Evaluation of Experimental Sunflower Hybrids Derived from Interspecific Crosses for Drought Resistance[1]

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Abstract

The purpose of this research was to select water-stress tolerant hybrids of sunflower. Two experiments were performed in 1994 in two locations of Friuli under irrigated rainfed conditions. A trifactorial experimental design was used (locations (A), moisture level (B) and hybrids (C)) with three replicates. Forty-five experimental hybrids derived from *H. annuus* x *H. argophyllus*, *H. anomalus*, *H. niveus*, *H. debilis*, *H. praecox* and five commercial hybrids (*H. annuus*) used as controls, were evaluated. Drought conditions were recorded during the reproduction phase in both experiments in rainfed treatments.
The ANOVA analysis of ten measured characteristics showed significant differences ($P \leq 0.05$ and 0.01) for factors A, B and C and their interactions. A stepwise regression analysis revealed two biocybernetic models for the two moisture levels. Yield was significantly ($p \leq 0.05$ and 0.01) correlated with LAI and LAD under rainfed conditions and with seed number/head, head diameter and oil percentage under irrigation. The best hybrids under drought conditions were: 887xT+ and HA89xBaracca with 27 and 22 q ha^{-1} and 41.5 and 48.1 for seed yield and oil percentage, respectively.

Key words: evaluation, interspecific hybrids, drought resistance, sunflower

Introduction

In general, cultivated sunflower has limited genetic variability, especially for major agronomic traits, therefore a large number of breeders use wild sunflower species for the development of source populations.
To increase drought resistance in cultivated sunflower, there are wild sunflowers which grow under extremely dry conditions which have commercial potential: dry, sandy soils are inhabited by such species as *H. anomalus*, *H. deserticola*, *H. neglectus* and *H. niveus* spp. *niveus* (Seiler, 1992), *H. argophyllus* (Serieys, 1980; Seiler 1988). Drought resistance is a complex trait which includes resistance to water deficits in the soil and air. Breeding for drought resistance implies improvement in the efficiency of the root system, architecture of the main plant parts, time of maturation, resistance to diseases, water uptake from soil and efficient utilisation of nutrients (Skoric, 1992).
The aim of this research was to select water-stress tolerant interspecific varieties of sunflower in order to provide better water-use efficiency in the crop, selecting in the field for agronomic traits.

Material and methods

In 1994, forty-five lines and gene pools derived from *H. annuus* x *H. argophyllus*, *H. anomalus*, *H. niveus*, *H. debilis*, *H. praecox*, supplied by INRA Montpellier, Arlesa Semillas, Rustica Semences and Udine University were compared for yield, oil content, phenological and morphological traits in two experiments in two locations of Friuli Venezia-Giulia under irrigated-rainfed field conditions, through combinations with the tester lines HA 89 and 887.

This region has a humid climate, according to the Thornthwaite and Mather (1955) parameters, with 1440 mm total annual rain fairly well distributed during the year. The lowest monthly mean temperature is 3.7 °C in January and the highest is 22 °C in July. The first location, Udine, is characterised by deep medium clay loam soil, the second, San Vito al Tagliamento, by a shallow and very permeable soil. During summer months in this latter location, excessive drainage and shallow soil can lead to very serious hydric stress. Both locations are representative of the region's soils.

Fig. 1 shows the thermopluviometric trend in the two locations during the growing season. The irrigation treatments involved two levels:

- rainfed plots: never irrigated,
- irrigated plots: irrigation with 40 mm each week from bud stage to physiological maturity.

A trifactorial experimental design was used (locations (A), moisture level (B) and hybrids (C)) with three replications (each experimental unit was 22.5 m^2). The hybrids were sown on 21st April at a density of 5 plants/m^2 (after thinning out) and were harvested between 5th August and 5th September, depending on the rainfed or irrigated conditions and the location. In addition to the usual fertilisation (100-60-50), boron was applied (1 Kg ha^{-1}) to avoid boron deficiency phenomena.

Phenological, morphological and agronomic traits were measured both in dry and irrigated plots and in both locations: flowering (stage 4.3-4.4 CETIOM), plant height at flowering physiological maturity (stage 5.3 CETIOM), head diameter, leaf area per plant (LA) (dm^2), calculated using the relationship followed by Pouzet *et al.* (1985) at flowering, 21 days after flowering and 42 days after flowering to calculate leaf area index (LAI) and leaf area duration (LAD).

At harvest, ten plants were taken at random manually from the central two rows of each plot and the following measurements were performed on the seeds: seed number (estimated seed number per head); seed weight (1000 achene weight) in g; seed oil content, measured by nuclear magnetic resonance (N.M.R.); grain yield (dry matter) in q ha^{-1}.

Before sowing, the forty-five hybrids were divided in two groups: in the first, called "first group", there were 30 hybrids and in the second, called "second group", there were 16 hybrids (listed in Table 1a and 1b respectively). All testers were sowed separately for each group.

All the data acquired were submitted to the analysis of variance which tested the effects of the treatments and their interactions. A linear regression and correlation matrix, between all traits, was obtained. The significant correlations found allowed some biocybernetic models to be developed, relating the factors (hybrids, moisture conditions, locations) yield processes and the products (seeds and oil content) (Gomez Sanchez, 1985; Gomez Sanchez *et al.*, 1990). Moreover, for each hybrid in the four treatments the drought susceptibility index "S" (Fisher and Maurer, 1978) was calculated as follows

$$S = \frac{1 - (SY_d / SY_p)}{D}$$

where (SY_d/SY_p) is the ratio of drought to irrigation yield for each line and *D* is the yield reduction under drought averaged for all lines.
The statistical analyses were performed using the MSTAT-C statistical program (1989).

Results and discussion

"First Group" Hybrids
The statistical analysis of treatments and interaction effects is reported in Table 2a.
The effects of location, variety, water supply and their interactions were highly significant for yield. In Udine until flowering, the weather conditions were rainy enough not to create big differences between irrigated and rainfed conditions; the severe drought took place after flowering. In this location, the mean yield under irrigated conditions was 35.8 q/ha and on rainfed plots 25.6 q/ha (-28%). The water stress affected seed weight (64.2 g under irrigated conditions and 43.7 in the rainfed sites -32%), but not seed number. Water stress did not particularly affected the oil content (47.19 % vs. 45.9%).
In S. Vito, the drought conditions took place before flowering and severely affected the LAI (rainfed conditions) for some varieties, so that the intense water stress severely affected yield, seed weight and oil content. Under irrigated conditions, the mean yield was more than three times as much as on rainfed plots (35.8 vs. 11.4 q/ha) and the seed weight was more than double (54.8 gr. vs. 20 g - -63.5%). The oil content was 52.2 % under irrigated conditions and 42.8 % in rainfed fields (- 18%) (data not shown).
In Tables 3a, 3b, 3c and 3d the significant correlations obtained from a linear correlation matrix (not shown) are reported.
The yield processes occurring under the different moisture conditions were particularly interesting. As the location effect was significant, the two locations were analysed separately. At Udine, under rainfed conditions (Fig. 2b) the yield was related to plant height, LAI, LAD and the head diameter, while under irrigated conditions it was not related to any phenological or morphological trait observed (Fig. 2a).
In S. Vito, under rainfed conditions (Fig. 2d), the yield was related to LAI and LAD but under irrigated conditions (Fig. 2c) with the head diameter only.
In Udine, the "S" index value was greater for the testers than the experimental hybrids (102 vs. 101) (data not shown) and between the hybrids with "S" > 102 the best were: HA89xANN ANO (S=130.4 and n. 5 in Fig. 4a), 887xT+ (S=124 and n. 16 in Fig. 4a) and 887xPNRM 6.51.(S=131 and n. 21 in Fig. 4a).
At S. Vito, the "S" index value was greater for the experimental hybrids than the testers (104 vs. 91) (data not shown) and between the hybrids with "S" > 104 the best were: HA89xANN ANO (S=147 and n. 5 in Fig. 4b), HA89xDEB DEB (S=145 and n. 16 in Fig. 4b) and 887xPNRM 6.51. (S=171 and n. 21 in Fig. 4b).

"Second Group" Hybrids
Significant differences were found between locations (A), moisture (B) and hybrids (C) and the (AxB), (AxC) and (BxC) interactions for yield. (Table 2b).
Obviously, the productive parameters were influenced in the same way by climatic and soil conditions in comparison with the first group: the mean yields under irrigated conditions were 36.1 q/ha and on the rainfed plots 27 q/ha (-25.2 %).
In Udine, water stress affected seed weight (49.5 g under irrigated conditions and 42.4 g on rainfed sites -28.4 %), but not seed number (Table 7b) and in particular did not affect the oil content (49.8 % vs. 47.5%).
At S. Vito, the very intense water stress severely affected yield, seed weight and oil content. The mean yield under irrigated conditions was more than three times as much as

on the rainfed plots (37.5 vs. 12.7 q/ha) and seed weight was 50.7 g under irrigated conditions vs. 36.3 g - 28.4% under rainfed conditions (data not shown). The mean oil content was 52.2 % under irrigated conditions and 42.8 % under rainfed conditions (-18%).

In Tables 4a, 4b, 4c and 4d the significant correlations obtained from a linear correlation matrix (not shown) are shown.

For this second hybrids group, the significant interactions also allowed the development of some biocybernetic models.

In Udine, under rainfed conditions (Fig. 3b) correlations between LAD, seed number, head diameter and yield were found; conversely, under irrigated conditions, between seed weight and yield only (Fig. 3a).

At S. Vito, significant correlations were found under rainfed conditions between seed number, LAD and yield (Fig. 3d), but under irrigated conditions only between head diameter and yield (Fig. 3c).

In Udine, the "S" index value was greater for the experimental hybrids than the testers (100 vs. 98) (data not shown) and between the hybrids with "S" > 100 the best were: HA89x3801 (S=113 and n. 4 in Fig. 5a), HA89x13B (S=133 and n. 6 in Fig. 5a), HA89x83HR4 (S=120 and n. 8 in Fig. 5a) and HA89xBaracca (S=105 and n. 11 in Fig. 5a).

At S. Vito, the "S" index value was greater for the experimental hybrids than the testers (110 vs. 108) and between the hybrids with "S" > 110 the best were: HA89x3801 (S=166 and n. 4 in Fig. 5b), HA89x880 (S=140 and n.5 in Fig. 5b) and HA89xBaracca (S=158 and n. 11 in Fig. 5b).

Conclusions

The purpose of this research was to select water-stress tolerant interspecific hybrids of sunflower adapted to different agropedological conditions of Friuli Venezia-Giulia region. The first results were good and even if the two locations chosen in our region were different for statistical analysis, probably because of soil type, the two hybrid groups ("first group" and "second group" hybrids) showed there was the same physiological behaviour: yield correlated with LAI and LAD under rainfed conditions, while under irrigated conditions production was correlated with secondary characters only.

The clear environmental differences existing in our region will oblige us to consider the different texture characteristics where the selection for drought resistance is carried out and to study especially the relationships between root system development and soil structure.

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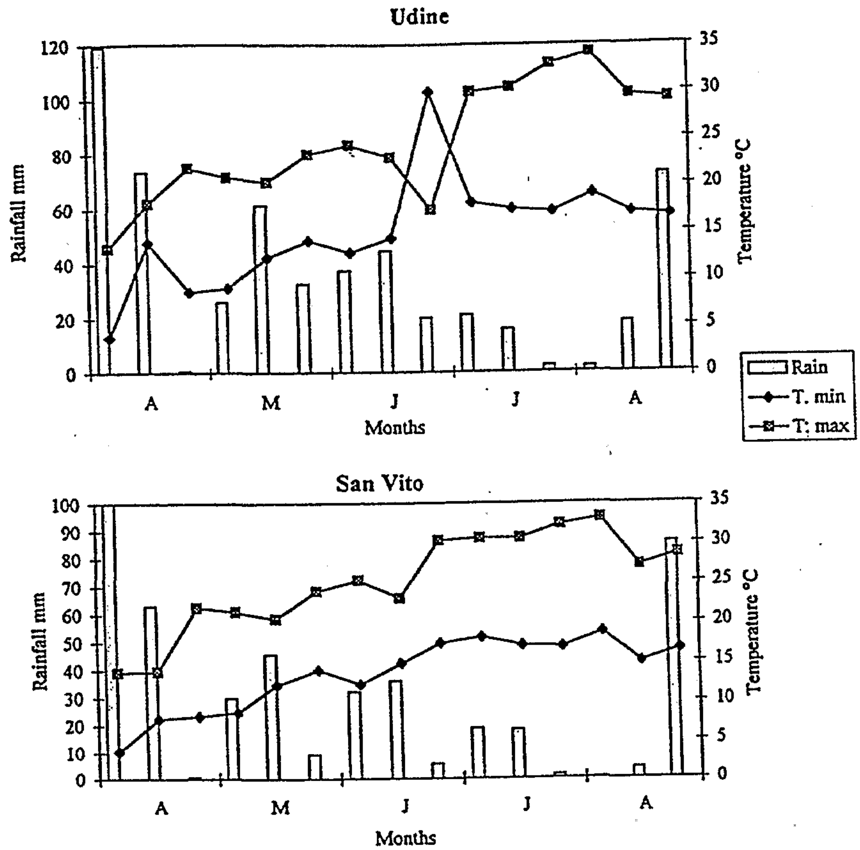

Figure 1 - Ten days values of rainfall and temperatures throughout the growing season in the two locations.

Table 1a-1b List of experimental hybrids used in the experiment

Table 1a -"First group"		Table 1b - "Second group".	
1	HA 89 x T+	1	HA 89 x 1803
2	HA 89 x T-	2	HA 89 x 2801
3	HA 89 x ARG REC	3	HA 89 x 2804
4	HA 89 x AA/7.2.4	4	HA 89 x 3801
5	HA 89 x ANN ANO	5	HA 89 x 880
6	HA 89 x PNRM 6.5.1	6	HA 89 x 13B
7	HA 89 x ANN NIT	7	HA 89 x 2807
8	HA 89 x 91T608	8	HA 89 x 83HR4
9	HA 89 x 91T622	9	HA 89 x 1802
10	HA 89 x DEB DEB	10	HA 89 x 2802
11	HA 89 x 89-1471-12	11	HA 89 x BARACCA
12	HA 89 x GIZZEH 91	12	887 x 880
13	HA 89 x GIZZEH 91533	13	887 x 83HR4
14	HA 89 x 89B1	14	887 x 1813
15	HA 89 x 89B2	15	887 x 3802
16	887 x T+	16	887 x 1801
17	887 x T-	17	P 113 (tester)
18	887 xARG REC	18	SH 25 (tester)
19	887 x AA/7.2.4.	19	Pulsar (tester)
20	887 x ANN ANO	20	Albena (tester)
21	887 x PNRM 6.5.1	21	Euroflor (tester)
22	887 x ANN NIT		
23	887 x 91T608		
24	887 x 91T622		
25	887 x DEB DEB		
26	887 x 89-1471-12		
27	887 x GIZZEH 91		
28	887 x GIZZEH 91533		
29	887 x 89B1		
30	887 x89B2		
31	P 113 (tester)		
32	SH 25 (tester)		
33	Pulsar (tester)		
34	Albena (tester)		
35	Euroflor(tester)		

Table 2a - Hybrids "first group": analysis of variance for hybrids characters analyzed during the trial.

Sources	df	FLO	MAT	Plant height	Head diameter	LAI	LAD	Seed weight	Seed number	Oil	Yield
		Mean squares									
Locations (A)	1	2645.280*	16576.333**	3916.251*	728.443*	155.239**	8177.670**	29669.249*	470448*	106.436	57.592**
Moisture (B)	1	111.021**	41028.009**	332.327	2863.143**	39.486**	2726.153**	82515.901**	810506.815*	3034.833**	315.912**
AxB	1	5.558	6.259	2629.96	90.173*	1.646*	530.395**	5507.653**	638177.815*	1739.660**	52.149**
Hybrids (C)	4	152.729**	221.125**	3795.099**	95.328**	2.031**	44.008**	1302.026**	1323349.767**	120.483**	1.587**
AxC	4	145.785**	143.652**	2599.015**	7.057*	0.55**	29.426**	95.639*	178570.524**	30.001**	0.230*
BxC	4	37.659	142.214**	531.409	11.63**	0.399	17.514*	148.442**	246415.481**	48.341**	0.594**
ABC	4	41.148	142.540**	460.541	5.491	0.345	15.654	62.469	171727.977*	19.362*	0.261**
Error	32	51.912	36.730	414.495	4.605	0.399	11.374	50.541	97096.315	12..105	0.147

FLO: dd. sowing-mid flowering, MAT: dd. sowing-physiological maturity, Seed weight: 1000 achene weight in g, Seed number: estimated seed number per head, Oil: seed oil content in %, Yield: seed yield in q ha^{-1}

*,**Significant at the 0,05, 0,01 probability respectively.

Table 2b - Hybrids "second group": analysis of variance for hybrids characters analyzed during the trial.

Sources	df	FLO	MAT	Plant height	Head diameter	LAI	LAD	Seed weight	Seed number	Oil	Yield
		Mean squares									
Locations (A)	1	2364.015*	6903.409*	6753.887	123.684	95.268**	7181.618**	397.636	7899180.136	32.924	27.723**
Moisture (B)	1	0.970	19725.47**	287.919	709.136**	21.222**	1745.544**	7614.23**	10700464.015*	1379.180*	189.131**
AxB	1	14.561**	427.636*	473.395	162.778**	0.365	218.691**	871.273	438551.515	318.495	41.152**
Hybrids (C)	4	343.592**	701.793**	3609.607**	37.480**	3.663**	55.004**	573.587**	373853.576**	248.714**	0.720**
AxC	4	333.793**	621.592**	3489.9**	17.904	0.425**	42.415**	292.028**	104901.43	173.740**	1.060**
BxC	4	1.620	98.192	299.335**	25.601**	0.298**	6.654**	221.230**	326838.674*	46.515	0.662**
ABC	4	0.942	97.247	260.855**	21.484*	0.110	5.962**	254.893**	231928.936	75.180	0.546**
Error	32	38.864	135.155	115.878	13.017	0.151	3.048	95.134	180186.450	68.191	0.122

FLO: dd. sowing-mid flowering, MAT: dd. sowing-physiological maturity, Seed weight: 1000 achene weight in g, Seed number: estimated seed number per head, Oil: seed oil content in %, Yield: seed yield in q ha^{-1}

*,**Significant at the 0,05, 0,01 probability respectively.

Table 3c - Hybrids "first group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of San Vito in irrigated conditions.

x	y	y = a + bx	r
Height of plant	dd. sowing-phys. mat.	y = 108.14 + 0.110 x	0.660**
Height of plant	LAI	y = -2.52 + 0.022 x	0.703**
Height of plant	LAD	y = -7.49 + 0.070 x	0.863**
Height of plant	Oil content	y = 79.13 - 0.142 x	-0.533*
dd. sowing-flowering	LAI	y = -20.15 + 0.285 x	0.506*
dd. sowing-flowering	LAD	y = -48.79 + 0.713 x	0.492*
dd. sowing-phys. mat.	LAD	y = - 27.89 + 0.261 x	0.536*
LAI	LAD	y = 2.27 + 2.079 x	0.810**
LAI	Head Diameter	y = 14.24 + 1.579 x	0.524*
1000 Seeds Weight	Seeds Number/head	y = 2707.24 - 27.30 x	-0.547*
Head Diameter	Yield	y = -0.21 + 0.218 x	0.548*
Oil content	Yield	y = -0.48 + 0.076 x	0.553*

*,**Significant at the 0,05, 0,01 probability respectively.

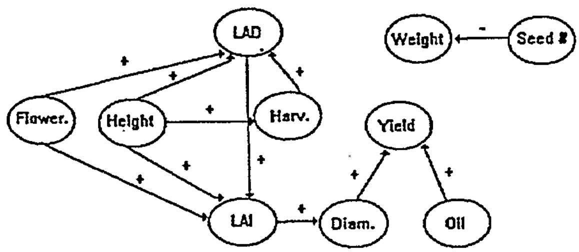

Figure 2c - Hybrids "first group". Biocybernetic model developed according to the significant correlations (r) above reported.

Table 3d - Hybrids "first group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of San Vito in rainfed conditions.

x	y	y = a + bx	r
Height of plant	dd. sowing-flowering	y = 66.40 + 0.055 x	0.615**
Height of plant	dd. sowing-phys. mat.	y = 82.95 + 0.140 x	0.793**
Height of plant	LAD	y = -3.21 + 0.033 x	0.625**
dd. sowing-flowering	dd. sowing-phys. mat	y = -10.43 + 1.288 x	0.652**
dd. sowing-flowering	LAI	y = -6.18 + 0.093 x	0.671**
dd. sowing-flowering	LAD	y = - 22.32 + 0.329 x	0.563*
dd. sowing-flowering	Head Diameter	y = 53.02 - 0.550 x	-0.511*
dd. sowing-phys. mat.	LAI	y = - 2.78 + 0.034 x	0.486*
dd. sowing-phys. mat.	LAD	y = - 13.23 + 0.148 x	0.500*
LAI	LAD	y = - 0.65 + 3.798 x	0.899**
LAI	Yield	y = 0.45 + 0.740 x	0.577*
LAD	Yield	y = 0.52 + 0.214 x	0.705**
1000 Seeds Weight	Seeds Number/head	y = 2412.71 - 42.76 x	-0.568*
1000 Seeds Weight	Head Diameter	y = 7.35 + 0.168 x	0.595**

*,**Significant at the 0,05, 0,01 probability respectively.

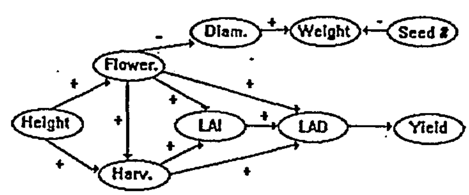

Figure 2d - Hybrids "first group". Biocybernetic model developed according to the significant correlations (r) above reported.

Table 4a - Hybrids "second group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of Udine in irrigated conditions.

x	y	y = a + bx	r
Height of plant	LAI	y = 6.19 - 0.019 x	-0.599**
Height of plant	LAD	y = 32.17 - 0.133 x	-0.559**
Height of plant	Yield	y = 0.81 + 0.016 x	0.576**
dd. sowing-flowering	Yield	y = 19.66 - 0.221 x	-0.469*
dd. sowing-phys. mat.	LAI	y = -7.83 + 0.076 x	0.574**
dd. sowing-phys. mat.	LAD	y = -50.51 + 0.486 x	0.581**
dd. sowing-phys. mat.	Seeds Number/head	y = -1983.92 + 27.5 x	0.530**
dd. sowing-phys. mat.	Head Diameter	y = -9.54 + 0.186 x	0.427*
LAI	LAD	y = -0.00 + 6.152 x	0.978**
LAI	Head Diameter	y = 11.21+ 1.871 x	0.569**
LAD	Seeds Number/head	y = 1375.4 + 28.48 x	0.457*
LAD	Head Diameter	y = 11.04 + 0.314 x	0.601**
1000 Seeds Weight	Seeds Number/head	y= 2422.92 - 10.83 x	-0.452*
1000 Seeds Weight	Head Diameter	y = 9.98 + 0.128 x	0.634**
1000 Seeds Weight	Yield	y = 1.98 + 0.032 x	0.607**

*,**Significant at the 0,05, 0,01 probability respectively.

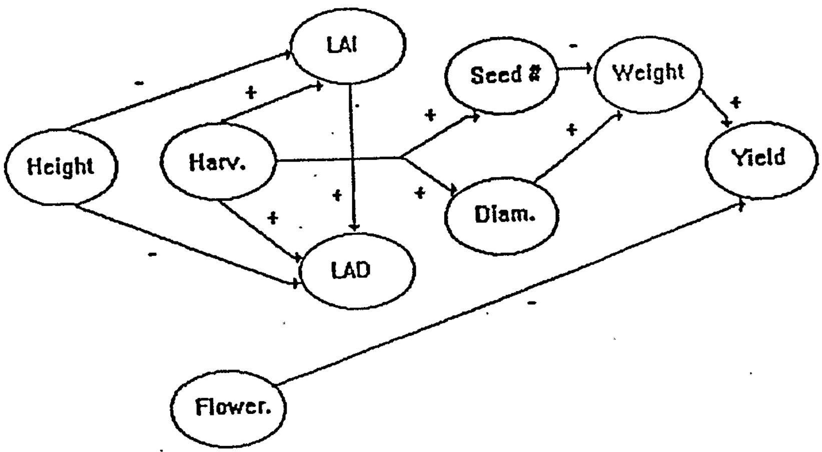

Figure 3a - Hybrids "second group". Biocybernetic model developed according to the significant correlations (r) above reported.

Table 4b - Hybrids "second group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of Udine in rainfed conditions.

x	y	y = a + bx	r
Height of plant	dd. sowing-phys. mat.	y = 135.98 - 0.076 x	-0.478*
Height of plant	LAI	y = 3.70 - 0.008 x	-0.412*
Height of plant	LAD	y = 19.06 - 0.051 x	-0.481*
Height of plant	Head Diameter	y = 21.44 - 0.040 x	-0.551**
dd. sowing-flowering	Oil content	y = -48.36 + 1.337 x	0.635*
dd. sowing-phys. mat.	LAI	y = -6.92 + 0.075 x	0.623**
dd. sowing-phys. mat.	LAD	y = -36.07 + 0.377 x	0.568**
dd. sowing-phys. mat.	Head Diameter	y = -11.72 + 0.213 x	0.463*
LAI	LAD	y = -1.22 + 4.942 x	0.899**
LAI	Seeds Number/head	y = 1000.63+ 230.2 x	0.444*
LAD	Seeds Number/head	y = 879.29 + 63.89 x	0.677**
LAD	Head Diameter	y = 10.36 + 0.400 x	0.577**
LAD	Yield	y = 1.84 + 0.086 x	0.441*
Seeds Number/head	Head Diameter	y = 7.89 + 0.004 x	0.583**
Seeds Number/head	Oil content	y = 33.03 + 0.010 x	0.433*
Seeds Number/head	Yield	y = 0.76 + 0.001 x	0.619**
Head Diameter	Yield	y = 0.78 + 0.134 x	0.479*
Oil content	Yield	y = 0.86 + 0.038 x	0.443**

*,**Significant at the 0,05, 0,01 probability respectively.

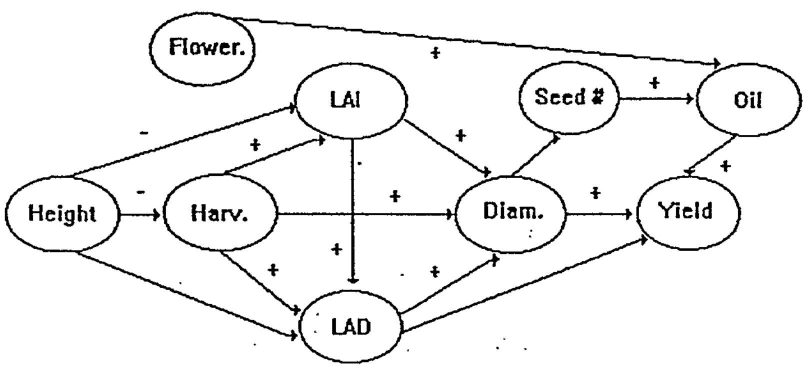

Figure 3b - Hybrids "first group". Biocybernetic model developed according to the significant correlations (r) above reported.

Table 4c - Hybrids "second group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of San Vito in irrigated conditions.

x	y	y = a + bx	r
Height of plant	dd. sowing-phys. mat.	y = 142.82 - 0.082 x	-0.548**
dd. sowing-flowering	LAD	y = -23.55 + 0.366 x	0.423*
LAI	LAD	y = 1.69 + 1.672 x	0.748**
LAI	Oil content	y = 59.78 - 2.866 x	-0.492*
1000 Seeds Weight	Seeds Number/head	y= 2328.55 - 11.62 x	-0.521**
1000 Seeds Weight	Oil content	y = 63.64 - 0.159 x	-0.573**
Head Diameter	Yield	y = 3.37 + 0.019 x	0.545**
Oil content	Yield	y = 8.25 - 0.082 x	-0.526**

*,**Significant at the 0,05, 0,01 probability respectively.

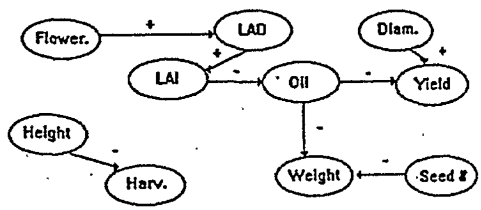

Figure 3c - Hybrids "first group". Biocybernetic model developed according to the significant correlations (r) above reported.

Table 4d - Hybrids "second group". Linear regression and correlations among morphophysiological traits in sunflower experimental hybrids derived from interspecific crosses, growing in the location of San Vito in rainfed conditions.

x	y	y = a + bx	r
Height of plant	dd. sowing-phys. mat.	y = 125.52 - 0.099 x	-0.625**
Height of plant	LAI	y = 2.19 - 0.007 x	-0.440*
Height of plant	LAD	y = 5.16 - 0.023 x	-0.606**
dd. sowing-flowering	1000 Seeds Weight	y = 165.6 - 1.689 x	-0.488*
dd. sowing-phys. mat.	LAD	y = -11.14 + 0.114 x	0.480*
LAD	Yield	y = 1.12 + 0.203 x	0.448*
Seeds Number/head	Yield	y = 0.94 + 0.000 x	0.395*

*,**Significant at the 0,05, 0,01 probability respectively.

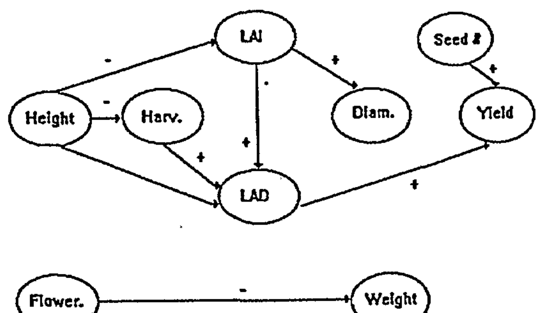

Figure 3d - Hybrids "first group". Biocybernetic model developed according to the significant correlations (r) above reported.

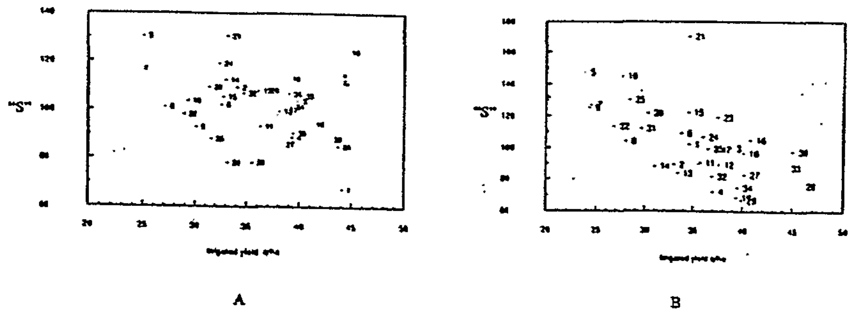

Figure 4 - Hybrids "first group". Relationship between seed yield under irrigation (x) and the drought susceptibility index "S" in the locations of Udine (a) and of S. Vito (b). The numbers indicate the genotypes listed in Table 1.

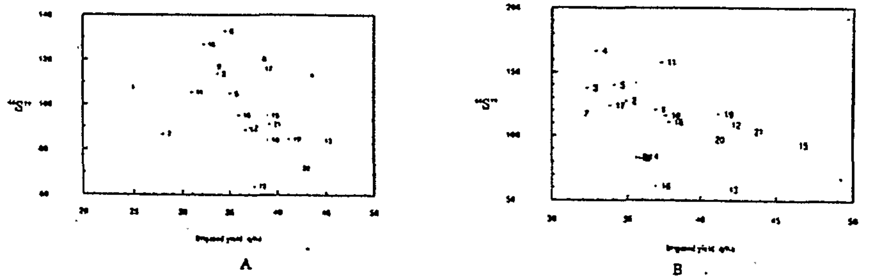

Figure 5 - Hybrids "second group". Relationship between seed yield under irrigation (x) and the drought susceptibility index "S" in the locations of Udine (a) and of S. Vito (b). The numbers indicate the genotypes listed in Table 1.