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STEM AND LEAF RESPONSE OF SUNFLOWER HYBRIDS TO SALT STRESS

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Abstract

Pot-culture experimentation was carried out to note the influence of four distinct treatments of salts having an EC 1.19, 9.54, 16.48 and 22.38 dSm^{-1} on stem and leaf characteristics of four diverse hybrids (i.e., DO-728, DO-730, Hysun-33 and Suncross-843) of sunflower (*Helianthus annuus* L.). Salt treatments were prepared by dissolving premeditated quantity of different salts *viz.,* Na_2SO_4; $CaCl_2$; NaCl, and $MgCl_2$ in ½ strength Hoagland nutrient solution. Results revealed that all the salinity treatments significantly ($p<0.05$ & $p<0.01$) effect stem and leaf growths. Hybrids and their interactions also exhibited significant response towards salt stress levels. It was noted that there was a linear decrease in length and size of measured attributes as salinity level increased. A significant reduction in plant length (3.3 cm), girth of stem (0.3 cm), length of leaf (1.8 cm), width of leaf (1.2 cm) and number of leaf $plant^{-1}$ (4.3) were recorded in highest dose of applied salts (22.38 dSm^{-1}). Different hybrid responded differentially and significantly with increasing the level of salinity. A maximum significant ($p<0.05$) plant length (10.4 cm), stem girth (0.5 cm), leaf length (4.8cm), leaf width (2.6 cm), leaf $plant^{-1}$ (9.9) and leaf burnt (1.5) were noted for hybrid DO 728 followed by DO 730 and Hysun 33, whereas a minimum significant values (7.4, 3.3, 2.2, 0.4 and 6.8 cm) for the same growth attributes (except for leaf burnt) respectively registered for hybrid Suncross-843. Based on the overall better growth performance, DO-728 could be ranked as salt tolerant followed by DO-730 and Hysun-33 as moderately tolerant and Suncross-843 as salt susceptible hybrid in response.

Key words: Salinity, Sunflower, Morphology, Stem, Leaf.

Introduction

Sunflower (*Helianthus annuus* L.) is a New World vegetable crop plant, has been developed into a valuable source of edible oil and meal. It is ranked as 3rd important vegetable oil crop after soybean and rapeseed. With the increasing popularity of edible vegetable oils that, like sunflower contain high percentage of poly-unsaturated fatty acids and low level of cholesterol (Anon., 1993).

Salinity is one of the major abiotic environmental stresses reducing the plant growth and productivity through out the world (Majeed *et al.,* 2010; Khan *et al.,* 2014; Abd-allah *et al.,* 2015; Muhammad *et al.,* 2015). Research studies revealed that various physiological & bio-chemical changes, as well as the process of enlargement, carbon assimilation, take in of oxygen, locomotion of solute dissolved in solvents, ion-uptake, nutrient-metabolism, and different growth characteristics in crop plants are badly affected by induced salts (Schroeder *et al.,* 2013; Naz & Bano, 2015). Salinity and sodicity has affected about 10% of the world's agricultural land (Szabolcs, 1991). Approximately 20 million hectare land deteriorated to zero production every year (Malcolm, 1993) mainly due to salinization. In Pakistan nearly 6.67 million hectare land is salt affected (Khan, 1998), out of which 60% is saline sodic. The effects of salt stress on agricultural crops are complex and incompletely understood (Javed *et al.,* 2014). The accumulation of ions in leaves under conditions of salt stress causes reduction in photosynthesis and growth (Gadallah, 1999). Excess of Na^+ and Cl^-, the predominant ions, create high ionic imbalances that may impair the selectivity of root membranes (Bohra & Dörffling, 1993). According to Dejampour *et al.* (2012) salinity is fashioned when there is a high amount of sodium chloride and sulphate content. Therefore, in salt affected soil, sodium is a fundamental ion which plays an essential role in toxicity, because it is very rapidly absorbed and taken up by the root-cells of crop plant (Hasegawa, 2013). Assessing response of crops/plants to salinity under naturally saline conditions is not feasible to extreme variability in soil salinity both spatially and temporally (Richards, 1983). To avoid these problem comparative differences for salt tolerance among crops/cultivars can be studied under artificially salinized control conditions. Different physiological characters viz., selectivity for K^+, exclusion and/or compartmentation of Na^+ and Cl^- ions, osmotic adjustment by accumulation of organic solutes have also been related to salt tolerance of crop plants (Wyn Jones & Storey, 1981).

In this perspective, the present study was therefore mainly designed to identify the sunflower cultivars showing tolerance toward induced salinity at different salinity levels viz., salts having an EC 1.19, 9.54, 16.48 and 22.38 dSm^{-1}. The selected may be recommended for use by the farmers of salt affected lands according to the intensity of salinity problem.

Materials and Methods

This learning relates through present study deals with the effect of four different levels of added salts (*viz.*, T_1, T_2, T_3 and T_4) having an EC of 1.19, 9.54, 16.48 and 22.38 dSm^{-1}, respectively on various stem and leaf characteristics of four hybrids of sunflower (*Helianthus annuus* L.). The certified seeds of 4 diverse varieties of Sunflower hybrids *i.e.,* DO-728, DO-730, Hysun-33 and Suncross-843 were received from Research Institute Agriculture, Sariab Road Quetta, Balochistan, Pakistan. The aforementioned salinity levels be set by mixing premeditated quantity of 4 different salts like NaCl, Na_2SO_4, $CaCl_2$ and $MgCl_2$ in ½ strength

Hoagland nutrient solution as suggested by Machlis & Torrey (1956) (Table 1). The electrical conductivity, pH, morality, and osmotic potential of the salt treated solutions were also measured as described by Achakzai (2014).

The growth study of tested crop was conducted in plastic pots. Each pot was of 175 mm in diameter & 65 mm deep, and also had a drainage hole at the bottom of each pot. About 12 pots were used for every cultivar, and every of the prepared salt regime (T) was replicated 3 times. Each of the pot was full with an equal quantity of carefully wash and wet sand. Roughly identical mass and identical number of seeds was sown in every pot. Thereafter pots were irrigated day after day with the same quantity i.e., 50 ml relevant salt containing solution. All these pots were then rearranged in a CRD manner on a Laboratory bench nearly for fifteen days. Later on the complete germination, number of seedlings were reduced, and left them upto 5 in every of the experimental pot. All these pots were thereafter shifted to glass room. After sixty days of seedling growth, a complete set of the experimental plants was carefully uprooted from each one treatment / replicate, and then average values of the following subsequent growth parameters were measured:-

1. Maximum plant length (cm)
2. Stem girth (cm)
3. Length of leaf (cm)
4. Width of leaf (cm)
5. Number of leaf plant^{-1}
6. Number of burnt leaf

The data obtained for above growth parameters were statistically analyzed using ANOVA techniques, and multiple comparison tests by means of computer software Statistix (version 8.1). The analysis was aimed to determine the influence of applied salinity treatments (T), hybrids (HB) response, and their interactions (T x HB).

Results and Discussion

The obtained results reflected that in relation to a variety of applied salinity treatments (T) all studied growth parameter of sunflower as well as hybrids (HB) behavior, and their interactions (T x HB) exhibit greatly considerable response ($p<0.01$) (Table 2).

Data presented in Table 3 depicted that as salinity level increased a linear decline in all mentioned growth attributes were observed (except of leaf burnt). A maximum reduction in plant length (3.3 cm), stem girth (0.3 cm), length of leaf (1.8 cm), width of leaf (1.2 cm) and average number of leaf plant^{-1} (4.3) were recorded in highest dose of applied salinity (T_4) having an EC value of 22.38 dS/m. The maximum growth rate for the same parameters were recorded in lowest level of added salts i.e., T_1 (1.19 dSm^{-1}). Maximum average number of leaf burnt (2.0) was also noticed in T_4 and minimum i.e., 0.01 for the same attribute was recorded in T_1 (1.19 dSm^{-1}). The findings have proved that salinity reduces most of the growth attributes of crop plants. In present study, applied salt treatments induced considerable decline in growth attributes of stem and leaf in sunflower hybrids. Khan & Asim (1998) explained that it could be due to decrease in cell division which ultimately reduces cell volume. In another research study Lea-Cox & Syvertsen (1993) reported that salinity also hinders water up-take due to osmotic potential of induced medium. The studies reported by Jaleel *et al.* (2007) also expressed that the universal response of plants toward applied salts is retardation in growth approximately relative to the solute strength. Plant subjected under this salt containing medium may accumulate a variety of ionic solutes for instance Na^+ and Cl^- by changing diverse biochemical pathways which result in reduced shoot growth of crops in response to excess salts (Garg & Gupta, 1997; Kamal *et al.,* 2003; Kaya *et al.,* 2003; Ramoliya *et al.,* 2006). While reverse was found by Smillie & Norr (1982). They noted that the color of leaf appeared normal and there was no any apparent sign of premature senescence at the bottom leaves of sunflower. Ream & Furr (1976) also stated that visible symptoms viz., frequently leaf burns are rather late manifestations of severe salt stress, and except in few cases like citrus. Similarly Heidari *et al.* (2011) explain that the association between Na & K cations designates that at least in sunflower, accretion of K dependant to Na influx. In other words, the cultivars/ lines that build up high Na was have more K content and vice versa.

Data also suggested that there was a significant variation of all mentioned growth attributes among hybrids in response to added dose of salts. Statistically maximum plant length (10.4 cm), average stem girth (0.5 cm), length of leaf (4.8 cm), width of leaf (2.6 cm), number of leaf plant^{-1} (7.8) and number of burnt leaf (1.5) were recorded in sunflower hybrid DO-728 followed by DO-730 and Hysun-33, whereas minimum plant length (7.4 cm), stem girth (0.4 cm), length of leaf (3.3 cm), width of leaf (2.2 cm), and total number of leaf plant^{-1} (6.8) were recorded for hybrid Suncross-843. Moreover, minimum number of leaf burnt (0.8) were recorded in sunflower hybrid Hysun-33. Results further showed that interaction between salinity (T) and sunflower hybrids (HB) also exhibited significant response. A maximum value of interaction for plant height (18.5 cm), stem girth (0.8 cm), average leaf length (6.8 cm), leaf width (3.4 cm) and number of leaf plant^{-1} (10.3) were noted for T_1 x HB_1. Whereas, minimum values (2.0, 0.3, 1.2, 0.9 & 4.1) of interaction for the same attributes were recorded for T_4 x HB_4.

Table 1. Amount of salt dissolved in one-liter solution of different salinity treatments.

Salinity treatments (EC = dSm^{-1})	Amount of salts, g L^{-1}.				Molar concentration (mM)	Osmotic potential at 20°C (MPa)	pH
	NaCl	$Na_2SO_4.H_2O$	$CaCl_2$	$MgCl_2$			
T_1 = 1.19	-	-	-	-	-	0.00	4.03
T_2 = 9.54	1.17	3.2	2.35	1.9	20	-0.47	4.40
T_3 = 16.48	2.34	6.4	4.70	3.8	40	-0.93	4.36
T_4 = 22.38	3.51	9.6	7.05	5.7	60	-1.40	4.30

Table 2. Analysis of variance (ANOVA) for stem and leaf morphology of four varieties of sunflower (*Helianthus annuus* L.) subjected to various levels of salinity.

	Growth variables	Sum of square			Mean square			F-value of variables at an error of 32		
		Treatments (T)	Hybrids (HB)	T x HB	Treatments (T)	Hybrids (HB)	T x HB	(T)	(HB)	T x HB
1.	Maximum plant length (cm)	972.83	54.300	16.560	324.276	18.101	1.840	2910.21*	385.72*	39.22*
2.	Average girth of stem (cm)	0.509	0.115	0.038	0.170	0.038	0.0042	409.53*	92.09*	10.24*
3.	Average length of leaves (cm)	93.278	14.301	1.421	31.093	4.767	0.158	2868.06*	439.71*	14.56*
4.	Average width of leaves (cm)	28.990	1.558	2.145	9.663	0.519	0.238	3367.90*	181.01*	83.07*
5.	Average number of leaf $plant^{-1}$	205.866	6.988	3.266	68.622	2.330	0.363	1961.62*	66.59*	10.37*
6.	Average leaf burnt	27.490	3.892	7.9134	9.164	1.298	0.879	11326.70*	1603.68*	1086.82*

*Data is significant at p<0.01

Table 3. Effect of different treatments of salinity on various morphological attributes (average values) of sunflower (*Helianthus annuus* L.) hybrids.

Salinity treatments (T) dSm^{-1}	Maximum plant length (cm)	Stem girth (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaf $plant^{-1}$	Number of burnt leaf
T_1 = 1.19	15.5 a	0.6 a	5.6 a	3.3 a	9.9 a	0.0 d
T_2 = 9.54	9.7 b	0.5 b	4.3 b	2.9 b	8.1 b	0.8 c
T_3 = 16.48	6.6 c	0.4 c	3.3 c	2.4 c	6.4 c	1.5 b
T_4 = 22.38	3.3 d	0.3 d	1.8 d	1.2 d	4.3 d	2.0 a
Sunflower hybrids (HB)						
HB1 = DO 728	10.4 a	0.5 a	4.8 a	2.6 a	7.8 a	1.5 a
HB2 = DO 730	8.9 b	0.5 a	3.8 b	2.6 a	7.0 b	1.0 b
HB3 = Hysun 33	8.4 c	0.4 b	3.6 c	2.5 b	7.0 b	0.8 c
HB4 = Suncross 843	7.4 d	0.3 c	3.3 d	2.2 c	6.8 c	1.0 b
Interaction T x HB						
T_1 x HB1	18.5 a	0.7 a	6.7467 a	3.3733 a	10.333 a	0.0100 c
T_1 x HB2	15.0 b	0.6 a	5.6000 b	3.5000 a	10.167 a	0.0100 c
T_1 x HB3	15.1 b	0.5 b	5.3267 b	3.4267 a	10.167 a	0.0100 c
T_1 x HB4	13.3 c	0.5 bc	4.8000 c	2.9100 b	8.983 b	0.0100 c
T_2 x HB1	10.3 d	0.5 cd	4.8700 c	2.9433 b	8.450 bc	2.0500 a
T_2 x HB2	10.5 d	0.5 b	4.2567 de	3.4267 a	8.007 c	0.0100 c
T_2 x HB3	9.5 e	0.5 bc	4.1500 e	2.9100 b	8.050 c	0.0100 c
T_2 x HB4	8.6 f	0.4 cde	4.0067 e	2.5000 c	8.000 c	1.0000 c
T_3 x HB1	7.7 g	0.4 def	4.5667 cd	2.4000 cd	7.250 d	2.0833 a
T_3 x HB2	6.4 h	0.4 ef	3.4533 f	2.2967 d	6.123 e	2.0000 a
T_3 x HB3	6.3 h	0.3 gh	3.5000 f	2.5167 c	6.033 e	1.0000 b
T_3 x HB4	5.9 h	0.3 hi	3.2100 f	2.4500 cd	6.050 e	1.0000 b
T_4 x HB1	4.9 i	0.4 ef	2.8400 g	1.8633 e	5.217 f	2.0000 a
T_4 x HB2	3.6 j	0.4 fg	1.7200 h	1.2300 f	4.000 g	2.0167 a
T_4 x HB3	2.5 k	0.3 hi	1.2433 i	1.000 g	4.000 g	2.0000 a
T_4 x HB4	2.0 k	0.3 i	1.2233 i	0.8967 g	4.100 g	2.0000 a
Coefficient of variance (CV %)	2.47	4.68	2.71	2.16	2.60	2.64
Grand mean	8.76	0.4354	3.8483	2.477	7.1831	1.0756

Mean values sharing the same letter(s) within the same column of salinity treatments (T), sunflower hybrids (HB) and their interactions (T x HB) are statistically non-significant @ p<0.05

A significant hybrid difference was also renowned by earlier researchers. They explained that salinity adversely influenced the growth and survival of most of the glycophytic plants. A thoughtful response of plants toward salinity is of vast handy repercussion. There is experimental evidence that elevated concentration of inorganic salts encompass damaging effects on plant escalation parameter of different hybrids/ cultivars. Therefore, present findings are sturdily in line up with the remarks highlighted by so many previous scholars (Mer *et al.,* 2000; Gulzar *et al.,* 2005; Afzal *et al.,* 2005; Shereen *et al.,* 2005; Li *et al.,* 2006; Sharif *et al.,* 2007; Tunçturk *et al.,* 2008). This turn down in stem and leaf growth characteristics might be accredited to low water potential of the rooting medium, and due to elevated ion meditation as first growth embarrassment in saline circumstance is associated to osmotic property as explained by Munns *et al.* (1995). Similar significant reduction in term of plant height, stem girth and leaf area etc were also narrated by Ahmed *et al.* (2005) for various sunflower cultivars grown in saline environment. This reduction in growth attributes would ultimately tended to decrease the oil percentage. Akhtar *et al.* (1992) have also been discussed the same. Gale & Zeroni (1984) further reported that under saline environment the plant cell turgor pressure reduces and stomatal closing take position, resultant in decline rate of photoassilation or carbon fixation. But as soon as salts build up to lethal range in leaf again the growth embarrassment would starts. Ibrahim (2003) reported that injurious effects of Na^+ & Cl^- ions possibly will be the 2^{nd} cause for reduced shoot growth with blown up salt level for hybrids medium. Kumar *et al.* (2014) explain that this drop off in growth attributes at higher salinity levels might be due to the toxic effects of salinity, which badly affected plant physiological aspects such as osmotic adjustment and ion accumulation creating drought-like conditions for the plants subjected to salt stress.

Results based on overall better growth performance also deciphered that amongst 4 sunflower hybrids, DO 728 can rank as salt tolerant followed by DO 730 & Hysun 33 as salinity intermediate and Suncross 843 as salt sensitive in response.

Conclusions

It can be accomplished that as added salt treatment intensify, plant growth attributes abridged significantly. A maximum reduction in growth attributes was recorded in highest level of applied salts (EC = 22.38 dSm^{-1}), whereas a reverse was true for average number of leaf burnt. A significant hybrids response was also noticed for each attribute. On the basis of growth performance, sunflower hybrid DO 728 might be rank as salinity tolerant followed by DO 730 & Hysun 33 as salinity intermediate and Suncross 843 as salt perceptive hybrid in response.

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