T1992BRE13

Heritability of osmotic adjustment in sunflower (<u>Helianthus annuus L.</u>).

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Summary.

Osmotic adjustment is a trait that can confer adaptation to drought. Its has been shown to occur in sunflower and the existence of intraspecific variability for this trait has been established in this species. Nothing is known about the heritability of the trait, an important prerequisite for the establisment of effective breeding programs directed to incorporate this trait as a source of drought resistance in sunflower. We report the results of an investigation on the heritability of osmotic adjustment.

Parental lines of two two commercial hybrids that differed significantly (P=0.05) in their capacity for osmotic adjustment were used: Contiflor III and Contiflor VI (high and low osmotic adjustment, respectively). An incomplete diallel cross was made using the parental lines. Subsequently capacity for osmotic adjustment in parental lines and crosses was determined at the 8 leaf stage. Analysis using Griffing model 1 method 2 showed that the additive gene effects were an important factor contributing in the heritability of this trait in sunflower. The heritability in narrow sense was 60%. These results indicate that it should be feasible to breed for osmotic adjustment in a breeding program directed to improving drought resistance in sunflower.

Introduction.

Breeding improved genotypes for drought-prone environments by selecting for grain yield is difficult, because of the variability in the amount and temporal distribution of available soil moisture from year to year (Ludlow and Muchow, 1990). Plant physiologists believe better adapted genotypes could be bred more efficiently if attributes that confer yield maintenance under water limited conditions could be identified and used as selection criteria (Ludlow and Muchow, **op.cit.**).

It is important to establish whether an attribute of interest has an effective and significant relationship with drought resistance and how it contributes to final yield; that sufficient genetic variability for the attributes exists; and that the heritability of the attribute should be sufficient. The development of a simple methodology for identifying the presence of the attribute is a further prerequisite for effective use of this approach.

Osmotic adjustment results from the accumulation of solutes within cells, which lowers the osmotic potential and maintains turgor during periods with water stress. This allows turgor driven processes which affect either the performance and the yield of the crop to be maintained or the effects of drought to be minimized (Turner, 1986). Osmotic adjustment has been shown to have a direct relationship with survival and yield in several crop species exposed to water stress i.e., rice, sorghum, corn and wheat (Morgan **et al.**, 1986; Sobrado, 1986; Turner **et al.**, 1986; Santamarina **et al.**, 1990). These precedents suggest that the use of this attribute in breeding programs for drought resistance could be valuable.

It has also been established that intraspecific variability for osmotic adjustment in sunflower is important, and a simple technique which allows early identification (8-leaf stage) of genotypes with a high degree of osmotic adjustment has been developed (Chimenti and Hall, 1988).

The aim of this work was to investigate the heritability of the capacity for osmotic adjustment in sunflower. To achieve this objective an incomplete diallel cross was made using the parental lines of two commercial hybrids that differed significantly in their degree of osmotic adjustment (Chimenti and Hall, **op. cit.**).

Materials and Methods.

An incomplete diallel cross was made using the parental lines of two commercial hybrids that differed significantly (P=0.05) in their capacity for osmotic adjustment: Contiflor III (parents A and B) and Contiflor IV (parents C and D) (high and low osmotic adjustment respectively) (Chimenti and Hall, **op.cit.**).

Estimates of the capacity for osmotic adjustment of the F1 crosses and parental lines were derived from water status measurements made on the leaves of plants exposed to water stress. The plants were grown in the field at Junin, Pcia. de Buenos Aires (34° 33' S, 60° 57' W), in 12 l pots in a mixture of soil and sand (2:1 v/v), and were well provided with water and nutrients.

At the 8-leaf stage, the watering regime was modified and the daily irrigation of the plants of the water stress treatment was reduced to 37% of the evapotranspiration of the control plants. The objective here was to avoid a rapid drying out of the soil that affects the degree to which osmotic adjustment is manifested (Jones and Rawson, 1979). To avoid the effects of rain on plant water balance, the water stress treatment was covered with a shelter of polyethylene film that reduced incident PAR by 18%. During the period of water stress, which had a duration of 12 days, the daily mean maximum temperature daily was 32°C and the minimum 17°C. The mean evapotranspiration of the control treatment was 905 ml/pot/day.

During the exposure to water stress, the changes in water status were defined in terms of leaf relative water content (RWC) and leaf osmotic potential (π) using the techniques described in Chimenti and Hall (**op. cit.**). The ln RWC/ln π relationship was used to estimate the degree of osmotic adjustment. Degree of osmotic adjustment was expressed as the estimated value of RWC for a π of -1.7 MPa (RWCe). Thus, a high value of RWCe indicates a high degree of osmotic adjustment.

Statistical procedures.

The RWCe data were transformed by arc sin p before being subjected to analysis. General combining ability effects (GCA) and specific combining ability effects (SCA) were estimated according to Griffing's diallel analysis, model 1 method 2; and the heritability value through the relationship between the additive and phenotypic variance (Griffing, 1956).

Results.

The range of the values for the RWCe was between 56.5 and 68.6% for the parental lines and between 59.2 and 66.3% for the F1 crosses (Table 1). The variability for RWCe among the genetic materials used was significant at P=0.01 (Table 2).

The parental lines, with the exception of line D, had a higher degree of osmotic adjustment than the crosses (Table 1). Line A showed the most favorable genetic effects when parental and F1 crosses were contrasted (Table 3).

When the mean squares for the crosses were partitioned into GCA and SCA effects, significant differences (P=0.01) for GCA were found (Table 2). The genetic effects of the GCA (additive) were more important than the SCA (non-additive). Heritability in narrow sense for this attribute was estimated as 60% confirming these results.

The evaluation of the GCA effects for each line showed that line A had the highest additive effects on the increment of the capacity for osmotic adjustment of the progeny (Table 4).

Discussion.

The results of this work indicate that the additive genetic effects are more important that the non-additive ones in the control of the capacity for osmotic adjustment in sunflower. This finding and the high heritability for this atttribute (ca. 60%) suggests that the genetic progress expected in a breeding program would be interesting.

To summarize the results of this and with previous reports, it has been shown that the capacity for osmotic adjustment in sunflower shows a high heritability and that the intraspecific variability for this attribute is interesting. In addition, an adequate method has been developed for the detection, in juvenile ontogenetic stages, of genotypes with a high degree of osmotic adjustment. It should therefore be feasible to breed for osmotic adjustment in a breeding program directed to improving drought resistance in sunflower.

For a complete evaluation of the value of osmotic adjustment as a source of drought resistance in this species, it will be necessary to test the yield maintenance capacity under drought conditions of isogenic lines that differ in degree of osmotic adjustment. This work will allow a complete evaluation of the value of osmotic adjustment as an attribute that may contribute to drought resistance in this species.

TABLE 1
Mean performance of parental lines and F1 crosses for osmotic adjustment. Mean values of RWCe. RWCe= relative water for a π of -1.7 MPa. Values (%) are means +/- S.E. (n=4).

Line	A	B	C	D
A	68,6 +/- 1,5	66,3 +/- 0,8	63,6 +/- 1,3	61,9 +/- 1,8
B		64,1 +/- 0,8	60,0 +/- 0,6	59,9 +/- 1,0
C			61,2 +/- 3,1	59,2 +/- 1,0
D				56,5 +/- 0,6

TABLE 2
Mean squares from the diallel analysis, among sunflower lines and their F1 crosses. Data were transformed by arc sin $\sqrt{p}$.

Source of variation	df	MS
Genotypes	9	18,26 **
Parents	3	36,41 **
Parents vs. Crosses	1	2,48
Crosses	5	10,53 **
GCA	3	14,31 **
SCA	2	1,63
Residual	30	2,97

GCA= general combining ability. SCA= specific combining ability.
** = significant at 0.01 level of probability.

TABLE 3
Mean values +/- S.E. of RWCe (%) (n=12) for parental and F1 crosses derived from the same parental lines.

Line	Parents	Crosses
A	68,6 +/- 1,5	63,9 +/- 1,3
B	64,1 +/- 0,8	62,0 +/- 2,1
C	61,2 +/- 3,1	60,8 +/- 1,3
D	56,5 +/- 0,6	60,3 +/- 0,8

TABLE 4
Estimates of general combining ability effects (arc sin$\sqrt{p}$) for the sunflower parental lines.

Parental line	GCA
A	1,83 **
B	0,36
C	- 0,55
D	- 1,63 *

* significant at 0.05 and ** 0.01 level of probability.

Acknowledgements.

Financial support by CONICET and Compania Continental S.A. are gratefully acknowledged. We thank to Ing.Agr. R.Siciliano for much assistance during the experiments.

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