HELIA, **24**, Nr. 35, p.p. 149-158, (2001) UDC 631.81.031:631.413.3:633.854.78

EVALUATION AND PERFORMANCE OF DIFFERENT COMMERCIAL SUNFLOWER HYBRIDS UNDER SALINE CONDITIONS

Arshad Ali*, Badr-uz-Zaman and M. Salim

Soil Salinity Laboratory, Land Resources Research Institute, National Agricultural Research Center, Park Road, Islamabad 45500, Pakistan

Received: May 05, 2001
Accepted: October 26, 2001

SUMMARY

A hydroponic study was conducted to evaluate the performance of five-sunflower hybrids, *i.e.*, PARSUN, SH-3322, XF-4623, SMH-9706 and XF-4619, at 0, 75 and 150 mM NaCl salinity in root medium. Sunflower (*Helianthus annuus* L.) seeds were germinated in moist quartz sand, twelve-day old seedlings were foam plugged in lids of plastic pots containing 2.5 l of continuosly aerated half-strength Hoagland's nutrient solution. The experiment was organized in completely randomized design (CRD) using four replications. Sunflower growth deceased drastically with increasing concentration of NaCl in root medium. Sunflower hybrid XF-4619 registered maximum shoot and root fresh weight, stem diameter and leaf area. Furthermore XF-4619 exhibited the least decrease in these parameters under saline conditions. XF-4619 exhibited 14 and 53% decrease in shoot fresh weight, 11 and 35% decrease in root fresh weight, 6 and 34% decrease in stem length, 12 and 34% decrease in stem diameter, 10 and 40% decrease in leaf area, 2 and 31% decrease in root dry matter and 13 and 50% decrease in shoot dry matter yield at 75 and 150 mM NaCl, respectively, as compared with the control. Moreover, Ca and K were also efficiently taken up by XF-4619 in saline and non-saline root medium. This is indicative of it having better yield potential than the other commercial sunflower hybrids.

Key words: Ca alleviation effects, NaCl salinity, sunflower hybrids

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is becoming an increasingly important source of edible oil throughout the world because of its high polyunsaturated fatty acids content and very low cholesterol. Pakistan imported 1.9 million tons of edible oil spending US$ 788 million during the year 1999-2000 (GOP, 2000). The cropped area under sunflower is gradually increasing due to the increasing demand for edi-

* Corresponding author

ble oil in the country. Sunflower is moderately salt tolerant crop therefore it may be grown successfully on many marginal salt affected lands. Moreover, the oil content of the seed for which the crop is grown shows little response to salinity (Francois, 1996). The oil content of sunflower on an average is 47.5%. Sunflower is ranked next to peanut (48.5%) in terms of oil content among flax, soybean safflower, cotton seed, mustard and rape (Tesar, 1984). This places sunflower in the same tolerance category as soybean (Maas and Hoffman, 1997) and safflower (Francois and Bernstein, 1964), the other two major edible oil crops. Although the threshold for all the three species is nearly identical, the rate of yield decline above the threshold is lesser for sunflower as compared with soybean and safflower (Francois, 1996). Presently many sunflower hybrids are being grown in different areas of Pakistan. However, performance of these hybrids under saline condition is not documented. Therefore, screening of these commercial hybrids under saline conditions is needed to formulate proper recommendation to exploit yield potential of these under salt stress. This study described the growth response of different sunflower hybrids in varied NaCl salinity. Total biomass production, dry matter yield, stem diameter, leaf area, uptake of Na^+, K^+ and Ca^{2+} by sunflower hybrids grown in a saline medium are also discussed in this paper.

MATERIAL AND METHODS

The experiment was conducted in solution culture. Seeds of five sunflower hybrids (*Helianthus annuus* L.), PARSUN, SH-3322, XF-4623, SMH-9706 and XF-4619, were germinated in moist quartz sand. Four twelve-day old seedlings were each foam plugged in a lids of a plastic pot containing 2.5 l of continuously aerated half-strength Hoagland's nutrient solution (Hoagland and Arnon, 1950). The nutrient solution was changed at ten-day intervals. The light intensity was 450 mol m^{-2} s^{-1} with 14 h light and temperature at 30 ± 2°C. The solution pH was adjusted to 5.9 with HCl and KOH and monitored regularly. Three salinity levels (0, 75 and 150 mM NaCl) were imposed one week after transplantation by incremental addition of 25 mM NaCl on alternate days. The pots were arranged according to a completely randomized design (CRD) in four replications. The plants were harvested on 36th day after transplantation. The shoots and roots of the plants were immediately separated after harvesting, rinsed with deionized water and blotted with tissue paper. The leaf area of each fully expanded leaf was measured. Stem and shoot diameters were measured at harvest using vernier calipers. The plants were oven dried at 65°C to a constant weight. The dried plant samples were ground by wiley mill to pass a 40-mesh sieve. Ground sub-samples of root and shoot were digested in 2:1 perchloric-nitric mixture to estimate Na^+, K^+ and Ca^{2+} in the digest by atomic absorption spectroscopy. The data were statistically analyzed according to CRD and treatment means were compared using Duncan's multiple range (DMR) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Shoot and root fresh weight

Shoot fresh weight was significantly ($P<0.05$) decreased with increasing NaCl salinity in the root medium (Table 1). Twenty-six and 46% reduction in shoot fresh weight was recorded at 75 and 150 mM NaCl levels, respectively, compared with 0 mM NaCl level. Significant ($P<0.05$) variation in shoot fresh weight of sunflower hybrids was observed (Table 1).

Table 1: Shoot fresh weight (g pot^{-1}) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	20.7	13.09	10.47	14.75 C
SH-3322	19.1	11.67	9.42	13.40 C
XF-4623	22.5	18.85	18.47	19.95 B
SMH-9706	17.58	10.29	7.19	11.69 C
XF-4619	37.87	32.26	17.8	29.31 A
Mean	23.55 A	17.32 B	12.67 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

Maximum shoot fresh weight (29.31 g/2 plants) was registered in XF-4619 and minimum fresh weight (11.69 g/2 plants) in SMH-9706. Shoot fresh weight pattern of different sunflower hybrids was:

XF-4619 > XF-4623 > PARSUN > SH-3322 > SMH-706

The interactive effect was also significant ($P<0.05$). Sunflower hybrid XF-4619 performed significantly better under both salinity levels as compared with the other sunflower hybrids. XF-4623 gave the second highest shoot fresh weight. Increasing NaCl salinity in root medium significantly ($P<0.05$) decreased root fresh weight (Table 2).

Table 2: Root fresh weight (g pot^{-1}) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	5.98	3.64	2.60	4.07 C
SH-3322	6.74	4.81	2.58	4.71 C
XF-4623	9.41	8.25	5.16	7.94 B
SMH-9706	9.03	5.17	4.21	6.14 B
XF-4619	18.6	16.55	12.10	16.41 A
Mean	9.95 A	7.68 B	5.33 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

At 75 and 150 mM NaCl, 23 and 46% reduction in root fresh weight, respectively were recorded as compared with 0 mM NaCl salinity levels in root medium.

Root fresh weight of different sunflower hybrids was significantly varied ($P<0.05$) (Table 2). Maximum root fresh weight (16.41 g/2 plants) was produced by XF-4619, while XF-4623 and SMH-9706 ranked next. PARSUN and SH-3322 produced minimum root fresh weight. Salinity x sunflower hybrid interaction was also significant (Table 2). Sunflower hybrid XF-4619 gave the highest root fresh weight at all salinity levels and percent reduction in root fresh weight at all the salinity levels was minimum as compared with the other hybrids while XF-4623 was in the second place. The sunflower hybrid XF-4619 produced maximum shoot and root fresh weight among the five hybrids tested under saline condition, which had exhibited potential to perform better under saline conditions.

Plant height

Plant height or stem length is an important biomass yield determinant. Stem length was significantly ($P>0.05$) decreased with increasing NaCl salinity in root medium (Table 3).

Table 3: Stem length (cm) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	52.5	43.0	39.7	45.1 B
SH-3322	45.0	36.2	31.0	37.4 C
XF-4623	47.2	45.2	42.5	45.0 B
SMH-9706	41.0	39.0	29.0	36.33 C
XF-4619	62.0	58.0	41.0	53.66 A
Mean	49.5 A	44.3 B	36.6 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

There was 11 and 26% decrease in stem length at 75 and 150 mM NaCl, respectively, compared with the control. Stem length was also significantly varied among different sunflower hybrids (Table 3). The maximum stem length (53.66 cm) was attained by XF-4619 followed by XF-4623 and PARSUN. SH-3322 and SMH-9706 had the lowest plant height. Significant salinity x sunflower hybrid interaction was noticed (Table 3). There was an overall decrease in plant height of sunflower hybrids with increasing salinity levels. However, XF-4619 and XF-4623 exhibited the least decrease in plant height at 75 and 150 mM NaCl levels while SMH-9706 registered the maximum decrease in plant height (Table 3).

Stem diameter

There was significant ($P<0.05$) interactive effect of NaCl salinity and sunflower hybrids on stem diameter (Table 4). Decrease in stem diameter with increasing root medium salinity was linear and significant in case of all five sunflower hybrids. Hussain and Elahi (1995) and Ali *et al.* (1999) reported adverse effect of root medium salinity on plant growth. Stem diameter on sunflower hybrid XF-4619 decreased by 12 and 27% at 75 and 150 mM NaCl root medium salinity, respectively, while XF-4623 stood next to XF-4619. Stem diameter of sunflower hybrids PARSUN, SH-3322 and SMH-9706 was badly affected to maximum extent.

Table 4: Stem diameter (cm) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	4.75	3.50	3.37	3.87 C
SH-3322	5.50	4.25	3.25	4.33 C
XF-4623	6.25	5.75	5.25	5.75 B
SMH-9706	5.25	4.50	3.75	4.50 C
XF-4619	8.00	7.00	5.25	6.75 A
Mean	5.95 A	5.00 B	4.17 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

Leaf area

Leaf area is an index of crop growth activity. Significant ($P<0.05$) decrease in leaf area of different sunflower hybrids was noticed with increasing root medium salinity. Maximum leaf area was attained in sunflower hybrid XF-4619 at all salinity levels. Percent reduction in leaf area was 11 and 40 at 75 and 150 mm NaCl levels as compared to control treatment, respectively, whereas XF-4623 performed next to XF-4619. Leaf areas of PARSUN, SH-3322 and SMH-9706 were decreased to maximum extent.

Table 5: Leaf area (cm^2) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	43.59	28.99	27.47	33.35 C
SH-3322	50.20	26.40	23.91	33.50 C
XF-4623	63.39	40.46	30.71	44.85 B
SMH-9706	41.52	24.72	24.01	30.08 C
XF-4619	79.42	71.49	47.91	66.27 A
Mean	55.62 A	38.41 B	30.80 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

Dry matter yield

Root dry matter yield (g/2 plants) was significantly decreased by interactive effect of root medium salinity and sunflower hybrids. However, sunflower hybrid XF-4619 outyielded all others hybrids. It registered almost 100% root dry matter yield increase over the other hybrids. Moreover, it performed excellently under saline conditions (Table 6). The performance of the other hybrids in terms of root dry matter yield was statistically at par and registered maximum decrease in root growth with increasing root medium salinity.

Table 6: Root dry matter yield (g pot^{-1}) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	0.39	0.24	0.20	0.28 D
SH-3322	0.29	0.23	0.18	0.24 D
XF-4623	0.41	0.41	0.37	0.40 B
SMH-9706	0.47	0.27	0.27	0.34 C
XF-4619	0.83	0.81	0.57	0.74 A
Mean	0.48 A	0.39 B	0.32 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

Similarly, shoot dry matter yield was significantly adversely affected by interactive effect of root medium salinity and sunflower hybrid. Again, the hybrid XF-4619 registered maximum yield under non-saline as well as under saline conditions (Table 7). The yield increase over PARSUN, SH-3322 and SMH-9706 was almost 100%, while XF-4623 performed similarly to XF-4619 in saline conditions.

Table 7: Shoot dry matter yield (g pot^{-1}) of different sunflower hybrids at various salinity levels (means of three replications)

Sunflower hybrid	Salinity level			Mean
	0 mM NaCl	75 mM NaCl	150 mM NaCl	
PARSUN	1.30	0.99	0.64	0.98 C
SH-3322	1.26	0.78	0.55	0.86 C
XF-4623	1.68	1.59	1.31	1.53 B
SMH-9706	1.30	0.81	0.59	0.89 C
XF-4619	2.80	2.44	1.38	2.21 A
Mean	1.67 A	1.32 B	0.89 C	

Means sharing the same letter(s) are statistically similar at 5% probability level

Calcium uptake

Data in Figure 1 indicate calcium uptake by the different sunflower hybrids at 0, 75 and 150 mM NaCl salinity levels. The maximum calcium uptake was noted for XF-4619 at 0, 75 and 150 mM NaCl salinity. The second highest uptake was recorded for XF-4623. The other three sunflower hybrids took minimum calcium and were statistically at par. Many research workers have documented the positive role of calcium in plant growth under saline conditions. Application of external calcium has been known to ameliorate salinity stress symptoms in many species, although this effect is based on several phenomenon (Kinraide, 1998). Clear physiological basis is now available from many studies on the impact of Ca^{2+} on ion channel. He also reported that calcium could relieve Na-toxicity when NaCl concentration was less than 135 mM. Furthermore, high Na^{+} can impose an osmotic stress that calcium is unable to relieve. The result of this study is in accordance with these findings.

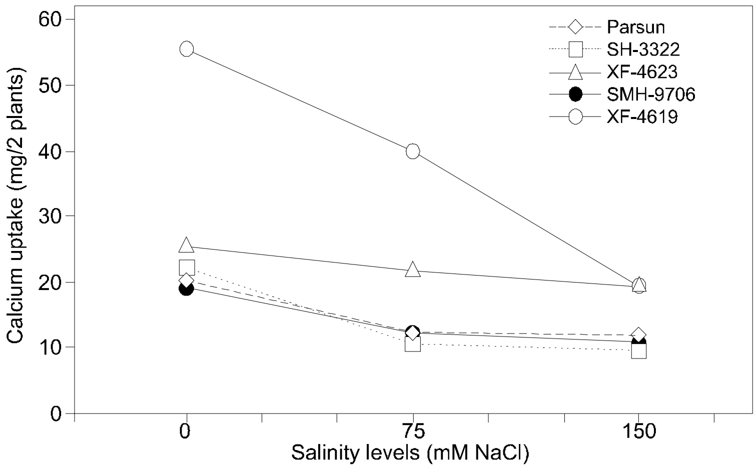

Figure 1: Calcium uptake by different hybrids under saline conditions

Sodium uptake

Data in Figure 2 indicate Na uptake by different sunflower hybrids under saline conditions. With increasing root medium salinity, there was an increase in Na uptake by all sunflower hybrids. Sodium concentration was similar in all hybrids at given salinity level. However, Na uptake is significantly varied due to significant yield differences among sunflower hybrids.

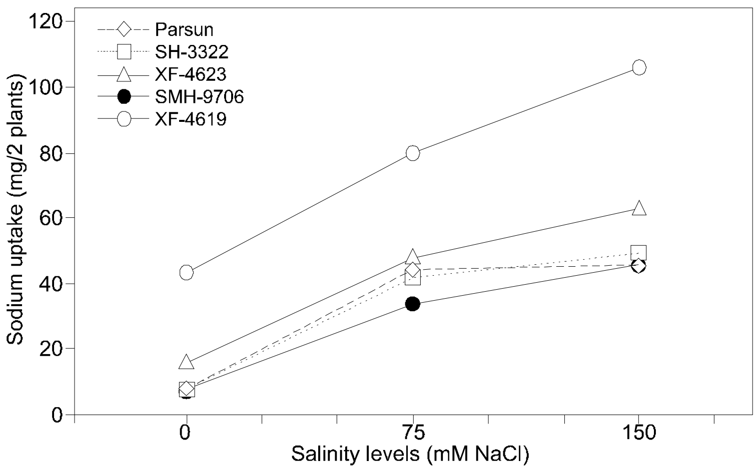

Figure 2: Sodium uptake by different sunflower hybrids under saline conditions

Potassium uptake

Data in Figure 3 exhibit K uptake by the five sunflower hybrids at 0, 75 and 150 mM NaCl salinity in root medium. Again XF-4619 registered maximum uptake at all salinity levels while XF-4623 ranked second in K uptake with increasing NaCl salinity level. XF-4619 showed maximum calcium uptake from the medium. In the presence of more calcium, plants absorbed and translocated more K. Pitman (1966) reported that calcium can alter the selectivity of K uptake in certain plants. Part of the calcium may in this way have simple physical effects on root permeability. In addition, it seems reasonable to think that calcium acts on metabolism, in view of its own effects on enzyme system and in particular on certain ATPase system. Moreover, Kinraide (1999) in his study concluded that calcium prevents the leakiness of intercellular K.

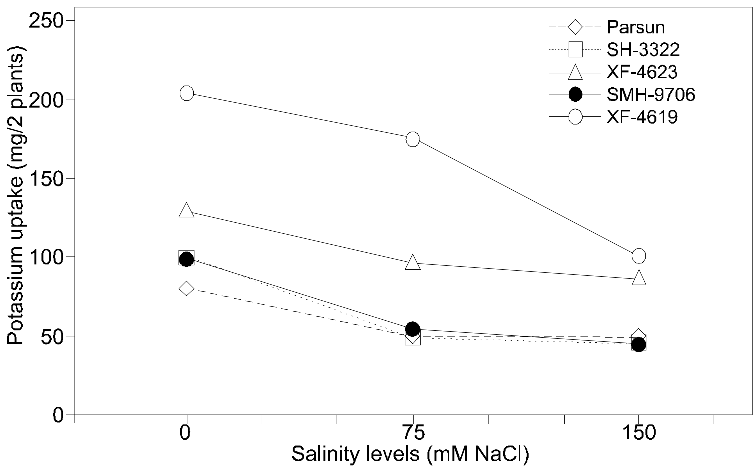

Figure 3: Potassium uptake by different sunflower hybrids under saline conditions

CONCLUSIONS

Sunflower hybrid XF-4619 registered maximum shoot-root fresh weight, shoot-root dry matter yield, stem length, stem diameter and leaf area. Furthermore, XF-4619 exhibited decrease in these parameters under saline conditions. Moreover, Ca and K were also efficiently taken up by XF-4619 in saline and non-saline root medium. This is indicative of it having a better yield potential than the other commercial sunflower hybrids under salt stress.

REFERENCES

Ali, A., Gill, S.M., Rahmatullah and Salim, M., 1999. Effect of Ca^{2+} on Na^{+}/K^{+} selectivity under saline conditions. Int. J. Agri. Biol., 1(4): 250-259.

Francois, L.E. and Bernstein, L., 1964. Salt tolerance of safflower. Agronomy J., 56: 38-40.

Francois, L.E., 1996. Salinity effects on four sunflower hybrids. Agronomy J., 38: 215-219.
Gomez, K.A. and Gomez, A.A., 1976. Statistical Procedures for Agricultural Research. John Wiley & Sons, Inc.
GOP, 2000. Foreign Trade. Federal Bureau of Statistics, Statistical Division, Government of Pakistan, Vol. 01, p. 111.
Hoagland, D.R. and Arnon, D.I., 1950. The water culture method of growing plants without soil. Univ. Calif. Barkeley Coll., Agric. Circ. No. 347.
Hussain, F. and Elahi, I., 1995. Effect of saline conditions on the germination, growth performance and oil composition of two cultivars of soybean. In: Biology of Salt Tolerant Plants, p. 419. Department of Botany, University of Karachi, Karachi.
Kinraide, T.B., 1998. Three mechanisms for the calcium alleviation of mineral toxicity. Plant Physiol., 118: 513-520.
Kinraide, T.B., 1999. Interaction among Ca^{2+}, Na^{+} and K^{+} in salinity toxicity: quantitative resolution of multiple toxic and ameliorative effects. J. of Exp. Botany, 50: 1495-1550.
Maas, E.V. and Hoffman, G.J., 1997. Crop salt tolerance. Current assessment. J. Irrig. Drain. Div. Am. Soc., Civ. Eng., 103: 115-134.
Pitman, M.G., 1966. Uptake of K^{+} and sodium by seedling of *Sinapis alba*. Aust. J. Biol. Sci., 19: 257-269.
Tesar, M.B., 1984. Physiological Basis of Crop Growth and Development. American Society of Agronomy, Inc. USA, p. 40.

EVALUACION Y COMPORTAMIENTO DE DIVERSOS HIBRIDOS COMERCIALES DEL GIRASOL EN LAS CONDICIONES DE SALINIDAD

RESUMEN

Cinco hibridos, Parsun, SH-3322, XF-4623, SMH-9706 y XF-4619, fueron investigados en las condiciones hidroponicas para evaluar su comportamiento en las concentraciones de NaCl de 0, 75 y 150 mM en la solucion nutritiva. Las semillas del girasol (*Helianthus annuus* L.) eran germinando en la arena cuarzosa. Las plantulas de 12 dias eran metidas a traves de las tapas de macetas plasticas de las cuales cadauna contenia 2.5 l de la solucion de Hoagland continuamente mezclada, diluida a 50%. El experimento fue efectuado en la disposicion al azar (CDR) con cuatro repeticiones. El crecimiento de plantas del girasol se reducia drasticamente con el aumento de la concentracion de NaCl en la solucion. En los hibridos XF-4619 fue notado el peso minimo de la masa fresca de la parte sobre el suelo y de la raiz, del diametro de tallo y la superficie de hoja. En XF-461 fue tambien notada la reduccion minima de estos parametros en las condiciones de salinidad. Con la concentracion de 75 mM de NaCl, la masa fresca de la parte sobre el suelo fue reducida en 14%, la masa fresca de la raiz en 11%, el largo del tallo en 6%, el diametro del tallo en 12%, la superficie de hoja en 10%, la masa seca de la raiz en 2%, y la masa seca de la parte sobre el suelo en 13%. Con la concentracion de 150 mM de NaCl, la masa fresca de la parte sobre el suelo fue reducida en 53%, la masa fresca de la raiz en 35%, el largo del tallo en 34%, el diametro del tallo en 34%, la superficie de hoja en 40%, la masa seca de la raiz en 31%, y la masa seca de la parte sobre el suelo en 50%. Ademas, XF-4619 tomaba Ca y K eficazmente en la solucion salina asi como esa no salina. Eso indica que este hibrido tiene el mas grande potencial para el rendimiento que todos otros hibridos comerciales investigados.

ÉVALUATION ET COMPORTEMENT DE DIFFÉRENTS HYBRIDES COMMERCIAUX DU TOURNESOL DANS DES CONDITIONS SALINES

RÉSUMÉ

Les cinq hybrides de tournesol, Parsun, SH-3322, XF-4623, SMH-9706 et XF-4619 ont été observés dans des conditions hydroponiques pour déterminer leur réaction à des concentrations de NaCl de 0, 75 et 159 mM dans la solution nutritive. Les semences de tournesol (*Helianthus annuus* L.) ont germé dans un sable quartzeux humide. Les germes de 12 jours ont été placés à travers les couvercles de pots en plastique dont chacun contenait 2.5 l de solution nutritive Hoagland diluée à 50% et continuellement mélangée. L'expérience a été faite selon le schéma de la distribution accidentelle (CDR) à quatre reprises. La croissance de la plante de tournesol a diminué radicalement avec l'augmentation de la concentration de NaCl dans la solution. Pour l'hybride XF-4619 on a noté un poids maximal de la masse fraîche de la partie aérienne et de la racine, du diamètre de la tige et de la surface feuillue. Pour le même hybride (XF-4619), on a aussi noté le moins de diminution de ces paramètres dans les conditions salines. Quand la concentration était de 75 mM NaCl, la masse fraîche de la partie aérienne était diminuée de 14%, la masse fraîche de la racine de 11%, la longueur de la tige de 6%, le diamètre de la tige de 12%, la surface feuillue de 10%, la masse sèche de la racine de 2% et la masse sèche de la partie aérienne de 13%. Quand la concentration était de 150 mM NaCl, on a noté une diminution de 53% de la masse fraîche de la partie aérienne, de 35% de la masse fraîche de la racine, de 34% de la longueur de la tige, de 34% du diamètre de la tige, de 40% de la surface feuillue, de 31% de la masse sèche de la racine et de 50% de la masse sèche de la partie aérienne. De plus, l'hybride XF-4619 a assimilé efficacement le Ca et le K autant dans la solution saline que dans la solution non saline. Ceci montre que cet hybride a un plus grand potentiel de rendement que les autres hybrides commerciaux examinés.