Resistance to salinity stress and available water levels at the seedling stage of the common vetch (*Vicia sativa* L.)

A. Orak[1], E. Ateş[2]

[1]*Department of Field Crops, Tekirdağ Agriculture Faculty, Trakya University, Turkey*
[2]*Plant Breeding Application and Research Centre, Trakya University, Tekirdağ, Turkey*

ABSTRACT

This research was carried out in the Field Crop Department, Tekirdağ Agriculture Faculty, and Plant Breeding Application and Research Centre, Trakya University, Turkey. The response of common vetch (*Vicia sativa* L.) seedlings to salt and available water level tolerance were compared for its water retention capability and the dry matter of shoots, root and shoot weights after 2 h incubation at 30°C and 1 h incubation at 105°C under the conditions of absence, as well as the presence of various levels of salinity and available water. Germination was not affected by the salinity and available water treatments. 1.35 dS/m salinity water treatment resulted in increasing the fresh weights of its shoot (1.179 g) and root (0.580 g), weights after 2 h incubation at 30°C (shoot: 0.0456 and root: 0.0325 g) and 1 h incubation at 105°C (shoot: 0.0104 g and root: 0.0073 g), water retention capability (0.0123 g) and dry matter (0.0236 g) of the shoot in seedlings. The highest fresh weight (root: 0.567 g and shoot: 1.113 g) and water retention capability (0.0112 g) were determined from capacity of the field.

Keywords: water retention capability; fresh weight; dry matter; shoot; root; seedling

Soil salinity is one of the world's most serious environmental problems. About 7% of the world's total land area is affected by salt, as in a similar percentage of its arable land (Ghassemi et al. 1995, Munns et al. 2002). Soil salinity can result from natural processes, or from crop irrigation with saline irrigation water under poor drainage conditions. Excessive soil salinity occurs in many semi-arid to arid regions of the world where it can affect nutrient movement to plants, soil properties, and various soil chemical reactions including pH (Al-Busaidi and Cooksen 2003) and inhibits the growth and yields of crop plants (Tanji 1990). Plant growth in saline soils is affected mainly by the reduced availability of water due to the high osmotic pressure. Salt-affected plants are stunted with dark green leaves, which, in some cases, are thicker and more succulent than normal. In the woody species, high soil salinity may lead to leaf burn and defoliation. High salinity causes alfalfa yield to decrease while the leaf-to-stem ratio increases, influencing forage quality. Grasses also appear dark green and stunted with leaf burn symptoms (Katuby-Amacher et al. 2004). However, salinity that causes other physiological and morphological changes in plants could be mitigated by calcium, which also increased leaf the extension rate of salt-stressed plants by increasing hydraulic conductance (Cramer 1992). Similarly, salinity reduced water potentials in the leaves of clovers (*Trifolium* sp.) and maize (*Zea mays* L.), reduced length and dry mass of the stem (Izzo et al. 1991) and affected leaf elongation and water transport in xylem vessels in the plants, as well as the length and conductivity of the root in clovers and maize (Evlagon et al. 1992, Maiti et al. 1994, Maiti et al. 1996). A high specificity of the genetic differences between isogenic maize hybrids was found with respect to betaine accumulation (Rhodes et al. 1989) and the genetic relationship of tolerance to saline-sodic soils was found in maize (Nordquist et al. 1992).

Plants differ in their tolerance to salt. Generally, fruits, vegetables, and ornamentals are more salt sensitive than forage or field crops. In addition, certain varieties, cultivars, or rootstalks may tolerate higher salt levels than others. For example, white clover (*T. repens* L.) has a low salt tolerance than Persian (*T. resupinatum* L.) and strawberry (*T. fragiferum* L.) clovers. Ranking from high to low, some legume species differ in their degree of resistance to becoming salinified as follow: Narrowleaf birds foot trefoil (*Lotus tenuifolius* L.), 5 dS/m > big birds foot trefoil (*L. uliginosus* Schk.), 2.3 dS/m > alfalfa (*Medicago sativa* L.), 2.0 dS/m > white clover, 1.5 dS/m = red clover (*T. pratense* L.) = berseem clover (*T. alexandrinum* L.) (Maas 1990). Marcum et al. (1997) investigated the tolerance of some grasses to salinity. The more salt tolerant grasses had a greater rooting depth and a greater total root dry weight under salinity stress. They defined salt tolerant grasses; and the osmotic potential was controlled, more than in susceptible plants. The growth stage of the plant is very important when considering salt tolerances. Plants are more sensitive to high salinity during germination and in the seedling stages, immediately after transplanting, and when subject to other (e.g., disease, insect, nutrient) stresses (Sağlam 1993, Bischoff and Werner 2004, Katuby-Amacher et al. 2004). But information on seedling resistance in the common vetch (*Vicia sativa* L.) and other vetch species to salinity is not available (Bugg 1995).

Although from the agronomy stand point, the most important trait is seed and hay production, the variability in seedling properties of common vetch cultivars submitted to salinity reflect their adaptation at the early crop establishment phase and their potentials of yields. Therefore, the objective of this study was to determine the resistance of the common vetch to salinity and different water quantities at the seedling stage, particularly for use in improving crop establishment in the arid and semiarid regions of Turkey (Açıkgöz and Tekeli 1980, Tuna and Orak 2002).

MATERIAL AND METHODS

The material of the common vetch (cv. Orakefe) was provided by the Department of Field Crops, Tekirdağ Agriculture Faculty, Trakya University in Turkey. This is obtained with a cultivar proposed for adaptation in semiarid regions. In this experiment, the common vetch was evaluated for seedling resistance in three salinity stress (control, 1.35 dS/m and 2.70 dS/m) and four available water levels (25%, 50%, 75% and field capacity), adopting a randomized completely in a block design in three replications for each treatment (Turan 1995). Five seeds were sown in pots (13.5 cm high and 7.6 cm in diameter) with a bottom drainage hole in xeralf (Cangir and Boyraz 2001) at 3 cm depth. Each pot contained 350 g xeralf. The permanent wilting point was measured on xeralf samples (350 g) passing through a 2 mm sieve, saturated for 24 hours, and then equilibrated for 72 to 96 hours at 1500 kPa on a pressure-plate apparatus. The available water capacity (AWC) was calculated from AWC = FC – PWP. Where AWC is the available water capacity, FC is field capacity and PWP is the permanent wilting point (Özdemir et al. 2000, Arin and Kiyak 2003). After sowing, the pots were irrigated with top water (0 dS/m, 1.35 dS/m and 2.70 dS/m salinity water) to FC. Two concentrations of NaCl (MERCK) namely, 864 ppm and 1728 ppm were used for 1.35 dS/m, 2.70 dS/m salinity water. After FC, by means of the mentioned methods above, pots were weighed (seeds and pot weights to eliminate any replications) until determining PWP. AWC was maintained by weighing each pot every day and applying the required amount of water (water solution did not include plant nutrient elements or salt). Germination was not affected by the salinity and the available water treatments. Four

Table 1. Root and shoot fresh weights of seedlings

Salinity	Shoot (g)				Root (g)			
	25%	50%	75%	field capacity	25%	50%	75%	field capacity
0 dS/m	0.542	0.814	1.139	1.396	0.320	0.380	0.570	0.540
1.35 dS/m	1.159	1.341	1.011	1.205	0.458	0.680	0.390	0.790
2.70 dS/m	0.603	0.744	0.921	0.737	0.310	0.360	0.460	0.370

Table 2. Root and shoot weights after 2 h incubation at 30°C of seedlings

Salinity	Shoot (g)				Root (g)			
	25%	50%	75%	field capacity	25%	50%	75%	field capacity
0 dS/m	0.0223	0.0263	0.0373	0.0457	0.0177	0.0166	0.0290	0.0330
1.35 dS/m	0.0463	0.0463	0.0400	0.0497	0.0290	0.0343	0.0313	0.0353
2.70 dS/m	0.0257	0.0363	0.0340	0.0257	0.0196	0.0233	0.0220	0.0200

LSD 5%, shoot (salinity = 0.00336, available water = 0.00176), root (salinity = 0.00193, available water = 0.00223)

Table 3. Root and shoot weights after 1 h incubation at 105°C of seedlings

Salinity	Shoot (g)				Root (g)			
	25%	50%	75%	field capacity	25%	50%	75%	field capacity
0 dS/m	0.0063	0.0073	0.0066	0.0056	0.0035	0.0033	0.0059	0.0063
1.35 dS/m	0.0116	0.0100	0.0090	0.0110	0.0066	0.0076	0.0068	0.0080
2.70 dS/m	0.0116	0.0076	0.0053	0.0073	0.0053	0.0065	0.0063	0.0051

LSD 5%, shoot (salinity = 0.00142, available water = 0.00164), root (salinity = 0.000191, available water = 0.00098)

Table 4. The water retention capability () and dry matter of shoots

Salinity	The retention capability (g)				Dry matter (g)			
	25%	50%	75%	field capacity	25%	50%	75%	field capacity
0 dS/m	0.0053	0.0069	0.0060	0.0134	0.0126	0.0166	0.0126	0.0196
1.35 dS/m	0.0176	0.0093	0.0080	0.0143	0.0293	0.0226	0.0170	0.0253
2.70 dS/m	0.0060	0.0046	0.0046	0.0060	0.0176	0.0206	0.0090	0.0130

days after the emergence of all the seedlings, the seedlings were thinned to four in each pot (Maiti et al. 1996). Thirty days after emergence, the plants were removed from the pots, and the shoot and root were separated from the seeds (Misra and Dwivedi 2004). The shoot and root fresh weight (FW), after 2 h incubation at 30°C and after 1 h incubation at 105°C were determined. The water retention capability of the shoot was calculated using the following formula (Clarke 1986):

Retention capability (g) = (FW – DW)/DW

Shoot samples were dried (one seedling was dried from each pot) at 78°C for 24 h, to determine dry matter (Ateş and Tekeli 2001). The results were analyzed using the TARİST software (Açıkgöz et al. 1994, Tekeli and Ates 2003).

RESULTS AND DISCUSSION

There were statistically significant ($P < 0.05$) differences among salinity stress and available water level treatments for fresh weights, retention capability, dry matter of shoots, weights after 2 h incubation at 30°C and 1 h incubation at 105°C. 1.35 dS/m salinity water treatment resulted in increasing the fresh weight, and weights after 2 h incubation at 30°C and 1 h incubation at 105°C, water retention capability and dry matter of seedlings as compared to their respective non-saline water values in common vetch seedlings at different levels of salinity (Tables 1–4 and Figures 1–3). Arin and Kiyak (2003) stated that the fresh weight and seedling diameter was increased by stress

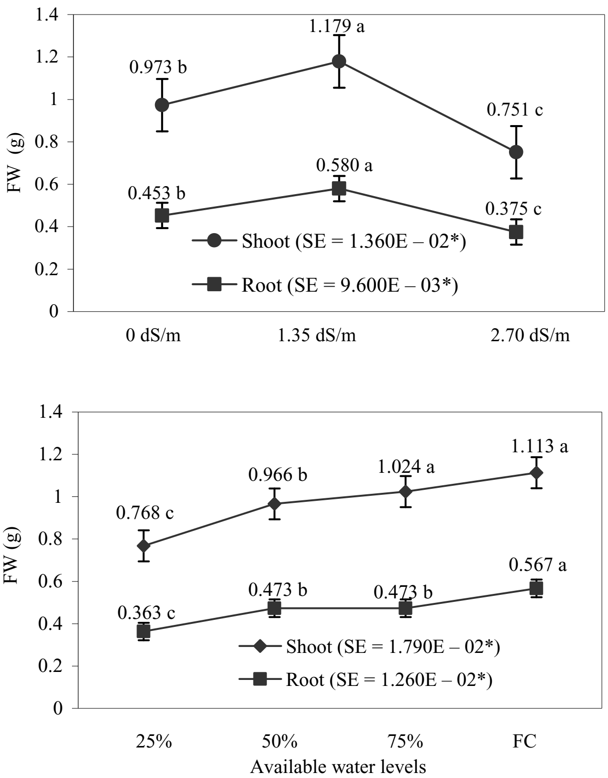

Figure 1. Effects of salinity and available water levels on shoot and root fresh weight in common vetch seedlings; *$P < 0.05$, FW – fresh weight, FC – field capacity

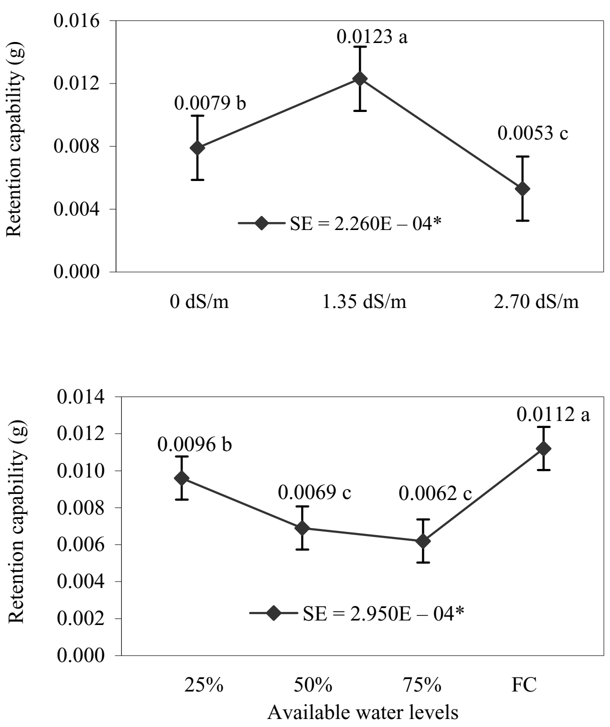

Figure 2. Effects of salinity and available water levels on water retention capability of shoots; *P < 0.05, FC – field capacity

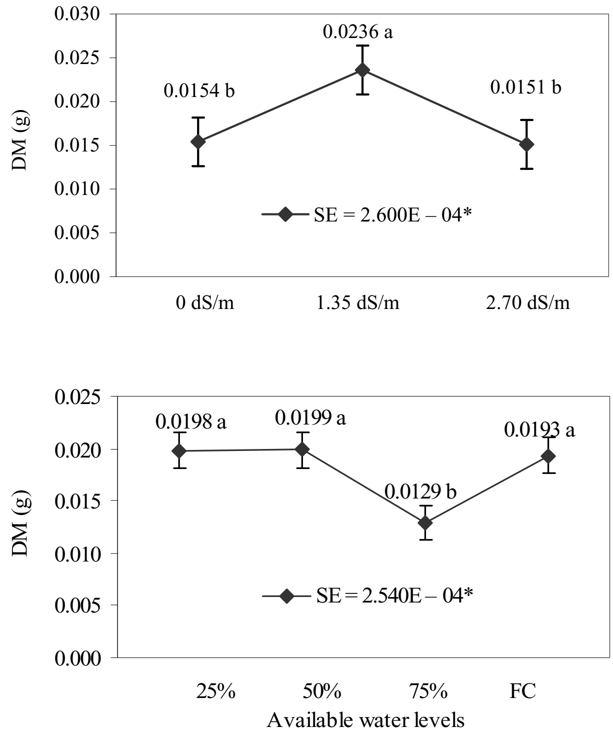

Figure 3. Effects of salinity and available water levels on dry matter of shoots; *P < 0.05, FC– field capacity

conditions, but these results were in accordance with Misra and Dwivedi (2004). They reported that the fresh weight and dry weight in seedlings were decreased by salinity. Other values were similar to those designated by Maas (1990), Izzo et al. (1991), Evlagon et al. (1992), Maiti et al. (1994, 1996).

As can be seen in the Tables, the effect of available water levels on its characteristics were all significant ($P < 0.05$). The maximum fresh weight and water retention capabilities were determined from the field capacity (Tables 1, 4 and Figures 1, 2). In addition, the highest weights after 2 h incubation at 30°C were found to be in the 75% available water level and field capacity (Table 2). The 25% and 50% available water treatments resulted in increasing the shoot weight after 1 h incubation at 105°C in plants as compared to their respective 75% available water level and field capacity values (Table 3). The maximum root weights after 1 h of incubation at 105°C were obtained from field capacity with 75% and 50% available water treatments (Table 3). One of the important seedling vigor components in the shoots dry matter in seedling growth. The 75% available water treatment gave the lowest shoot dry matter; furthermore the other treatments gave the highest shoot dry matter (Table 4 and Figure 3). The results of our findings were similar to other researchers (Forbes and Watson 1992).

REFERENCES

Açıkgöz N., Akbaş M.E., Moghaddam A., Özcan K. (1994): Turkish data based statistics programmer for PC. 1st Turkey Field Crops Congress, Ege University Press: 264–267.

Açıkgöz E., Tekeli A.S. (1980): Önemli Yembitkileri ve Tarımı. T.C. Tarım ve Orman Bakanlığı Ziraat İşleri Genel Müd. Yayınları: 20–21.

Al-Busaidi A.S., Cooksen P. (2003): Salinity-pH relationships in calcareous soils. Agricultural and Marine Science, *8*: 41–46.

Arin L., Kiyak Y. (2003): The effects of pre-sowing treatments on emergence and seedling growth of tomato seed (*L. esculentum* Mill.) under several stress conditions. Pakistan Journal of Biological Science, *6*: 990–994.

Ateş A., Tekeli A.S. (2001): Comparison of yield and yield components wild and cultivated Persian clover (*T. resupinatum* L.). 4th Turkey Field Crops Congress, PAYMAŞ Press, Grassland and Forage Crops, *3*: 67–72.

Bischoff J., Werner H. (2004): Salt salinity tolerance of common agricultural crops in South Dakota; Forages and grasses/grain and field crops. http://agbiopubs.sdstate.edu/articles/FS903.pdf.

Bugg R.L. (1995): Cover crop biology: A minireview. Part I. Sustainable Agriculture Technical Reviews, *7*: 4.

Cangir C., Boyraz D. (2001): Trakya'daki toprakların alt ordolarına göre yayılımı ve farklı yörelerdeki ilçelerin arazi kullanım potansiyellerinin değerlendirilmesi. Proceedings of the Trakya Soil and Water Sources Symposium, Köy Hizmetleri Atatürk Araştırma Enstitüsü Müdürlüğü, Kırklareli.

Clarke J.M. (1986): Effect of leaf rolling on leaf water loss in *Triticum* ssp. Canadian Journal of Plant Science, *66*: 885–891.

Cramer G.R. (1992): Kinetics of maize leaf elongations. II. Responses of a Na-excluding cultivar and Na-including cultivar to varying Na/Ca salinities. Journal of Experimental Botany, *43*: 857–864.

Evlagon D., Ravina I., Neumann P.M. (1992): Effects of salinity stress and calcium hydraulic conductivity and growth in maize (*Zea mays* L.) seedlings roots. Journal of Plant Nutrition, *15*: 795–803.

Forbes J.C., Watson R.D. (1992): Plants in agriculture. London, Cambridge University Press: 32–60.

Ghassemi F., Jakeman A.J., Nix H.A. (1995): Salinisation of land and water resources: Human causes, extent, management and case studies. UNSW Press, Sydney, Australia and CAB International, Wallingford, UK.

Izzo R., Navari-Izzo F., Quartacci M.F. (1991): Growth and mineral absorption in maize seedlings as affected by increasing NaCl concentrations. Journal of Plant Nutrition, *14*: 687–699.

Katuby-Amacher J., Koenig R., Kitchen B.K. (2004): Salinity and plant tolerance. http://extension.usu.edu/publica/agpubs/salini.htm.

Maas E.V. (1990): Crop salt tolerance. In: Tanji K.K. (ed): Agricultural salinity assessment and management. New York, ACSE Manuals and Reports on Engineering Practice, *71*: 262–304.

Maiti R.K., Amaya L.E.D., Cardona S.I., Dimas A.M.O., DelaRosaIbarra M., Castillo H.D. (1996): Genotypic variability in maize cultivars (*Zea mays* L.) for resistance to drought and salinity at the seedling stage. Journal of Plant Physiology, *148*: 741–744.

Maiti R.K., De La Rosa-Ibarra M., Sandoval N.D. (1994): Genotypic variability in glossy sorghum lines for resistance to drought, salinity and temperature stress at the seedling stage. Journal of Plant Physiology, *143*: 241–244.

Marcum K.B., Marcic A.A., Kopec D.M. (1997): Tolerance of warm season and alternative turfgrasses to salinity. http://ag.arizona.edu/turf/index.htm.

Misra N., Dwivedi U.N. (2004): Genotypic difference in salinity tolerance of green gram cultivars. Plant Science, *166*: 1135–1142.

Munns R., Husain S., Rivelli A.R., James R.A., Condon A.G., Lindsay M.P., Lagudah E.S., Schachtman D.P., Hare R.A. (2002): Avenues for increasing salt tolerance of crops, and the role of physiologically based selection traits. Plant and Soil, *247*: 93–105.

Nordquist P.T., Hergert G.W., Skates B.A., Compton W.A., Marwell J.P. (1992): Phenotypic expression of different maize hybrid genotypes grown on saline-sodic soil. Journal of Plant Nutrition, *15*: 2137–2144.

Özdemir N., Gülter C., Aşkın T. (2000): Determination of relations between some soil properties and some soil moisture constants using Path analysis. International Symposium on Desertification 2000, Konya, Soil Science Society of Turkey.

Rhodes D., Rich P.J., Brunk D.G., Rhodes G.C., Pauly J.C.M.H., Hansen L.A. (1989): Development of two isogenic sweet corn hybrids differing for glycinebetaine content. Journal of Plant Physiology, *91*: 1112–1121.

Sağlam M.T. (1993): Chemical properties of soil. In: Sağlam M.T., Bahtiyar M., Cangir C., Tok H.H. (eds.): Soil science. Istanbul, Anadolu Matbaa Tic. Koll. Şti. Press: 177–236.

Tanji K.K. (1990): Agricultural salinity assessment and management. Irrigation and Drainage Division, American Society of Civil Engineers, NY, USA.

Tekeli A.S., Ates E. (2003): Yield and its components in field pea (*Pisum arvense* L.) lines. Journal of Central European Agriculture, *4*: 313–318.

Tuna C., Orak A. (2002): Yield and yield components of some important common vetch (*V. sativa* L.) genotypes. Bulgarian Journal of Agricultural Science, *8*: 215–218.

Turan Z.M. (1995): Research and experimental methods. Uludağ University, Agricultural Faculty Press, No. 62, Bursa, Turkey.

Received on May 26, 2004

ABSTRAKT

Odolnost mladých rostlin vikve seté (*Vicia sativa* L.) vůči stresu vyvolanému salinitou nebo nedostatkem vody

Pokusy probíhaly v Oddělení polních plodin Zemědělské fakulty a v Aplikovaném a výzkumném středisku šlechtění rostlin Univerzity Trakya (Turecko). Byl sledován vliv různých hladin salinity a dostupnosti vody na růst, schopnost retence vody a hmotnost sušiny prýtů a kořenů po dvouhodinové inkubaci při 30°C a jednohodinové inkubaci při 105°C mladých rostlin vikve seté (*Vicia sativa* L.). Salinita ani omezení dostupnosti vody neovlivnilo klíčení. Salinita vody odpovídající 1,35 dS/m zvýšila svěží hmotnost prýtu (1,179 g) i kořene (0,580 g), jejich hmotnost po dvouhodinové inkubaci při 30°C (prýt: 0,0456 g, kořeny: 0,0325 g) i po jednohodinové inkubaci při 105°C (prýt: 0,0104 g, kořeny: 0,073 g), schopnost retence vody (0,0123 g) a hmotnost sušiny prýtu (0,0236 g) mladých rostlin. Nejvyšší svěží hmotnost (kořeny: 0,567 g, prýt: 1,113 g) a schopnost retence vody (0,0112 g) byla stanovena u rostlin pěstovaných při plné polní kapacitě.

Klíčová slova: schopnost retence vody; svěží hmotnost; sušiny; prýt; kořeny; mladé rostliny

Corresponding author:

Ertan Ateş, Plant Breeding Application and Research Centre, Trakya University, Tekirdağ, Turkey
phone: + 90 282 293 1464, fax: + 90 282 293 1454, e-mail: ertan_ates@hotmail.com