DROUGHT RESISTANCE IN A WILD SPECIES (*Helianthus argophyllus* T&G) WITH RESPECT TO CULTIVATED SUNFLOWERS.

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Abstract

The influence of water stress on gas exchange and dry matter accumulation in a wild sunflower (*Helianthus argophyllus* T&G) and four cultivated sunflower (*Helianthus annuus* L.) cultivars (HA 89, RHA 856, 207 A and C) were compared in a glasshouse experiment in 1989-1990 period. Plants were cultivated in a silty-peaty soil using two benches; one was maintained in a well-watered condition until physiological maturity, in the other drought stress was imposed by terminating irrigation just before flowering. Measurements were made of photosynthesis, transpiration, relative leaf water content, pre-dawn leaf water potential and leaf area index and total dry matter at harvest. Under dry conditions, the water deficit was smaller in the wild species than in the cultivated lines and photosynthesis and leaf hydration decreased more rapidly with drought in the cultivated lines compared with the wild genotype. At a pre-dawn leaf water potential of -2.0 MPa, these differences disappeared. The above results and the lower reduction of dry matter production, the increase in root/shoot ratio under drought at harvest and unchanged leaf area after 12 days of drought, in H.argophyllus, indicate it has a drought avoidance mechanism.

Introduction

Various studies have contributed to the evaluation of the variability present in cultivated sunflower (Rawson et al., 1980; Blanchet and Merrien, 1984; Fereres et al., 1986; Gimenez and Fereres, 1986) and have identified some physiological processes related to seed yield under drought. One line of research is based on the exploitation of wild species, coming from dry environments. Many authors have reported H.argophyllus as an interesting source for improving drought resistance in cultivated sunflower (Serieys, 1980; Seiler, 1988), because physiological studies indicate a greater efficiency in water use in wet conditions compared to cultivated sunflower (Blanchet and Gelfi, 1980; Iouras and Voinescu, 1984). In the exploitation of wild sunflower, seed yield may not be a useful criterion for drought resistance because of their indeterminate and multiflowering habit (Blum, 1987; Sobrado and Turner, 1983) which is the case for H.argophyllus. The aim of this study is to evaluate differences in physiological activity and dry is to evaluate differences in physiological activity and dry matter yield under drought among H.argophyllus and four sunflower cultivars in order to assess possible mechanism for adaptation to drought and the possibility of using this species in breeding programmes.

Materials and Methods

The wild species, H.argophyllus, was compared with four sunflower cultivars, selected for high yield potential (HA89, RHA856, 207A, and C).

Seeds were sown in two separate benches of identical dimensions (10 metres long, 1.5 metres wide and 0.6 metres deep) with a silty-peaty soil in a glasshouse. During the study period the temperature, regulated by a thermostat, varied between 18° to 20 °C during the night, while during the day the values varied from a minimum of 20°C to a maximum of 30°C. A constant 16 hours photoperiod was assured by a timer connected to 4 lamps per bench (Philips SGR 200/400) of 400 watts each, which assured a minimum light intensity of about 900 µE s^{-1} cm^{-2} at the top of the canopy. Each genotype was transplanted in 6 rows, with two rows for each replication, which were randomized across the benches, with a distance between the plants in the rows and between the rows of 25 cm. Guard rows were established at two extremities of each bench. In one treatment, the soil was maintained at approximately field capacity until physiological maturity, by irrigating every 2-3 days (controls). In the second treatment, irrigation was suspended 45 days after sowing (DAS, when all the genotypes were at pre-flowering time), resulting in progressive water stress until physiological maturity (terminal stress). The following measurements were made at 2 day intervals from 45 DAT to 65 DAT (during achenes filling stage): gaseous exchanges of the plants as photosynthesis (A), were recorded between 0.5 h before and 1 h after solar noon, using a commercial ADC (Analytical Development Co., England) open-portable system (Long and Hallgren, 1985; Steduto et al., 1988). Transpiration efficiency (TE) was calculated from the ratio of photosynthesis to transpiration rate. All measurements were made in the midsection of three top fully expanded leaves of three replicate plants for each treatment.

Relative water content of the leaves (RWC) was measured following the methodology suggested by Sobrado and Turner, (1983). From another same leaf per plant on which values of gaseous exchange was obtained, the leaf water potential at pre-dawn was measured with a pressure chamber, following the methodology suggested by Turner (1981). Leaf area measurements (LA), to calculate leaf area index (LAI), were made on two occasion when the irrigation was supsended and 12 days later and were determined using the methodology suggested by Rawson et al., (1980). At maturity three intergral plants per plot were harvested, partitioned into above-ground matter and root and dried at 80°C for 48 h

before weighing. Care was taken when pulling plants to recover the root system. The four cultivated cultivars were harvested at 80 DAT date and the wild sunflower at 98 DAT.
The data obtained from the control and water-stress experiments were analyzed separately by ANOVA using a randomized block design with three replications, considering as the only source of variation the genotypes within the treatments and the moments of the determinations; the LSDs (bars on the graphs for P=0.01) were calculated (n=3) to check the statistical differences among genotypes (Gomez and Gomez, 1984).

Results

Leaf water relation

After suspending irrigation pre-dawn leaf water potential of all genotypes esibiva a progressive decrease with time (Fig. 1). Cultivar HA89 showed a faster decrease in leaf water potential than the other genotypes. The wild sunflower maintained a higher leaf water potential (less negative) than the other genotypes from 4 days after suspending irrigation.
During the whole period of the experiment, H. argophyllus also maintained a higher RWC (Fig.2), while cultivar HA 89 had the lowest RWC in the period between 6 and 18 days.

Leaf gas exchange

Photosynthetic rates of H. argophyllus were greater than the other genotypes, during the whole period, with the exception of that of the cultivar 207 A especially in the early stage of the experiment (2,4 and 6 days) (Fig.3).
Wild sunflower had greater transpiration efficiency (TE) (expressed by $\mu M\ CO_2\ m^{-2}\ sec^{-1} / mM\ H_2O\ m^{-2}\ sec^{-1}$) during the experiment compared the other genotypes (Fig. 4). TE was almost constant for the whole period. For the well-watered treatment the genotypes had similar values of leaf water potential, RWC, photosyntesis and transpiration (e.g. see time 0 of the Figure 1, 2, 3 and 4 respectively) and these values remained approximately constant for each genotype up the flowering time.

Dry matter and leaf area

The leaf area when irrigation was suspended (T0) was different among genotypes and these differences were present 12 days later (T1) (Tab.1). The depletion of water from the soil during the 12 days after the last irrigation substantially stressed the plants causing reduction in leaf area. The percentage reduction in leaf area was substantially less for the wild sunflower (19%) than the other genotypes (46 to 62%).
At harvest the effects of water stress on dry matter production were substantial for the cultivars (35 to 45% reduction), but less for the wild sunflower (20% reduction) (Tab.2). Considering the ratio between root dry matter and

total dry matter, while no differences were apparent among the genotypes in wet conditions, in the stress teatment this ratio increased more in H.argophyllus than in the other genotypes (Tab.2).

Discussion and Conclusion

Our purpose was to determine whether a wild sunflower species differed from some cultivated genotypes in their physiological response to drought. The greater transpiration efficiency of the wild sunflower (Fig.4) was due to its greater photosynthetic rate especially under activity under dry conditions (Fig.3) as reported by Morizet et al., (1984). The mainteinance of photosyntetic activity under drought by the wild sunflower was associated with greater relative water content of the leaves (Fig.2) and slighty higher leaf water potential at the pre-dawn (Fig.1). Apparently the wild sunflower has greater dehydratation avoidance than the cultivars.

Consequently, the dehydration avoidance and the high TE of the wild sunflower may be due to its greater allocation of dry matter to roots under drought than the cultivars (Tab.2) (Hsiao and Acevedo, 1974). Similar results among peanut cultivars were olso observed in glasshouse and field studies (Hubick et al., 1986; Wright et al., 1988).

The reductions in photosynthesis were not solely due to stomatal limitations. Cultivars Ha 89, C and R 856 had a substantial reduction in photosynthesis (30-45%) at -0.8 Mpa, but only a small decrease in transpiration (15-20%), at the same water potential. For these reasons, in agreement with Boyer (1970) and Cox and Joliff (1987), non-stomatal factors, not very well identified, could also have limited the photosynthesis in these sunflower genotypes when subjected to drought.

H. argophyllus may be useful in breeding programmes for drought resistance in sunflower, in that it has some dehydration avoidance due possibly to greater root development and impoved water uptake. Since the greater root development only occurred under drought, this mechanism of drought resistance may not limit yield under well-watered conditions.

Table 1 - LAI at the interruption of the irrigation (T0), 12 days after (T1) and its % reduction. The % values, for statistical analysis, were trasformed in the Arc Sine √% Means within a column that don't have a common letter are significantly different by LSD 0.01 test.

Genotypes	T0	T1	% reduction
HA 89	3.08 ab	1.32 b	57.14 ab
RHA 856	2.07 c	0.78 c	62.32 a
207 A	2.52 bc	1.36 b	46.03 b
C	2.02 c	0.85 c	57.92 ab
H.Argophyllus	3.88 a	3.13 a	19.33 c

Table 2 - Total plant dry weight (DW), % reduction and root to total dry weight ratio of the studied genotypes at the harvest time. The % values, for statistical analysis, were trasformed in Arc Sine √%. Means within a column that don't have a common letter are significantly different by LDS 0.01 test.

	control	stress		stress	control
Genotypes	Total DW	Total DW	DW reduction	Root/Total DW	Root/total DW
	(g)	(g)	% of control		
HA 89	91.25 a	59.15 b	35.17 a	0.066 b	0.062 a
RHA 856	75.41 b	41.51 c	44.94 a	0.068 b	0.063 a
207 A	70.25 b	45.23 c	35.61 a	0.078 b	0.069 a
C	52.90 c	28.85 d	45.46 a	0.065 b	0.062 a
H.Argophyllus	99.23 a	79.75 a	19.63 b	0.117 a	0.071 a

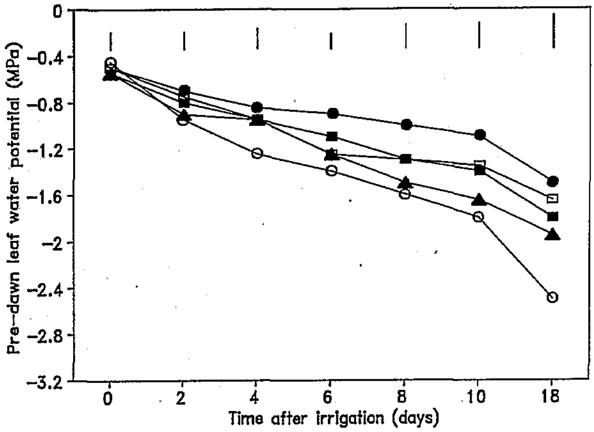

Fig. 1 - Increment of the pre-dawn leaf water potential (Mpa) over the time after the interruption of irrigation (days) (0 is the first day after the last irrigation) *for HA 89* (O), *856* (■), *207 A* (▲), C (□) *and H.* Argophyllus (●). The vertical bars represent the LSD value (n = 3 for each genotype) at P= 0.01 for each day measurement.

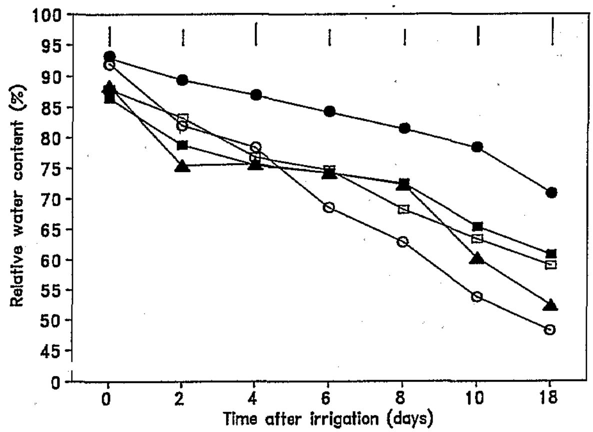

Fig. 2 - Relative water content of the leaf (%) over the time after the interruption of irrigation (days) for HA 89 (O), 856 (■), 207 A (▲), C (□) and H.Argophyllus (●). The vertical bars represent the LSD value (n = 3 for each genotype) at P= 0.01 for each day measurement.

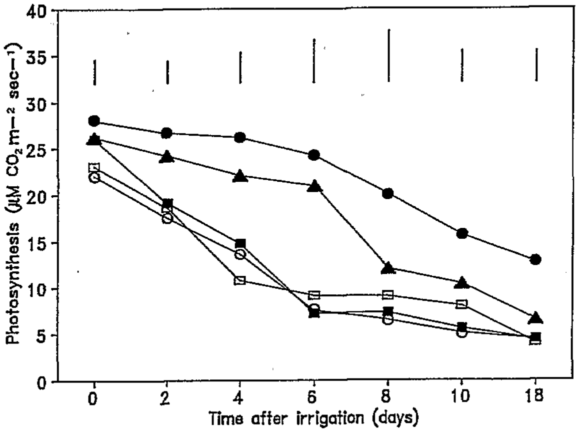

Fig. 3 - Photosynthetic rate (μM CO_2 m^{-2} sec^{-1}) over the time after the interruption of irrigation (days) for HA 89 (○), 856 (■), 207 A (▲), C (□) and H.Argophyllus (●). The vertical bars represent the LSD value (n = 3 for each genotype) at P= 0.01 for each day measurement.

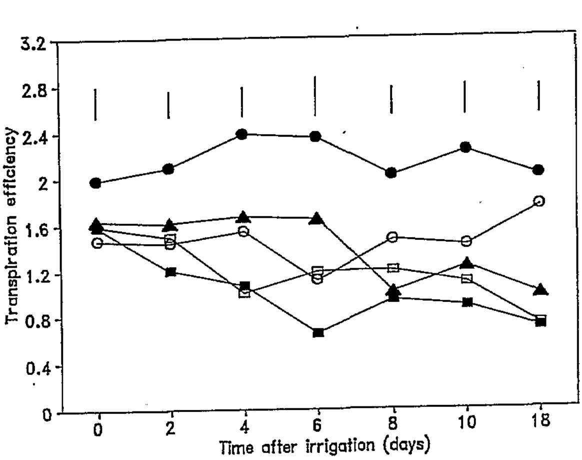

Fig. 4 - Traspiration efficiency calculated as photosyntetic / traspiration activity (μM CO_2 m^{-2} sec^{-1}/mM H_2O m^{-2} sec^{-1}) over the time after the interruption of irrigation (days) (0 is the first day after the last irrigation) for HA 89 (○), 856 (■), 207 A (▲), C (□) and H.Argophyllus (●). The vertical bars represent the LSD value (n = 3 for each genotype) at P= 0.01 for each day measurement.

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