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BREEDING SUNFLOWER FOR SALT TOLERANCE: INTERRELATIONSHIP OF MORPHO-PHYSIOLOGICAL PARAMETERS IN SUNFLOWER (*Helianthus annuus* L.) FOR SALT TOLERANCE

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SUMMARY

Two independent experiments were conducted under normal and saline soil conditions with an aggregate EC_e 15.50 dSm^{-1} and pH of 8.23. Phenotypic and genotypic correlation coefficients were computed between various morphological and physiological parameters in both experiments independently. Phenotypic and genotypic correlation coefficients under normal and saline conditions for all the traits agreed very closely. This similarity was due to the control of experimental error. Under normal and saline conditions almost all the parameters in the study showed positive correlation to achene yield except days to flower which was negative and oil content and Na^+ concentration which was non-significant under normal soil and days to flower and K^+ concentration in leaves were negative under saline soil conditions. All achene yield components showed positive association with each other under both soil conditions. Association of physiological parameters under saline soil is rather confusing. It is suggested that selection for high achene yielding lines under normal soil conditions can be based on head diameter, achene setting percentage, 100-achene weight and leaf area and under saline soil conditions selection should be practiced on the basis of yield components in early flowering lines.

Key words: ***Helianthus annuus* L., correlations, saline conditions, field study.**

INTRODUCTION

Salinity remains one of the oldest and most serious environmental problems from which arid and semi-arid regions of the world suffer. An estimated 230 x 10^6 ha are irrigated worldwide (Wittwer, 1979) and one third is affected by excess

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salinity (Mass and Hoffman, 1977). A large area of Pakistan, 5.7 x 10^6 ha, is in the severe grip of salinity and sodicity (Muhammad, 1978, 1983) which increased to 6.3 x 10^6 ha (Anonymous, 1989). In sunflower, plant growth and seed yield was adversely affected under high salinity levels (Farah et al., 1980; Girdhar, 1988; Rehman and Hussain, 1992; Hussain and Rehman, 1992). Seed yield in sunflower starts decreasing beyond EC_e 2.5 dSm^{-1} (Anonymous, 1992) and 49.21 percent seed yield losses were reported at EC_e 10 dSm^{-1} (Hussain and Rehman, 1992). Increasing level of salinity also increased Cl^- and Na^+ concentration in leaves and K^+ concentration was decreased at higher salinity levels (Cheng, 1984) whereas it was reported that sunflower has the ability to maintain Na^+ at a low level in young growing leaves under salinity (Hussain and Rehman, 1993). Low Na^+ concentration and a high K^+/Na^+ ratio in young growing leaves of salt tolerant lines was also reported (Hussain and Rehman, 1994).

In sunflower, plant height (Vanisree et al., 1988), leaf area (Giriraj et al., 1987), seed weight (Singh et al.,1977), and head diameter (Ayyasamy et al., 1977; Singh et al., 1977), were reported to be positively correlated to seed yield. Positive correlation between yield and yield components as well as within yield components was also reported (Khan et al., 1989). Leaf area was found positively correlated with yield components such as 100-seed weight and oil content (Tsvetkova,1975), days to maturity was found positively correlated with plant height (Rana et al., 1988), while plant height was correlated positively with head diameter and number of achenes per head (Carrasco et al., 1986).

Correlation studies are important for plant breeding for high seed yield but all information available are under good or optimum soil conditions. Therefore, the present study was conducted to work out the degree of association among various plant traits in sunflower under normal and saline conditions, simultaneously. This study will provide important information for breeding sunflower for salt tolerance.

MATERIALS AND METHODS

The experimental material comprised of two salt tolerant (GIMSUN-856, -603) and two sensitive (GIMSUN-457, -198) inbred lines and their single crosses (excluding reciprocals). These inbred lines have been previously developed from open pollinated Russian and Rumanian cultivars and from segregating populations of commercial hybrids from the United States, after six successive years of selfing and then alternate sib pollination. The breeding material consisted of the following parental lines and their crosses.

The above listed materials were evaluated for salt tolerance using a randomized complete block design with three replications under non-saline and saline soil conditions in two experimental fields in the same location.

Parental lines
1. GIMSUN-856
2. GIMSUN-603
3. GIMSUN-457
4. GIMSUN-198

Crosses
6. GIMSUN-856 X -603
7. GIMSUN-856 X -457
8. GIMSUN-856 X -198
9. GIMSUN-603 X -457
10. GIMSUN-603 X -198
11. GIMSUN-457 X -198

Experiment 1.

The experiment was conducted under non-saline soil conditions at an aggregate EC_e of 1.76 dSm^{-1}. The experimental unit comprised a 4.5 meter long double row with 60 and 30 cm row to row and plant to plant distance, respectively. In total five irrigations of 5 cm each were applied throughout the experiment with irrigation water of EC_e 0.21 dSm^{-1}. Nitrogen and phosphorous fertilizers were added in amounts equivalent to 86 and 62 kg ha^{-1}, respectively (Chaudhry, 1985). The phosphorous fertilizer was applied at the time of planting, while a half of the nitrogenous fertilizer was applied at planting and the rest at flowering.

Experiment 2.

The second experiment was conducted under saline field conditions where EC_e ranged form 14.75 to 15.85 dSm^{-1} with an aggregate of 15.30 dSm^{-1} (average of 50 soil samples mixed from top layer to 45 cm deep). Records of EC_e in dSm^{-1} determined during experiment at different intervals are given in Appendix 1. All other agronomic and cultural operations like irrigation, nutrient application, hoeing, hilling, etc., were kept similar in the two experimental fields within the same location.

Data were recorded on twenty randomly selected guarded plants from each entry and replications in both experiments on the following parameters.

1. Days to flowering
2. Leaf area (cm2)
3. Plant height (cm)
4. Head Diameter (cm)
5. Seed setting percentage
6. 100-seed weight (g)
7. Seed yield per plant (g)
8. Oil content (%)
9. Cl-1(mol m-3) conc. in leaves.
10. Na^+ (ppm) concentration in leaves.
11. K^+ (ppm) concentration in leaves.

In both experiments flowers were allowed to open pollinate and than achene setting (%) and achene yield were recorded and difference in achene setting (%) was actually created by difference in soil conditions. Therefore, no difference was created by self-incompatibility or compatibility system in sunflower. Chloride, sodium and potassium ion concentration were determined using tissue sap anal-

ysis in the top most fully expanded leaf of the selected plants from each entry and replication.

The data thus collected were subjected to analysis of variance and covariance (Steel and Torrie, 1980). Phenotypic and genotypic correlation coefficients were calculated as proposed by Kwon and Torrie, (1964). The significance of the phenotypic correlation coefficient was tested using t-test as proposed by Steel and Torrie (1980). The standard error of the genotypic correlation coefficient was calculated using the procedure of Reeve (1955) and Robertson (1959). The estimates of genotypic correlation coefficient were considered significant if their absolute value exceeded twice their respective standard error.

Phenotypic and genotypic correlation coefficient were worked out following the procedures of Kwon and Torrie, 1964.

$$r_p = \frac{Co\sigma p_{ij}}{\sqrt{(\sigma p_i)(\ \sigma p_j)}}$$

where

r_p = phenotypic correlation,

$Co\sigma p_{ij}$ = phenotypic covariance of i^{th} and j^{th} trait, and

σp_i, σp_j = phenotypic variance of the i^{th} and j^{th} trait, respectively.

$$r_g = \frac{Co\sigma g_{ij}}{\sqrt{(\sigma g_i)(\sigma g_j)}}$$

where

r_g = genotypic correlation,

$Co\sigma g_{ij}$ = genotypic covariance of i^{th} and j^{th} trait, and

σg_i, σg_j = genotypic variance of the i^{th} and j^{th} trait, respectively.

Statistical significance of phenotypic correlation was determined by using "t" test as described by Steel and Torrie, 1980.

$$t = \frac{r_g}{\sqrt{\frac{1 - r^2_p}{n - 2}}}$$

where

r_p = phenotypic correlation coefficient and "n" is the total number of observations which is thirty in this case (ten entries and three replications).

Phenotypic correlation coefficient is considered significant if the "t" calculated was greater than "t" tabulated at n-2 degree of freedom.

Genotypic correlation coefficients were tested for their statistical significance according to the formula derived from Reeve (1955) and Robertson (1969).

Table 1: Mean squares from analysis of variance for eleven traits of sunflower genotypes under non-saline and saline soil conditions

Source of variation	df	Cl^- Conc.	Na^+ Conc.	K^+ Conc.	Days to flower	Leaf area	Plant height	Head diameter	Achene setting	100-achene weight	Oil content	Achene Yield
		(mol m^{-3})	(ppm)	(ppm)		(cm2)	(cm)	(cm)	(%)	(g)	(%)	(g)
Non-saline												
Genotypes	9	1038.52**	246.07**	1959655.17**	36.21**	1982.02**	357.74**	3.05**	48.50*	1.49**	8.38NS	171.70**
Error	18	44.12	25.07	67793.08	1.84	491.61	76.44	0.70	14.79	0.17	8.27	21.20
Saline												
Genotypes	9	858.70**	644.21**	7439049.63**	80.03**	417.17NS	132.97**	7.48**	142.01*	2.57**	35.09*	78.08**
Error	18	125.77	9.41	94460.40	8.79	300.49	19.96	0.54	42.72	0.15	14.15	0.91

*, **, NS $p \leq 0.05$, $p \leq 0.01$, and non-significant, respectively

Table 2: Genotypic correlation coefficients with respective standard error among mature plant traits in sunflower under non-saline conditions

Trait	Na^+ conc.	K^+ conc.	Days to flower	Leaf area	Plant height	Head diameter	Achene setting	100-achene weight	Oil content	Achene yield
	(ppm)	(ppm)		(cm^2)	(cm)	(cm)	(%)	(g)	(%)	(g)
Conc. (mol m^{-3})	0.006±0.014	0.271±0.058	0.043±0.230	0.363±0.008	0.272±0.014	0.042±0.048	0.634±0.015	0.171±0.052	0.667±0.033	0.276±0.015
Na^+ conc. (ppm)		-0.619±0.001	0.301±0.031	0.148±0.014	0.464±0.017	0.321±0.065	0.184±0.037	-0.191±0.076	-0.977±0.004	0.023±0.024
K^+ conc. (ppm)			-0.128±0.003	0.310±0.001	0.164±0.002	0.283±0.007	0.369±0.003	0.154±0.008	1.215±0.004	0.316±0.002
Days to flower				0.261±0.021	0.812±0.011	-0.443±0.091	-0.826±0.019	-0.843±0.036	-0.527±0.099	-0.443±0.031
Leaf area (cm^2)					0.558 ±0.009	0.481±0.037	0.211±0.024	0.348±0.046	0.269±0.054	0.577±0.011
Plant height (cm)						0.136±0.070	-0.192±0.036	-0.399±0.066	-0.494±0.066	0.146±0.024
Head diameter (cm)							0.845±0.036	0.622±0.060	-0.232±0.276	0.868±0.020
Achene setting (%)								0.734±0.064	0.668±0.086	0.671±0.024
100-achene weight (g)									0.525±0.225	0.563±0.060
Oil content (%)										0.159±0.096

Table 3: Phenotypic correlation coefficients among mature plant traits in sunflower under non-saline conditions

Trait	Na^+ conc. (ppm)	K^+ conc. (ppm)	Days to flower	Leaf area (cm^2)	Plant height (cm)	Head diameter (cm)	Achene setting (%)	100-achene weight (g)	Oil content (%)	Achene yield (g)
Cl^- Conc. (mol m^{-3})	0.012	0.247	0.049	0.304	0.250	0.009	0.483**	0.133	0.449*	0.079
Na^+ conc. (ppm)		-0.623**	0.282	0.142	0.375*	0.186	0.155	-0.208	-0.655**	-0.015
K^+ conc. (ppm)			-0.129	0.265	0.146	0.300	0.301	0.155	0.716**	0.329
Days to flower				0.186	0.726**	-0.421*	-0.627**	-0.778**	-0.304	-0.432*
Leaf area (cm^2)					0.578**	0.450*	0.107	0.271	0.196	0.566**
Plant height (cm)						0.135	-0.138	-0.368*	-0.164	0.146
Head diameter (cm)							0.620**	0.583**	-0.105	0.829**
Achene setting (%)								0.560**	0.323	0.535**
100-achene weight (g)									0.327	0.542**
Oil content (%)										0.089

*, ** $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 4: Genotypic correlation coefficients with respective standard error among mature plant traits in sunflower under saline conditions

Trait	Na^+ conc. (ppm)	K^+ conc. (ppm)	Days to flower	Leaf area (cm^2)	Plant height (cm)	Head diameter (cm)	Achene setting (%)	100-achene weight (g)	Oil content (%)	Achene yield (g)
Cl^- Conc. (mol m^{-3})	-0.322±0.011	0.357±0.001	0.066±0.022	-0.153±0.027	0.371±0.017	0.354±0.034	0.218±0.021	0.440±0.041	-0.276±0.025	0.508±0.015
Na^+ conc. (ppm)		-0.941±0.001	-0.525±0.016	1.204±0.012	0.644±0.012	0.522±0.028	0.246±0.020	0.290±0.046	0.501±0.020	0.086±0.020
K^+ conc. (ppm)			0.644±0.001	-1.390±0.003	-0.558±0.002	-0.583±0.003	-0.146±0.002	-0.254±0.005	-0.538±0.002	-0.458±0.002
Days to flower				-1.084±0.009	-0.621±0.022	-0.561±0.047	-0.460±0.031	-0.621±0.055	0.128±0.047	-0.745±0.016
Leaf area (cm^2)					1.168 ±0.016	1.415±0.087	-0.796±0.018	0.668±0.062	0.999±0.001	0.989±0.001
Plant height cm)						0.530±0.045	0.202±0.034	0.595±0.052	-0.141±0.043	0.692±0.017
Head diameter (cm)							0.429±0.056	0.845±0.045	0.633±0.051	0.833±0.020
Achene setting (%)								0.862±0.023	0.597±0.031	0.615±0.023
100-achene weight (g)									0.296±0.100	0.927±0.012
Oil content (%)										0.296±0.042

$$SEr_g = \frac{1 - r^2_g}{\sqrt{2}} \sqrt{\frac{\delta h^2_i \cdot \delta h^2_j}{h^2_i \cdot h^2_j}}$$

where

SEr_g = standard error for genotypic correlation coefficient,

r^2_g= genotypic correlation coefficient,

δh^2_i, δh^2_j = standard error for heritability for i^{th} and j^{th} trait, and

h^2_i, h^2_j = heritability estimates for i^{th} and j^{th} trait, respectively.

A genotypic correlation coefficient was considered significant if its absolute value exceeded twice the respective standard error.

RESULTS AND DISCUSSION

Mean squares from analysis of variance for different plant traits of sunflower evaluated under non-saline (experiment 1) and saline (experiment 2) soil conditions are presented in Table 1. It is concluded that differences between sunflower inbreds and their crosses were significant for all the parameters studied except oil content under non-saline soil conditions (experiment 1). Similarly, differences were significant for all the parameters except leaf area under saline soil conditions (experiment 2).

Correlation between different traits is generally due to the presence of linked genes, epistasis, or pleiotropic effect of different genes. Environment plays an important role in correlation. In some cases environment effects favor both the traits simultaneously in the same direction or sometimes in different directions. Genetic and environmental causes of correlation combine together and give phenotypic correlation. If both characters have low heritabilities, then the phenotypic correlation is mainly determined by environmental correlation and if they have high heritabilities, then the genetic correlation is more important. The dual nature of phenotypic correlation makes it clear that the magnitude of genetic correlation cannot be determined from the phenotypic correlation.

In the present study genotypic and phenotypic correlations were studied between eleven traits of sunflower genotypes and crosses, independently under normal and saline conditions.

Experiment 1. Interrelationship of different traits under normal soil conditions.

The results presented (Table 2, 3) showed that Cl^- concentration in leaves correlated positively to K^+ concentration in leaves, leaf area, plant height, 100-achene weight, and achene yield at genotypic level and to achene setting percentage, and oil content at both genotypic and phenotypic level. Na^+ concentration in leaves correlated positively to days to flower, leaf area, head diameter and achene setting percentage at genotypic level and to plant height at both genotypic and phenotypic level while it correlated negatively to 100-achene weight at genotypic level and K^+ concentration in leaves and oil content at both genotypic and phenotypic level. K^+ concentration in leaves positively correlated to leaf area, plant height, head diameter, achene setting percentage, 100-achene weight and achene yield at genotypic level and to oil content at both genotypic and phenotypic level while it negatively correlated to days to flower at genotypic level.

Days to flowering positively correlated to leaf area at genotypic level and to plant height both at genotypic and phenotypic level while it negatively correlated to oil content at genotypic level and head diameter, achene setting percentage, 100-achene weight, and achene yield at both genotypic and phenotypic level. Leaf area was found to be positively correlated to achene setting percentage, 100-achene weight, and oil content at genotypic level and to plant height, head diameter and achene yield at both genotypic and phenotypic level. Plant height positively correlated to achene yield at genotypic level while it negatively correlated to achene setting percentage and oil content at genotypic level and to 100-achene weight at both genotypic and phenotypic level.

Head diameter positively correlated to achene setting percentage, 100-achene weight and achene yield at both genotypic and phenotypic level. Achene setting percentage correlated positively to oil content at genotypic level and to 100-achene weight and achene yield at both genotypic and phenotypic level. 100-achene weight correlated positively to oil content at genotypic level and to achene yield at both genotypic and phenotypic level.

Experiment 2. Interrelationship of different traits under saline soil conditions.

The results presented in Table 4 and 5 manifested that Cl^- concentration in leaves positively correlated to days to flower, plant height, head diameter, achene setting percentage and K^+ concentration in leaves at genotypic level, and to 100-achene weight and achene yield at both genotypic and phenotypic level whereas it negatively correlated to Na^+ concentration in leaves and oil content at genotypic level. Na^+ concentration in leaves showed positive correlation to achene setting percentage and 100-achene weight at genotypic level and to leaf area, plant height, head diameter, oil content and achene yield at both genotypic and phenotypic level while it showed negative correlation to K^+ concentration in leaves and

days to flowering at both genotypic and phenotypic level. K^+ concentration in leaves showed positive correlation to days to flowering at both genotypic and phenotypic level whereas it negatively correlated to achene setting percentage and 100-achene weight at genotypic level and to leaf area, plant height, head diameter, oil content and achene yield at both genotypic and phenotypic level.

Days to flowering positively correlated to oil content at genotypic level, while it negatively correlated to achene setting percentage at genotypic level and to leaf area, plant height, head diameter, 100-achene weight and achene yield at both genotypic and phenotypic level. Leaf area was found to be positively correlated to oil content at genotypic level and to plant height, head diameter, 100-achene weight and achene yield at both genotypic and phenotypic level, while it negatively correlated to achene setting percentage at genotypic level. Plant height positively correlated to achene setting percentage at genotypic level and to head diameter, 100-achene weight and achene yield at both genotypic and phenotypic level while it negatively correlated to oil content at genotypic level.

Table 5: Phenotypic correlation coefficients among mature plant traits in sunflower under saline conditions

Trait	Na^+ conc.	K^+ conc.	Days to flower	Leaf area	Plant height	Head diameter	Achene setting	100-achene weight	Oil content	Achene yield
	(ppm)	(ppm)		(cm^2)	(cm)	(cm)	(%)	(g)	(%)	(g)
Cl^- Conc. (mol m^{-3})	-0.273	0.317	0.019	-0.041	0.319	0.275	0.142	0.389*	-0.237	0.446*
Na^+ conc. (ppm)		-0.940**	-0.497**	0.617**	0.570**	0.492**	0.176	0.279	0.377*	0.692**
K^+ conc. (ppm)			0.604**	-0.721**	-0.490**	-0.554**	-0.104	-0.248	-0.418*	-0.445*
Days to flower				-0.528**	-0.519**	-0.516**	-0.280	-0.587**	-0.071	-0.699**
Leaf area (cm^2)					0.582**	0.756**	-0.175	0.392	0.282	0.516**
Plant height (cm)						0.488**	0.234	0.522**	-0.065	0.638**
Head diameter (cm)							0.322	0.812**	0.515**	0.803**
Achene setting (%)								0.666**	0.332	0.529**
100-achene weight (g)									0.247	0.893**
Oil content (%)										0.234

*, ** $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 6: Record of electrical conductivities and pH with respective range values in parenthesis and SAR during experiment 2 at different intervals

Time of soil sampling/ Stage of plant growth	EC_e in dS m^{-1} †	pH †	SAR †
1. Before seed planting	15.30 (14.75-15.85)	8.23 (7.98-8.35)	12.65
2. Flower initiation	15.25 (14.68-15.83)	8.19 (8.00-8.32)	12.67
3. Seed setting	15.22 (14.65-15.80)	8.15 (8.00-8.05)	12.75
4. Physiological maturity	15.23 (14.65-15.82)	8.18 (8.05-8.28)	12.78

† Average of fifty (before seed planting) and then thirty (later growth stages) soil samples in each case.

Head diameter positively correlated to achene setting percentage at genotypic level and to 100-achene weight, oil content and achene yield at both genotypic and phenotypic level. Achene setting percentage positively correlated to oil content at genotypic level and to 100-achene weight and achene yield at both genotypic and phenotypic level. 100-achene weight positively correlated to oil content at genotypic level and achene yield at both genotypic and phenotypic level. Oil content showed positive correlation to achene yield at genotypic level.

Phenotypic and genotypic correlation coefficients under normal and saline conditions for all the traits agreed very closely. This similarity was due to the control of experimental error. Under normal soil conditions almost all parameters in the study showed positive correlation to achene yield except days to flower which was negative and oil content and Na^+ concentration which were non-significant. Cl^- and K^+ concentrations in young growing leaves showed positive association to achene yield and its components. Only Cl^- showed non-significant corelation to head diameter. Na^+ concentration showed negative correlation to 100-achene weight, oil content and K^+ concentration but positive to head diameter and achene setting percentage which was little confusing. However, it could be suggested that high Na^+ concentration in leaves decreased achene yield by producing light and small achenes. Na^+ also checks the uptake of K^+ which is a necessary constituent in many biochemical processes within cell thus causing metabolic limitations. Under non-saline soil conditions Na^+ never reaches toxic concentrations but it is common under saline conditions.

Yield components such as head diameter, seed setting percentage and 100-achene weight also showed positive association with each other. Similarly, leaf area showed positive association with achene yield and its components. Plant height showed positive association to achene yield but negative to yield components. Therefore, it is suggested that selection for high yielding lines under normal soil conditions can be based on head diameter, achene setting percentage, 100-achene weight and leaf area.

Under saline soil conditions, similar to normal soil, almost all plant traits showed positive correlation to achene yield except days to flower and K^+ concentration in leaves which were negative. It appeared surprising that toxic ions like Cl^- and Na^+ concentration in leaves showed positive association to all achene yield components whereas desirable K^+ concentration in leaves showed negative correlations to achene yield components. Similarly, Cl^- and Na^+ concentrations in leaves showed positive whereas K^+ concentration in leaves showed negative association to achene yield. All achene yield components showed positive associations with each other. Similarly, leaf area and plant height showed positive associations to achene yield components except leaf area to achene setting percentage and plant height to oil content which were negative. Therefore, it is suggested that under saline conditions high achene yielding lines may be selected from early flowering lines on the basis of yield components.

CONCLUSIONS

Direction of phenotypic and genotypic correlation coefficients under normal and saline conditions was similar for all the traits. Almost all parameters in the study showed positive correlation to achene yield except days to flower which was negative and oil content and Na^+ concentrations which were non-significant under normal soil and days to flower and K^+ concentrations in leaves were negative under saline soil conditions. All achene yield components showed positive association with each other under both type of soils. Association of physiological parameters under saline soil is rather confusing. It is suggested that selection for high achene yielding lines under normal soil conditions can be selected on the basis head diameter, achene setting percentage, 100-achene weight and leaf area whereas under saline soils selection should be practiced on the basis of yield components in early flowering lines.

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MEJORA PARA TOLERANCIA A SALINIDAD INTERRELACION ENTRE PARAMETROS MORFOFISIOLOGICOS EN GIRASOL (*Helianthus annuus* L.) PARA TOLERANCIA A SALINIDAD

RESUMEN

Dos experimentos independientes fueron conducidos bajo condiciones de suelo normales y salinas con un agregado de EC_e 15-50 dSm^{-1} y pH 8.23. Los coeficientes fenotípicos y genotípicos de correlación fueron calculados independientemente entre varios parámetros morfológicos y fisiológicos en ambos experimentos. Estos coeficientes tuvieron gran coincidencia para todos los caracteres para las condiciones normales y salinas. Esta similitud fué debida al control del error experimental. Bajo condiciones salinas y normales casi todos los parámetros en el estudio mostraron una correlación positiva con el rendimiento en semilla excepto para dias a floración que fué negativa y contenido en aceite y concentración de Na^+ que no fué significativa bajo condiciones normales de suelo y días a floración y concentración de K^+ en las hojas que fueron negativas en condiciones de suelo salinas. Todos los componentes de rendimiento de los aquenios mostraron una asociación positiva entre ellos bajo ambas condiciones de suelo. La asociación de

parámetros fisiológicos bajo condiciones salinas fué mas bien confusa. Esta será mas clara cuando las correlaciones genéticas sean divididas en componentes de efectos directos e indirectos. Se sugiere que la selección para lineas con alto rendimiento en semilla bajo condiciones normales de suelo puede estar basada en diámetro de capitulo, porcentage de semilla formada, peso de 100 aquenios y área foliar bajo condiciones de suelo salinas debe ser llevada a cabo en base a componentes de rendimiento en lineas de floración precoz.

SÉLECTION DU TOURNESOL POUR LA TOLÉRANCE À LA SALINITÉ: RELATIONS ENTRE LES PARAMÉTRES MORPHO-PHYSIOLOGIQUES DU TOURNESOL (*Helianthus annuus* L.) POUR LA TOLÉRANCE À LA SALINITÉ

RÉSUMÉ

Deux expérimentations indépendantes ont été réalisées en conditions normales et salines avec une combinaison EC_e 15.50 dSm^{-1} et pH de 8.23. Les coefficients de corrélation phénotypiques et génotypiques ont été calculés indépendamment dans les deux expériences entre divers paramétres morphologiques et physiologiques. Les coefficients de corrélation phénotypique et génotypiques en conditions normales et salines correspondent trés étroitement pour tous les caractéres. Cette similarité résulte du contrôle de l'erreur expérimentale. En conditions normales et salines presque tous les paramétres de l'étude montrent une corrélation positive avec le rendement en grains, à l'exception du nombre de jours pour la floraison qui en sol normal est corrélé négativement, de la teneur en huile et de la concentracion en Na^+ qui ne sont pas reliées significativement et enfin du nombre de jours pour la floraison et la concentration en K^+ des feuilles corrélées négativement, en conditions de sol salin. Toutes les composantes du rendement en akénes révélent une association positive avec l'ensemble des autres dans les deux types de sol. Les relations entre les paramétres physiologiques en conditions de sol salin sont plutôt confuses. Elles deviennent plus claires lorsque les corrélations génétiques sont séparées selon leurs composantes à effets directs ou indirects. Il est suggéré que la sélection pour des lignées à rendement élevé en akénes en conditions de sol normal peut être basée sur le diamétre du capitule, le taux d'akénes formés, le poids de 100 grains et la surface foliare; en condition de sol la sélection devrait être pratiquée sur la base des composantes du rendement au sein des lignées à floraison précoce.