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Research Paper

IDENTIFICATION OF SUNFLOWER (Helianthus annus L.) SALT TOLERANT GENOTYPES

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Abstract: Salinity is one of the major problems limiting the crop production including oil seeds. The reclamation of these saline soils are expensive and time consuming. As agricultural crops and their varieties differ considerably with regard to salt-tolerance, study of salt genotypes seems promissing. Keeping in view, a greenhouse experiment was carried out for the identification of salt tolerant genotypes of sunflower, as well as their characteristics. Nine genotypes were grown in aerated Hoagland's nutrient solution. Three salinity levels 40, 80 and 120 mol m-3 were artificially maintained with the help of commercial NaCl.Wheras, control contained Hoagland's nutrient solution only. Results showed that shoot length decreased significantly with increase in salinity and maximum shoot length was found in SH-3322 while, the minimum in QPS-1001 at 40,80 and 120 mol m-3 level. Maximum root length was found in SH-3322 at all levels. Shoot fresh weight, shoot dry weight, root fresh weight and root dry weight decreased significantly with increased salinity. The maximum Na+ concentration was recorded for ICI-HYSUN-33. while minimum was observed for SH-3322 and SF-187 in all salinity levels. On an overall basis SH-3322 was proved to be the best in saline soil.

Key words: salinity, sunflower, salt tolerant genotype, oil seeds, reclamation.

Introduction

Edible oil is one of the most important consituent of our daily diet. With passage of time and increase in population, the demand for edible oil is increasing. Salinity is one of the major problems limiting the crop production and the reclamation of these saline soils are expensive and time consuming. To save the time and money efficient utilization of these saline soils is the demand of the future. Non-conventional oil seeds like sunflower have the potential to bridge up the gap between production and requirements of edible oil. Sunflower ranked with soybean, rapeseed and peanut as one of the most important oil seed crops in the world grown for edible oil (Putt, 1997). Sunflower is a rich source of oil on world level and fulfills about 12.8% of the total edible oil requirements (Hatam and Abbasi, 1994).

To increase production from salt affected soils as well as from normal soils there is a need to identify salt tolerant genotypes of potential oil seed crops. Sunflower is documented as moderately salt tolerant crop (Katerji et al, 2000). The situation necessitates a regular selection/screening of new genotypes. Owing to the importance of sunflower as oil seed crop and the soil and climatic conditions under which it is by and large grown in Pakistan. The research work was conducted to study variation in salinity tolerance of sunflower and to identify the sunflower genotypes showing tolerance to salinity. The selected genotypes may be recommended for use by the farmers of salt affected areas.

Material and Methods

Healthy and uniform sized seeds of nine sunflower genotypes V1= QPS-1001, V2 = QPS-1002,V3=QPS-1003,V4=QPS-1004,V5= QPS-1005, V6 = QPS-1006, V7 = ICI-Hysun-33, V8= SF-187, V9= SH-3322 and V9= SH-3322 were sown in gravel filled iron trays and kept moistened with distilled water.

At two leaf stage the seedlings were transplanted to 200 L capacity iron tubs lined with polythene sheet containing ½ strength Hoagland's nutrient solution (Hoagland and Arnon, 1950). Six healthy plants of each of genotype were transplanted into foam-plugged holes in polystyrene sheets floating over continuously aerated nutrient solution. There were 4 levels T_o = Control (15 mol m^{-3}), T_1 = 40 mol m^{-3},T_2 = 80 mol m^{-3} and T_3 = 120 mol m^{-3} and these salinity levels were maintained by NaCl.The pH of each tub was adjusted daily in the range of 6-6.5 with the help of NaOH or HCl. The solutions were changed after 15 days during the entire experimental period.

Plants were harvested after 30 days of transplantation. Two fully expanded youngest leaves from each plant were collected and stored in Eppendorf tubes at freezing temperature.At harvesting, shoot and root fresh weight (g/plant), shoot and root length(cm) and after oven drying at 65 ^{0}C, oven dry weights of roots and shoots were recorded.

Frozen leaf samples in Eppendorf tubes were thawed. After washing with distilled water the tissue sap was extracted by using metal rod. The sap was stored in 1.5 cm^3 Eppendorf tubes for at least two minutes. The stirred leaf sap was centrifuged at 6500 rpm for five minutes. The supernatant leaf sap was collected in another Eppendorf tube and diluted as required for analysis of Na^+ and K^+.Sodium and Potassium were determined by using flame photometer.

Results and Discussion

Effect of salinity on shoot length (cm) of sunflower genotypes

Data regarding shoot length (SL) and relative yield of different sunflower genotypes at different NaCl concentration levels (Table1) showed that all genotypes significantly decreased in shoot length (SL) with increasing salinity. At 40 mol m^{-3} , the maximum SL (37.5 cm) was observed in SH-3322 followed by SF-187 (34.1 cm) and QPS-1002 (31.7 cm). SH-3322 significantly differed with SF-187. The minimum SL was found in QPS-1001 (23.0 cm) followed by ICI-HYSUN-33 (25.2 cm). These genotypes differed non-significantly with each other. At 80 mol m^{-3}, the maximum SL was recorded for SH-3322

(32.4 cm) followed by SF-187 (30.8 cm) and QPS-1002 (30.2 cm). These genotypes differed significantly. The minimum SL was recorded for QPS-1001 (22.1 cm), QPS-1006 (22.5 cm) followed by ICI-HYSUN-33 (23.1 cm). These genotypes non-significantly differed to each other. At 120 mol m^{-3}, the maximum shoot length was found in SH-3322 (32.7 cm), SF-187 (31.2 cm), QPS-1002 (28.5 cm) and for QPS-1004 (28.0 cm). Genotypes SH-3322 was significantly higher than all the others. Whereas, SH-3322 and SF-187 differed significantly with one another. The minimum SL values were observed in QPS-1005 (18.5 cm), QPS-1001 (21.3 cm) and ICI-HYSUN-33 (22.2 cm). QPS-1001 and ICI-HYSUN-33 non-significantly varied to one another and both these significantly varied to QPS-1005. SH-3322 was of significantly higher value than those of other readings. These results are in coincide with those of Jiang *et al* (2005) in cotton,, Hussain and Rehman (1995), Francois (1996) and Ghumman (2000) in sunflower. Excessive accumulation of salts in cell wall modified the metabolic pathway, limit the cell wall elasticity and ultimately the shoot length. Further, secondary cell appears sooner and cell wall becomes rigid. As a consequence turgor pressure efficiency in cell enlargement declines. These processes may cause the shoot to remain smaller.

Effect of salinity on shoot fresh weight (g/plant) on sunflower genotypes

Data regarding shoot fresh weight (SFW) (Table 2) revealed that with increased in salinity, SFW was reduced significantly. At 40 mol m^{-3}, the maximum SFW of 23.9 g was recorded in SH-3322 followed by SF-187 (17.4 g) and QPS-1002 (11.4 g). These genotypes varied significantly to each other. The minimum SFW was recorded in ICI-HYSUN-33 (9.1 g) followed by QPS-1006 (9.2 g) and QPS-1005 (9.4 g). These genotypes also differed significantly to each other. At 80 mol m^{-3} , SH-3322 was found to have the maximum SFW 18 g followed by SF-187 (14.7 g) and QPS-1004 (10.8 g). These genotypes differed significantly to each other. The minimum SFW was observed in ICI-HYSUN-33 (6.3 g) followed by QPS-1001(6.4 g). These genotypes also differed significantly to each other. At 120 mol m^{-3} , the maximum SFW was observed in SH-3322 (14.3 g) followed by SF-187 (11.5 g) and QPS-1002 (8.5 g). The genotypes QPS-1001 and ICI-HYSUN-33 were found to have minimum SFW as low as 5.3 g and 3.9 g, respectively. The results are in agreement with those of, Akhtar *et al.* (2002) in wheat, Andria *et al*. (1997), Hussain and Rehman (1995) and Mehdi *et al.* (2000) in sunflower.Reduction in SFW could be attributed to decreased water potential of rooting medium due to high ion concentration as initial growth inhibition in saline condition is related to osmotic effect .High Na and Cl concentration in the rooting medium could have suppressed K^{+}, Ca^{+2} and NO^{-3} etc. and ultimately the growth (Gorham and Wyn Jones, 1993).

Table 1. Effect of Salinity on Shoot Length (cm) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120 mol m-3 NaCl
QPS-1001	27.1±0.7	23.0±1.4	22.1±0.7	21.3±0.8
QPS-1002	33.5±0.8	31.7±1.7	30.2±2.3	28.5±1.4
QPS-1003	33.3±1.0	28.6±0.9	27.0±1.6	25.8±0.3
QPS-1004	33.8±0.7	32.2±0.8	28.0±2.6	24.0±1.8
QPS-1005	28.0±0.9	26.7±1.0	22.5±1.3	18.5±1.3
QPS-1006	30.2±1.4	27.6±0.5	25.1±1.1	23.5±0.1
ICI-HYSUN-33	27.5±0.7	25.2±1.0	23.1±0.5	22.2±0.6
SF-187	36.5±0.9	34.1±0.7	31.8±0.7	30.2±0.8
SH-3322	40.2±1.4	37.5±0.8	32.4±0.7	32.7±0.6
Mean	32.2±0.9	29.6±1.0	26.9± 1.1	25.2±1.2

Table 2. Effect of salinity on shoot fresh weight (g/plant) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120mol m-3 NaCl
QPS-1001	10.4±0.35	9.65±0.52	6.43±0.30	5.3±0.10
QPS-1002	13.0±0.35	11.4±0.55	10.1±1.72	8.5±0.30
QPS-1003	10.8±0.41	9.81±0.27	8.0±0.74	6.1±0.14
QPS-1004	11.5±0.84	10.8±0.91	10.3±1.64	6.4±0.42
QPS-1005	11.4±0.37	9.42±0.46	7.60±0.19	5.9±0.18
QPS-1006	10.5±0.23	9.23±0.16	8.20±0.34	6.0±0.16
ICI-HYSUN-33	9.91±0.24	9.13±0.17	6.30±0.28	3.9±0.15
SF-187	18.8±1.15	17.4±0.77	14.7±0.73	11.5±0.2
SH-3322	24.9±1.98	23.9±1.69	18.0±0.63	14.3±0.3
Mean	13.5±0.66	12.4±0.61	10.0±0.73	7.3±0.22

Effect of salinity on shoot dry weight (g/plant)

Shoot dry weight (SDW) is also an important criterion for observing the performance of crop plants against salinity stress(Tab 3) shows decreasing trend with increased salinity. At 40 mol m^{-3} , the maximum SDW 4.8 g was observed for SH-3322 followed by SF-187 (4.2 g) and QPS-1004 (2.2 g). These genotypes varied non-significantly to each other. The minimum SDW of 1.2 g was observed in QPS-1001 and ICI-HYSUN-33.At 80 mol m^{-3} , the maximum SDW was observed in SH-3322 (4.3 g) followed by SF-187 (3.5 g) and QPS-1002 (1.8). The minimum SDW was observed for QPS-1001 (0.09 g) and ICI-HYSUN-33 (0.09 g). At 120 mol m^{-3}, the three genotypes, i.e. SH-3322 (2.6 g), SF-187 (2.2 g), QPS-1002 (1.2 g) were at the top in case of SDW, respectively. These differed significantly. The genotypes QPS-1005 (31%), ICI-HYSUN-33 (0.4 g) followed by QPS-1001 (0.5

g) and QPS-1005 (0.5 g) produced the lowest shoot dry weight. The decrease in SDW with increased salinity was also reported by , Khatoon *et al*. (2000) in sunflower and Akhtar *et al*. (2002) in wheat, and Ashraf *et al*. (2004) in Brassica species. The decrease in SDW under saline condition was due to reduced growth as a result of decreased water uptake. Toxicity of Na^+ and Cl^- in the shoot cells as well as reduced photosynthesis. The decrease in dry weight of shoot with increasing salinity may be due to imbalanced nutrients, solute suction in toxic quantities and inefficient use of metabolites .

Effect of salinity on root length (cm) of sunflower genotypes

The data showed that the root length of different sunflower genotypes at different salinity levels decrease significantly with increasing salinity levels. At 40 mol m^{-3} , the maximum RL was recorded for SH-3322 (18.2 cm) followed by SF-187 (17.7 cm) and QPS-1002 (17.3 cm). Genotype SH-3322 was non-significantly differed to QPS-1002 and SF-187. The minimum RL was recorded for QPS-1001 (14.2 cm) and ICI-HYSUN-33 (14.2 cm). There was non-significant variation among these genotypes. At 80 mol m^{-3} NaCl salinity, the maximum RL was recorded for SH-3322 (17.3 cm) followed by SF-187 (17 cm) and QPS-1002 (16.7cm). Genotype QPS-1003 (16.3 cm) was at the next position. The minimum RL was recorded in ICI-HYSUN-33 (13.3 cm) followed by QPS-1001 (13.6 cm). SH-3322 and SF-187 varied non-significantly to each other. At 120 mol m^{-3} , the maximum RL was observed for SH-3322 (16.9 cm) followed by SF-187 (16.04 cm) and QPS-1002 (15.2 cm). SH-3322 differed non-significantly to SF-187 but differed significantly to QPS-1002. The minimum RL was recorded for ICI-HYSUN-33 (12.5 cm) and QPS-1005 (12.5 cm) followed by QPS-1001 (13.1 cm). These genotypes varied non-significantly to each. These results matched to the findings of Hussain and Rehman (1994), and Ghumman (2000). Reduction in RL in response to salinity may be due to Na^+ and Cl^- affects root permeability and integrity due to the displacement of Ca^+ from the plasmlemma, which inhibits root growth and root length.

Table 3. Effect of salinity on shoot dry weight (g/plant) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120mol m-3 NaCl
QPS-1001	1.3±0.09	1.2±0.05	0.9±0.06	0.5±0.04
QPS-1002	2.5±0.08	2.1±0.09	1.8±0.21	1.2±0.10
QPS-1003	1.7±0.09	1.4±0.06	1.1±0.19	0.7±0.08
QPS-1004	2.3±0.06	2.3±0.22	1.6±0.14	0.8±0.07
QPS-1005	1.7±0.07	1.6±0.08	1.4±0.13	0.5±0.02
QPS-1006	1.5±0.09	1.7±0.07	1.1±0.04	0.6±0.06
ICI-HYSUN-33	1.3±0.05	1.2±0.05	0.9±0.04	0.4±0.06
SF-187	4.6±0.11	4.2±0.06	3.5±0.18	2.2±0.07
SH-3322	5.2±0.21	4.8±0.09	4.3±0.08	2.6±0.08
Mean	2.4±0.09	2.3±0.08	1.8±0.12	1.1±0.06

Table 4. Effect of salinity on Root Length (cm) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120 mol m-3 NaCl
QPS-1001	14.6±1.15	14.2±1.30	13.6±0.56	13.1±0.70
QPS-1002	18.5±0.90	17.3±0.40	16.7±0.95	15.2±0.60
QPS-1003	17.7±1.14	16.9±0.43	16.3±1.0	14.8±1.95
QPS-1004	16.8±1.35	16.5±0.70	15.6±0.9	15.0±0.53
QPS-1005	15.4±0.53	15.6±0.54	13.8±0.65	13.0±0.56
QPS-1006	16.5±0.38	15.8±0.90	15.4±0.77	15.2±0.38
ICI-HYSUN-33	14.6±0.53	14.2±0.26	13.3±0.42	12.5±0.32
SF-187	19.4±0.96	17.71±0.60	17.1±1.60	16.1±1.02
SH-3322	19.4±0.84	18.1±1.24	17.3±1.09	17.0±0.76
Mean	16.8±0.86	16.3±0.70	15.4±0.84	14.6±0.70

Effect of salinity on root fresh weight (g/plant) on sunflower genotypes

Data pertaining to root fresh weight (RFW) of sunflower showed (Table 5) that RFW of all the genotypes decreased with increase in salinity.At 40 mol m^{-3}, the maximum RFW was recorded in SH-3322 (13.7 g) followed by SF-187 (11.8 g), QPS-1002 (7.1 g) and QPS-1004 (7.1 g). SH-3322 and SF-187 genotypes differed significantly with each other. While the genotypes QPS-1002 and QPS-1004 varied non-significantly to each other. In contrast the minimum RFW was found in ICI-HYSUN-33 (4.8 g) followed by QPS-1001 (5.1 g). These genotypes also varied non-significant to each other.At 80 mol m^{-3} , SH-3322 (11.1 g) was found to have maximum RFW followed by SF-187 (9.2 g) and QPS-1002 (6.2 g) in contrast the minimum RFW was recorded for ICI-HYSUN-33 (4.2 g) and QPS-1001 (4.2 g). These genotypes differed non-significantly to each other. At maximum salinity level, the highest RFW was observed in SH-3322 (9.7 g) followed by SF-187 (8.1 g) and QPS-1002 (5.7 g) in contrast the minimum RFW was observed in ICI-HYSUN-33 (2.8 g) followed by QPS-1001(3.4 g). These Genotypes varied significantly to each other.Decreased RFW with increased salinity was also reported earlier by Mehdi *et al*. (2000) in rice and Nawaz *et al*. (2002), in sunflower. Reduction in root fresh weight is due to the accumulation of toxic quantities of various ions within the plant.

Table 5. Effect of salinity on Root fresh weight (g/plant) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120mol m-3 NaCl
QPS-1001	6.13±0.09	5.08±0.17	4.2±0.08	3.4±0.12
QPS-1002	8.15±0.36	7.07±0.17	6.2±0.54	5.7±0.20
QPS-1003	6.87±0.44	5.35±0.13	5.1±0.66	4.3±0.10
QPS-1004	7.33±0.50	7.13±0.43	5.4±0.32	5.0±0.07
QPS-1005	6.49±0.22	5.31±0.04	4.8±0.26	4.2±0.10
QPS-1006	6.40±0.17	5.30±0.11	4.8±0.22	4.2±0.10
ICI-HYSUN-33	6.15±0.15	4.89±0.10	4.2±0.05	2.8±0.09
SF-187	12.1±0.33	11.8±0.38	9.2±0.18	8.1±0.11
SH-3322	14.3±0.49	13.7±0.60	11.1±0.15	9.7±0.23
Mean	8.20±0.31	7.31±0.24	6.18±0.27	5.30±0.13

Effect of salinity on root dry weight (g/plant) on sunflower genotypes

Data pertaining to root dry weight (RDW) (Table 6) revealed that root dry weight significantly decreased with increasing salinity. Differences among genotypes at various levels of salinity were also significant.At 40 mol m^{-3} , the maximum RDW was found in SH-3322 (1.9 g), followed by SF-187 (1.0 g) and QPS-1002 (0.7 g). All these genotypes differed significantly. In contrast the minimum RDW was recorded in ICI-HYSUN-33 (0.2 g) followed by QPS-1001 (0.35 g). All genotypes except QPS-1001 and QPS-1006 were found to have significant differences. At 80 mol m^{-3} , the genotypes with relative higher RDW were in the order of SH-3322 (1.4 g), SF-187 (0.8 g) and QPS-1002 (0.61 g). There were significant differences among these genotypes. The genotypes with relatively lower RDW could be arranged in the order of ICI-HYSUN-33 (0.15 g) followed by QPS-1001 (0.35 g) and QPS-1003 (0.4 g). These genotypes differed significantly. The genotypes QPS-1001 and QPS-1006 varied non-significantly to each another.At 120 mol m^{-3} , SH-3322 (1.3 g), SF-187 (0.6 g), and QPS-1002 (0.5 g) were at the top in the case of RDW. These genotypes differed significantly. The genotypes with lower RDW were ICI-HYSUN-33 (0.1 g) followed by QPS-1006 (0.2 g) and QPS-1001 (0.2 g). Genotypes QPS-1001 and QPS-1006 varied non-significantly to each other while both these varied significantly to ICI-HYSUN-33. The reduction in RDW under saline conditions was due to reduced growth as a result of decline in water uptake, toxicity of Na^+ and Cl^- in root cells . Reduction in RDW was correlated with reduction in RFW. High Na^+ and Cl^- concentration in rooting Medium could suppress the uptake of K^+, Ca^{+2} and NO^{-3} and ultimately the growth (Gorham and Wyn Jones, 1993).

Table 6. Effect of salinity on root dry weight (g/plant) of sunflower genotypes

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120mol m-3 NaCl
QPS-1001	0.43±0.03	0.37±0.02	0.25±0.01	0.2±0.015
QPS-1002	0.83±0.05	0.65±0.03	0.55±0.04	0.5±0.05
QPS-1003	0.56±0.04	0.53±0.03	0.42±0.01	0.3±0.01
QPS-1004	0.69±0.05	0.59±0.03	0.52±0.07	0.4±0.01
QPS-1005	0.50±0.03	0.46±0.02	0.34±0.03	0.3±0.01
QPS-1006	0.42±0.02	0.37±0.02	0.29±0.02	0.2±0.02
ICI-HYSUN-33	0.32±0.03	0.23±0.02	0.15±0.02	0.1±0.01
SF-187	1.10±0.04	1.01±0.03	0.81±0.02	0.6±0.03
SH-3322	2.01±0.05	1.90±0.07	1.44±0.07	1.3±0.05
Mean	0.82±0.04	0.74±0.03	0.65±0.03	0.40±0.02

Table7. Effect of salinity on Na^+ concentration (mol m^{-3}) of sunflower leaves

Genotypes	Control (15 mol m-3) NaCl	40 mol m-3 NaCl	80 mol m-3 NaCl	120mol m-3 NaCl
QPS-1001	11.1±0.31	33.8±0.88	69.0±0.50	93.1±1.64
QPS-1002	10.0±0.07	26.2±1.03	52.8±2.84	83.8±1.67
QPS-1003	10.8±0.15	33.8±0.88	59.4±1.05	87.8±1.10
QPS-1004	12.2±0.20	30.2±1.03	60.4±1.17	86.8±2.20
QPS-1005	13.6±0.23	30.3±0.75	61.7±1.45	90.2±1.27
QPS-1006	11.1±0.27	30.9±0.40	64.4±1.13	88.5±1.56
ICI-HYSUN-33	14.4±0.16	35.6±0.80	70.6±0.95	100.1±1.61
SF-187	7.42±0.23	30.6±1.0	51.5±0.80	77.4±0.84
SH-3322	8.41±0.17	29.1±0.67	48.2±1.55	72.9±0.60
Mean	11.0±0.20	30.3±0.83	59.8±1.27	86.7±1.39

Effect of salinity on sodium concentration (mol m^{-3}) in expressed leaf sap

It is evident from the data that Na^+ concentration significantly increased with increasing salinity (Tab 7). On an overall mean basis, the minimum Na^+ concentration was found in QPS-1002 (16.2 mol m^{-3}) at 40 mol m^{-3} , while the maximum Na^+ concentration was found in ICI-HYSUN-33 (100.1 mol m^{-3}) at 120 mol m^{-3}. At 40 mol m^{-3} , the minimum Na^+ concentration was observed in QPS-1002 (26.2 mol m^{-3}) followed by SH-3322 (29.1 mol m^{-3}) and QPS-1004 (30.2 mol m^{-3}) in an ascending order. The genotype QPS-1002 differed significantly to the SH-3322 and QPS-1004. It was observed that ICI-HYSUN-33 (35.6 mol m^{-3}) was with significantly higher Na^+ concentration than those of QPS-1001 (33.8 mol m^{-3}) and QPS-1003 (33.7 mol m^{-3}). Genotypes ICI-HUSUN-33 and QPS-1001 were found to be varied significantly. At 80 mol m^{-3} , the genotypes ICI-HYSUN-33 (70.6 mol m^{-3}) had the maximum Na^+ concentration followed by QPS-1001 (69.0 mol m^{-3}) and QPS-1006 (64.4 mol m^{-3}). After calculating standard error of each and every observation, it was found that ICI-HYSUN-33 and QPS-1001 had a non-significant relation to each other. The minimum Na^+ concentration was found in SH-3322 (48.2 mol m^{-3}) followed by SF-187 (51.5 mol m^{-3}) and QPS-1002 (52.8 mol m^{-3}). Non-significant relation existed among these three genotypes. At 120 mol m^{-3} NaCl concentration level, the maximum Na^+ concentration was recorded in ICI-HYSUN-33 (100.1 mol m^{-3}). It was followed by QPS-1001 (93.1 mol m^{-3}). Significant differences were found among the two genotypes. The minimum Na^+ concentration was found in SH-3322 (72.9 mol m^{-3}) followed by SF-187 (77.4 mol m^{-3}) and QPS-1002 (83.3 mol m^{-3}). There was also significant variation among these genotypes. Increase in Na^+ concentration with increase salinity was also reported earlier, e.g. in in rice by Jiang *et al.* (2005), and in sunflower by Parakash *et al*. (1996), Ballesteros *et al*. (1996, 1997), Ashraf and O'Leary (1995) and Nawaz *et al.* (2002). Exclusion of Na^+ at leaf or cellular level is an important salt tolerance mechanism in sunflower (Ashraf and Noor, 1993). Tolerant crop plants maintain less Na^+ concentration in leaves at high stress level and plant maintain this low leaf Na^+ concentration mainly by efficient exclusion of Na^+ both at room or leaf better than wheat due to efficient exclusion of Na^+ and Cl^- from the younger leaves. A positive correlation exists between Na^+ exclusion and relative salt tolerance in sunflower (Hussain and Rehman, 1994; Ashraf and Sultana, 2000). Efficient Na^+ exclusion is a good selection criterion for salt tolerance in sunflower and other glycophytes (Nawaz *et al*., 2002).

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