The International Journal of Engineering and Science (IJES)
|| Volume || 7 || Issue || 9 Ver.I || Pages || PP 54-58 || 2018 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

Improvement of Abiotic Stress Tolerance in Onion: Selection Studies Under Salinity Conditions

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----------ABSTRACT----------
Onion (Allium cepa L.) is one of the most important vegetable in Turkey, and often cultivated in arid and semiarid regions with salinity problems. In the first year of the study, three onion varieties were evaluated at various levels of salinity to identify susceptibility and tolerance levels. At the end of the experiment, "Akgun" determined more tolerant than the other varieties. At 9.6 dSm^{-1} condition, the survived individuals of this variety were selected as "candidate line". Selected individuals were grown to maturity and self-pollinated to produce next generations. In the third year of the study, the plants have been grown in vermiculite by substrate culture technique. The early plant stage at the 250 mM NaCl was used for the second selection studies. The same selection procedures were repeated once more on the next season. At each selection stage, the individuals were selected based on plant mortality. At the last year of study, the selected line was evaluated for both seed germination and seedlings growth at three treatment levels of 0 (nonstress), 250 mM, and 350 mM NaCl and were compared with the unselected population. The results indicated that selections were effective at all two salt-stress levels.

KEYWORDS: Allium, Salinity, Selection, Variation

Date of Submission: 25-08-2018 Date of acceptance: 08-09-2018

I. INTRODUCTION

The saline conditions have numerous intensive effects on plant growth because of a low particular ion effect, osmotic potential of the soil solution, nutritional instabilities, or a combination of these factors [1;2]. According to the predictions of the scientists, around 50% of the current planted land for cultivation might be lost by 2050 if the present scenario of salinity stress would continue [3]. In addition to this, worldwide yearly losses in agricultural output from salt-affected lands are in excess of US$12 billion and rising [4].

Developing varieties able to maintain productive at low to moderate levels of salt stress by breeding studies may provide a relatively cost-effective short-term solution to this issue [5]. The determination of varieties as tolerant or sensitive would be an influential strategy to accomplish the salinity stress. According to the behavior in saline environments, plants can be classed as glycophytes (salt susceptible) halophytes (salt tolerant) [6;7]. Many glycophytes are incapable to transcribe osmotically under salt stress. In contrast, halophytes generally sustain high turgor potential by the accumulation of ions [6]. According to Flowers and Yeo (1995), five methods can be suggested to develop salt-tolerant varieties: (1) develop new crops from halophytes, (2) interspecific hybridization between current crops, (3) utilization of the variation already present in available crops, (4) create variation within present crops by using repeated selection, mutagenesis or tissue culture, (5) developing new varieties for high yield rather than salt tolerance [8]. Strategies for breeding for salt tolerance were described long ago for in both cross-pollinating and self-pollinating species by Dewey (1962) and Ramage (1980) [9;10].

Onion (*A. cepa* L.) has a big importance in agricultural production in over the entire world. Vavilov (1926) reported that the main center of domestication and diversity is Southwest Asia. In addition, the Mediterranean region is defined as the secondary center of origin for onions with large bulbs [11;12]. In 2016, 93 million tons of onions were harvested from 4.96 million hectares area worldwide. The Turkeys' onion production quantities were 2.12 million tons in the same year [13]. Onion is classified as salt-sensitive with 1.2 dS·m−1 electrical conductivity (EC) threshold [14;15]. A lot of reports have been published about on influence of salinity on germination capability, growth parameters, yield attributes, and flavor in this crop [16;17;18;19;20;21].

The present study was designed with the aims of the selection of onion genotypes for moderate salinity stress tolerance. For this aim, the effectiveness of repeated phenotypic selection was investigated.

II. MATERIAL AND METHOD

The study was conducted between 2011 and 2018 at the laboratories and greenhouses of the Atatürk Central Horticultural Research Institute. The selected individuals of "Akgun" variety were plant material of the study. This selection has been done during the project of "The determination of abiotic stress tolerance levels of some Turkish onion varieties". In this project, onion varieties were tested with different methods such as germination tests, in vitro screening, pot trials etc. [22;23;24]. The schematic representation of the experiments has been shown in Figure 1.

In the first year of the study, the germination of some onion varieties was tested at different salinity conditions [22]. At the end of germination test, the tolerance levels of varieties were determined using morphological parameters such as mean germination time (days) germination percentage (%), seedling fresh and dry weight (mg), shoot length (cm). At highest salinity condition, the survived seedlings of the most tolerant variety were selected as "candidate line" (Akg-Tz-1). These seedlings were transferred into plastic pots and were grown to maturity. The bulbs of these plants harvested at end of the season and stored until the sowing. The bulbs of the selected line were planted in the second year and, flowers were self-pollinated. Matured seeds were collected from individual plants.

In the third year of the study, the seeds of "Akg-Tz-1" were sown in viols which filled with perlite/peat (1:1) material. After 21 days, seedlings were transplanted into 1.6 liters pots. The pots were filled with 1.5 liters of vermiculite. The planted seedlings were watered during a two-day period with Hoagland's solution [25] before selection treatments. During the selection stage, salinity level in the nutrition solution was increased by steps of 25 mM per irrigation until the final NaCl concentration was reached to 300 mM. The individuals were selected at the end of 4th week of the selection stage based on plant mortality. These plants (The line: Akg-Tz-2) were transferred into plastic pots and were grown until bulb formation. The bulbs of these plants harvested and stored for the next season. These bulbs were planted in the fourth year and, flowers were self-pollinated. Bulked seeds were collected from plants [22].

During the third selection stage, all stages were repeated as in the previous stage. The line Akg-Tz-3 established at the end of the fifth year. In the last year of study, the selected line was evaluated for both seed germination and seedlings growth at four treatment levels of 0 (nonstress), 250, and 350 mM NaCl and were compared with unselected populations

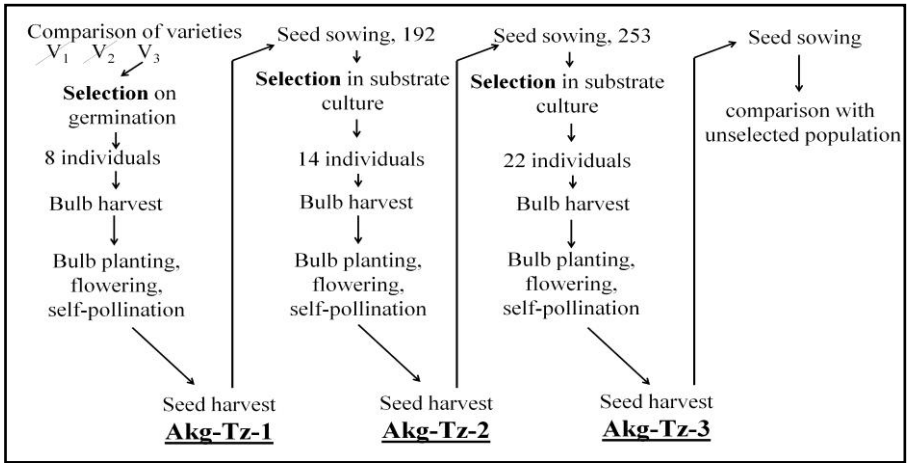

Figure 1. Diagrammatic representation of the method conducted to selection for salt tolerance during germination and early plant development in onion.

III. RESULTS

1.1. Experiment-1

In general, germination rates were reduced by increased salinity level (Table 1). This effect was more prominent in "İmralı Kirmasi-15" than in other varieties. In each variety, the highest percentage of seed germination was obtained in the control treatment. Generally, shoot length declined as salinity concentration increased. In all salinity conditions, "Akgun" indicated a higher germination percentage than the other varieties.. Significant variation was monitored between the three varieties for germination percentage, especially at higher salt conditions. In this stage of the study, the "Akgun" variety has been determined as more salt-tolerant than other varieties [22]. At 9.6 ds/m salinity condition, the survived seedlings (a total of 12 individuals) of the "Akgun-12" were selected as "candidate line" (Akg-Tz-1).

Table 1. Germination percentage of varieties in salinity conditions (%) [22].

Salinity (ds/m)	Varieties		
	Kantartopu	Imrali Kirmasi	Akgun
0.0	91.00**A* a***	82.50B a	92.00A a
1.2	76.50A b	79.50A a	85.50A ab
2.4	64.50BC c	74.50AB a	79.50A bc
4.8	48.50B d	63.00A b	73.00A cd
9.6	44.50B d	46.50B c	66.50A d

*Indents inside of each row that has varied capital letter are statistically significantly different from each other. Indents inside each column that have a different small letter are significantly different from each other ($P < 0.01$).

Table 2. Survived individuals of onion varieties under the different salt concentrations

Salinity (ds/m)	Sowed Seeds	Kantartopu			Akgun			Imrali Kirması		
		Germinated (14 d)	Survived (30 d)	%	Germinated (14 d)	Survived (30 d)	%	Germinated (14 d)	Survived (30 d)	%
0	200	181	Not observed		183	Not observed		164	Not observed	
1.2	200	151			170			158		
2.4	200	128			159			149		
4.8	200	96			145			125		
9.6	200	88	1	0.5	132	8	4.0	92	1	0.5

1.2. Experiment-2 and Experiment-3

A total of 192 seeds were sowed at the second stage of the study. Only 14 of them survived at end of the experiment. All observed parameters such as plant length (cm), neck diameter (mm), leaf number (amount), leaf diameter (mm) were reduced by increased salinity level. At the beginning of the third stage, a total of 253 seeds were sowed. After the selection in substrate culture experiment, 22 individuals were selected based on plant mortality (Table 3). These plants were grown to maturity and self-pollinated to produce the next generations.

Table 3. Survived individuals of candidate line during selection 2 and selection 3 stages

Salinity (mM)	Akg-Tz-1 (Selection 2)			Akg-Tz-2 (Selection 3)		
	Sowed	Survived (60 d)	%	Sowed	Survived (60 d)	%
300 mM	192	14	7.3	253	22	8.7

1.3. Experiment-4

Germination performance of Akg-Tz-3 line and the unselected populations have been shown in Table 4. Seeds of Akg-Tz-3 showed higher germination percentage than the unselected population under control and salinity conditions. At the 250 mM and 350 mM salt concentration, the unselected population did not show 50% germination by the end of experiments (14 d). Under non-saline condition, their germination responses were similar to the Akg-Tz-3.

Table 4. Comparasion of the Akg-Tz-3 line and the unselected population under the different salt concentrations

Salinity (mM)	Sowed	Akg-Tz-3				Akgun (unselected population			
		Germinated (14 d)		Survived (60 d)		Germinated (14 d)		Survived (60 d)	
		Number	%	Number	%	Number	%	Number	%
0	90	84	93.3	82	91.1	83	92.2	82	91.1
250	90	65	72.2	39	43.3	41	45.5	16	17.8
350	90	32	35.6	13	14.4	18	20.0	2	2.2

IV. DISCUSSION

It is known that the mechanism of tolerance to salinity showed the mutagenic inheritance, and regulated by a lot of genes. A number of reports indicate that these genes are distributed all along the entire set of chromosomes In some genomes. Some factors such as interactions between genotype and environment, Epistasis, strong environmental effects makes difficult development workings to promotion salinity tolerance of a number of crops. Additionally, it is assumed that the yield is the most main criterion for specifying the

response to various abiotic stresses including salinity stress, but the underlying genetic mechanisms for grain yield are complex with substantial environmental influence. Two main factors, low heritability, and complex inheritance restrict the influences of selection for grain yield or biomass production under abiotic stresses [1]. In recent years, researchers have made substantial developments to improve salinity tolerance in a number of agricultural crops with high potential using conventional breeding and artificial selection techniques. These attempts rely on sufficient heritability of the overall trait, for which there is evidence for sorghum [26], tomato [27;28], wild grasses [29], maize [30]. The effectiveness of selection under saline conditions have been proved in both rice [31] and tomato [32].

V. CONCLUSION

The current study indicates that onion is sensitive to moderate levels of NaCl. According to results of present study, seed germination capability and seedlings growth were reduced at salt concentrations above 150 mM. The sectional results represent that onion seed germination and seedling growth under salinity conditions can be effectively improved by directional phenotypic selection. And this selection can be applied during germination and early plant development stage. This research reported the salt-tolerant onion line from selection, it will be essential to further study about the fertility in saline fields. The highly salt-tolerant onion line may be used as a genetic resource to understand the genetic mechanism of tolerance.

VI. ACKNOWLEDGMENTS

This research was supported by the Republic of Turkey, General Directorate of Agricultural Research and Policies (TAGEM/BBAD/12/A09/P07/01).

REFERENCES

[1]. M. Ashraf, Breeding for salinity tolerance in plants, Critical Reviews in Plant Sciences, 13,1994, 17– 42
[2]. H. Marschner, Mineral nutrition of higher plants. (Academy PR, London,1995).
[3]. W. Wang, B. Vinocur, A. Altman, Plant responses to drought, salinity and extreme temperatures: towards genetic engineering for stress tolerance. Planta, 218, 2013, 1-14.
[4]. Shabala, S., 2013. Learning from halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. Annals of Botany, 112, 1209-1221.
[5]. S. Bhardwaj, N. Sharma, P. Srivastava, G. Shukla, Salt tolerance assessment in alfalfa (Medicago sativa L.) ecotypes. Botany Research Journal, 3, 2010, 1-6.
[6]. T.J. Flowers, P.F. Troke, A.R. Yeo, The mechanism of salt tolerance in halophytes, Annual Review of Plant Physiology, 28, 1977, 89– 121
[7]. E.V. Maas, R.H. Nieman, Physiology of plant tolerance to salinity. In: Jung, G. A. (ed.) : Crop tolerance to suboptimal land conditions, Agron. Soc. America, Crop Sci. Soc. America and Soil Sci. Soc. America, Madison WI, 1978, 277– 299.
[8]. T.J. Flowers, A.R. Yeo, Breeding for salinity resistance in crop plants: where next? Australian Journal of Plant Physiology 22, 1995, 875-884.
[9]. P.R. Dewey, Breeding crested wheatgrass for salt tolerance, Crop Science 2, 1962, 403-407.
[10]. R. Ramage, Genetic methods to breed salt tolerance in plants. In: D. Rains, R. Valentine, A. Hollaender, eds. Genetic engineering of osmoregulation impact on plant productivity for food, chemicals and energy. (New York: Plenum Press, 1980, 311-318)
[11]. N.I. Vavilov, Origin and geography of cultivated plants, 1926. English translation by D Love (1992), (Cambridge Univ Press, Cambridge, UK).
[12]. V.R. Castell, C.M. Portas, Alliacea production systems in the Iberian Peninsula: facts and figures of potential interest for a worldwide R&D network, Acta Horticulturae, 358, 1994, 43-47.
[13]. FAO, FAOSTAT Agricultural Database. http://www.fao.org/faostat/en/#data/ QC, 2016.
[14]. E.V. Mass, and G.J. Hoffman, Crop salt tolerance, Current assessment. J. Irr. Drainage 103:1977, 115–134.
[15]. N. Joshi, P. Sawant, Response of Onion (Allium cepa L.) Seed Germination and Early Seedling Development to Salt Level, International Journal of Vegetable Science, 18: 2012, 3–19,
[16]. J.L. Mangal, S. Lala, P.S. Hooda, Salt-tolerance of the onion seed crop. Journal of Horticultural Sciences, 64:1989, 475–477.
[17]. A.R. Al-Harbi, H.H. Hegazi, A.A. Alsadon, F. El-Adgham, Growth yield of onion (Allium cepa L.) cultivars under different level of irrigation water salinity. J. King Saud Univ. 14, 2002, 23–32.
[18]. P.T. Chang, W.M. Randle, Sodium chloride timing and length of exposure affect onion growth and flavour, Journal of Plant Nutrition, 28, 2005, 1755–1766.
[19]. C.P.S. Chauhan, P.K. Shisodia, P.S. Minhas, R.S. Chauhan, Response of onion (Allium cepa) and garlic (Allium sativum) to irrigation with different salinity waters with or without mitigating salinity stress at seedling establishment stage. Indian Journal of Rice Science, 77, 2007, 483–485.
[20]. A.A. Jafarzadeh, N. Aliasgharzad. Effect of soil salinity on different onion cultivars germination. Proc. 3rd Intl. Conf. on Land Degradation, Rio de Janeiro, Brazil, 17–21 Sept. 2001.
[21]. N.S. Corrêa, J.M. Bandeira, P. Marini, I.C.G. Borba, N.F. Lopes, D.M. Moraes, Salt stress: antioxidant activity as a physiological adaptation of onion cultivars, Acta Botanica Brasilica, 27, 2013, 394-399.
[22]. F. Hanci, E. Cebeci, Y.Y. Mendi, Effects of NaCl and $CaCl_2$ on Germination Performance of Some Local Onion (Allium cepa L.) Cultivars in Turkey, Acta Horticulturae, 960, 2012, 203-209.
[23]. F. Hanci, E. Cebeci, Investigation of Proline, Chlorophyll and Carotenoids Changes Under Drought Stress in Some Onion (Allium cepa L.) Cultivars. Turkish Journal of Agricultural and Natural Sciences, Special Issue: 2, 2014, 1499-1504
[24]. F. Hanci, E. Cebeci, Comparison of Salinity and Drought Stress Effects on Some Morphological and Physiological Parameters in Onion (Allium cepa L.) During Early Growth Phase, Bulgarian Journal of Agricultural Science, 21, 2015, 1204-1210
[25]. D.R. Hoagland, D. I. Arnon., 1950. The water culture method for growing plants without soil, (Circ. 347. Berkeley, CA: California Agricultural Experiment Station, 1950).

[26]. R.K. Maiti, M. Rosa-Ibarra, N.D. Sandoval, Genotypic variability in glossy sorghum lines for resistance to drought, salinity and temperature stress at the seedling stage, Journal of Plant Physiology 143, 1994, 211-244.
[27]. Y. Saranga, A. Cahaner, D. Zamir, A, Marani, J. Rudich, Breeding tomatoes for salt tolerance: inheritance of salt tolerance and related traits in interspecic populations. Theoretical and Applied Genetics, 84, 1992, 390-396.
[28]. Y. Saranga, D. Zamir, A. Marani, J. Rudich, Breeding tomatoes for salt toleranceÐvariations in ion concentrations associated with response to salinity, Journal of the American Society for Horticultural Science, 118, 1993, 405-408.
[29]. M. Ashraf, T. McNeilly, A.D. Bradshaw, Response and ion uptake of selected salt tolerant and unselected lines of three legume species, New Phytol. 104, 1986, 463– 472.
[30]. R.K. Maiti, L.E.D.Amaya, S.I. Cardona, A.M.O. Dimas, M. Rosa Ibarra, H.D. Castillo, Genotypic variability in maize cultivars (Zea mays L.) for resistance to drought and salinity at the seedling stage, Journal of Plant Physiology, 148, 1996, 741-744.
[31]. A.R. Yeo, M.E. Yeo, T.J. Flowers, Selection of lines with high and low sodium transport from within varieties of an inbreeding species, rice (Oryza sativa L.), New Phytol. 110: 1988, 13– 19.
[32]. M.L. Foolad, Response to Selection for Salt Tolerance During Germination in Tomato Seed Derived from PI 174263. Journal of American Society of Horticultural Sciences, 121, 1996, 1006–1011

Fatih Hanci"Improvement of Abiotic Stress Tolerance in Onion: Selection Studies Under Salinity Conditions "The International Journal of Engineering and Science (IJES) 7.9 (2018): 54-58