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EFFECT OF PERIODS OF MOISTURE STRESS DURING VARIOUS PHASES OF GROWTH OF SUNFLOWERS IN THE GREENHOUSE

J. L. MURIEL and R. W. DOWNES
(Spain)

Water relations are particularly important in many regions which have only recently expanded sunflower production where crops are grown almost completely on stored soil moisture, and where rainfall variability is high, periods of moisture stress must be anticipated in view of the high water requirements of sunflower (Downes, 1974).

Extended periods of water deficit have been shown to reduce yield (Sionit et al, 1973) and even short periods of stress during flower and seed development have an adverse effect (Robelin, 1967). Since the rate of expansion of leaf area is reduced by water stress conditions (Robelin, 1967), it appears important that the significance of leaf area in determining yield be defined.

Because the vegetative stage before floral initiation is sensitive to adverse conditions in sorghum (Downes, 1972 a)) it appeared desirable to determine the effect of stresses during the early development of sunflowers although one might expect plants to compensate for early deficiencies during subsequent growth.

The preliminary study reported here was conducted in pots in a greenhouse at Córdoba. Moisture stresses were applied during various phases of growth to determine their effect on seed yield on the one hand, and the degree of compensation for, and adaptation to adverse conditions, on the other.

MATERIALS AND METHODS

Plants of the sunflower variety Morden 1267 were established one per pot, in soil plastic pots 17 cm in diameter. The greenhouse was unheated throughout the experiment conducted in winter and spring at Córdoba when temperature and radiation conditions were low.

Three moisture treatments were applied :

A Control, sufficient water to meet demand (0 bars water potential)

B Approximately 0.6 of the water in A (—2 bars)

C Approximately 0.2 of the water in A (—8 bars)

During the course of the experiment pots were wrapped in plastic to minimize evaporation from the pot. Water was added on alternate days to maintain the moisture conditions about the mean.

These treatments were applied during three phases of growth :

I after germination until floral initiation.

II from initiation to flowering.

III from flowering to maturity.

The various combinations used are shown in table 1. Plants were harvested on five occasions during the experiment and at maturity. There were 4 replications. At harvest, the area of living leaf tissue was determined, and at the end of the experiment, the weight of stem and seed produced and the plant height were recorded, and the oil percentage of the seed determined.

Table 1

Water potential in pots during 3 phases of growth and their effect on seed yield and on water use efficiency

Treatments*) during phases**)			Seed yield relative to control (AAA)	Water use efficiency, g seed produced per mm of water, × 10^3
I	II	III		
A	A	A	100	29
B	B	B	58	26
C	C	C	13	17
B	A	A	72	21
C	A	A	67	21
A	B	A	48	16
A	C	A	33	13
A	A	B	95	34
A	A	C	61	30
B	B	A	59	20
C	C	A	34	15
A	B	B	59	25
A	C	C	0	0
B	A	B	72	27
C	A	C	28	17

*) Water potential (bars); (A, O; B, — 2; C, —8)
**) Phases: I, to floral initiation; II, from initiation to flowering; III, from flowering to maturity.

RESULTS AND DISCUSSION

Stress conditions prior to floral initiation did not have a conspicuous effect at the time, merely a reduction in leaf area from 265 cm^2 per plant in plants with adequate water, to 205 cm^2 in the case of those with a water potential of —8 bars.

During the period between initiation and flowering, normally a time of rapid growth, the effects were much more pronounced. Leaf area at flowering was greatest in plants that had never experienced stress. Plants which had experienced stress conditions before initiation responded well to subsequent conditions of adequate moisture but their ultimate leaf area never exceeded about 75% of that of controls. Leaf development was poor on plants exposed to a soil water potential of —8 bars during the initiation to flowering phase (figure 1).

Overall, stress conditions induced leaf wilting wich reduces photosynthesis (Pîrjol-Săvulescu et al, 1972). Consequently, lack of assimilate would account for the reduction in size of new leaves produced under stress conditions, so that relaxation of stress conditions would not be expected to permit recovery of the lost potential. At flowering, all leaves have expanded so that no further compensation for reduced leaf area induced by earlier treatments is possible. However wilted leaves became turgid and presumably more effective when more water became available.

In plants receiving various treatments before flowering, and water potentials of 0 or —2 bars after flowering, there was a clear relationship between leaf area at flowering and seed yield (figure 1). Clearly seed

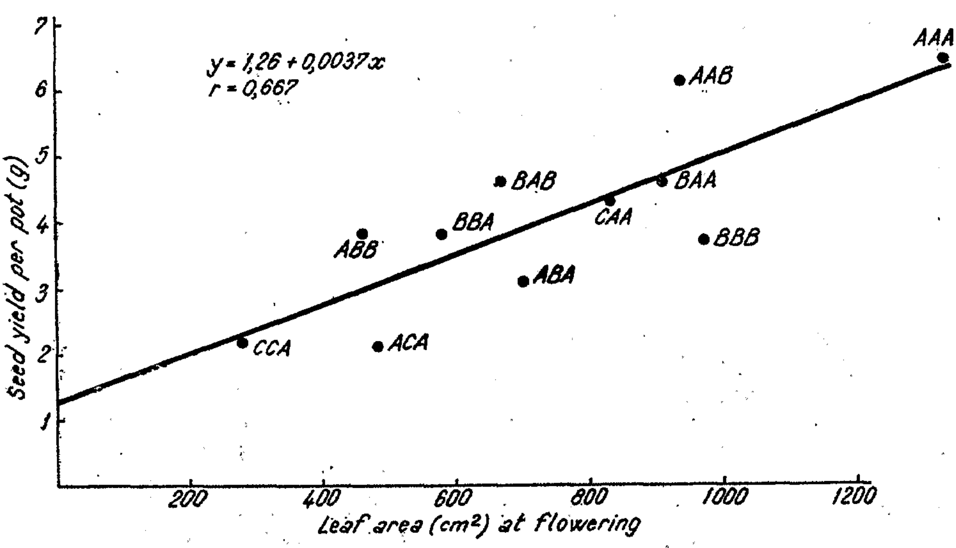

Fig. 1 — The relationship between leaf area at flowering and seed yield.

production is dependent on current assimilate though stem weight tended to decrease during the seed filling period. When plants experienced —8 bars water potential after flowering, leaf area at flowering can not be expected to have a strong bearing on seed production, so that data from these treatments are excluded from figure 1.

In contrast to the effect on leaf area, treatments had little effect on plant height except in the case of —8 bars continuously from germination to flowering. Here the plants reached only 33 cm compared with a mean of 70 cm in other treatments. However genetic variability for height in the variety made it difficult to detect small effects due to treatments.

The effects of stress treatments in reducing yield is shown in table 1. Stress in the preinitiation phase resulted, much later, in a 30% decrease in seed yield. The effect of limited water supply between initiation and flowering gave a 60% reduction in yield as in the field experiments (Muriel et al, 1974). After flowering, a water potential of —2 bars did not reduce yield though a severe deficit had a greater effect. Extended periods of severe moisture stress reduced yield by 66 to 100% depending on the duration and time of application.

Stress conditions had a consistent effect on oil percentage only after flowering, plants with adequate water producing 45% oil while those at — 8 bars produced 39%.

Stress conditions had a generally adverse effect on efficiency of water usage, in terms of weight of seed produced per unit of water used (table 1).

There was a little difference in efficiency if adequate water was available, or if plants were continuously exposed to a water potential of —2 bars, plant development apparently being in balance with the environmental conditions.

Efficiency dropped slightly if stresses were applied before floral initiation, and substantially if water was deficient between initiation and flowering. After flowering, stress conditions did not reduce efficiency. Plants apparently adapted to extended periods of stress though efficiency was not as great as in control treatments.

CONCLUSIONS

Although the sunflower uses water rapidly and inefficiently in comparison with other species when water is not limiting (Downes, 1974), so that water reserves may be depleted rapidly under conditions of high evaporative demand, the plant has the ability to withstand periods of severe moisture stress. However severe stress conditions at any stage of growth reduce leaf area. This in turn reduced photosynthetic capacity and ultimately, seed yield. With relaxation of stress conditions, partial but not complete compensation is observed. Thus the plant is not drought resistant.

In the field situation, studies on water stress in sunflowers have implications in both agronomy and plant breeding. The adverse effects of stress can be avoided or minimized by agronomic means if crops are grown when soil moisture reserves are adequate and/or when rainfall is normally expected. Cool growing conditions decrease the rate of water loss as can appropiate populations and row spacings.

Although the plant breeder can attempt to select genotypes which are better able to tolerate moisture stress, it may prove easier to develop types which avoid stress. When stresses can be reliably predicted late in the season, early maturing genotypes might be used to escape adverse conditions.

On the other hand, effects of high temperature (Downes, 1974) and or moisture stress (Pîrjol-Săvulescu et al, 1972) in reducing yield and oil content, provide hazards for plant breeders making selection in nurseries. Either adequate checks are necessary, or, depending on selection aims, sowing date can be modified and irrigation supplied so that comparative oil yields of plants in breeding nurseries are not confounded by chance conditions (Downes, 1972 b).

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