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EFFECT OF ANTITRANSPIRANT TREATMENT ON LEAF TEMPERATURES

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THAMES (*1*) working with pine seedlings and WILLIAMSON (*2*) working with tobacco, found increased mortality of plants treated with antitranspirant. Both ascribe this to the elevation of the temperatures of the treated plants as a result of reduction of transpiration.

Theoretical and experimental analysis (*3*) of the thermal balance of plant leaves under field conditions shows that transpiration could not lower leaf temperatures by more than about 5°. Under most conditions even this maximum figure would not be critical. During hot weather the stomata of many plants close towards midday (*4*) and transpiration is reduced at the very time when its cooling effect would be most advantageous. Furthermore, the very best antitranspirants known to the present authors do not reduce transpiration by more than 30–40%.

The effect of antitranspirant treatment on leaf temperature was therefore studied under various conditions. Measurements were made in the field under natural conditions and in the laboratory, where microclimatic factors could be changed at will.

In the field work a thermistor probe was used (Model TP–7, TRI–R Instrument Co.), having a response time of approximately 15 seconds and an accuracy of ±0.25°. For broad leaf plants, the thermistor was pressed to the leaf surface and counter pressure was applied to the other side of the leaf with a foam acrylic pad. The temperatures of pine needles were obtained by pressing the probe onto a bunched group of needles. The results obtained, although not of absolute accuracy, can be used for comparison of treatments. Later, a much improved, rapidly equilibrating thermocouple contact probe was built (*5*), and used in the laboratory experiments. Air temperatures were obtained in the field either from the shaded thermistor probe or from the dry bulb of a whirling hygrometer. In the laboratory a shaded thermocouple was used.

Three different antitranspirants were used—all of the plastic, emulsion type—(1) Tag—a polyethylene based emulsion produced by Machteshim Co. Bersheba, (2) S-789—a copolymer dispersion of acetate acrylate esters and (3) S-4000 a copolyacrylic emulsion, both supplied by Serafon Co. Rehovoth. Tag has not been found to be toxic to any of the plants to

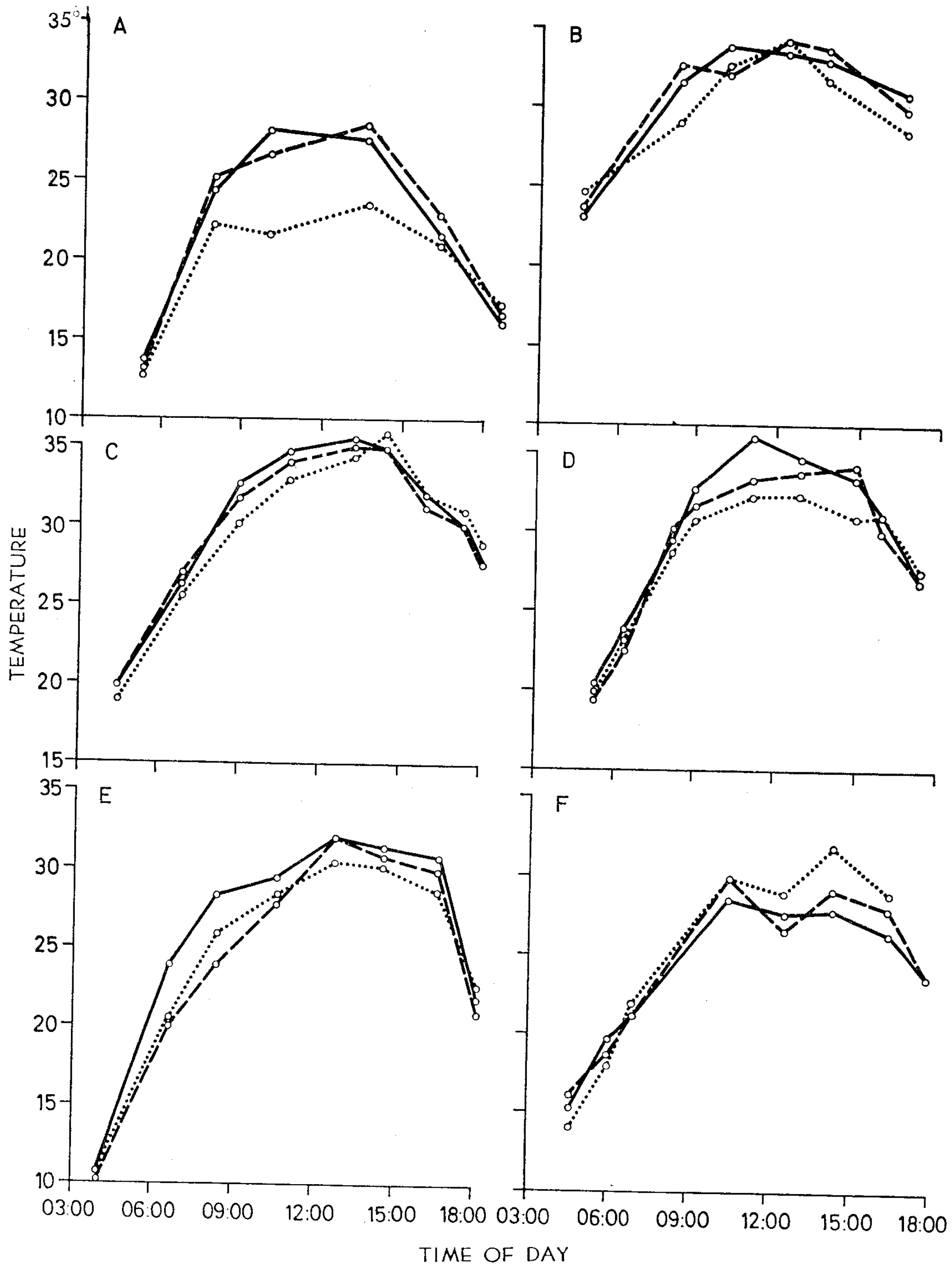

Fig. 1. Leaf temperatures of control and antitranspirant treated plants under field conditions. ○····○, air temperature; ○— — —○, leaf temperature, control plants; ○——○, leaf temperature, treated plants. Each point of leaf temperature is the average of 10 determinations. A: *Pinus brutia* on hot windless day. Treatment 12% Tag. B: *Pinus brutia* on very hot windy day. Treatment 12% Tag. C: *Gossypium* species. Treatment 6% S-789. D: *Citrus sinensis*. Treatment 6% S-789. E: *Beta vulgaris* "mangold." Treatment 8% Tag. F: *Beta vulgaris* "sugar beet." Treatment 8% Tag.

which it was applied in these experiments though it is toxic to beans. S-789 and S-4000 were not toxic to any plants to which they have been applied so far.

No accurate figures can be given for the percentage reduction of transpiration in the field experiments, owing to the lack of any reliable method of measurement under field conditions. However, previous experience indicates an average reduction of about 30%. In the laboratory experiment transpiration was determined gravimetrically.

The variation of leaf temperature during the day for five cultivated crops, with and without antitranspirant treatment are shown in Fig. 1. The data given were obtained on some of the hottest days of the summer. From these data it is evident that despite the wide fluctuations of air temperature, when there was even moderate wind (Fig. 1, B–F) leaf temperatures were at all times $\pm 2°$ of the ambient air temperature. Only in Fig. 1–A which depicts pine needle temperatures on a day on which there was almost no wind, was there a considerable difference between plant and air temperatures.

There was no consistent difference between the leaf temperatures of control and antitranspirant-treated plants. In the mangold plants (Fig. 1–E) there was, during the morning hours, an elevation of the temperature of the treated leaves to a maximum of 5° above that of the controls. However, during the hottest noon hours, temperatures of control and treated plants were almost identical. This may have been due to the midday reduction of transpiration of the control plants as a result of closure of their

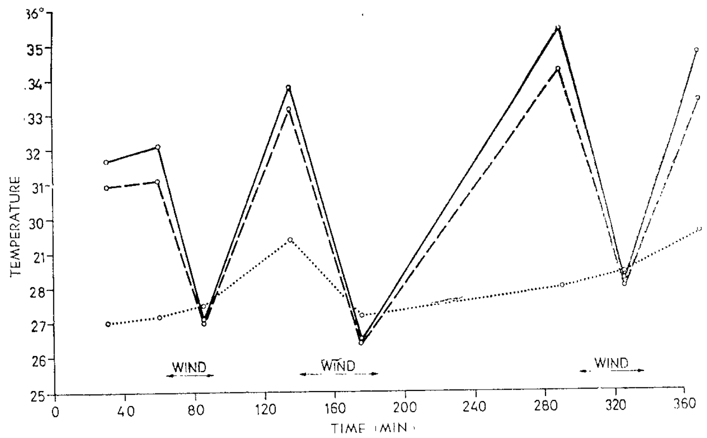

Fig. 2. Effect of wind on the elevation of bean (*Phaseolus vulgaris*) leaf temperatures resulting from treatment with an antitranspirant (S–789) spray. ○····○, air temperature; ○— — —○, leaf temperature, control plants; ○——○, leaf temperature, treated plants. Radiation about 0.85 cal. cm^{-2}. min^{-1}. Wind 100∼190 m/min. Each leaf temperature; average of measurements made on 8 different leaves of 4 plants. Transpiration of the treated plants, relative to controls; 64%.

stomata (*4*). A similar effect can be seen with the citrus leaves (Fig. 1-D), but later in the day.

The effect of the antitranspirant (S-789) treatment on leaf temperature of bean plants, under different simulated conditions is shown in Fig. 2. In this experiment the treatment reduced transpiration by 36%. It can be seen from these data that in the absence of wind, leaf temperatures rose 5-7° above ambient, those of the treated plants being 1-1.5° above the controls. When the fan was turned on, leaf temperatures fell to the level of the ambient air and there was no significant difference between the temperatures of the treated and the control leaves.

These results and the data from the field experiment (Fig. 1) are in good agreement with those of other workers, who concluded that under field conditions transpiration would be only a minor factor in cooling plant leaves (*3, 6*). It seems, therefore, most unlikely that antitranspirants could raise plant leaf temperatures to the thermal death point. Antitranspirants may also affect leaf temperatures by altering their albedo, as suggested by THAMES (*1*), by trapping long wave radiation or by modifying the convective sensible cooling of the air by changing the surface texture of the leaf. As yet there are no data on these factors, but the results given above indicate that their total effect is small. Should transpiration be reduced by 100% and not just by 30%, the resulting increase in leaf temperature due to treatment would be at the most $1.5° \times 3$. However, the resulting steeper gradient between leaf and air temperature would increase sensible heat exchange.

It seems therefore unlikely that antitranspirants kill plants, or reduce their growth, by increasing their temperature to dangerous levels. The reason for the deterious effects which have sometimes been reported in experiments with antitranspirants (*1, 2, 4, 7*) should be sought in the direct phytotoxicity of the emulsions used, or in other physiological effects, such as the reduction of photosynthesis by interference with gas exchange (*4, 7*).

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