concentrations than hybrid genotypes (Progen Favorite, Progen 1550, HK Heroic and BC 566). While Adıyaman-2 genotype had higher vigor index than the others at 100mM NaCl, Çanakkale-2 genotype had its highest vigor index at 25mM NaCl treatment. In addition, BC 556 genotypes had the lowest vigor index value across the all treatments.

As a result of the study, the reactions of genotypes to different temperatures and salt treatments were different (Khan & Gulzar, 2003). Khan *et al*., (2001) and Mittova *et al*., (2002) stated that the rate of germination of seeds were different at salty medium. In previous works, varieties and lines were also reported as differed to salt tolerance (Fortmeier, 1995). The variation among genotypes to salt tolerance can not be explained with single criteria (Ashraf & Haris, 2004). In our study, we found that popcorn landraces have more superior traits compared to hybrid types. As regard to ability of landraces to deal with negative conditions, by transferring salt tolerance traits of popcorn landraces to hybrid corns, the effects of much irrigated and salty soils on germination of hybrid corn seeds will be able to be increased.

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