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Effects on yield, net photosynthesis, and leaf duration, of a well-defined water stress applied on sunflower from beginning flowering to maturity

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ABSTRACT

Water availability is a major factor of sunflower yield elaboration. So, it is of importance to specify the response of some cultivars to water stress and to investigate water stress adaptation.

A range of moisture stress levels (-0.3 to -1.8 MPa) was applied at "bud 1cm" stage to plants grown in greenhouse. Soil water potential was maintained constant by using a new system (Snow and Tingey,1985) based on a limitation of the capillarity flow through a special device of column sustaining the roots. The matrical potential at the root surface depends on the distance between roots and nutritive medium, on the transpiration rate of the plant, and on the hydraulic conductivity of the substrate filling the column.

A 34 to 100% decrease in yield, depending on both the water stress level and the cultivar, was observed.

An unusual reduction of harvest index occured in all moisture stress levels. A dramatic decrease in both leaf area (especially during reproductive period) and in total net photosynthesis were noted, wich explained the large decline in grain filling due to water stress.

Soil moisture is a major factor of sunflower seed production. Numerous field studies have focused on the effects of water stress on sunflower yield, but forecasting drought acclimation is still difficult (Quinones et al,1990) and mechanisms of drought adaptation are not well known yet. In fact, little information is available about the influence of a well-defined water deficit (soil water potential) on sunflower.

The objective of this study is to specify the response of 2 cultivars (Flamme and Viki; the former expected to be more tolerant than the latter) to water stress by controlling soil water potential.

MATERIAL AND METHODS

Water deficit was applied at "bud 1cm" stage by using the Snow and Tingey system (1985) (Fig.1). From this stage to maturity, the matric potential at root surface was maintained constant. Matric potential was assessed by predawn water potential, so the potential was -0.3 MPa for controls.

RESULTS

In our experiment, yield was strongly affected by drought (Fig.2). On average, yield decreased by 80%. For mild water deficit (water potential ranged from -0.45 to -0.6 MPa), yield reduction already reached 70%.

The negative effect of water privation appeared to be higher on Flamme.

Harvest Index (H.I.) was positively correlated with soil water potential (Fig.3). Due to water stress, H.I. decreased by 60% for Flamme and by 45% for Viki, which explained the difference in yield observed between these cultivars.

Leaf Area Duration (L.A.D.) which stands for the hability of leaf canopy to receive light is presented in Fig.4.

Decreasing soil water potential decreased L.A.D. . For both cultivars, L.A.D. appeared to be very sensitive to the water stress, but the inhibitory effect of drought was higher on Flamme.

The ratio Total Dry Matter/L.A.D. (T.D.M./L.A.D.) stands for the global photosynthesis per area for the whole plant development (Fig.5). The depressive effect of water deficit on T.D.M./L.A.D. indicated a reduction in photosynthesis due to drought.

Thus, both photosynthesis per area and leaf area declined under water stress which induced a decrease in total dry matter production.

DISCUSSION AND CONCLUSION

Several authors reported an increase in H.I. due to water stress. Thus the decrease in T.D.M. was partly compensated and the decline in yield wasn't too important (Turner and Rawson,1982; Connor et al,1985; Blanchet et al,1990).

In our experiment, drought induced a reduction of H.I. which accounted for the large decrease in yield. The low H.I. observed under water deficit was caused by the dramatic reduction of L.A.D. after flowering. This decrease in L.A.I. and its duration, which is an adaptation to drought, appeared to be very depressive on yield.

Usually, in field conditions, drought doesn't induce a such important decrease in yield. In our experiment, soil water potential was constantly applied on the whole rooting system; it might explain the marked effect of water deficit. In fact, in field conditions, the crop adaptation to drought, especially leaf area reduction and root prospection increase, leads to a reduction in the soil water constraint sustained by the whole plant. Moreover, the plants were grown in a glasshouse during summer, and may have suffered of extreme climate values (temperature, relative humidity).

On contrast with yield observations (Serieys, person. com.), in our experiment, Viki was more tolerant to drought than Flamme. In potting mixture, the increase in root prospection during water deficit couldn't operate. The discrepency noted between field and glasshouse experiments could be attributed to this phenomenon.

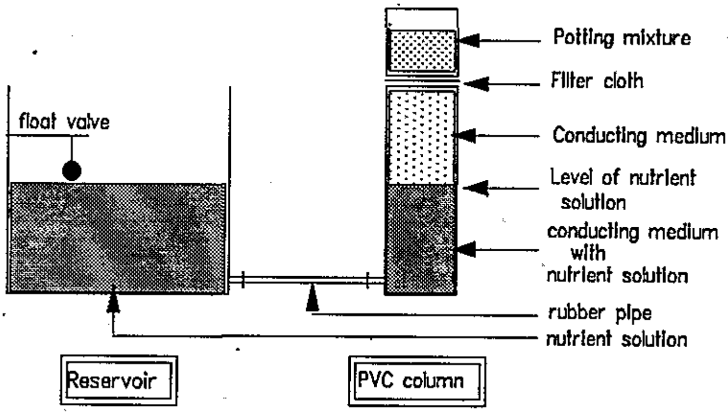

Fig.1: Snow and Tingey system
The plant grows in a potting mixture above a PVC column. The roots are stopped by a Nylon cloth. Nutrient solution flows to the roots by capillarity.
The matric potential at the root surface is governed by:
- the distance from the roots to the nutrient solution (levels of solution inside the reservoir and the column equilibrate one another; the level of the former is controlled by a float valve)
- the hydraulic conductivity of the conducting medium
- the transpiration rate of the plant

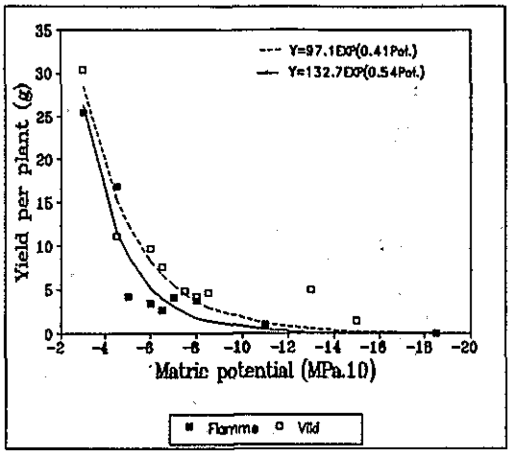

Fig.2: Effects of water stress on yield

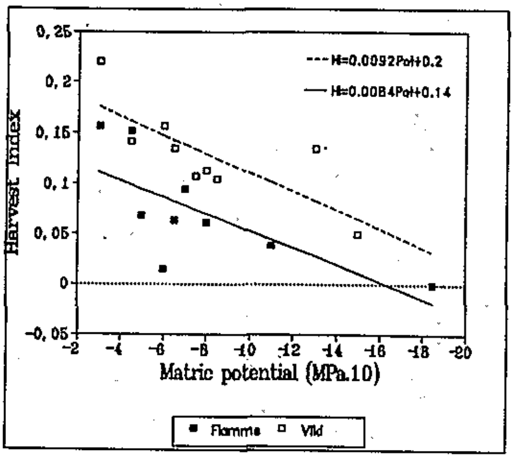

Fig.3: Effects of water stress on Harvest Index (H.I.)

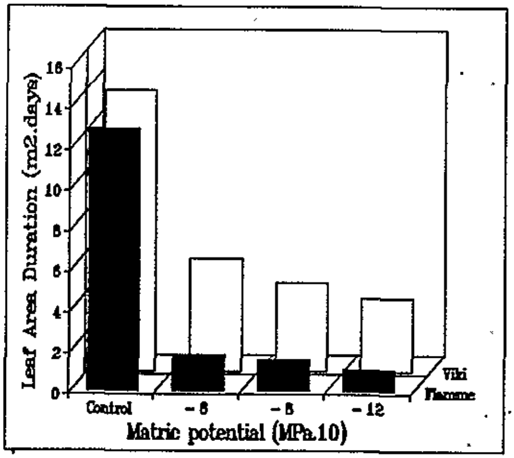

Fig.4: Effects of water stress on post flowering Leaf Area Duration (L.A.D.)

Fig.5: Effects of water stress on Total Dry Matter/Leaf Area Duration (T.D.M./L.A.D.)

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