Published September, 1978



# PREVENTION OF CHILLING INJURY TO SEEDLING COTTON WITH ANTI-TRANSPIRANTS[1]

M. N. Christiansen and E. N. Ashworth[2]


## ABSTRACT

**Emerged cotton (*Gossypium hirsutum* L.) seedlings are severely damaged or killed by temperatures below 10 C. Prolonged chilling induces severe foliar water deficit as a consequence of root water uptake inhibition which causes cotyledonary necrosis, growth retardation or death of seedlings. We tested, under controlled environment, the efficacy of antitranspirant treatments in maintenance of seedling water status, and preventation of chilling injury by high humidity or by antitranspirant treatments. The antitranspirant treatments reduced seedling water loss to approximately 40%. Maintenance of seedling water status by ambient high humidity or antitranspirant sprays reduced seedling death and cold stress inhibition of subsequent growth. Field experimentation with antitranspirants is suggested to provide means of reducing farm loss of cotton stands.**


***Additional index words:* *Gossypium hirsutum* L., Desiccation, Cold stress.**

THE limiting effect of low soil temperature on root water absorption has been known for more than two centuries (Hales, 1727). Kramer (1949) summarized differences in water uptake among plant species in response to low temperature. Water uptake by roots of tropical species is notably restricted at temperatures below 15 C. Arndt (1937) and Guinn (1971) reported that cotton (*Gossypium hirsutum* L.) plants wilt at 12 to 20 C. Cucumber, *Cucumis sativus* L., (Schroeder, 1939) and muskmelon, *Cucumis melo* L., (Raleigh, 1941) roots absorbed water slowly at soil temperatures below 18 C. Desiccation injury associated with low soil temperature has been reported for *Citrus* sp. (Cameron, 1941) and for cucumber (Schroeder, 1939). Considerable loss of cotton seedling stands occurs as a consequence of temperatures below 15 C or interaction of temeprature with other abiotic and biotic factors. Monetary losses may approach $60 million annually (Peacock, 1962).

In the research herein reported, we investigated the efficiency of foliar antitranspirant treatment in preserving cotton seedling water status; and the efficacy of antitranspirants to prevent chilling-induced desiccation damage to seedling foliage.

## MATERIALS AND METHODS

### Antitranspirant Water Loss Experiments

Plastic pots (10 cm) were lined with polyethylene bags and filled with fully hydrated Jiffy Mix[3] commercial potting mixture. Seeds of M-8 genetic strain of cotton were planted 2.5 cm deep and germinated at 30 C. After emergence, plants were thinned to one seedling per pot. When the primary leaf initiated visible growth, the seedling foliage was dipped into a solution of Pro-Tec 100[3] antitranspirant or into water for controls. After the foliage had dried, the polyethylene bag was closed around the seedling hypocotyl so that all water loss was restricted to seeding transpiration. Plants were weighed at the beginning of the experiment and daily for 4 days thereafter to determine water loss from control and anti-transpirant treatments. Six replications of six plants per treatment were used in duplicate tests. During the experiments, plants were in a continuous controlled environment of 30 C and 50% relative humidity. Photosynthetic active radiation consisted of 16 hours at 65 nE cm$^{-2}$ sec$^{-1}$, and 8 hours in the dark.

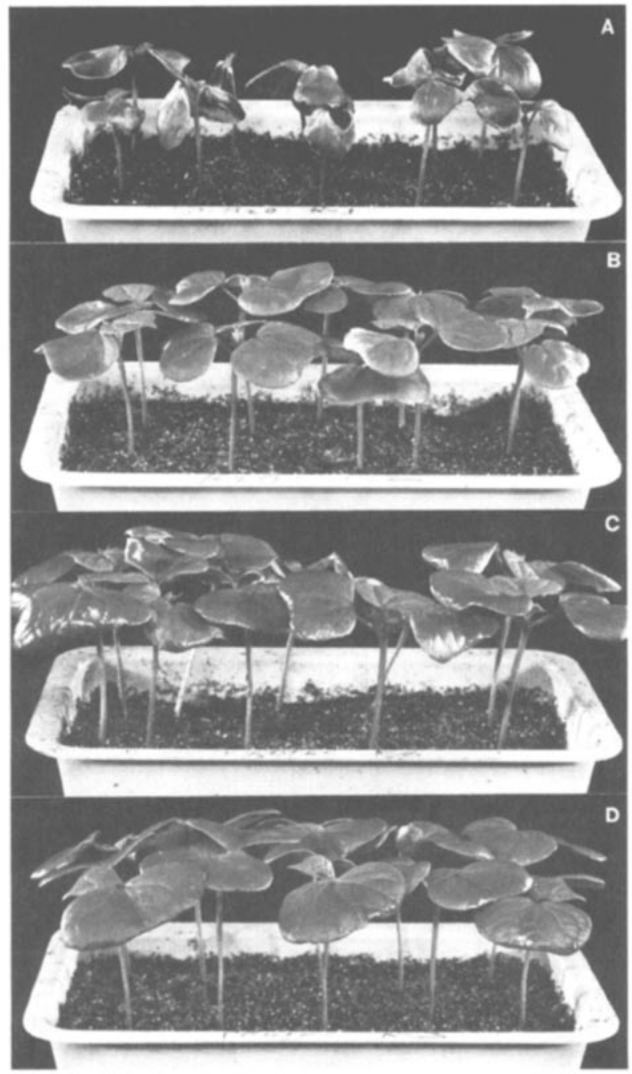

**Fig. 1. Cotton seedlings. A) Control seedlings chilled 2 days at 8 C followed by 7 days at 30 C. B) Seedlings covered with plastic bag during 8 C chilling for 2 days; bag removed and seedlings cultured at 30 C for 7 days. C) Pro-Tec 100 spray treated seedlings chilled 2 days at 8 C then cultured at 30 C for 7 days. D) Pro-Tec 100 spray treated seedlings covered with plastic bag during 8 C chilling for 2 days; bag removed and seedlings cultured at 30 C for 7 days.**

### Chilling Experiments

The experiments were conducted in a controlled environment with ±1 C temperature and ±5% relative humidity control. Ten seedlings were cultured in Jiffy Mix potting mixture in 20 × 20 × 5 cm plastic flats. Germination and prechilling culture was the same as in the water loss experiments.

Pro-Tec 100 antitranspirant was applied at manufacturer's recommended concentration with a laboratory sprayer at 0.4 ml

[1] Plant Stress Laboratory, USDA-SEA, FR, Beltsville, MD 20705. Received 24 Apr. 1978.

[2] Plant physiologists.

[3] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by USDA and does not imply its approval to the exclusion of other products that may also be suitable.

**Table 1. Water loss in grams per seedling per day at 30 C and 50% relative humidity.**

| Day | Water loss | | Water loss as % of control |
|---|---|---|---|
| | Control | Antitranspirants | |
| 1 | 11.3 ± 2.3 | 3.6 ± 1.4 | 32 |
| 2 | 17.3 ± 4.7 | 7.3 ± 1.3 | 42 |
| 3 | 19.4 ± 5.6 | 8.0 ± 1.6 | 41 |
| 4 | 22.6 ± 5.4 | 9.3 ± 3.8 | 41 |

**Table 2. Seedling classification 7 days after chilling of emerged seedlings 2 days at 8 C.**

| Treatment | Seedling class** | | |
|---|---|---|---|
| | Normal | Abnormal‡ | Dead |
| | % | | |
| Control | 17 | 41 | 42 |
| Antitranspirant | 78 | 20 | 2 |

** Means of control and antitranspirant treatments within classes of seedlings differ statistically at 0.01 level of probability. † Based on foliar injury. Normal = less than 50% of cotyledon damaged. Abnormal = greater than 50% of cotyledon damaged.

per seedling to both surfaces of the cotyledon. Control seedlings were sprayed with distilled water. After a 30-min drying period, half of the control and antitranspirant treatment flats were enclosed in polyethylene bags and all flats were placed at 8 C for 48 hours. Experiments were replicated six times with one flat of 10 seedlings per treatment. Experiments were duplicated.

Following chilling, plastic bags were removed and all seedlings were cultured at 30 C for 7 days to determine post-cold stress growth. Growth parameters measured included seedling survival, leaf area, fresh weight, and seedling classification based on amount of cotyledon tissue damaged; e.g., normal with less than 50% cotyledon necrosis, abnormal greater than 50% necrosis.

## RESULTS AND DISCUSSION

Loss of water from seedlings was reduced approximately 60% by antitranspirant treatment (Table 1). Control of water loss gradually dissipated as new leaves expanded anduntreated leaf tissue was exposed

Chilling injury was markedly reduced by either enclosure of plants in plastic bags to elevate humidity or by anti-transpirants (Fig. 1A, B, C, and D). Foliage wilting began after as little as 4 hours at 8 C in untreated controls; seedlings sprayed with antitranspirant showed little wilting after 48 hours of chilling and no wilting was evident among plastic bag-enclosed plants.

The consequences of chilling-induced physiological drouth on subsequent survival and performance of seedlings are illustrated by data presented in Table 2. Approximately 40% of control seedlings were killed by chilling and only 17% had less than 50% necrotic foliar tissue. The antitranspirant treatments had 78% normal seedlings, 20% with more than 50% foliar necrosis and 2% failed to survive.

In another experiment (Table 3), leaf area and fresh weight of antitranspirant treated seedlings were more than double those of control seedlings. Plants chilled in plastic bags survived and developed at a rate equal to those treated with antitranspirant. The leaf area

**Table 3. Leaf area and fresh weight of seedlings 7 days after chilling 2 days at 8 C.**

| Treatment | Leaf area | Fresh wt. |
|---|---|---|
| | cm | g |
| Control | 78.6 C* | 4.32 B |
| Control in plastic bag | 166.6 B | 9.54 A |
| Antitranspirant | 170.0 B | 8.69 A |
| Antitranspirant in plastic bag | 188.0 A | 10.41 A |

* Means not designated with the same letter differ significantly at P ≤0.05 as determined by Duncan's multiple range test.

of plants treated with antitranspirant and chilled in the plastic bag was significantly greater than that observedwith the antitranspirant or plastic bag alone. No adverse antitranspirant effect was expressed during post-chilling seedling growth, as shown by comparison of the plastic bag treatment with the antitranspirant treatment.

These data indicate that chilling injury to seedling cotton is a consequences of a lack of root water absorption and resultant foliar desiccation. The data also strongly suggest that antitranspirants can provide a measure of chilling protection through maintenance of seedling hydration. Field climatic conditions differ widely from controlled environment chambers; thus, field grown plants experience a great fluctuation of temperature, light, humidity, wind, and moisture. As a consequence of stress hardening, field plants often response quite differently to treatment than controlled environment chamber-grown plants. In the present case, field experimentation with antitranspirants appears warranted to determine the efficiency of antitranspirants in preventing chilling injury on seedling cotton as well as other chilling-sensitive crops such as tomato, pepper, cucurbits, and citrus. Antitranspirants may also serve to prolong the effectiveness of foliar-applied pesticides by reducing loss from oxidation or "wash off" by rainfall.

## REFERENCES


1. Arndt, C. H. 1937. Water absorption in cotton plant as affected by soil and water temperatures. Plant Physiol. 12: 703-720.
2. Cameron, S. H. 1941. The influence of soil temperature on the rate of transpiration of young orange trees. Proc. Am. Soc. Hort. Sci. 38:75-79.
3. Guinn, G. 1971. Changes in sugars, starch, RNA, protein and lipid-soluble phosphate in leaves of cotton plants at low temperatures. Crop Sci. 11:262-265.
4. Hales, S. 1727. Vegetable staticks. W. and J. Innys and I. Woodward, Publ., London.
5. Kramer, P. J. 1949. Plant and soil water relationships. 1st Ed. McGraw-Hill, New York. pp. 227-234.
6. Peacock, H. A. 1962. Research needs and opportunities in breeding and genetics of cotton. Proc. Symposium on Problems Related to Getting a Stand of Cotton. Natl. Cotton Council, Memphis, Tenn.
7. Raleigh, G. J. 1941. The effect of culture solution temperature on water intake and wilting of the muskmelon. Proc. Am. Soc. Hort. Sci. 38:487-488.
8. Schroeder, R. A. 1939. The effect of root temperature upon absorption of water by cucumber. Missouri Annu. Exp. Stn. Bull. 309.