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Effect of soil salinity on germination and growth of sunflower (*Helianthus annuus* L.) cultivars

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ABSTRACT: With the increase in the population, the demand for energy is also increasing. Salinity, a major environmental stress, reduces plant growth and development all over the world. Sunflower (*Helianthus annuus L*.) is the most resistant crop towards salinity as compared to other crops. Present study was designed to study the effects of four different naturally salt affected soils having electrical conductivity (EC) of 1.15, 8.33, 15.48 and 20.23 dSm^{-1}, respectively on seed germination and growth parameters of five sunflower hybrids. Certified seeds of 5 diverse varieties of sunflower hybrids namely HU-777, CRN-1435, DK-3915, Super-25 and Hysun 33 were used in this study. Growth study was conducted in plastic pots using randomized complete design for 30 days. After that, a set of seedlings was uprooted carefully from each treatment for the measurement of growth parameters i.e. number of leaves $plant^{-1}$, leaf length (cm), leaf width (cm), number of burnt leaves, plant length (cm) and stem girth (cm). Germination and growth of all sunflower hybrids were significantly reduced with increase in salinity. Among all sunflower genotypes, Super-25 and Hysun-33 showed better tolerance to salinity and performed well even under high salinity level (20.23 dS m^{-1}).

KEYWORDS: Salinity; Sunflower; Germination; Salt affected soils

INTRODUCTION

Salt affected (saline/sodic) soils occupy about 954 millions of hectares all over the world, and cultivated lands are about 23% saline and 37% sodic (Khan and Duke, 2001). Worldwide, soil salinity is a great threat for the efficient plant growth and yield. (Majeed et al., 2010: Khan et al., 2014: Abdullah et al., 2015: Muhammad et al., 2015). It has been reported that salts in rhizosphere negatively affect the plant establishment through a variety of physiological and bio-chemical changes including tissues enlargement, carbon assimilation, solutes dislocation, nutrients and ion-uptake metabolism etc. (Schroeder et al., 2013; Naz and Bano, 2015).

Seed germination is the most critical stage in the plants life cycle on which the seedlings establishment and growth initiation relies. Seed germination may be affected by several abiotic factors including water, temperature, light and salts concentration (Jaleel et al., 2007). Among these factors salt is the main factor which limits germination and seedling establishment. (Almansouri et al., 2001, Ghoulam and Fares, 2001). Seed germination can be affected either by the creation of an external osmotic potential gradient or due to the toxic effects of ions. (Gulzar and. Khan, 2001, Murillo-Amador et al., 2002, Hosseini, et al., 2003). Higher sulphate or sodium chloride contents in the soil are mainly responsible for soil salinity (Dejampour et al., 2012). Sodium is the most fundamental ion having an essential role in toxicity as its absorption is very rapid by the root cells of plants (Hasegawa, 2013).

Accumulation of different solutes including soluble proteins, soluble sugars and free prolines, in germinating seeds have been reported under salinity stress. Inhibition of leaf growth is the main attack of drought and salinity stress (Zdunek and Lips, 2001). Several studies were conducted to evaluate the response of various agronomic crops to salt stress, such as soybean (Hosseini et al., 2002), wheat (Shaheen and Hood-Nowotny, 2005) and rice (Cha-Um et al., 2007). However, the knowledge regarding the response of sunflower towards salinity during seed germination is scarce so far. Sunflower has been considered as a moderate sensitive crop towards salinity (Katarji et al., 2003). Presently, several genotypes of sunflower are available but few of them have been reported for resistant to salt stress (Lui and Barid, 2003). Under salinity stress the screening of sunflower genotypes can be helpful in the selection of appropriate genotypes for cultivation on salt affected soils. In this perception, present study was conducted to identify the salinity tolerant sunflower cultivars at different soil salinity levels.

MATERIALS AND METHODS

Four naturally salt affected soils were collected having electrical conductivity (EC) of 1.15, 8.33, 15.48 and 20.23dSm^{-1}. Certified seeds of 5 diverse varieties of sunflower hybrids namely HU-777, CRN-1435, DK-3915, Super-25 and Hysun 33 were used in this study. Growth study was conducted in plastic pots (175 mm diameter and 65 mm depth along with a bottom drainage hole). Ten seeds of each genotype were sown in each respective portion in a complete randomized design (CRD) with three repeats. After complete germination, numbers of seedlings were reduced up to 5 per pot. All pots were placed in a glass house. After thirty days of seedling growth, plants were carefully uprooted from each pot for the measurement of growth parameters i.e. number of leaves plant^{-1}, leaf length (cm), leaf width (cm), number of burnt leaves, plant length (cm) and stem girth (cm). The collected data were subjected for analysis by using Statistic 8.1 and the comparison between treatment means was carried out by Duncan's Multiple Range (DMR) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Soil salinity adversely affected germination percentages of all sunflower varieties. Significant differences were observed among salinity levels in terms of decreased germination of all cultivars, however, these differed significantly among each other at all salinity levels (Fig: 1-5). Cultivar DK-3915 gained minimum germination of 40 % at salinity levels of 15.46 and 20.23 dSm^{-1}, whereas Hysun-33 gained highest germination at all salinity levels as compared to other varieties throughout the testing period. At salinity level of 1.15 dSm^{-1}Hysun-33 achieved maximum germination throughout the testing period except at 30th day of germination. i.e. starting from 10th day (100 %) up to 25th day (97 %) of germination. While at 30th day of germination Super-25 out class the Hysun-33 at all salinity levels, proving best variety for salt tolerance. In sunflower the seedling emergence and post-emergence seedlings mortality are greater determinants of salt tolerance (Turhan and Ayaz, 2004). Akhtar et al. (2002) and Ali et al. (2013) have documented the harmful salinity effects on Brassica campestris growth and reported variable responses of different Brassica species and varieties towards salt stress.

Plant height of different sunflower genotypes decreased significantly with increase in salinity level (Table 1). Overall, genotype Hysun-33 showed the best results at all salinity levels and attained highest plant height. The salt tolerant cultivars have the mechanism of Na^+ exclusion from shoot to roots via phloem transport which reduces the Na^+ content of shoot and promotes plant height. (Jaleel et al. 2007) reported the growth retardation in plants in correspondence with the strength of solutes in the plant rhizosphere.

Stem girth of sunflower genotypes decreased with increase in salinity (Table 1). Sunflower genotypes differed significantly among each other with respect to stem girth. Sunflower Hysun-33 attained the highest stem girth (1.1 cm) than rest of the genotypes. Plants subjected to salinity were affected by a variety of changes in the biochemical pathways resulting in the reduced root-shoot growth of sunflower genotypes (Kamal et al., 2003; Kaya et al., 2003; Ramoliya et al., 2006).

Salinity significantly affected the leaf length (Table 1). Hysun- 33 showed the maximum leaf length among other sunflower hybrids in all salinity levels. Hysun- 33 exhibited positive results in leaf length. Leaf length is an important contributor in photosynthesis. Increase in salinity decreased leaf width of all sunflower varieties. There was significant difference in leaf width of all cultivars at different salinity levels (Table 1). Cultivar Hysun-33 gained the maximum value of leaf width at all salinity levels comparing other sunflower hybrids. High salinity adversely disturbs the growth parameters. During the plants vegetative growth, decreased water uptake leading to reduced cell turgor and depressed root shoot elongation rates are the main consequences of salinity stress. (Fricke et al., 2006). Salts disturb the water uptake to exclude the toxic salts from the specialized mechanism developed in salt tolerant crop (Horie and Schroeder, 2004).

Higher level of salinity significantly decreased number of leaves plant^{-1} in all sunflower varieties (Table 1). Cultivar Hysun-33 gained the maximum number of leaves plant^{-1}at all salinity levels comparing other sunflower hybrids. Salinity limits greatly plant growth and productivity (Munns and Tester, 2008; Rozema and Flowers, 2008; Kronzucker and Britto, 2011 and Zhang and Shi, 2013).

Increase in salinity increased significantly number of burnt leaves in all sunflower varieties (Table 1). Cultivar DK-3915 gained the maximum number of burnt leaves in all salinity levels comparing other sunflower hybrids. The major detrimental salinity effect is the accumulation of Na^+ and Cl^- ions in plants tissues, grown on highly concentrated NaCl soils (Maathuis et al. 2014). Uptake inhibition of an essential plant macronutrient, K^+ is the consequence of higher Na^+ accumulation in the plant tissues. This severely retards the plants growth and overall productivity and in extreme cases

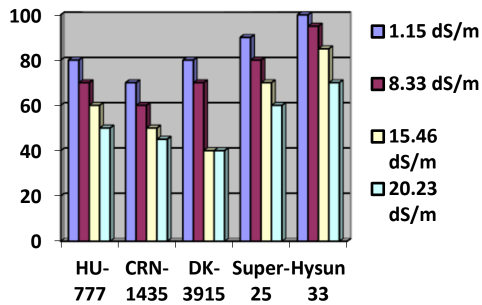

Figure 1: Salinity levels effects on sunflower germination (%) at 10th day

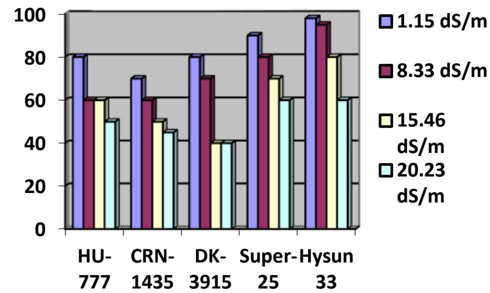

Figure 2: Salinity levels effects on sunflower germination (%) at 15th day

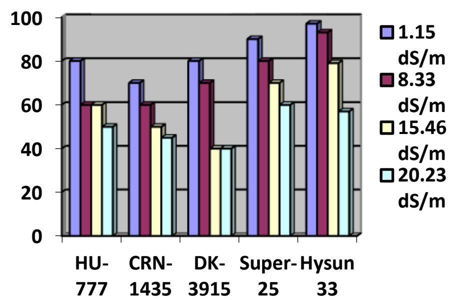

Figure 3: Salinity levels effects on sunflower germination (%) at 20th day

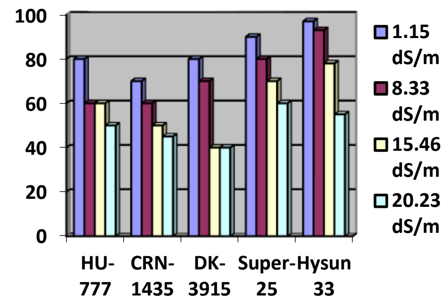

Figure 4: Salinity levels effects on sunflower germination (%) at 25th day

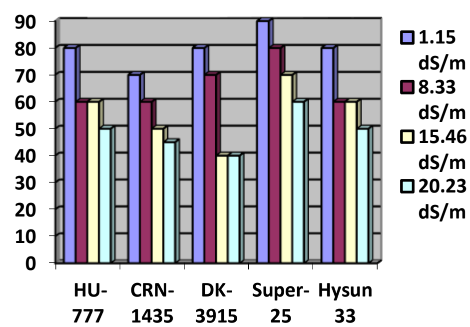

Figure 5: Salinity levels effects on sunflower germination (%) at 30th day

may lead towards plants mortality (Kronzucker et al., 2013; Gupta and Huang, 2014).

CONCLUSION

Germination and growth of all sunflower hybrids were significantly reduced with increase in soil salinity levels. Among all the genotypes, Cultivars Super-25 and Hysun-33 showed tolerance to salinity and performed well even under adverse salinity (20.23dSm^{-1}) level.

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AUTHORS CONTRIBUTION

Imdad Ali Mahmood, Syed Ishtiaq Hyder and Syeda Sana Aamir conducted the experiment, Muhammad Arshad Ullah and Muhammad Rasheed collected and analyzed the data and wrote the manuscript, Abdul Hafeez, Muhammad Shaaban and Tariq Mahmood critically reviewed the manuscript and furnished the final format of manuscript, Abdul Hafeez proceeded for its publication.

CONFLICT OF INTEREST

Authors have no conflict of interest.

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Table 1. Salinity levels effects on different morphological attributes of sunflower cultivars

Salinity level (dSm^{-1})	Plant height (cm)	Stem girth (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves $plant^{-1}$	Number of burnt leaves
Cv. HU-777						
1.15	13.2 a	0.7 a	5.8 a	2.9 a	8.3 a	0.0 d
8.33	8.5 b	0.6 b	4.5 b	2.6 b	7.1 b	0.9 c
15.46	5.0 c	0.5 c	3.5c	2.3 c	5.8. c	1.6 b
20.23	3.0 d	0.4 d	1.9 d	1.8 d	4.1 d	2.1 a
CRN-1435						
1.15	14.5 a	0.5 a	6.0 a	3.0 a	8.9 a	0.0 d
8.33	8.7 b	0.5 b	5.1. b	2.3 b	7.2 b	1.0 c
15.46	6.0 c	0.4 c	4.0. c	2.0 c	6.8 c	1.8 b
20.23	3.6 d	0.3 d	2.8 d	1.9 d	4.2 d	2.2 a
DK-3915						
1.15	16.2 a	0.7a	6.2 a	3.9 a	10.5 a	0.0 d
8.33	10.1 b	0.7 b	5.1 b	3.1 b	9.4 b	1.1 c
15.46	7.7 c	0.5 c	4.0 c	2.5 c	7.2	1.7 b
20.23	4.5 d	0.4 d	2.2 d	1.4 d	5.5 d	2.9 a
Super-25						
1.15	11.5 a	0.4 a	4.1 a	2.7 a	8.2 a	0.0 d
8.33	7.7 b	0.4 b	3.8 b	2.0b	7.31 b	0.9 c
15.46	4.6 c	0.2 c	2.5 c	1.8 c	5.5 c	1.7 b
20.23	2.3 d	0.1d	1.1 d	1.0 d	3.9 d	2.0 a
Hysun-33						
1.15	17.7 a	1.1 a	7.1 a	4.5 a	10.9 a	0.0 d
8.33	10.8 b	0.8 b	5.2 b	3.6 b	9.2 b	1.0 c
15.46	7.5 c	0.6	4.3 c	2.9 c	7.3 c	1.5 b
20.23	4.1 d	0.5 d	2.4 d	1.7 d	5.4 d	2.4a

Values (means, n=3) sharing different letters in columns differ significantly at $p < 0.05$