# EVALUATION OF PLANT-WATER RELATIONS OF WILD PERENNIAL SUNFLOWER SPECIES UNDER IRRIGATION

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## INTRODUCTION

During plant evolution, different mechanisms enabling plants to survive drought have been selected ; not all of them fully maintain the plant productive processes (Turner, 1979) For plants living in natural ecosystems, survival of drought is probably more important than high productivity, whereas in agricultural systems, maximization of productivity is of paramount importance (Turner, 1981). It is conceivable, therefore, that during selection by plant breeding for high productivity, some drought resistance characters have been inadvertently lost and that current breeding programs to improve drought resistance of cultivated sunflower (*Helianthus annuus L.*) plant may benefit from an infusion of germplasm from wild sunflower species.

Water stress is one of the most widespread environmental variables affecting plant growth. Water stress performance is expressed as the sum of many parts of the plant from whole organs to the fine structure of the cytoplasm (Slayter, 1967; Hsiao et al., 1976). Measurement of leaf water potential characteristics integrates a wide array of water stress avoidance and tolerance mechanisms. Examination of plant turgor response is especially appealing because maintenance of turgor integrates both water supply and water loss mechanisms of the plant.

The wild sunflower species germplasm contains considerable genetic variability for many agronomic and physiological characteristics (Rogers et al., 1982; Thompson et al., 1981). Identification of physiologically adapted sunflower plant germplasm for potential water stress tolerance is necessary to increase sunflower production under variable environmental conditions. Very little information exists concerning the water relation characteristics of the perennial wild sunflower species and the potential they may have to improve stress tolerance in cultivated sunflower.

The present study was initiated to determine if leaf water characteristics (leaf water potential, osmotic potential, and turgor pressure potential) differ among several different wild perennial sunflower species (*Helianthus* spp.) under optimum growing conditions of full irrigation to provide baseline data for future studies.

## MATERIALS AND METHODS

A perennial sunflower species nursery was established from 1979—1984 at Bushland, Texas. The nursery was fertilized with 56 kg N $ha^{-1}$ in the spring of each year. Plots were furrow irrigated as needed to maintain maximum plant growth. The commercial hybrid 894 was planted to coincide with the perennial's phenology. The 28 perennial and one annual species examined in the present study are listed in *Table 1*.

The experiment was conducted during the summer of 1986.It had a completely randomized design with plots 1.5 by 7.5 m. Three replicated per species were used. Each replicate consisted of two randomly selected fully expanded upper leaves from different plants. Each plot was sampled at three different growth stages : vegetative, flowering and post-flowering.

Since the wild species are branched and multiheaded and have variable periods of development and flowering, definitions of maturity stages are not exactly the same as for cultivated sunflower. Also, not all species were at the same stage of maturity at one time. An attempt was made to remove maturity differences by defining maturity stages and sampling by these defined stages and not by set dates. The vegetative stage was defined as the stage when no buds were visible in the plot. Clusters of leaves were visible, but no buds had been formed. This stage is equivalent to a late V-stage of cultiva-

*Table 1*

**Sunflower species examined for water relations characteristics**

| Common name | Botanical name |
|---|---|
| *Wild sunflower* | |
| Dwarfish | *Helianthus pumilis* Nutt. |
| Arizona | *H. arizonesis* R. Jackson |
| Jagged-Edge | *H. laciniatus* Gray |
| Texas Blueweed | *H. ciliaris* DC. |
| Soft | *H. mollis* Lamb |
| Western | *H. occidentalis* ssp. *occidentalis* Ridd |
| Branching Western | *H. occidentalis* ssp. *plantagineus* (T&G) Heiser |
| Divergent Sunflower | *H. divaricatus* L. |
| Rough | *H. hirsutus* Raf |
| Eggert's | *H. eggertii* Small |
| Ten-Petal | *H. decapetalus* L. |
| Swollen | *H. strumosus* L. |
| Jerusalem artichoke | *H. tuberosus* L. |
| Stiff | *H. rigidus* ssp. *rigidus* (Cass.) Desf. |
| Cheerful | *H.* × *laetiflorus* Pers. |
| Giant | *H. giganteus* L. |
| Thick-Tooth | *H. grosseserratus* Martens |
| Nuttall's | *H. nuttallii* ssp. *nuttallii* T&G |
| Maximillian | *H. maximiliani* Schrader |
| Willow-Leaf | *H. salicifolius* Dietr. |
| California | *H. californicus* DC. |
| Small-Headed | *H. microcephalus* T&G |
| White-Leaf | *H. glaucophyllus* Smith |
| Smooth | *H. laevigatus* T&G |
| Smith's | *H. smithii* Heiser |
| Narrow | *H. angustifolius* L. |
| Imitative | *H. simulans* Watson |
| Odorous | *H. silphioides* Nutt. |
| *Commercial Sunflower* | |
| Hybrid 894 | *H. annuus* L*. |

* Indicates annual species ; all others are perennial.

ted sunflower as defined by Schneiter and Miller (1981). The flowering stage was defined as 50% of the heads in the population in flower (anthesis). This is the equivalent of an R—5.5 stage in cultivated sunflower. The fruiting stage was defined as the physiological maturity stage, which is equivalent to the R—9 stage in cultivated sunflower. Maturity differences resulted in samplings at four different dates. These dates were July 10 (DOY 191), August 11, (DOY 223), September 10 (DOY 253), and October 8 (DOY 281). Leaf water potential measurements were taken as soon after an irrigation as possible when plots were dry enough to sample (generally 3—5 days). Meteorological data (windspeed, solar radiation, air temperature, and vapor pressure deficit) for the sample dates and sampling period (1 300—1 500 hours) were taken adjacent to the experimental field *(Table 2)*.

The leaf water potential components that were measured were leaf water potential ($\psi_\omega$), osmotic potential ($\psi_\pi$), and turgor pressure potential ($\psi_p$). All measurements were made on clear days between 1 300 and 1 500 hours on randomly selected plants. Samples for $\psi_\omega$ measurements were taken from the center portion on one side of the leaf mid vein of fully developed upper leaves of the central branches below the terminal node.

The $\psi_\omega$ measurements were made using randomly assigned leafcutter psychrometers (0.24 $cm^2$ leaf disc). The psychrometers were transported in an ice chest to the laboratory immediately after all samples were taken. They were connected to a thermocouple psychrometer and allowed to equilibrate in a water bath for 3 hours at 30°C prior to reading. A psychrometer readout meter was used to measure the microvolt output of each psychrometer after a 5 second delay and 15 second cooling period. These outputs were converted to $\psi_\omega$ from individual psychrometer calibration against saturated KCl solutions of known molality. Periodic reading showed that values stabilized within 3 hours. Immediately after $\psi_\omega$ measurements were taken, the psychrometers were frozen for 60 seconds in liquid nitrogen and stored for 12 hours at —20°C, thawed at room temperature for 1 hour and then allowed to equilibrate in the water bath (30°C) for 3 hours for $\psi_\pi$ determinations. Turgor potential ($\psi_p$) was calculated as the difference between $\psi_\omega$ and $\psi_\pi$.

The psychrometric value after freezing and thawing is an estimate of the combined osmotic and matric potential components, $\psi_\pi$ and $\psi_m$. Matric potential becomes important only at very low relative water content (Boyer, 1967) and can be neglected. Measurements were not corrected for the dilution of symplastic solution by apoplastic water.

*Table 2*

**Environmental conditions (1 300—1 500 hours) on dates of measurements of leaf water status of wild perennial sunflower**

| Measurement date (calendar date) | Windspeed (m/s) | Solar radiation ($KJ/m^2/hr$) | Air temperature (°C) | Vapor pressure deficit (kPa) |
|---|---|---|---|---|
| July 10 (191) | 5.9 | 3 034 | 30 | 2.9 |
| August 11 (223) | 5.1 | 3 155 | 27 | 2.0 |
| September 10 (253) | 7.9 | 2 719 | 28 | 1.9 |
| October 8 (281) | 2.4 | 2 566 | 22 | 1.7 |

Data were analysed by analysis of variance, and means were compared using the least significant difference (LSD) test at the 0.05 probability level.

## RESULTS AND DISCUSSION

Analysis of variance indicated that there were significant differences at the 0.05 level of probability for all leaf water measurements between the three stages of maturity and among the species but not between replicates and subsamples within replicates. Environmental conditions on the days that leaf water measurements were taken are shown in Table 2.

### Leaf water potential

The $\psi_\omega$ of the perennial wild sunflower (averaged across all species) at the vegetative stage was higher than the cultivated annual sunflower, —1.17 MPa and —1.42 MPa, respectively. Individual wild species varied from a high of —0.24 MPa in *H. angustifolius* to a low of —2.07 MPa in *H. divaricatus*. About half of the perennial species had significantly different $\psi_\omega$ than the cultivated hibrid (Table 3). Several species of the series Corona-solis, such as *H.hirsutus, H. tuberosus, H. grosseserratus,* and *H. nuttallii* ssp. *nuttallii,* had low $\psi_\omega$ (*Table 3*). One interesting observation about these species is that in their natural habitat, they generally require a very moist soil to survive and have a high water requirements ; some grow in or near standing water Sobrado and Turner (1983 a) indicated that *H. nuttallii* ssp. *nuttallii* had a predawn $\psi_\omega$ of —0.3 MPa at the vegetative stage of growth under irrigation. Perennial species in the Ciliares series usually grow in more arid areas, and they had higher $\psi_\omega$. These species include *H. arizonesis, H. laciniatus,* and *H. ciliaris* (Table 3). Previous reports of $\psi_\omega$ in *H. ciliaris* are given by Blachet and Gelfi (1980). They reported predawn $\psi_\omega$ of —1.0 MPa and midday $\psi_\omega$ of —1.2 MPa.

At the flowering stage of maturity, the average $\psi_\omega$ was slightly lower than at the vegetative stage. Fifteen of the 28 perennial species had $\psi_\omega$ that were significantly different from the cultivated hybrid (Table 3). The $\psi_\omega$ averaged from —0.27 MPa for *H. angustifolius* to —2.30 MPa for *H. divaricatus*. All species in the Corona-solis series except *H. californicus* and *H. maximiliani* were not significantly different from the cultivated hybrid in $\psi_\omega$.

Leaf water potential averaged the lowest (—1.44 MPa) across all species at the fruiting stage of maturity (Table 3). This was very similar to the cultivated hybrid (—1.37 MPa). Ten of the 28 perennial species had significantly different $\psi_\omega$ than the cultivated hybrid. *Helianthus angustifolius* had the highest $\psi_\omega$ (—0.27 MPa) at thii stage, and *H. divaricatus* had the lowest level (—2.40 MPa). Kirkham et al. (1985) indicated that the seasonal average $\psi_\omega$ of a nonstressed cultivated sunflower crop was —1.61 MPa. In the present study, the seasonal average $\psi_\omega$ of the cultivated sunflower was —1.50 MPa. The wild perennial sunflower $\psi_\omega$ averaged —1.24 MPa, with considerable variation about the mean, depending on the species.

In cultivated sunflower and wild annual prairie sunflower (*Helianthus petiolaris*), there exists a relationship between stomatal conductance and midday $\psi_\omega$ (Sobrado and Turner, 1983 b). They found that stomatal conductance decreased almost linearly by 8 to 9 mm $s^{-1}$ $MPa^{-1}$ from 0.5 MPa to —2.0 MPa. At $\psi_\omega$ below —2.0 MPa, the change in conductance was negligible. Implications of these findings would be that the perennial species with low $\psi_\omega$ may maintain lower leaf conductance. In the present study, leaf conductance was not measured, so it is only conjecture at this point if that is what is happening in the perennial species. Data will need to be collected as the perennial species undergo moisture stress to better assess this relationship.

### Leaf osmotic potential

There is a strong interest in the importance of a decrease in $\psi_\pi$ on osmotic adjustment as an adaptive mechanism to water stress (Kramer, 1980). The average $\psi_\pi$ of the perennial species was —1.25 MPa at the vegetative stage of maturity. The cultivated sunflower had an average $\psi_\pi$ of —1.64 MPa. *Helianthus simulans* had the highest $\psi_\pi$ (—0.65 MPa), while *H. divaricatus* had the lowest (—1.74 MPa) (Table 3). Sixteen of the 28 perennial species had significantly different $\psi_\pi$ from the cultivated sunflower.

By the flowering stage, average $\psi_\pi$ of the perennial species had decreased to —1.39 MPa, while the cultivated sunflower decreased to —1.87 MPa. *Helianthus divaricatus* had the lowest $\psi_\pi$ (—1.93 MPa), while *H. simulans* had the highest (—0.72 MPa) (Table 3). Eighteen of the 28 perennial species had significantly different $\psi_\pi$ than the cultivated sunflower.

Leaf osmotic potentials were at their lowest level at the fruiting stage of maturity for the perennial species (—1.55 MPa). The cultivated sunflower $\psi_\pi$ increased slightly to —1.80 MPa. *Helianthus angustifolius* had the highest $\psi_\pi$ (—0.93 MPa), while *H. hirsutus* had the lowest (—2.07 MPa) (Table 3). Nine of the 28 wild perennial species had significantly different $\psi_\pi$ from the cultivated sunflower. In the present study, the average $\psi_\pi$ for the fully irrigated cultivated sunflower was —1.76 MPa. This is slightly lower than reported by Kirkham et al. (1985) for nonstressed cultivated sunflower (—1.49 MPa). Wild perennial sunflower species appear to be adjusting osmotically under full irrigation conditions, with a general decrease in $\psi_\pi$ as the species mature. Osmotic adjustment is considered a beneficial drought resistance character (Turner, 1979), allowing stomata to remain open at lower leaf water potentials and allowing root growth to continue as water deficits

*Table 3*

**Perennial wild sunflower species and commercial hybrid 894 leaf water potential ($\psi_\omega$), osmotic potential ($\psi_\pi$), and turgor pressure potential ($\psi_p$) for plants at three different stages of maturity grown under irrigation in 1986**

| Species | Vegetative | | | Flowering | | | Fruiting | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\psi_\omega$. | $\psi_\pi$. | $\psi_p$. | $\psi_\omega$. | $\psi_\pi$. | $\psi_p$. | $\psi_\omega$. | $\psi_\pi$. | $\psi_p$. |
| MPa | | | | | | | | | |
| Series *Pumili* and *Ciliares* | | | | | | | | | |
| *pumilus* | —0.98 | —1.12 | 0.14 | —1.09 | —1.24 | 0.15 | —0.87 | —1.31 | 0.44 |
| *arizonesis* | —1.08 | —1.53 | 0.45 | —1.09 | —1.70 | 0.61 | —1.46 | —1.62 | 0.16 |
| *laciniatus* | —0.80 | —1.26 | 0.46 | —0.88 | —1.40 | 0.52 | —1.50 | —1.60 | 0.10 |
| *ciliaris* | —0.46 | —1.05 | 0.59 | —0.51 | —1.17 | 0.66 | —0.81 | —1.39 | 0.58 |
| Series *Corona-solis* | | | | | | | | | |
| *mollis* | —1.19 | —1.37 | 0.18 | —1.32 | —1.52 | 0.20 | —1.33 | —1.61 | 0.28 |
| *divaricatus* | —2.07 | —1.74 | —0.33 | —2.30 | —1.93 | —0.37 | —2.40 | —2.01 | —0.39 |
| *hirsutus* | —1.53 | —1.67 | 0.14 | —1.70 | —1.85 | 0.15 | —2.20 | —2.07 | —0.13 |
| *eggertii* | —1.41 | —1.36 | —0.05 | —1.56 | —1.51 | —0.05 | —1.23 | —1.51 | 0.28 |
| *decapetalus* | —1.40 | —1.38 | —0.02 | —1.56 | —1.54 | —0.02 | —1.37 | —1.52 | 0.15 |
| *strumosus* | —1.46 | —1.15 | —0.31 | —1.62 | —1.27 | —0.35 | —1.66 | —1.47 | —0.19 |
| *tuberosus* | —1.51 | —1.32 | —0.19 | —1.68 | —1.47 | —0.21 | —1.91 | —1.67 | —0.24 |
| *giganteus* | —1.37 | —1.17 | —0.20 | —1.53 | —1.32 | —0.21 | —1.77 | —1.67 | —0.10 |
| *grosseserratus* | —1.61 | —1.59 | —0.02 | —1.80 | —1.77 | —0.03 | —1.97 | —2.04 | 0.07 |
| *nuttallii* ssp. *nuttallii* | —1.63 | —1.55 | —0.08 | —1.82 | —1.73 | —0.09 | —1.66 | —1.50 | —0.16 |
| *maximiliani* | —0.99 | —1.17 | 0.18 | —1.10 | —1.30 | —0.20 | —1.77 | —1.33 | —0.44 |
| *salicifolius* | —1.27 | —1.64 | 0.37 | —1.41 | —1.82 | —0.41 | —1.85 | —1.75 | —0.10 |
| *californicus* | —0.58 | —1.05 | 0.47 | —0.65 | —1.17 | —0.52 | —0.80 | —1.08 | 2.28 |
| Series *Microcephalii* | | | | | | | | | |
| *microcephalus* | —0.99 | —1.18 | 0.19 | —1.03 | —1.31 | 0.28 | —1.44 | —1.71 | 0.27 |
| *glaucophyllus* | —0.73 | —1.06 | 0.33 | —0.81 | —1.18 | 0.37 | —1.63 | —1.58 | —0.05 |
| *laevigatus* | —1.12 | —1.26 | 0.14 | —1.24 | —1.40 | 0.16 | —1.50 | —1.59 | 0.09 |
| *smithii* | —0.70 | —0.77 | 0.07 | —0.78 | —0.85 | 0.07 | —1.82 | —1.37 | —0.45 |
| Series *Atrorubentes* | | | | | | | | | |
| *occidentalis* ssp. *occidentalis* | —1.09 | —1.48 | 0.39 | —1.22 | —1.64 | 0.42 | —1.51 | 1.64 | 0.13 |
| *occidentalis* ssp. *plantagineus* | —0.76 | —1.20 | 0.44 | —0.85 | —1.33 | 0.48 | —1.25 | —1.53 | 0.28 |
| *rigidus* ssp. *subrhomoboideus* | —0.83 | —1.18 | 0.35 | —0.92 | —1.31 | 0.39 | —0.93 | —1.22 | 0.29 |
| × *laetiflorus* | —1.13 | —1.29 | 0.16 | —1.26 | —1.44 | 0.18 | —1.81 | —1.75 | —0.06 |
| *silphioides* | —0.47 | 1.06 | 0.59 | —0.58 | —1.20 | 0.62 | —0.77 | —1.60 | 0.83 |
| Series *Angustifolii* | | | | | | | | | |
| *angustifolius* | —0.24 | —0.77 | 0.53 | —0.27 | —0.86 | 0.59 | —0.27 | —0.93 | 0.66 |
| *simulans* | —0.78 | —0.65 | —0.13 | —0.87 | —0.72 | —0.15 | —0.68 | —0.18 | 0.50 |
| Means (overall) | —1.07 | —1.25 | 0.18 | —1.19 | —1.39 | 0.20 | —1.44 | —1.55 | 0.11 |
| L.S.D. (0.05) (overall) | 0.42 | 0.34 | 0.09 | 0.54 | 0.38 | 0.08 | 0.49 | 0.38 | 0.20 |
| CV (%) (overal) | 26.1 | 16.6 | 29.6 | 27.3 | 16.7 | 34.1 | 21.0 | 14.9 | 31.8 |
| Commercial hybrid 894 | | | | | | | | | |
| Hybrid 894' | —1.42 | —1.64 | 0.22 | —1.72 | —1.87 | 0.15 | —1.37 | —1.80 | 0.43 |

+ Infrageneric classification follows Schilling and Heiser, 1981

develop (Turner and Jones, 1980). We see considerable variation in $\psi_\pi$ in the perennial species. How the perennial species adjust their $\psi_\pi$ as they undergo water stress will have to be studied further in future studies.

**Leaf pressure (turgor) potential**

It is generally agreed that water movement is controlled by the water potential and cell enlargement by the turgor or pressure. Now there is increasing interest in the possibility that reduced turgor is the factor directly affecting metabolic processes in stressed plants (Kramer, 1980). In the vegetative stage of growth, the average $\psi_p$ of the perennial species was 0.18 MPa, compared to 0.22 MPa for the cultivated sunflower. Twenty-one of the 28 perennial species had $\psi_p$ significantly different from the cultivated sunflower (Table 3). Leaf turgor pressure varied from a high of 0.59 MPa in *H. ciliaris* and *H. silphioides* to a low in *H. divaricatus* (—0.33 MPa). It is interesting that *H. ciliaris* and *H. silphioides* had a high positive $\psi_p$ because in their natural habitats, they grow in dry soils and are subjected to periods of water stress. Under irrigated conditions, the root systems of these species may allow them to extract adequate water from soil and maintain a high positive $\psi_p$. The lowest $\psi_p$ was found in *H. divaricatus* (—0.33 MPa). This species grows in dry open habitats (Rogers et al., 1982). Why this species maintains such a negative $\psi_p$ under irrigation is not known. Several species in the Corona-solis series maintained a negative $\psi_p$ at the vegetative stage of growth (Table 3). Such species as *H. strumosus, H. tuberosus, H. giganteus, H. grosseserratus* and *H. nuttallii* ssp. *nuttallii* in their natural habitat require high levels of soil water (i.e. some grow in standing water). The fully irrigated conditions of the experiment, which are adequate for the cultivated sunflower, may not have been adequate for the demands of these perennial wild species. Nine of the 28 perennial species had negative $\psi_p$ at the vegetative stage of growth. These perennial species were not able to osmotically adjust to maintain a positive $\psi_p$, even under irrigated conditions.

Leaf turgor pressure potential at the flowering stage had increased slightly in the perennial species 0.20 MPa and decreased in the cultivated sunflower to 0.15 MPa. Twenty-one of the 28 perennial species had significantly different $\psi_p$ compared to the cultivated sunflower. The same 9 species that had negative $\psi_p$ at the vegetative stage had negative $\psi_p$ at the flowering stage. *Helianthus divaricatus* had the lowest $\psi_p$ (—0.37 MPa), while *H. ciliaris* had the highest (0.66 MPa). It appears that as some of the perennial species mature, they do not change their $\psi_p$, at least in the above mentioned species, to maintain a positive $\psi_p$.

At the fruiting stage of maturity of perennial species, the average $\psi_p$ reached its lowest level (0.11 MPa). The cultivated sunflower had a $\psi_p$ of 0.43 MPa. This oscillation in the $\psi_p$ of cultivated sunflower is similar to that reported by Kirkham et al. (1985). Nineteen of 28 perennial species had significantly different $\psi_p$ from the cultivated sunflower. Eleven of the 28 perennial species had negative $\psi_p$. Nine of the perennial species that had negative $\psi_p$ at the vegetative and fruiting stages of growth still had negative $\psi_p$ at maturity. The increase in the number or perennial species with negative $\psi_p$ may have results because the plants were senescing and no longer required a positive turgor pressure for cell growth.

In a glasshouse study, Sobrado and Turner (1983 b) indicated that *H. annuus* (cultivated) and *H. petiolaris* ssp. *fallax* (annual prairie sunflower) differ in their ability to osmotically adjust to water deficits. They suggest that some of the observed osmotic adjustement may have resulted from a decrease in cell size while solute amounts constant. In contrast, a field experiment of Sobrado and Turner (1983 a) concluded that there was little difference in tissue water relations (elasticity, apoplastic water content, relative water content at zero turgor, and osmotic potential at zero turgor) between wild (*H. petiolaris* ssp. *fallax* and *H. nuttallii* ssp. *nuttallii*) and cultivated sunflower as the plants undergo stress. Morizet et al. (1984) evaluated an interspecific hybrid between cultivated annual *H. annuus* and *H. argophyllus*. They concluded that plant of the *argophyllus* type plants wilted more rapidly and at higher leaf water potential than the cultivated *annuus* type. Further studies will be needed fully assess the osmotic adjustment and resulting turgor influence on cell growth, size, and solute content as the perennial species undergo plant water stress.

## CONCLUSIONS

The present study indicates that there is considerable variability for leaf water relation characteristics among the wild perennial species. In general $\psi_\omega$ and $\psi_\pi$ of the perennial species decreased as the plants matured. Turgor pressure increased until the flowering stage of the maturity, then decreased. In the cultivated sunflower, $\psi_\omega$, $\psi_\pi$ and $\psi_p$ decreased until the flowering stage, then increased at the fruiting stage. Some perennial species maintain a negative $\psi_p$, even under irrigation. It is conceivable that as these species undergo any type of strese, they will lower their $\psi_\omega$ even more. While this may suggest that there may be little potential for improving the drought resistance of cultivated sunflower using these perennial species based on leaf water relations, this should not, of course, preclude the possibility that other perennial species with other drought resistance characters, such as deep roots or rapid root development after rain, may be available in some of the xerophytic wild perennial sunflowers. In the present study, the perennial species were not studied as they undergo stress ; this will be the subject of future studies.

## REFERENCES

Blanchet R., Gelfi N., 1980. *Caractères Xérophytiques de Quelques Espèces d'Helianthus Susceptibles d'être Utilisés pour Améliorer l'Adaption aux Conditions Seches du Tournesol Cultivé (Helianthus annuus)*, C.R. Acad. Sci. Paris, Ser. D 290, 279—282.

Boyer J. S., 1967. *Matric Potential of Leaves*, Plant Physiol., 42, 213—217.

Hsiao T.C., Acevedo E., Fereres E., Henderson D.W., 1967. *Water Stress, Growth, and Osmotic Adjustment*, Philos. Trans. R. Soc. Lond., Ser. B 273, 479—500.

Kirkham M.B., Redelphs M.S., Stone L.R., Kanemasu E. T., 1985. *Comparison of Water Status and Evapotranspiration of Six Row Crops,* Field Crops Res., 10, 257—268.

Kramer P. J., 1980. *Drought, Stress and the Origin of Adaptations,* pp. 7—20. In : N.C. Turner, P.J. Kramer (eds.), Adaptation of Plants to Water and High Temperature Stress, John Wiley and Sons, New York.

Morizet J., Cruiziat P., Chatenoud J., Picot D., Leclercq P., 1984. *Improvement of Drought Resistance in Sunflower by Interspecific Crossing with a Wild Species, Helianthus argophyllus : Methodology and First Results.* Agronomie, 4(6), 577—585.

Rogers C. E.,Thompson T. E.,Seiler G. J., 1982. *Sunflower Species of the United States.* Natl. Sunflower Assoc., Bismarck, NS, 75 pp.

Schilling E.E., Heiser C.B., 1981. *Infrageneric classification of Helianthus (Compositae).* Taxon., 30(2), 393—403.

Schneiter A.D., Miller J. F., 1981. *Description of sunflower growth stages.* Crop Sci., 21, 901—903.

Slayter R. O., 1967. *Plant-water Relationship.* Academic Press, New York, 366 pp.

Sobrado M.A., Turner N. C., 1983 a. *Influence of Water Deficits on the Water Relations Characteristics and Productivity of Wild and Cultivated Sunflower.* Aust. J. Plant Physiol., 10, 195—203.

Sobrado M.A., Turner N. C., 1983 b. *A Comparison of the Water Relations Characteristics of Helianthus annuus and Helianthus petiolaris when subjected to water deficits.* Oecologia, 53, 309—313.

Thompson T. E., Zimmerman D. C., Rogers C. E., 1981. *Wild Helianthus as a Genetic Resource, Field Crops Res., 4, 333—343.*

Turner N. C., 1979. *Drought Resistance and Adaptation to Water Deficits in Crop Plants,* pp. 343—372. In : H. Musselo, R.C. Staples (eds.), Stress Physiology in Crop Plants, John Wiley and Sons, New York.

Turner N. C., 1981. *Designing Crops for Dryland Australia : Can the Deserts Help Us ?* J. Aust. Inst. Agric. Sci., 47, 29—34.

Turner N. C., Jones M. M., 1980. *Turgor Maintenance by Osmotic Adjustment : A Review and Evaluation,* pp. 87—103. In : N.C. Turner, P.J Kramer (eds.), Adaptation of Plants to Water and High Temperature Stress, John Wiley and Sons, New York.

## RELATIONS PLANTE — EAU CHEZ LES ESPÈCES SAUVAGES VIVACES DE TOURNESOL EN REGIME IRRIGUÉ

### *Résumé*

En ce qui concerne les caractères des relations plante—eau il existe une considérable variabilité chez les espèces sauvages vivaces de tournesol. En général, le potentiel hydrique du feuillage et le potentiel d'osmose des espèces ont diminué à mesure que la plante atteignait la maturité. La pression de la turgescence augmente jusqu'à la phase de floraison et diminue plus tard. Chez le tournesol cultivé, le potentiel hydrique du feuillage, le potentiel d'osmose et le potentiel de la pression de turgescence ont diminué jusqu'à la floraison pour augmenter plus tard jusqu'à la formation des graines. Chez certaines espèces vivaces la pression de turgescence reste négative même en régime irrigué. Il est évident que lorsque ces espèces sont soumises à n'importe quel stress, elles réduisent d'avantage encore le potentiel hydrique des feuilles. Cette constatation prouve que les possibilités d'améliorer la résistance à la sécheresse des variétés cultivées de tournesol partant des espèces vivaces, en tenant compte des relations feuille eau, sont réduites. Il ne faut pourtant pas éliminer la possibilité de trouver dans les formes sauvages de tournesol de type xerophytique caractères de résistance à la sécheresse, par exemple des racines profondes ou un développement rapide des racines après la pluie.

## EVALUACION DE LAS RELACIONES AGUA—PLANTA DE ESPECIES PERENNES DE GIRASOL BAJO RIEGO

### *Resúmen*

La presente publicación muestra que hay una variación considerable para caracteristicas de relaciones hidricas en la hoja entre las especies silvestres perennes. En general el potencial de aqua en la hoja y el potencial osmótico de las especies perennes decreció con la maduración de las plantas. La presión de turgencia se incrementó hasta el estado de floración y maduración, decreció entonces. En el girasol cultivado, el potencial de aqua en la hoja, potencial osmótico y presión de turgencia disminuyeron hasta el estado de floración, y entonces aumentaron en el estado de fructificación. Algunas especies perennes mantienen una presión de turgencia negativa, incluso bajo riego. Es concebible que si estas especies experimentaron cualquier tipo de estrés, bajarian aún más el potencial de aqua en la hoja. Mientras esto puede sugerir que hay poco potencial para mejorar la resistencia a la sequia del girasol cultivado, utilizando estas especies perennes en base a las relaciones hidricas de la hoja, esto no deberia, desde luego, excluir la posibilidad de que otra especie perenne con otras caracteristicas de resistencia a sequia, como profundidad o rápido desarrollo radicular después de la lluvia, puedan existir entre las especies silvestres xerofitas de girasol.