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Effect of Succinamic Acid, 2-2-Dimethyl Hydrazide and Late-Season Night Temperature on the Maturity Indices of 'Stayman' Apples[1]

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Abstract. The effects of succinamic acid, 2-2-dimethyl hydrazide (Alar) and controlled late-season night temperatures on maturity indices of the sun-exposed and shaded sides of 'Stayman' apples were studied. The inhibitory effects of Alar on maturity were apparently reduced by warmer night temperatures. Warmer nights decreased soluble solids and red color but increased softening and acidity. These effects are attributed to an increased night respiration rate. Maturity indices data suggest that metabolic activities of the sun-exposed and shaded sides of the fruit respond differentially to increases in night temperature.

CONSIDERABLE variation in effect of Alar on apple maturity indices has been reported in the literature (1, 4, 5, 8, 10). The work reported here shows the response of apples to Alar under different late-season night temperatures, which is a possible factor in seasonal climatic variation.

MATERIALS AND METHODS

In 1966, adjacent limbs on mature 'Stayman' apple trees were paired, one limb being sprayed with 2000 ppm succinic acid, 2-2-dimethyl hydrazide (Alar) 2½ weeks after full bloom and the other left as a control. A limb-pair/tree was subjected to: (a) night heating to 68° F, (b) ambient nights having a 51.2° average minimum, or (c) night cooling to 44° for 44 days prior to harvest (October 16). The average daily maximum for the 44 day period was 71.0° F. Four replications were used. Heated and cooled limbs were surrounded by a double-lined plastic cage with removable side and front panels for day conditions (Fig. 1). Heating and refrigeration power was supplied by electricity from a portable diesel generator.

In 1967, one limb/tree was subjected either to heated (68° F) or ambient (51.7° average minimum) nights for 30 days prior to harvest (October 15). The average daily maximum for the 30 day period was 73.6° F. Three replications were used. Temperatures were controlled 12 hr each night in double layered plastic cages. No Alar was used.

At harvest, data were taken on the shaded and sun-exposed sides of the fruit. Average fruit weight was taken of all the fruit in a replicate. Fruit firmness was measured on 10 fruit/replicate with a Magness-Taylor Pressure Tester using a 7/16″ plunger. Ten halves/sun or shaded fruit side of a replicate were comminuted in a Waring Blendor. Soluble solids were determined on this slurry with a refractometer. The pH and titratable acidity were measured for 10 g of this slurry against a pH meter. Titrations were carried to pH 8. Surface color differences to a standard plate (Rd=5.8, a=25.4, b=7.0) were determined for 10 fruit/replicate on a Gardner Color Difference Meter. Conversions to b_L and a_L were made to compensate for the low Rd readings diminishing effect on b and a.

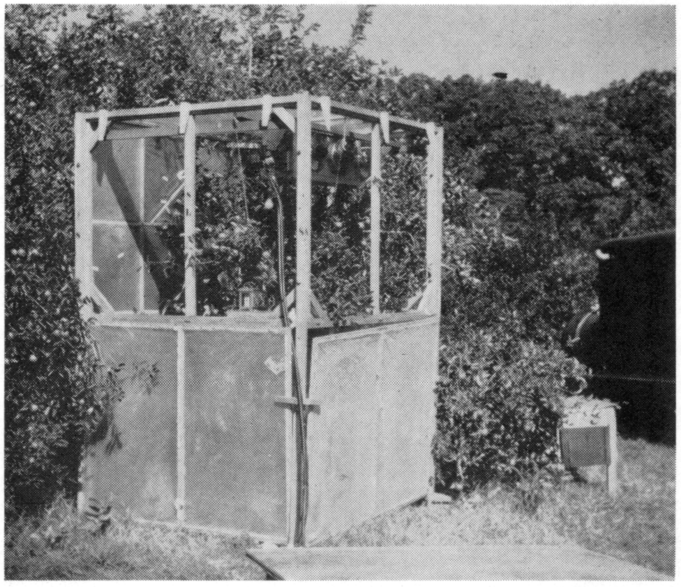

Fig. 1. Double layer plastic cage used for late season temperature control of paired apple limbs. Removable side panels for daytime and refrigeration coils and fan are shown.

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Results and Discussion

Alar applications resulted in firmer flesh on the sun-exposed side of the fruit regardless of night temperature (Fig. 2a). This influence was noted on the shaded side of the fruit only with cool nights. Firmness was lower (significant 1% level) for heated than ambient fruit in 1967 (data not presented).

At ambient temperatures, the sun-exposed side of the fruit accumulated more soluble solids than the shaded side (Fig. 2b). With heated nights this difference did not appear. These data support the firmness data as evidence that the sun-exposed and shaded side of the fruit respond differently to night temperature. The soluble solids of heated fruit are much lower than ambient temperature fruit regardless of sun-exposure.

Fresh weight (Fig. 2c) and soluble solids (Fig. 2d) were lower for Alar sprayed fruit than controls. There was a trend toward greater differences at the lower night temperatures. Fresh weights tended to be slightly higher for heated fruit in 1966 and in 1967 (not shown).

Titrations acidity was decreased by Alar sprays and cooler night temperatures (Fig. 2e). Acidity was slightly lower for ambient than heated fruit in 1967 (not shown).

Alar applications lowered the reflectance (Rd) of the shaded side of the fruit at ambient temperatures (Fig. 3a). Both higher and lower night temperatures removed this effect. The sun-exposed side of the fruit was lower in Rd than the shaded side. The comparatively low Rd values for the sun-side prompted the conversions (b_L and a_L) for evaluation of the yellow ground color (b) and redness color (a) data.

The shaded side of the fruit was more yellow (b_L) than the sun-exposed side only under ambient temperatures (Fig. 3b). Alar sprays had no effect on b_L values. Before conversion, b values were significantly lower for Alar-treated fruit under cooled nights compared to Alar fruit under heated nights (not shown).

The sun-exposed side of the fruit was redder (a_L) than the shaded side (Fig. 3c). Alar had no significant effect on a_L values. Before conversion, Alar treatments significantly reduced a values (not shown). This is completely opposite to the visual evaluation that Alar had increased red color. The lower color difference readings for Alar fruit could be due to increased chlorophyll levels in the skin of Alar-treated apples. Halfacre, Barden, and Rollins (6) noted a trend toward more chlorophyll/fresh weight in Alar-treated apple leaves. The color data presents an example of the difficulties often encountered in evaluating color data whether they are obtained subjectively or objectively.

The changes brought about by higher night temperatures in this study are compatible with the idea that higher night respiration rates resulted with a concurrent increase in use of substrate. Creasy (3) has proposed that higher orchard temperatures result in poorer color development through a high use of substrate in respiration. Alar may be less effective as a respiration inhibitor at

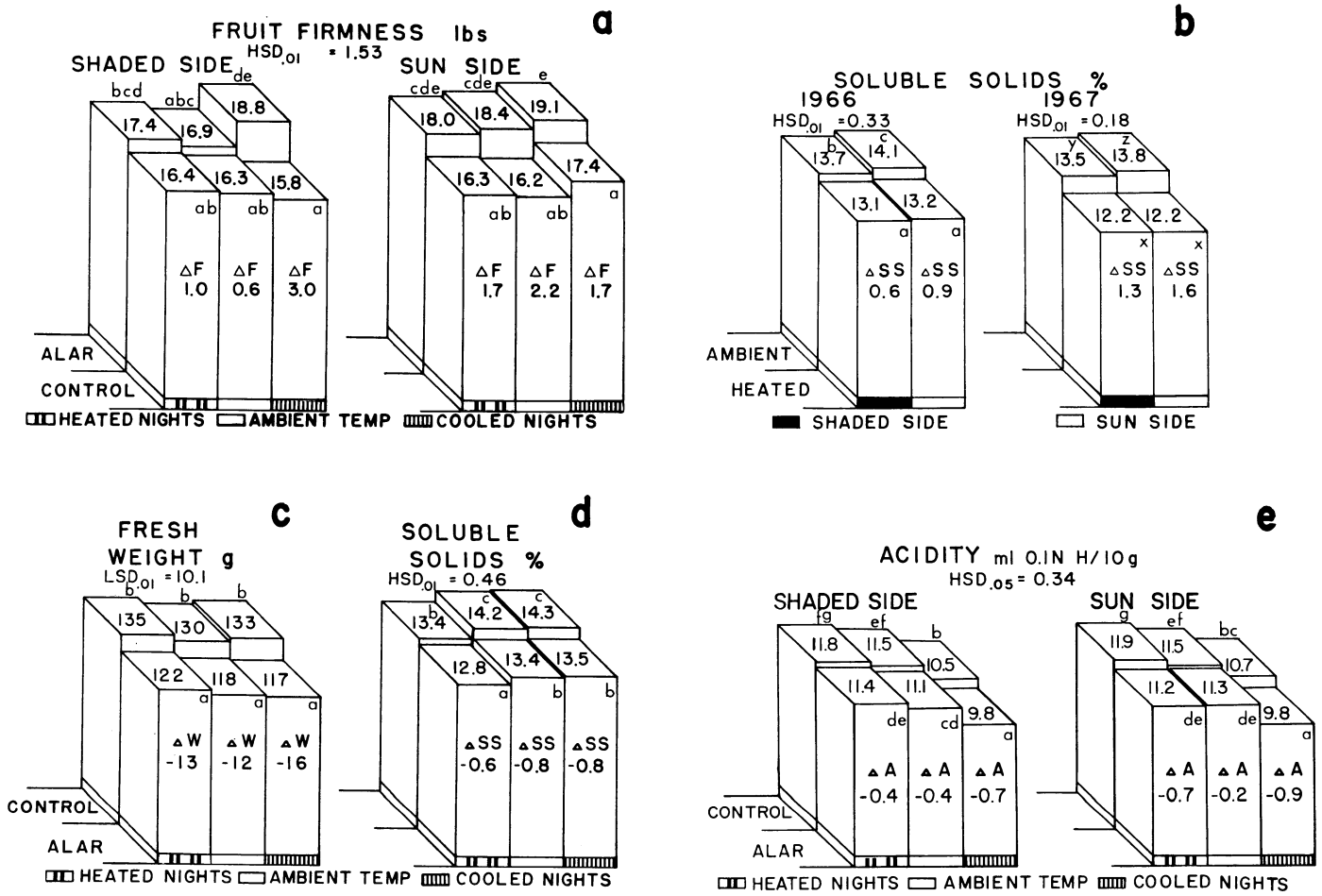

Fig. 2. Influence of 2000 ppm Alar and controlled late-season night temperature on several maturity indices of the shaded and sun-exposed sides of 'Stayman' apples at harvest (New Brunswick, New Jersey). The bars with different letters are significantly different at the 1% (a, b, c, and d) or 5% (e) level.

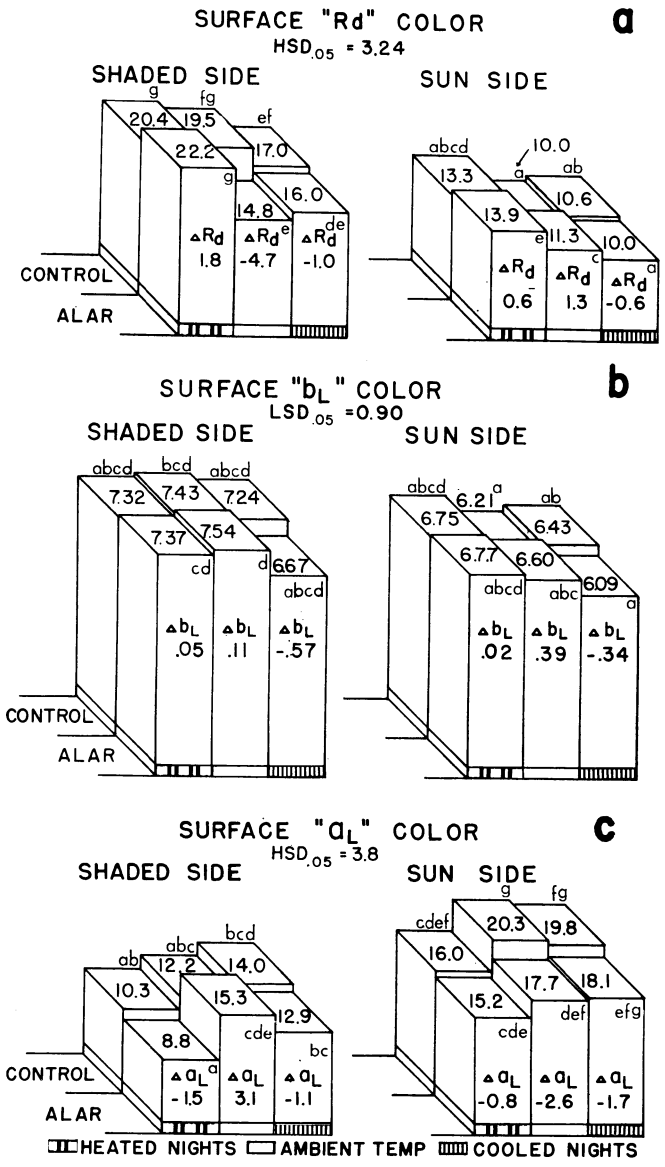

Fig. 3. Influence of 2000 ppm Alar and controlled late-season night temperature on the surface Rd, b_L and a_L color difference of the shaded and sun-exposed sides of 'Stayman' apples at harvest (New Brunswick, New Jersey, 1966). The bars with different letters are significantly different (5%).

higher night temperatures. Looney (7) has reported that Alar sprays reduce apple respiration rates. Cathey (2) has noted that Alar is a poor growth retardant for ornamentals at high growing temperatures. The lower soluble solids found in Alar-treated fruit may be due to reduced energy for active solute uptake. It is not at all clear why some of the maturity indices did not appear to respond to the differential night temperatures.

It appears reasonable that the sun-exposed and shaded side of the fruit would behave somewhat differently. Shutak and Hapitan (9) measured higher respiration for the red-side of 'Cortland' apples in storage. This difference should exist on the tree as well. The interaction of Alar with night temperature as presented here may explain some of the variation in response of apple maturity indices to Alar sprays which have been reported previously. This interaction could occur when comparing Alar responses from season to season and from one growing area to another.

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