Comparison of Some Antitranspirants on Orange Trees and Fruit

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Abstract. Antitranspirant sprays of 5 film-forming materials were compared on mature Citrus sinensis (L.) Osbeck cv. Valencia trees for film persistence and reduction of fruit weight loss after harvest. These materials were also sprayed on young 'Pineapple' (C. sinensis) or 'Valencia' orange trees growing in 7.6 liter containers on which weight loss was subsequently measured for 48-hour periods after watering. Spray solutions of equal or known film-forming ingredients (solids content) of 1 to 4% (weight/weight) were applied and compared. Plantgard film did not significantly increase the leaf epicuticular coating nor did it reduce fruit weight loss or young tree water use. Mobileaf, Vapor Gard, Nu-Film-17, and Wilt Pruf NCF did result in heavier leaf coatings and less fruit weight loss after harvest. These materials were also beneficial on fruit crops including grapes (10), cherries (15, 20), olives (7), peaches (6), and citrus (2, 3, 5). These benefits included increased fruit size (6, 7, 10, 20), reduced moisture stress and irrigation requirements (2, 5, 6), reduced pre- and postharvest water loss and shriveling (3, 7, 15), and improved postharvest keeping quality (3, 15). Generally, the required high rates of film-forming antitranspirants needed to significantly reduce transpiration make commercial use marginal on fruit crops. Only very effective, low priced materials could be used economically.

Although earlier work with antitranspirants showed few benefits (9) and some detrimental effects on fruit quality (13), later investigations demonstrated that antitranspirant sprays were beneficial on fruit crops including grapes (10), cherries (15, 20), olives (7), peaches (6), and citrus (2, 3, 5). These benefits included increased fruit size (6, 7, 10, 20), reduced moisture stress and irrigation requirements (2, 5, 6), reduced pre- and postharvest water loss and shriveling (3, 7, 15), and improved postharvest keeping quality (3, 15). Generally, the required high rates of film-forming antitranspirants needed to significantly reduce transpiration make commercial use marginal on fruit crops. Only very effective, low priced materials could be used economically.

Commercial film-forming antitranspirants have been compared simultaneously on only a few crops (4, 5, 8, 11, 14) and all but one test (8) were limited. Several tests have been made on citrus but none assessed long-term persistence of equal amounts of film-forming materials (4, 5, 11, 14). Several workers have measured short-term effectiveness and it became noticeable reduced in 2 to 3 weeks (11, 12, 14, 16). Davies and Kozlowski (8) tested several materials under constant growth chamber conditions for a period of 30 days. Few materials significantly reduced transpiration more than 10 days from application on a high-water-use plant, while several materials were effective for 30 days on low-water-use pine tree seedlings. Albrigo (1) reported little weathering of the antitranspirant Vapor Gard over a rainy 6-month period, but no evaluation was made of transpiration reduction over this same period. Benefits obtained from 4 consecutive annual applications of Vapor Gard did suggest effectiveness was long lasting and potentially valuable in Florida citrus production (2, 5).
The following report describes experiments to determine the relative persistence and effectiveness of 5 antitranspirants when sprayed on orange trees at equal rates of film-forming ingredients.

Materials and Methods

Antitranspirants tested were Plantgard (polyethylene emulsion — Polymetrics International, 919 Third Ave., New York), Wilt Pruf NCF (emulsified formulation of \(\beta\)-pinene — Nursery Specialty Products, 410 Greenwich Ave., Greenwich, Conn.), Mobileaf (wax emulsion — Mobil Oil Co., Paulsboro, New Jersey), Nu-Film-17, and Vapor Gard (low and high viscosity Pinolene, polyterpene, respectively — Miller Chemical and Specialty Products, 410 Greenwich Ave., Greenwich, Conn.), and also at 4% for Vapor Gard on 3 single-tree replications (18).

Samples of each were weighed and air dried in thin layers to determine their solids content so that sprays of approx equal film-forming ingredients could be formulated. Each material was sprayed dilute to drip at 2% (solids wt/wt), and also at 4% for Vapor Gard on 3 single-tree replications of mature 'Valencia' orange trees on Jan. 6, 1976. Fifty leaves and 4 fruit/replication were harvested 2 weeks and 5 months after spraying. Surface areas (top plus bottom) of the 50 leaves were measured (19) and then the leaves were extracted twice by dipping in successive 300 ml portions of 60°C CCl4:hexane (1:1, vol/vol) solvent for 1 and \(\frac{1}{2}\) min, respectively. The 2 extracts were filtered, evaporated, and dried 24 hr under vacuum at 30°C before weighing (1). In a previous experiment (1) this method was successful in removing the natural wax and the antitranspirant Vapor Gard. The fruit surface area was calculated and weight loss at room temp was followed for 1 week.

One-year-old budded orange trees, 'Pineapple' on sour orange (C. aurantium L.) and 'Valencia' on 'Rangpur' lime (C. limonia Osbeck), in 76 liter containers were sprayed with the various antitranspirants at 1 or 3% solids wt/wt in spring 1975 ('Pineapple') and fall and spring 1975-76 ('Valencia'). In spring 1975 ('Pineapple'), 3% Plantgard and 1 and 3% Vapor Gard were used. In fall 1975 ('Valencia'), 1 and 3% Vapor Gard and 3% rates of Plantgard, Nu-Film-17, and Mobileaf were used. In spring 1976 ('Valencia'), 3% rates of all materials including Wilt Pruf NCF were tested. Pots were surface sealed with removable 4 mil clear polyethylene plastic covers and weight loss was measured for 48-hr periods. The plants were watered before each 48-hr weighing period and weighing began within 1 week of spraying. Six, six, and three 1-tree replications and 3, 12, and 7 weighing periods, respectively, were used in the 3 tests. In the fall and spring 1975-76 tests, leaf surface area was measured by the method of Turrell (19).

Comparisons of means were made by the Tukey \(\alpha\)-procedure (18).

Results and Discussion

Sprays of 2% Plantgard deposited little material, Wilt Pruf NCF and Nu-Film-17 were intermediate, and Mobileaf and Vapor Gard added substantial material to the natural epicuticular leaf coating of mature trees as measured 2 weeks after application (Table 1). The latter materials almost added the equivalent of the natural epicuticular wax for each 1% in the spray when applied at the 2% rate. These results are similar to previous findings with Vapor Gard sprays (1). Reduction of fruit wt loss 2 weeks after spraying was similar in magnitude to the additional coating measured on the leaves. Mobileaf appeared to be most effective by this measurement, although the difference from Nu-Film-17 or Vapor Gard effects was not significant.

All the antitranspirants had weathered considerably 5 months after application (Table 1). Vapor gard and Nu-Film-17 were slightly more persistent than Mobileaf and from the fruit wt loss data at 5 months appeared to be the most effective as long-term antitranspirants on citrus. Although Wilt Pruf NCF is a \(\beta\)-pinene product like Vapor Gard and Nu-Film-17, it is in an emulsified formulation. The emulsifying agent(s) may have reduced the \(\beta\)-pinene's adherence to the leaves and fruit or diluted the actual antitranspirant when applied at an equal solids rate of formulated material. Mobileaf apparently lost all its effectiveness by 5 months even though some of the material may have still remained. Perhaps all the material over the stomatal pores had disappeared (8).

In the spring 1975 test using potted plants, Vapor Gard at the 3% rate significantly reduced the weight loss of 1-year-old 'Pineapple' orange trees during three 48-hr measurement periods (Table 2). Plantgard and 1% Vapor Gard were not significantly different from the control. These results agree with those from the subsequent tests on potted 'Valencia' trees (Fig. 1) although leaf area was not measured in this test on 'Pineapple'. Possible variability due to differences in leaf surface area was eliminated in subsequent tests by measuring total lower leaf surface area and expressing water use on a leaf area basis.

In the subsequent fall 1975 test using potted 'Valencia' trees, the 3% rates of Mobileaf and Vapor Gard significantly reduced transpiration compared to the control (Fig. 1). Nu-Film-17 (3%) significantly reduced transpiration only when an LSD statistical test was used (1% level). Plantgard was not effective.

When the twelve 48-hr weight measuring periods were analyzed as 4 separate chronological time periods extending from the time of spraying, no significant loss of effectiveness was found for either Vapor Gard or Mobileaf over the 2 months of measurements (Fig. 1). Control wt loss values for each time period indicate a decrease in the transpiration rate in the cooler months similar to the reduction in pan evaporation and probably related to the drop in temperature over the test period.

In a second potted 'Valencia' tree test (spring 1976), where Wilt Pruf NCF was included and only 3% rates used, no significant reductions in water use from the controls occurred through seven 48-hr weighing cycles (data not shown). The warmer spring climate resulted in higher transpiration rates.
controls — 56.1 vs. 49.0 mg/cm² day, spring 1976 vs. fall 1975) which may have resulted in considerable stress on the plants. Leaves on treated trees may have experienced less stomatal closing each day (lower levels of stress) than on control trees and thus transpired longer each day albeit at a lower rate due to the greater diffusion resistance of antitranspirant-treated leaves (4, 6, 7, 16).

The 7.6 liter container size limiting available soil water and the higher leaf numbers on the slightly older plants added to the likelihood that these plants in the spring test were under greater stress. For the control trees, the greater leaf area and the slightly older plants added to the higher leaf numbers on the slightly older plants added to the higher leaf area and the slightly older plants added to the higher leaf numbers on the slightly older plants. Though no adverse effects were noted in these tests. Unfortunately, Mobileaf is no longer available commercially.

Overall, the pure Pinolene products were the most effective over a 5 month period. Mobileaf was at least as good initially, but apparently weathered more rapidly after several months. Under some conditions, these film antitranspirants can significantly reduce water use of containerized citrus nursery trees. The possible reduction in effectiveness or stimulation of stomata (8) by the addition of some emulsifying agent(s), suggested by results with the Wilt Pruf NCF, warrants further investigation.

The higher viscosity grade of Pinolene, Vapor Gard, was more effective than the lower viscosity Nu-Film-17. Similarly, Parkinson (16) found that higher viscosities, in the range tested, of dimethyl silicones had a longer effective period. There are no published reports that the optimum viscosity or molecular wt of any of the film-forming antitranspirant materials has been determined. Too high a viscosity or molecular wt binders mixing in the spray tank and reduces film spreading on the leaf surface, while too low a viscosity may prevent film forming over the outer stomatal opening. A given viscosity (molecular wt) of an antitranspirant may not be the optimum for all plant species. Leaf pubescence and stomatal size (opening size and height above surface) may be important leaf factors interacting with viscosity. Davies and Kozlowski (8) found differential responses of various materials between 2 species.

However, Davies and Kozlowski (8) did not use equal rates of materials so that comparisons between materials are difficult to make.

Applying equal rates of material solids and measuring the leaf film along with the plant response does allow direct comparison of materials which is particularly important if the cost for equal effectiveness in eventual commercial use is to be considered.

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Fig. 1. Wt loss (fall 1975) of potted ‘Valencia’ on ‘Rangpur’ lime trees unsprayed (C) or sprayed with antitranspirant (3% Plantgard [3 PG], 3% Nu-Film-17 [3 NF], 3% Mobileaf [3 ML], or 1 or 3% Vapor Gard [1 VG, 3 VG]). Each data point represents 3 individual 48-hr wt loss measurements during the time period. Daily temp and pan evaporation data were averaged for each time period. Different letters, vertically, indicate significance at the 5% level.

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Effect of Nitrogen and Plastic Mulch on Properties of Troup Loamy Sand and on Yield of ‘Walter’ Tomatoes

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Additional index words: leaching, soil moisture management, Lycopersicon esculentum

Abstract. During 1975 and the spring of 1976, N requirements were determined for irrigated ‘Walter’ tomatoes (Lycopersicon esculentum Mill.) growing on Troup loamy sand with and without polyethylene mulch. Maximum soil moisture deviation occurred in the unmulched plots in the zone of illuviation to depths of 60 to 75 cm. Moisture ranged from 3 to 15% with the maximum recorded after vines were killed by frost. Highest N concentration (15.8 ppm NO₃-N) occurred in mulched plots at a depth of 15 cm; whereas the highest concentration (11.5 ppm NO₃-N) in unmulched plots occurred at 45 cm. The highest yield of 29.8 MT/ha was produced with 60 kg/ha N on mulched plots. The highest yield without mulch (25.6 MT/ha) required 138 kg/ha of N.

Sandy soils of the Atlantic Coastal Plain are easy to manage and are well-adapted to mechanization but are subject to excessive leaching. Mulching is beneficial to plant growth (1, 5, 7, 10, 11); in most cases, increased growth is attributed to more favorable moisture conditions (7, 10, 11). Giddens (3) measured moisture at a depth of 12.7 cm on a Cecil sandy loam and found more uniform moisture under plastic mulch. In a study by Knavel and Mohr (6) depth of rooting was correlated with moisture content and increased root development was associated with use of plastic mulch.

Mulches have been used to reduce loss of N by leaching. Wagner et al. (11) found higher nitrate levels under black plastic than transparent plastic, or aluminum mulch or under bare surface. However, they hypothesized that, while some leaching was evident, differences in nitrate were also caused by differences in mineralization. Nutrient leaching control comparable to full-bed plastic has been attained by narrow bands of siliconate spray (9).

Gunner and Colakoglu (4) found a significant correlation between soil moisture and NO₃ content. Similarly, Geraldson (2) demonstrated that yield and NO₃ concn were lower where the soil water table was maintained at 30 cm as opposed to 45 cm. Geraldson explained that roots developed where the most favorable ionic environment exists — an interaction between fertilizer placement location and soil moisture.

South Carolina farmers routinely apply high levels of N to full-season crops in sandy soils. Since few researchers (4) have demonstrated the interaction between nitrate concn at various soil depths with soil moisture, this research was initiated to define the NO₃-moisture balance existing with and without plastic mulch on sandy soils. Water and nutrients, except for N, were supplied at near optimum levels. Nitrogen fertilizer rates were varied with and without white plastic mulch. Yield of marketable tomatoes and fate of added N were determined.

Materials and Methods

‘Walter’ tomatoes were grown on 15.2 cm-high beds in Troup loamy sand at Pontiac, S.C., during the spring and fall of 1975 and the spring of 1976. The experimental design was split plot (mulch vs. no mulch) with whole plots (N rates) completely randomized. Plant population was 10,737 plants per ha. Each plot contained 8 plants spaced 50 cm within the row with rows 1.83 m apart. In the fall of 1975, 15, 56, 90 and 129 kg/ha of N as ammonium nitrate were applied with 5 replications of each treatment. The 1976 tests were treated similarly, but with N rates of 0, 41, 67 and 97 kg/ha.

Half of the N was applied preplant on the beds and incorporated into the topsoil. The beds were irrigated before transplanting and covering with a white surface (black underneath) 15.2-cm-wide polyethylene mulch that was 1.5 mils thick. The remaining N was added equally in 2 sidedressings, the first when plants were about 30 cm high and the other after fruit set. Prior to the test, the topsoil pH was raised to 6.0 to 6.5 with dolomitic limestone. Other than N, all plots received uniform treatment. Preplant broadcast applications included 784 kg/ha of CaSO₄, 48 kg/ha of P and 93 kg/ha of K which were applied on the beds and incorporated into the topsoil. An additional 23 kg/ha of CaSO₄, 25 kg/ha of P and 93 kg/ha of K was applied just after fruit set on the soil or mulch surface 15-20 cm to each side of the plants. Overhead irrigation washed the fertilizer through 1.5-cm diam holes punched in the mulch located at 15-cm intervals and 15-20 cm to each side of the plants.

Soil nitrate was measured with a nitrate-ion sensitive electrode in soil samples collected at 15-cm intervals to a depth of 120 cm. The pH was measured with a glass electrode. Soils were extracted for 5 min with a dilute acid (0.05N HCl + 0.025N H₂SO₄) at a 1:4 soil-extracting solution ratio; after