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Evaluating the Performance of Elite Sunflower Hybrids under Saline Conditions

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ABSTRACT

Salinity is a major obstacle in successful crop production. Selection of suitable varieties/hybrids of a crop is a requisite to harvest good crop from the marginal lands. This study was conducted to evaluate the performance of 13 sunflower (*Helianthus annuus* L.) hybrids in a saline field (ECe 12 dS m^{-1} & pH 8.02). Different hybrids showed significant variations in days to emergence, days to maturity, plant population, number of leaves per plant, plant height, number of achenes per head, 100-achene weight and achene yield when grown under saline conditions, while there was no difference amongst the hybrids for head diameter and days to flowering. Maximum achene yield was harvested from DKS-4040, G-101 and P64A93 owing to more plant population, head diameter, number of achenes per plant and heavier achenes; minimum achene yield was harvested from FH-315, Hysun-38, Hysun-39, Hyolic-41 and CF-31. In crux, sunflower hybrids DKS-4040, G-101 and P64A93 performed better under salinity stress and may be recommended for cultivation under saline conditions, while hybrids like FH-315, Hysun-38, Hysun-39, Hyolic-41 and CF-31, being sensitive to salinity stress should not be recommended for sowing in saline fields.

Key Words: Achene yield; Crop phenology; Morphology; Salinity; Sunflower hybrids

INTRODUCTION

Soil salinity is one of the major constraints in present day agriculture. Salinity affects about 76.6 Mha of land worldwide (Ghassemi *et al*., 1995). Salinity refers to the accumulation of soluble salts (chlorides & sulphates of Ca, Mg & Na) in the soil particularly in root zone up to a level, which severely affects the agricultural productivity, environmental health, and economic benefits. More than 25% of irrigated lands are saline in arid to semiarid regions of the world (Choukr-Allah, 1996). Salt-affected soils occur in more than 100 countries around the world. It is generally perceived that salinization occurs only in arid and semi-arid regions but in reality no climatic zone in the world is free from salinization (Bhutta *et al*., 2004; Rengasamy, 2006). In Pakistan, for example, more than 6.17 Mha are salt affected; however, about 2.8 Mha have salinity to some extent (Government of Pakistan, 2009-2010).

Plant growth is affected substantially in the saline environment. Saline soils contain excessive amount of salts to impair growth of plants (Bresler *et al*., 1982; Moller *et al*., 2009). El-Kader *et al*. (2006) reported considerable reduction in growth and yield related traits due to increase in salinity levels. During early seedling growth, salinity affects the sunflower growth by osmotic stress as well, thus disturbing plant water relations, and reducing the leaf area and dry matter production. Leaf, stem, and root growth are also reduced by salinity (Katerji *et al*., 1994). Similarly, salinity stress significantly decreased the yield and yield component of sunflower (Rehman & Hussain, 1998). Salinity also decreases the nutrient uptake and contents in leaves of sunflower; nitrogen, phosphorus, potash, manganese, zinc and iron level were decreased, whereas sodium and chloride were increased in leaves and achenes of sunflower grown in saline conditions (El-Kader *et al*., 2006).

Sunflower (*Helianthus annuus* L.) is a potential oilseed crop for countries like Pakistan. Being photo-insensitive, it can be grown twice in a year and fits best in the existing cropping systems of the country. It is a medium salt tolerant crop and appears to be well adapted for growth under moderately saline soil conditions (Francois, 1996). Furthermore, many researchers recorded significant variation in the response of sunflower genotypes to salinity (Muralidharudu *et al*., 1999). Hybrid sunflower shows more salt tolerance than synthetic cultivars (Bush & Van Auken,

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2004). Plant height, leaf number and leaf area of sunflower decreased with increase in salinity showing a reduction of 22, 9 and 37%, respectively at EC 10 dS m^{-1}, but the response of different sunflower genotypes to salinity varied (Rehman & Hussain, 1998). Although efforts have been made to improve sunflower tolerance to saline conditions (Bajehbaj, 2010; Sadak *et al*., 2010), its field testing has been the most reliable for yield appraisal (Bush & Van Auken, 2004).

Although several reports on behavior of sunflower genotypes for salinity tolerance are available (Ashraf & Tufail, 1995; Bajehbaj, 2010; Sadak *et al*., 2010), most of the trials had been conducted in screen houses, green houses, hydroponics or pots. Hence little information is available about the performance of different hybrids in the target saline environments. It is predicted that differences exist in the sunflower hybrids for salinity tolerance. In view of this prediction, this study was conducted to evaluate the performance of promising sunflower hybrids in saline fields based on some agronomic characters.

MATERIALS AND METHODS

Experimental site and soil: The study was conducted at Agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan, Pakistan during spring 2008. Different sunflower hybrids were grown in a saline field (clay loam soil having EC 12 dS m^{-1}, pH 8.02, Organic matter 0.76%, total nitrogen 0.039%, available P 5.1 ppm and available K 250 ppm. Weather data during course of investigation is given in Table I.

Plant material: Seeds of 13 commercially available sunflower hybrids were obtained from seed selling companies viz. Monsanto (G-101, DKS-4040), Syngenta (S-278), Poineer (P64A93), ICI (Hysun-33, Hyolic-41, Charrah, CF-31, Aguara-3, Hysun-38 & Hysun-39), Cargill (FH-315), and Proline (VDH-487) and sown on 21st Feb. 2008 in a saline field.

Crop husbandry: The experiment was laid out in randomized complete block design (RCBD) and replicated thrice having net plot size of 3 m × 5 m. Before seedbed preparation, pre-soaking irrigation of 10 cm was applied. When soil reached to workable moisture level, seedbed was prepared by cultivating the field for 2-3 times with tractor-mounted cultivator each followed by planking. All sunflower hybrids were sown on February 21, 2008. Sowing was done with the help of dibbler using seed rate of 8 kg ha^{-1} maintaining row to row distance of 60 cm and plant to plant distance of 25 cm. Fertilizers were applied at the rate of 150 kg N and 100 kg P_2O_5 ha^{-1} in the form of urea and diammunium phosphate (DAP). Half of nitrogen and whole of phosphorus were applied at the time of sowing, while remaining nitrogen was applied with 1st irrigation. When the soil reached to workable moisture level, hoeing was done in order to keep the field weed free followed by earthing up. Plant protection measures were adopted to keep crop free of insects and diseases.

Data collection: Data on days to emergence was recorded from the date of sowing till when more than 50% of seed got emerged in each plot. Days to flower initiation were recorded from the date of sowing till when more than 50% flower opened in each plot. Days to flower completion were also calculated from the date of sowing till when more than 50% flower had shed pollen grains. In each plot, the total numbers of plants were counted at the time of harvesting. Days to maturity were recorded when back side of about 50% head turned yellow and outer bracket turned brownish in each plot. Height of ten randomly selected plants from the central two rows in each plot was measured from ground level to the top edge of the collar disc with meter rod and then averaged. Number of leaves per plant was counted from ten randomly selected plants taken from central row in each plot and then averaged. Head diameter was measured from one edge to the other in ten randomly selected plants heads and then averaged. For number of achenes per head, ten selected randomly discs were chosen from each plot and then averaged. Five samples of hundred achenes from each plot were counted, weighed and then averaged to count 100-achene weight. Two central rows from each plot were harvested, threshed manually, dried and then weighed to record achene yield at 10% moisture level and then converted into kg ha^{-1}.

Statistical analysis: The collected data were statistically analyzed by analysis of variance (one way) using the computer statistical program MSTAT-C. Least significance difference (LSD) test was used to compare the difference among treatments means (Steel *et al*., 1996).

RESULTS

There was substantial difference amongst the hybrids for days to emergence. Here hybrid Charrah took maximum time for emergence, which was similar to all other hybrids except S-278, G-101, DKS-4040 and Hysun-39, while hybrid S-278 took minimum time for emergence but it was also at par with G-101 and DKS-4040 under saline conditions (Table II). While there was no difference for days to flowering, the hybrids differed for days to maturity. Here maximum days to maturity were taken by hybrid CF-31; however, that was similar to FH-315, Charrah, Hyolic-41, DKS-4040 and G-101 against the minimum days taken to maturity by Hysun-31 (Table II). Similarly, maximum number of leaves per plant was recorded in sunflower hybrid DKS-4040 but it was at par with G-101, Hyolic-41, VDH-487 and Aguara-3 against the minimum number of leaves that were recorded in Charrah followed by S-278, Hysun-33, CF-31, Hysun-38 and Hysun-39 grown under saline conditions (Table II).

Maximum plant height was recorded in P64A93 followed by G-101, DKS-4040, Hysun-33 and Aguara-3 against the minimum plant height in VDH-487 followed by

Table I: Weather data during the course of the study

Month	Mean Monthly Temperature (°C)	Mean Monthly Relative Humidity (%)	Total Monthly Rainfall (mm)
February	14.42	71.65	13.1
March	16.23	62.25	0.0
April	16.4	56.00	27.1
May	32.3	44.28	7.7

Source: Agricultural Meteorology Cell, Central Cotton Research Institute, Multan, Pakistan

Table II: Effect of salinity on the phenology and number of leaves per plant of different sunflower hybrids

Hybrids	Days to emergence	Days to flowering	Days to flower completion	No. of leaves per plant	Days to maturity
G-101	16.33 de	81.67	90.00 a	21.00 abc	117.33 abcd
S-278	14.66 e	77.67	85.00 abcd	16.33 fg	113.00 ef
DKS-4040	17.00 cde	80.67	88.67 ab	22.67 a	117.67 abc
P64A93	18.67 abcd	74.00	82.33 cd	19.67 bcde	116.00 bcde
Hysun-33	18.00 abcd	74.33	83.33 bcd	18.33 cdefg	111.33 f
Hyolic-41	20.00 a	79.00	85.67 abcd	20.33 abcd	118.67 ab
Charrah	20.33 a	79.67	86 abcd	15.67 g	118.00 ab
CF-31	19.67 ab	73.33	81.00 d	18.00 defg	120.00 a
VDH-487	18.67 abcd	78.67	87.33 abc	20.00 abcde	115.67 bcde
Aguara-3	19.00 abc	75.00	81.67 cd	22.00 ab	116.33 bcde
FH-315	18.33 abcd	76.00	84.33 abcd	18.67 cdef	117.00 abcd
Hysun-38	19.33 abc	71.33	80.67 d	17.33 efg	114.00 def
Hysun-39	17.33 bcd	78.00	86.33 abcd	17.67 defg	114.33 cdef
LSD value at 5% probability	2.63	NS	5.72	2.83	3.53

Table III: Effect of salinity on plant height, yield components and achene yield of different sunflower hybrids

Hybrids	Plant height (cm)	Number of plants at harvest (m^{-2})	Head diameter (cm)	No. of achenes $head^{-1}$	100- achene weight (g)	Achene yield ($kg\ ha^{-1}$)
G-101	127.56 ab	5.42 abcd	15.44	1021.67 abc	4.28 abcd	1626.67 abc
S-278	119.00 bcd	5.15 def	13.77	945.33 abcde	3.01 efg	1580.00 bc
DKS-4040	126.67 ab	5.71 a	17.28	1138.67 a	5.29 ab	1903.33 a
P64A93	135.67 a	5.53 abc	16.56	1046.00 ab	5.45 a	1788.00 ab
Hysun-33	124.33 abc	5.31 bcde	14.11	826.00 cde	4.15 bcde	1262.00 def
Hyolic-41	123.44 bc	5.60 ab	15.78	912.33 bcde	3.86 cdef	1106.33 efg
Charrah	109.67 de	4.60 hi	13.11	877.33 bcde	4.00 cde	1525.00 bcd
CF-31	119.67 bcd	4.80 gh	13.67	738.33 e	3.89 cdef	911.67 g
VDH-487	105.33 e	5.02 efg	14.11	942.33 abcde	3.93 cdef	1351.67 cde
Aguara-3	126.00 ab	5.38 abcde	15.22	965.67 abcd	5.05 abc	1757.00 ab
FH-315	117.00 bcd	4.35 i	13.89	824.33 cde	3.52 defg	885.00 g
Hysun-38	114.33 cde	4.69 ghi	12.89	854.66 bcde	2.62 g	1020.00 fg
Hysun-39	120.56 bcd	5.18 cde	13.22	761.67 de	2.76 fg	1206.67 ef
LSD value at 5% probability	11.53	0.37	NS	210.02	1.202	291.37

Means sharing the same letters in a column do not differ significantly ($p>0.05$)

Charrah and Hysun-38 when grown in saline field (Table III). There was no difference amongst the hybrids for head diameter (Table III). Sunflower hybrid DKS-4040 followed by G-101, P64A93 and Hyolic-41 displayed higher plant population due to greater emergence potential, but was the minimum in FH-35 followed by Hysun-38 and Charrah (Table III).

Maximum number of achenes were recorded in sunflower hybrid DKS-4040 followed by G-101, S-278, P64A93, VDH-487 and Aguarar-3 against the minimum number of achenes, which were recorded in CF-31 but it was at par with all other hybrids except G-101, DKS-4040 and P64A93 when grown in a saline field (Table III). Similarly, heavier achenes and highest achene yield was recorded in DKS-4040 but it was at par with other hybrids like G-101, P64A93 and Aguara-3. Lighter achenes and lowest achene yield was recoded in FH-315 but it was also at par with Hysun-38, Husun-39, CF-31 and Hyoilc-41 when grown under saline conditions (Table III).

Interrelationships of various germination, growth and yield characteristics were drawn for their possible role in salinity tolerance of these hybrids (Table IV). The correlation coefficients (r) values indicated that days to emergence and days to maturity were not correlated with any of the characters (data not shown), while days to flowering were positively associated with completion of flowering. Number of leaves per plant was positively correlated with yield characteristics including head diameter, number of achenes per head, 100 achene weight and achene yield per plant. Plant height was positively correlated with number of plants per m^2, head diameter and 100 achene weight, while number of plants per m^2 was positively correlated with all the yield attributes (Table IV). All the yield attributes were positively related with each other.

Table IV: Correlation coefficients (r) of growth and yield attributes of sunflower hybrids grown in a saline field (n = 13)

X-variable	Y-variable	r
Days to flowering	Days to flower completion	0.954**
	No. of leaves per plant	0.282ns
	Days to maturity	0.291ns
	Plant height	-0.062ns
	Number of plants	0.331ns
	Head diameter	0.333ns
	No. of achenes per head	0.451ns
	100-achene weight	0.166ns
	Achene yield	0.420ns
No. of leaves per plant	Days to maturity	0.302ns
	Plant height	0.498ns
	Number of plants	0.665*
	Head diameter	0.827**
	No. of achenes	0.655*
	100-achene weight	0.698**
	Achene yield	0.452ns
Plant height	Number of plants	0.701**
	Head diameter	0.719**
	No. of achenes per head	0.437ns
	100-achene weight	0.587*
	Achene yield	0.450ns
Number of plants	Head diameter	0.801**
	No. of achenes per head	0.648*
	100-achene weight	0.572*
	Achene yield	0.639*
Head diameter	No. of achenes per head	0.824**
	100-achene weight	0.825**
	Achene yield	0.639*
No. of achenes per head	100-achene weight	0.689**
	Achene yield	0.849**
100- achene weight	Achene yield	0.691**

Significant at ** $P<0.01$; * $P<0.05$ and ns $P>0.05$

DISCUSSION

Although sunflower is a moderately salt tolerant plant (Francois, 1996), salinity affects its growth and development from germination to maturity. In this study agronomic and yield related traits were substantially reduced by salinity stress owing to specific ion toxicity. Furthermore, salinity interfere the nutrient dynamics and uptake as well in sunflower; for instance El-Kader *et al*. (2006) reported decrease in uptake of nitrogen, phosphorus, potash, manganese, zinc and iron and increase in sodium (Na) and chloride (Cl) uptake in sunflower grown in saline fields. Increased uptake of Na and Cl is more important in determining the extent of salinity tolerance. The genotypes better able to restrict the Na and Cl uptake and improve K uptake can better tolerate salinity stress.

Seedling stage is more salt sensitive than other plant growth stages. Seedling emergence and post-emergence seedlings mortality are great determinant of salt tolerance in sunflower (Katerji *et al*., 1994; Wahid *et al*., 1999; Turhan & Ayaz, 2004). Hence seedlings survivorship at this critical stage was determined in the present case. Sunflower hybrids DK4040, P64A93, Aguara-3, S-278 with uniform and early stand establishment completed phenological stages in relatively shorter time (Tables II & III) enabling them to show higher achene yield. However, the hybrids Hysun-33, Hyolic-41, Charrah and CF-31 taking more time to emerge and establish stand, took relatively longer time to complete different growth events with lower achene yield (Tables II & III).

Plant stature and morphology are also very important in determining the salinity tolerance. For instance, hybrids with more and longer leaves were better able to withstand salinity stress giving higher achene yield (Yousaf *et al*., 1989). Salt tolerance of plant species is the result of mutual coordination of various plant organs; so their interrelationships are important to determine (Wahid *et al*., 1999). Determination of the correlation of various growth and yield attributes of the hybrids under investigation revealed that, amongst others, yield attributes were positively correlated with the number of plants per unit area and, most importantly, with the number of leaves per plant (Table IV). This is important in view of the fact that greater assimilate partitioning from broader and actively photosynthesizing leaves to the growing seeds ultimately determines the plant productivity.

It may be concluded that sunflower hybrids DKS-4040, G-101 and P64A93 are salt tolerant, so can be grown successfully in saline conditions, while hybrids FH-315, Hysun-38, Hysun-39, Hyolic-41 and CF-31 were sensitive to salt stress. Hybrids with greater number and area of leaves were better tolerant of salinity, and this character may be used as a criterion of salinity tolerance in sunflower and possibly in other plants.

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