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Effect of Antitranspirant Sprays on Water Relations, Growth and Yield of Irrigated Sunflower in a Semi-Arid Environment.

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SUMMARY

Sunflower hybrids, Hysun 31, Suncross 52 and Suncross 150, were grown under irrigation with and without foliar applications of antitranspirant ('Mobilcer C') during flowering-grainfilling period. Plants subjected to sprays grew taller but the leaf area was reduced by the treatment.

Antitranspirant sprays (ATS) were found to be effective in maintaining higher leaf water potentials by increasing leaf diffusive resistance. Decreases of up to 18% in water use at any one period were observed due to the spray treatment without showing any adverse effect on final grain yields. ATS resulted in yield increases in all cultivars. These results indicate that antitranspirants can be used to enhance crop yields by improving plant water status during critical stages of growth.

INTRODUCTION

In Australia sunflower is grown mostly in the semi-arid regions which are characterised by increased temperature and radiation during flowering to grain development of the crop. The evaporative demand of the crop increases due to the combined effect of increasing radiation, temperature and low relative humidity. A high transpiration rate during this time of growth adds considerable variation to the daily plant water potential (Turner and Begg 1981; Jones and Zur 1984) which could adversely affect the reproductive development, thereby reducing potential crop yields.

Water stress results from an imbalance of supply of water by the soil and the amount needed by the plant as determined by atmospheric demand. Although the long term reductions in plant water potentials are confined to the effects of decreasing soil water potentials, the daily cycle of water deficit is controlled by the plant's stomatal mechanism (Cawood 1980; Downton, Grant and Loveys 1988). In view of the relative insensitivity of sunflower stomata to leaf water deficits (Cawood 1980), yield reductions are more than likely due to the inability of the plants to sustain optimum plant water potentials during periods of high evaporative demand.

Antitranspirant sprays have proven to be beneficial in increasing the water use efficiency of many dryland crops due to their effects on the stomatal mechanism of plants (Rademacher, Maisch, Liessegang and Jung 1987; Han 1990). Very little is known about the possible effects of antitranspirants on the water relations of irrigated crops.

The study reported in this paper examines the effect of antitranspirant sprays on the water relations, growth and yield of irrigated sunflower grown under semi-arid conditions.

MATERIALS AND METHODS

The study was carried out at the Victorian College of Agriculture and Horticulture - Dookie Campus in Northern Victoria. The average annual evaporation ranges from 1200 - 1300 mm, 80% of which occurs from October through March. Flowering and grain development of irrigated sunflowers grown in this region are affected by the severity of the extreme evaporative demands during the February-March period. (Fig. 1).

Sunflower cultivars Hysun 31, Suncross 52 and Suncross 150 were grown in the glasshouse and in the field. The field study was conducted on red-brown earth - Dr. 2.33 (Northcote 1984). Soil used for the glasshouse experiment was collected from the field site. Each pot in the glasshouse contained two plants.

Plants were supplied with all necessary nutrients at the time of sowing. Tensiometer readings were used to apply water to the plants in the field experiment.

Treatments included antitranspirant sprays (ATS): 'Mobilicer C' -wax emulsion produced by Mobil Oil Australia Ltd. diluted with water to 1:5 ratio) on plants two times, one at flowering (73 days after sowing) and the other a fortnight after this application. The control group within each cultivar was sprayed with an equivalent quantity of water at both times. The cultivar-spray treatments were factorially combined and arranged in a completely randomised design with four replications. A similar procedure was applied for the conduct of the field experiment.

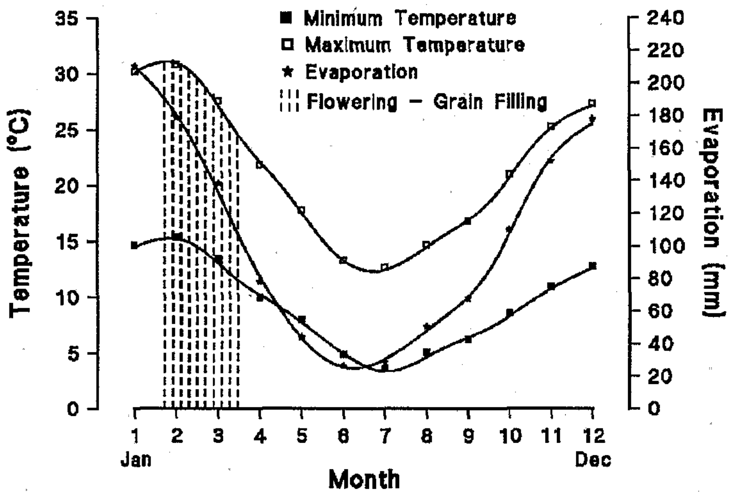

Fig. 1. Mean monthly minimum and maximum temperature, and evaporation from 1978 to 1991 at VCAH–Dookie

Water use by plants in the glasshouse experiment was calculated from loss in weight of pots over each weekly interval during flowering-grainfilling period. Adjustments were made to the addition of water to compensate the differences of pots due to weight of plants.

Water potential and leaf diffusive resistance were measured on one of the plants from each pot using the procedure as outlined by Parameswaran, Graham and Aspinall 1984; and leaf area was calculated using leaf area, maximum width and length correlations (Pereyara, Farizo and Cardinali 1982). Grain yields were assessed at maturity.

RESULTS

Plants treated with antitranspirants grew significantly taller compared to the untreated control although the leaf area was reduced by the spray (Table 1). There were significant differences between cultivars in relation to height and green leaf area.

The effects of antitranspirant sprays on the leaf water potential and diffusive resistance showed some interesting results (Table 2). The diffusive resistance of leaves was significantly increased in all treated plants indicating changes in stomatal sensitivity due to the spray. There was a corresponding increase in the leaf water potentials although these differences were not statistically significant.

Table 1. Plant height and leaf area per plant of various cultivars at flowering as affected by antitranspirant sprays (glasshouse experiment)

	Cultivar			
	Hysun 31	Suncross 52	Suncross 150	Mean
Plant height (cm)				
No spray	110.7	112.9	92.6	105.4
ATS	120.8	120.3	107.6	116.2
Mean	115.8	116.6	100.1	
LSD (P = 0.05)	Spray: 4.1; Cultivar: 5.1; Interaction: n.s.			
Leaf area (cm^2)				
No spray	1969	1817	1631	1806
ATS	1235	1535	1157	1309
Mean	1602	1676	1394	
LSD (P = 0.05)	Spray: 160; Cultivar: 196; Interaction: n.s.			

ATS: Antitranspirant Sprays

As expected plants sprayed with antitranspirants used significantly less water compared with the untreated control (Fig. 2). At any one time the treated plants reduced their water usage by about 12-18%.

Table 2. Diffusive resistance and water potential of leaf at anthesis as affected by treatments (glasshouse experiment)

	Cultivar			
	Hysun 31	Suncross 52	Suncross 150	Mean
Leaf diffusive resistance ($s\ cm^{-1}$)				
No spray	2.80	3.83	4.97	3.87
ATS	11.17	5.78	10.14	9.03
Mean	6.99	4.81	7.56	
LSD (P = 0.05)	Spray: 2.57; Cultivar and Interaction: n.s.			
Leaf water potential (-MPa)				
No spray	0.92	1.03	0.41	0.79
ATS	0.64	0.80	0.59	0.68
Mean	0.78	0.92	0.50	
LSD (P = 0.05)	Cultivar: 0.21; Spray and Interaction: n.s.			

Compared to the control group, plants sprayed with antitranspirants resulted in increases in grain yields of the three hybrids (Table 3). Mean yield increase due to spray was in the order of 11%. There was no significant interaction between cultivars and spray treatment.

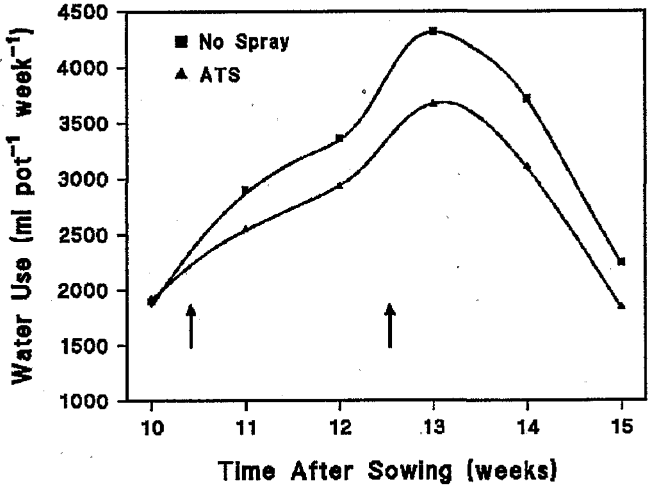

Fig. 2. Effect of antitranspirant on the water use of plants (↑ indicates the time of spray applications)

Table 3. Effect of spray treatment and cultivars on grain yield at maturity

	Cultivar			
	Hysun 31	Suncross 52	Suncross 150	Mean
Glasshouse experiment (g plant^{-1})				
No spray	62.25	54.46	52.61	56.44
ATS	63.82	61.36	60.52	61.90
Mean	63.04	57.91	56.57	
LSD (P = 0.05)Spray: 2.39; Cultivar: 2.92; Interaction: n.s.				
Field experiment (kg ha^{-1})				
No spray	1406	1286	1206	1299
ATS	1561	1345	1416	1441
Mean	1484	1316	1311	
LSD (P = 0.05)	Spray: 115; Cultivar: 141; Interaction: n.s.			

DISCUSSION AND CONCLUSION

Sunflower yields may vary depending on the sequence and nature of the environmental conditions during the critical stages of flowering and grain development. The observations reported here lend support to the view that changes in grain yields are more likely due to diurnal fluctuations in plant water status at this stage (Turner and Begg 1981; Rawson and Turner 1982).

The study shows that stomatal response in sunflowers can be modified to alter the plant water status by the use of antitranspirant sprays. Similar effects of antitranspirants have been observed on other crops (Rao 1985; Rademacher *et al.* 1987; Berkowitz and Rabin 1988).

Water potential thresholds vary for different physiological processes in plants (Hsiao 1973). Small changes in water potential may affect cell division or enlargement without necessarily affecting, for example, CO_2 diffusion or transpiration in plants. Sunflower treated with antitranspirants grew taller indicating that the cell division and elongation of the peduncle or head of these plants enjoyed relatively unimpeded growth compared to the untreated control. Antitranspirant sprays have resulted in plants sustaining comparatively higher plant water potential which could have favourably influenced the grain set and filling. More work is required to elucidate these aspects.

Reductions in green leaf area and subsequent reductions in plant water use did not result in yield decreases as reported in other studies (Rawson and Turner 1982; Parameswaran *et al.* 1984). It appears then that water use in sunflower will be somewhat extravagant under irrigation due to the plant's inability to modify stomatal action. As plant selection for improved day time stomatal resistance appears remote (Cawood 1980), foliar sprays using non-toxic antitranspirant sprays may prove particularly beneficial in maintaining higher yields of crops grown under irrigation in arid or semi-arid environments.

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