# THE EFFECT OF ALAR (SUCCINIC ACID 2, 2-DIMETHYL HYDRAZIDE) ON FRUIT MATURATION, QUALITY AND VEGETATIVE GROWTH OF RED TART CHERRIES (Prunus cerasus L., var. Montmorency)

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THE EFFECT OF ALAR (SUCCINIC ACID 2,2-DIMETHYL HYDRAZIDE) ON FRUIT MATURATION, QUALITY AND VEGETATIVE GROWTH OF RED TART CHERRIES (*Prunus cerasus* L., var. Montmorency)

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ABSTRACT

THE EFFECT OF ALAR (SUCCINIC ACID 2,2-DIMETHYL HYDRAZIDE) ON FRUIT MATURATION, QUALITY AND VEGETATIVE GROWTH OF RED TART CHERRIES (*Prunus cerasus* L., var. Montmorency)

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Field experiments were conducted on the use of Alar on Montmorency cherries at two locations in the state of Michigan from 1966 to 1968 to determine its usefulness in extending the harvest season and improving fruit quality. Randomized block design plots were established, using single whole tree treatments and two replications. Two times of application were used: Spring--two weeks after full bloom and Fall--shortly before leaf senescence. Alar concentrations of 1,000 to 8,000 ppm were applied.

Spring Alar applications significantly increased fruit color and decreased the force required to separate the fruit from its pedicel early in the harvest season. These differences were sufficient to advance commercial harvesting one week. Significant fruit firmness increases were found in both hand-picked and mechanically harvested Alar fruit. Alar-treated fruit showed a significant ability to resist softening when mechanically harvested. Increased

fruit color and firmness were evident in processed fruit, both canned and frozen. Alar treatment caused the fruit to go through an accelerated final swell and contributed to a more uniform fruit size through the harvest period. Alar-treated fruit had less acid and a lower respiration rate at harvest. The respiratory quotient was also significantly reduced.

Fall Alar treatments significantly reduced fruit color and increased fruit firmness early in the harvest season indicating less fruit maturity. Fruit from trees treated in the fall were significantly smaller throughout the entire harvest season.

All Alar application dates reduced vegetative growth and internode length and increased flower bud initiation.

The enhancement of fruit color and reduction in fruit removal force early in the harvest season indicated that Alar, applied in the spring, can extend the harvest season by advancing fruit maturity. This conclusion is supported by the enhancement of final fruit swell found with Alar treatment. Reduced fruit acidity and fruit respiration are also indicative of more mature fruit. Increased fruit color, increased fruit firmness and resistance to softening found with Alar treatment indicate a favorable affect on fruit quality.

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## INTRODUCTION

Alar* (succinic acid 2,2-dimethyl hydrazide)** was first introduced in 1962 under the code name of $B_{995}$. Riddell, et al (80) reported that the compound retarded the growth of a large variety of plants when applied to the foliage.

Alar has undergone extensive testing, particularly on horticultural crops. The greatest amount of research has been done on apples. Alar has been reported to control size of nursery trees (94), reduce growth of mature trees by reducing internode length (8), influence drought and cold tolerance (69, 30), influence time of flowering as well as promote flower bud initiation (42), enhance color development of fruits (35), influence fruit maturity (28), retard preharvest fruit drop (7), and increase storage and shelf life of fruits by delaying softening and the subsequent onset of storage disorders (66).

The tart cherry industry in Michigan produces over 65% of the total national crop. The industry has long been

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*Trademarked name for succinic acid 2,2-dimethyl hydrazide.

**A product of UNIROYAL Chemical Company, Division of UNIROYAL, INC., Naugatuck, Connecticut.

plagued by the problem of insufficient crop handling capacity at harvest time. Tart cherry production is almost entirely from one variety of cherry, the Montmorency. This single variety provides an optimum period of only 2 to 3 weeks to harvest, handle and process an average annual crop of over 200 million pounds of fruit before it becomes overmature. Over mature fruit leads to cullage loss and low quality.

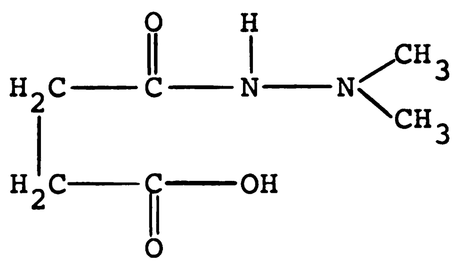
Processing plant capacity is insufficient to handle this volume in so short a period. Faster crop removal, as a result of mechanical harvesting, has amplified the handling, processing and storage problem to an enormous proportion. As a result, in two recent peak production years, 10 to 20% of the crop was not harvested because fruit quality was lost before harvesting and processing could be accomplished. The inability of processing plants to accommodate the fruit in these peak years has caused processors to pro-rate the amount of fruit which may be delivered by each grower. This, too, prolonged the harvest season. Variations in fruit color, size and firmness in certain years have also led to problems of excess bruising and pitter loss, resulting in a low-grade product.

The investigations in this thesis were designed to 1) determine the effects of Alar on extending the harvest period by influencing maturity and/or improving the quality of late harvested cherries and 2) to evaluate Alar's influence on other factors which contribute to processing cherry quality.

## REVIEW OF LITERATURE

### Alar

The existence of $B_{995}$ was first reported by Riddell, *et al* (80) in 1962. The potential of this growth retardant led to its formulation and trademarking as Alar-85 for use on fruit and vegetable crops. Alar has a molecular weight of 160.0. The structural formula is as follows:



Its white crystals have a very slight odor and melt at 154° to 156° C. The solubility of Alar at 25°C per 100 grams of solvent is 10 grams in distilled water; 5 grams in methyl alcohol; and 2.5 grams in acetone; it is not soluble in xylene. Alar has a pH of 3.8 at 5,000 ppm with a pKa of $1.12 \times 10^{-5}$. It is stable in unbuffered water for over two months and will break down in soil after twenty-one days at 80°F (2). Dahlgren and Simmerson (25) reported Alar to be very stable and not subject to intermolecular hydrolysis in aqueous solution.

Alar was first used by floriculturists to increase vase life and delay aging of cut flowers when dipped in 10 to 500 ppm solutions (45, 61, 62). Pre-harvest sprays of Alar were effective, also, in delaying aging and, also, have been reported to stimulate lateral shoot development, increase spike length, give larger flowers, reduce micro-organism growth and generally improve cut flower quality (61, 62). Other investigators found that Alar sprays, spaced at various intervals after propagation, reduced new growth and gave stronger and thicker necks of the flowers (57, 60, 85). Alar caused earlier flower bud initiation, earlier flowering and multiple flowers when applied to azaleas (74, 103). Grettendon, et al (44) reported some varieties of azaleas to respond with delayed flower initiation and heavier flowering yielding smaller flowers. Experiments on rhododendrons and chrysanthemums indicate Alar slowed growth and flower bud initiation and delayed flowering (21, 64).

Some vegetables have responded to Alar applications. Alar solutions delayed deterioration of Grand Rapids lettuce leaves and doubled shelf life (45). On cucumber plants Alar reduced internode length, decreased flower number and tendril development and increased individual leaf area (52). Tomatoes, also, responded well to Alar when applied three weeks after sowing at 600 to 6,000 ppm. Yield was increased, concentrated ripening was accomplished and cracking at harvest was reduced (2, 12).

Several researchers have found that Alar, used at concentrations ranging from 2,000 to 8,000 ppm, was effective in reducing growth of fruit trees in the nursery (15, 92, 94). Stahly and Williams (93, 94) attributed this growth reduction to the induction of earlier terminal bud formation by Alar, while Brooks (15) reported reduced apical dominance and increased secondary branching. Stahly and Williams (93, 94) reported normal tree growth and no adverse effect on foliage or trunk caliper the year following treatment when Alar was applied at 2,000 ppm to apple, pear, cherry and plum nursery trees. They concluded that Alar could prevent excessive growth of nursery trees and produce trees which are easier to handle and of a more desirable and saleable size.

Alar On Apples.--A majority of the field research reported on Alar has been done on apples. Numerous investigators have confirmed the growth-retarding effects of Alar on apples of various ages and varieties (6, 8, 14, 17, 28, 31, 34, 36, 38, 39, 41, 42, 65, 77, 97, 98, 100). They reported that this retarding effect was due to shortening internodes, which gave a denser tree with only a slight reduction in leaf number. These researchers used concentrations of

Alar, ranging from 500 to 5,000 ppm, with a mean of 1,000 to 2,500 ppm, and reported growth reduction of from 15 to 75% with most observing 40 to 50% reduction. Spring applications of Alar were applied 2 to 4 weeks after full bloom, and fall applications were applied soon after harvest.

Edgerton and Blanpied (31) applied Alar to Red Delicious at 2,000 ppm one month after full bloom and obtained 55% growth reduction and only 12% decrease in nodes, which demonstrated an extremely large reduction in internode length. They also observed the formation of the terminal bud two weeks early on treated trees. Edgerton and Hoffman (34) reported that Alar-treated trees had leaves of normal shape but they were slightly larger in size, darker green and thicker in texture. Tukey (98) found that Alar controlled water sprouts and sucker growth equally as well as shoot growth. Emerson and Dostal (38) concluded that the optimum dosage for adequate growth reduction was 1,000 ppm on Red and Golden Delicious. They found two sprays of 1,000 ppm gave a greater reduction than one spray of 2,000 ppm. One thousand ppm reduced vegetative growth more severely on Golden Delicious than on either Red Delicious or Jonathan, thus indicating a difference in varietal response to Alar. Bryant and Nixon (17) showed that 3,000 ppm of Alar applied eight weeks after bloom on young trees caused immediate terminal bud formation without any overcrowding of buds at the tip. According to Fochessati (41) the terminal bud formed may be enlarged. Wertheim and Van Belle (101) could find no transmission of effects from treated and untreated branches of the tree, and Looney, et al (65) could not find any appreciable growth reduction the following year, from the previous year's treatment, indicating that the carryover effect was not great.

Several experiments have verified that Alar applied to apple trees before bloom may cause a slight delay (1 to 5 days) in full bloom (31, 34, 37). Conflicting results have been reported by these researchers with regard to fruit set. The reports range from light to normal to increased fruit set in the various experiments. This discrepancy concerns the effect of frost and the effect of Alar on frost resistance following treatment.

Numerous reports indicate that Alar increased flower bud initiation the year after it was applied (4, 6, 8, 28, 31, 34, 36, 41, 42, 65, 77, 98, 100). The greatest response occurred when applications were made during the month following full bloom. Little effect was found if applications were made late, after initiation had occurred. Edgerton and Blanpied (31) indicated bloom was increased from 1 to 17% when Alar was applied one month after full bloom at 2,000 ppm. Edgerton and Hoffman (34) found a single application to be as effective in inducing flower bud initiation as repeated treatments. Edgerton, et al (36) reported that earlier bloom dates also result from the previous year's Alar applications, but this was dependent on variety, concentration and proper thinning. Two reports by Shutak, et al (87, 88) using Cortland apples conflict with these findings. They showed that trees treated the previous season bloomed 4 to 6 days later the following spring. Looney, et al (65) using Golden Delicious showed that a light bloom could occur the year after application of Alar to heavily-loaded trees, but continued annual applications helped stabilize bud initiation.

Van Belle (100) showed that applications of Alar could be timed so as to not effect growth, but to increase flower bud initiation to 38%, as compared to 23% on controls, and, as a result, increase yield. Dilley and Austin (28) found annual application rates of 1,000 to 2,000 ppm to be an aid to promoting annual bearing. Grenhalgh and Edgerton (42) indicated that high concentrations of Alar (5,000 ppm) reduced the amount of bloom the following year. Wertheim and Van Belle (101) supported this finding. They concluded that 2,000 to 2,500 ppm was most beneficial, and that higher concentrations tend to reduce flowering. They also found that Alar increased flower bud initiation even after a year of high production. This was especially true on varieties that were not definitely biennial bearing, but yield data for the year following application showed an increase for several varieties. Tukey (97, 98) and Dilley and Austin (28) found that fall applications of Alar delayed full bloom the next year by 1 to 5 days and modified flower and fruit form.

Wertheim and Van Belle (101) showed that fruit weight was reduced by spring applications of Alar at greater than 2,000 ppm or by repeated applications of lower concentrations. Van Belle (100) found increased yields the following year as a result of the effect on flower bud initiation the previous season.

A number of experimenters have reported that Alar influenced fruit set. Edgerton and Hoffman (34) and Wertheim and Van Belle (101) reported that spring applications of Alar before or during bloom adversely affected fruit set. Edgerton and Hoffman (36) found that Alar applied two weeks past bloom at 2,000 ppm caused reduced fruit set on Delicious. They attributed variations in fruit set data from Alar treatment to variety and crop load differences the previous year. Tukey (98) reported that spring Alar sprays act as both a fruit thinner as well as a fruit setting agent, depending on the time of application. He found that sprays applied in the balloon stage of bloom increased fruit set, while applications at petal-fall thinned apples. Tukey (97, 98), also, reported fall applications of Alar to cause excessive fruit set the following spring.

All researchers who have evaluated the effect of Alar on fruit size agreed that Alar reduced size when applied during the month following bloom (13, 28, 31, 34, 36, 38, 72, 73, 88, 92, 97, 98). Although all varieties respond, there is a varietal difference in response. Dilley and Austin (28) found a 10 to 20% reduction in size when Alar was applied two weeks after bloom at 1,000 to 2,000 ppm. Some experimenters (34, 73, 88, 92) noted that size reductions only occurred when Alar was applied relatively early in the growing season. They found no size response from pre-harvest applications. Blanpied, et al (13) found that the reduction in fruit size was a result of reduced cell size. Tukey (97, 98) reported fall applications of Alar not only to reduce fruit size the following year, but also to shorten and thicken fruits and stems.

Investigations with Alar indicate that almost all application times and rates stimulate red color development in apple fruits (28, 31, 35, 36, 72, 73, 86, 88, 90, 91, 92, 97, 98). Mattus (72) found that while red color was enhanced, ground color was not affected. Edgerton and Hoffman (35) and Southwick, et al (92) concluded that the color enhancement found with Alar was a direct effect of the chemical. Southwick (90, 92) found a varietal difference in response and indicated that Delicious did not respond. Tukey (97) indicated that the nature of the color response was characterized by an earlier and more intense red color.

All investigations concerning the effect of Alar on fruit firmness indicated that increased firmness is due to a reduced rate of fruit softening both before and after harvest as a result of Alar treatment (3, 7, 13, 28, 31, 34, 35, 36, 38, 39, 66, 72, 73, 86, 87, 88, 90, 91, 92, 95, 97, 98). These reports state that treated fruits softened less in storage and, as a result were firmer when removed from storage. Mattus (73) found a carryover effect in the fruit harvested the following year after treatment with Alar the spring of the previous year, as indicated by higher fruit firmness and reduced drop.

Several researchers indicated that pre-harvest drop could be effectively controlled with Alar (7, 13, 17, 28, 31, 35, 36, 39, 72, 73, 87, 92). These reports showed that 1,000 to 5,000 ppm was effective when applied from 20 to 60 days pre-harvest. Fisher and Looney (39) found that drop-preventing capacity of Alar sufficient to keep fruit firmly attached 3 to 4 weeks after normal harvest when it was applied twice at 2,000 ppm the month following bloom. Edgerton and Hoffman (35) showed that, while check fruits dropped 56%, Alar fruit treated at 500 ppm dropped only 6%. All application dates were effective in influencing drop except those applied immediately before harvest, but applications one month pre-harvest were most effective at lower concentrations. One report by Wertheim and Van Belle (101) indicated that June drop was reduced on some varieties by applying Alar at petal fall.

Various researchers have studied the effect of Alar on maturity and respiration. All agreed that Alar significantly delayed maturity 1 to 3 weeks, depending on variety and treatment (3, 7, 13, 28, 31, 35, 39, 86, 87, 91). Shutak (87) concluded that because of decreased rate of ripening, treatment with Alar made it possible to leave fruit on the tree 3 to 4 weeks longer than normal. Several experimenters indicated that Alar delayed by 2 to 3 weeks the onset of the respiratory climacteric in the fruit (3, 13, 28, 31, 86). Blanpied, et al (13) showed a delayed peak of ethylene evolution and lower post-peak ethylene levels, as well as decreased ethanol content in Alar treated fruit. Blanpied noted that while climacteric onset of fruit was delayed with Alar, the post-climacteric respiration levels were similar to non-treated fruit. Fisher and Looney (39) showed that on the basis of color, soluble soluble solids and acid content, Alar-treated fruits were as mature as check fruit, although treated fruits were firmer and trees showed less drop. They, also, showed at harvest, that Alar significantly increased soluble solids and titratable acidity in Golden Delicious but decreased these factors in Winsap. These differences persisted throughout storage. They considered these varietal differences in response as normal occurrences which will have to be considered in making commercial recommendations.

Experiments on the effects of Alar on physiological disorders of apples indicated that Alar may increase russetting of some varieties, particularly Golden Delicious (39, 72, 73, 101); reduce storage scald, although some variations in years and cultivars exist (3, 5, 28, 31, 72, 73, 87, 88, 90, 92, 101, 104); decrease susceptibility to rotting in storage (32); reduce internal breakdown (66, 90, 92); and delay development of water core (28, 66, 90, 91, 92). One instance of increased core browning and scald was reported on McIntosh by Blanpied, et al (13). Alar sprays and dips applied at harvest or immediately pre-harvest were not effective in controlling physiological disorders (72, 73, 90). The increased firmness and reduced rate of softening found with pre-harvest Alar treatment persisted throughout the storage life of the fruit in both regular and controlled atmosphere storages. This fact, coupled with reduced storage disorders, significantly extended the shelf life of the treated fruits after removal from storage (5, 16, 31, 66, 90, 104). Bryand and Nixon (17) reported shelf life experiments in which treated fruit stored at 36° to 40°F remained good until March, while control samples completely disintegrated by the end of December. Batjer and Martin (5) and Williams, et al (104) found that Alar applied to apple trees resulted in less water-soluble pectin and more total pectin in the fruit after storage. These findings explain the increased firmness of apples which result from Alar application.

Alar On Other Fruit Crops.--Johnson and Dilley (53) reported that applications of Alar to pears resulted in delayed fruit maturity if applied within 45 days of bloom. Alar did not increase safe storage time and tended to reduce fruit size. Alar had no effect on ethylene synthesis, but when ethylene was supplied, respiration of Alar-treated pears could not be stimulated as it could in control fruit, indicating delayed maturity. Griggs, et al (43) found that fall applications of Alar to pear trees delayed bloom the following spring, and thus avoided last frost injury and increased fruit set. Shoot growth was delayed but not reduced, and storage quality, ripening and flavor were not affected.

Batjer, et al (6, 8) indicated that Alar advanced maturity of sweet cherries. Ryugo (81) showed that the application of Alar at 2,000 ppm to sweet cherries reduced shoot growth and induced early production of anthocyanins in the fruit. Since the level of soluble solids and size of fruit were not affected, he concluded that Alar enhanced the biosynthesis of anthocyanins but did not advance the physiological maturity of the fruit. Chaplin and Kenworthy (22) applied Alar to sweet cherries at concentrations of from 1,000 to 8,000 ppm two weeks after full bloom. All concentrations reduced the force required to remove fruit from its pedicel and enhanced red color development early in the season, indicating earlier maturity. Soluble solids and titratable acidity were increased. And, shoot growth, internode length and number of buds per shoot were reduced.

Edgerton (30) found that 2,000 ppm of Alar applied eight weeks after bloom on peaches reduced terminal growth but allowed lateral buds to break near the shoot apex. Flower bud formation was slightly increased, but there was no effect on cold hardiness of buds. Hull (51) observed marked increases in fruit set when Alar was applied to grapes at 2,500 ppm any time from 1 week pre-bloom to 3 weeks post-bloom. The soluble solids content of fruit was not affected. Tukey (99) used Alar on grapes at concentrations ranging from 500 to 2,250 ppm and application dates from 10 days pre-bloom to post-bloom berry shatter. He found significant increases in weight per cluster and number of fruit per cluster and decreased weight per berry within the cluster. Applications applied at bloom were more effective than pre-bloom sprays, and post-bloom sprays had little or no effect. No differences were found in soluble solids. Bukovac, et al (19) showed that Alar-treated grape plants exhibited restricted shoot elongation because of suppressed internode extension. Treated plants consumed less water and were less susceptible to wilting under moisture stress. Alar influenced leaf mineral nutrient content, but had no effect on composition of stem tissue. Martin and Lopushinsky (69) tested the drought tolerance effects of Alar on apples and found that treated trees showed less water deficit in spurs. Treatment did not delay wilting but enhanced the ability of the plant to recover from severe drought conditions.

Broron, et al (16) tested the effects of Alar on the chilling requirement of Jonathan apples and noted that Alar sprays partly offset the deleterious effects of insufficient chilling and stimulated bud development. Mitterling (75) found that Alar inhibited both the number and length of runner plants on strawberries. No inhibition of runner rooting occurred. Single and Camphell (89) supported these results on runner inhibition but found decreases in dry weight of plants and length of roots. Plants treated in growth chambers showed effects similar to field-grown plants. Nutrient analysis showed Alar-treated plants contained larger amounts of Ca, Mg, and N in both foliage and roots. Monselise, et al (76) reported that Alar increased flower and fruit production of lemons, although leaves of treated branches had lower dry weight and less catalase activity. Hooks (49) found that Alar reduced internode length and increased chlorophyll and zinc content of pecans. Sciuchetti, et al (82, 83) showed that Alar significantly reduced the alkoloid content of Datura. Dostal and Emersen (29) found that the production of volatiles in apples was inversely proportional to the concentration of Alar treatment. This was related to the delayed maturity caused by Alar.

Mobility and Mode of Action of Alar.--Experiments on the mobility of Alar in sweet cherries were conducted by Ryugo (81). Alar was present in new leaves the spring following a late fall application. The residue level in green fruits decreased initially, but gradually increased in the ripening fruit, indicating a movement into the fruit. Edgerton and Greenhalgh (32, 33) found that $C^{14}$-labeled Alar, sprayed on limbs of apple trees, decreased by nearly one-half from the surface of the young fruit within 24 hours after application. The label in extracts of flesh and seed reached maximum values in about three weeks. Five weeks after treatment, no residue was detected on the fruit surface, and the levels of the absorbed compound in the flesh were diluted by growth of the fruit. The distribution of the $C^{14}$ label was measured during the dormant season. The compound accumulated in flower buds, vegetative buds, cluster bases, one-year-old bark and one-year-old xylem in the order listed. No translocation from treated to untreated branches was detected. All of the $C^{14}$ label present in the fruit and dormant buds was found to be in the intact compound and had not been broken down. Martin, et al (70, 71) showed that Alar applied as an injection or root dip was quite mobile and moved with the equivalent speed of many inorganic ions. The plant was able to pass Alar to the soil via the roots. After long periods, the majority of the injected $C^{14}$-labeled Alar remained intact with only slight breakdown to $C^{14}O_2$ occurring throughout the growing period.

Some attempts have been made to discover the mode of action of Alar. Heatherbell, et al (47) indicated that the growth-retarding effect of Alar on peas may be due to uncoupling of oxidative phosphorylation. Reed, et al (79) using peas found that growth inhibition with Alar was correlated with the inhibition of the oxidation of tryptamine $-2-C^{14}$ to indoleacetaldehyde $-2-C^{14}$. They attributed the action of Alar to the formation of 1,1-dimethyl hydrazine, in vivo, which strongly inhibited tryptamine oxidation. Greenhalgh and Edgerton (42) found increased levels of serine, Zn and Mn in the leaves of Alar-treated apple trees. They concluded that "the increase in serine and Zn might be explained by the hypothesis that Alar competes with N-N dimethyl ethanol amine for its active site in the enzyme system which converts serine to diolene."

## The Tart Cherry Industry

Michigan contributes slightly over 65% of the total national tart cherry production. In dollar value, tart cherries are second only to apples among fruit crops within the state. Michigan's tart cherry growers produce an average annual crop of close to two hundred million pounds. This is expected to increase to two hundred fifty million pounds by 1980. The industry has been plagued by lower grower profits as the result of spring frost damage and other climatic factors which have led to extremely wide production fluctuations. The tart cherry market potential exists if a continuous supply of quality cherries could be maintained (63). More uniform annual production would aid in providing better competition with other fruits and create a confidence in the industry which would stimulate new product development (40).

In 1964 and 1965, two full crop years, 20 and 10% respectively of the crop were never harvested (63). Tart cherry production is almost entirely from the Montmorency variety. Growers believe they must be able to harvest their total crop in a maximum of three weeks (50). After this time, firmness decreases, resulting in increased cullage and lower quality. From the processing standpoint, proper maturity and good quality are very important. Fruit in any given orchard is of desirable maturity for only 10 to 14 days at most. Immature cherries have stems firmly attached and the fruits are low in color. With overmaturity, cherries collapse when pitted, causing pitting problems and increasing juice loss (40). Processing plant capacity is insufficient to handle this volume of cherries in so short a period.

The problem of insufficient handling and processing capacity is not new, but the establishment of mechanical harvesting, to facilitate harvesting, has enhanced the processing bottleneck. Where a crew of three men used to require an hour to harvest one tree, the same three men can now mechanically harvest 30 to 60 trees per hour (84).

Variations in fruit color, size and firmness, in certain years, increase the ever-present problems of bruising, scald and pitter-loss and result in a lower-grade product. The tart cherry industry must reduce production fluctuations and cost, increase efficiency and keep cherries competitive with other fruits if it is going to maintain its place of horticultural importance (63).

Tukey (96) showed that the tart cherry exhibits a definite pattern of embryo, seed and pericarp development involving three well-defined stages. Stage I shows rapid development of the pericarp following fertilization. Stage II, which occurs in mid-season, exhibits delayed pericarp development and provides complete embryo and seed development. Stage III involves the final swell of the pericarp which carries the fruit to maturity. Kenworthy (55) showed that fruit enlargement did not stop at maturity, but instead showed a gradual but constant increase in size with delayed harvest after maturity was reached. He also showed that over a period of four harvest weeks, starting one week before the start of commercial harvest, firmness decreased rapidly beginning the second week. Other effects of delayed harvest were increased color and slight changes in soluble solids.

Kenworthy (56) showed that quality factors of tart cherries were not consistently related to any one nutritional element in the leaf. Significant correlations were found showing decreasing fruit sugar with increases in either N, P or K and decreased fruit color as either P or K increased. He concludes that other factors, such as cropload and climatic conditions, may control fruit quality. Curwen, et al (24) found that decreasing levels of K in the fruit resulted in softer fruit having a higher juice loss upon pitting and reduced insoluble pectin content. High K levels were associated with reduced Ca content. He suggested that this reduced Ca might in turn have resulted in the low insoluble pectin content which caused fruit softening. Harrington, et al (46) showed that the orchard culture must be considered in producing quality cherries. Bedford and Robertson (9) found that cultural practices, climatic conditions and the use of various spray materials all resulted in variations in processed cherry quality.

Cain (20) related the percent of fruit removal and ease of removal to the fruit retention force (FRF) of the pedicel. He found the FRF to be of major importance in fruit removal by mechanical harvesting. He concluded that fruit with a FRF of greater than 0.81 pounds (368 grams) could not be easily removed by mechanical harvesting.

Bruising is an ever-present problem in harvesting and handling of tart cherries. Mechanical harvesting, if done on good quality cherries to begin with and with proper equipment and handling, can minimize bruising (50). Water cooling and handling of cherries has proved helpful in minimizing bruise damage. Parker, et al (78) found that the degree of firming during storage at 40°F in water varied directly with initial bruise severity. The firmness of unbruised cherries did not change as a result of soaking, but pitter loss was reduced. Firmness increased and pitter loss decreased when bruised fruit was soaked for five hours, but complete recovery never occurred. Whittenberger and Hills (102) found that firmness of unbruised fruit was increased by soaking. They found that the exchange of solids and water between fruit and the soak media occurred through the area exposed as a result of stem removal.

Bedford and Robertson (10) could find no correlation between soluble solids, soak time or soak temperature and drained weight. Marshall, et al (68) found increased cullage as soak time increased. Cullage became excessive after twelve hours of soaking; however six hours appeared satisfactory to allow ease of pitting without deterioration. Hills, et al (48) could find no relationship between bruising and fruit maturity, yet LaBelle and Moyer (58) found that increased bruising and maturity both decreased firmness and drained weight.

Bedford and Robertson (11) showed that delayed harvest caused softer fruit, lower processed yield, increased soluble solids and color development as well as increased water and juice loss. LaBelle, et al (59) found bruising reduced firmness but the fruit largely recovered upon aging. Rebruising caused much greater firmness loss. Constantinides and Bedford (23) showed the cherry to be composed of 50 to 60% sugars on a dry-weight basis. Cherry sugars were 99% glucose and fructose, which occurred in a constant ratio of 1.0. Sugar concentration reached a maximum value when cherries became fully red and then remained generally constant throughout the rest of the harvest period. Das, et al (26) found malic acid to represent 75 to 95% of the total titratable acidity. The concentration of malic acid and total acidity generally decreased as the fruit matured. Al-Delainy (1) determined that water-soluble and water-insoluble pectins were higher in immature cherries than in mature and over-mature fruit, and that pectinesterase activity increased as cherries matured.

Buch, et al (18) noted that delayed processing after harvest increased the rigidity of cell walls. Textural changes were found to be related to changes in pectin esterification, but it was also found that firmed cherries have rigidity even when pectins are removed. Therefore, they concluded that processing produces some compound which imparts rigidity and resists distortion. Whittenberger and

Hills (102) found that lower temperatures gave firmer fruit. Floate (40) reported preliminary findings which showed a specific temperature range of firmness development of 50° to 55°F for cherries. Colder temperatures were found to inhibit chemical reactions required for firming.

## Summary

The response of fruit crops to Alar can be summarized as follows: reduced growth, increased flowering, altered fruit set, increased color development, reduced fruit size, reduced fruit drop, altered fruit maturity, increased yield, decreased or delayed storage disorders and enhanced storage and shelf life. The problems of the tart cherry industry, such as the harvest bottleneck, overmature soft fruit, bruising and processing losses, must be solved if full value of its investment and resources is to be realized. The objectives of this thesis are to evaluate the potential use of Alar toward solving some of these problems.

# EXPERIMENTAL PROCEDURE

## Location of Field Plots

Experimental field plots were located in three areas of Michigan's fruit belt. Research plots were located in David Friday's orchard (Location 1) at Hartford in 1966 through 1968; in Ray Alper's orchard (Location 2) at Lake Leelanau in 1966 and 1967; and in Jon Chase's orchard (Location 3) at Kent City in 1968. All trees used were 8 to 13 years old, except those used for mechanical harvesting at Location 1, which were approximately 17 years old.

## Experimental Design

The experimental design of all plots was a randomized block. Where harvest dates were involved, analysis was carried out as a split plot for harvest dates or sample time. All plots consisted of single tree treatments with two replicates. Statistical significance between means was determined by the use of Duncan's Multiple Range Test and orthogonal comparisons.

## Treatment Applications

Alar concentrations of 1,000, 2,000, 4,000 and 8,000 ppm were used. All treatments were applied to the foliage with a high pressure sprayer. All trees were completely covered to the drip point. Spring applications were applied two weeks after full bloom, while fall applications were applied just before leaf drop.

## Weekly Harvest Measurements

Measurements of several harvest parameters were taken at weekly intervals beginning at the earliest possible commercial harvest date of treated fruit, this was the week prior to the start of normal commercial harvest. All fruit sampling consisted of harvesting quart samples, which were transported to East Lansing in iced containers the same day, placed in a 40° F room over night and evaluated the next day. Measurements made were:

Fruit Size.--Fruit samples were divided into 5 size categories: less than 4/8-inch, 4/8- to 5/8-inch, 5/8- to 6/8-inch, 6/8- to 7/8-inch, and greater than 7/8-inch. The sizer was so constructed that minimum diameter of fruit was measured.

Fruit Firmness.--Ten fruit were selected at random from the size of fruit making up the largest portion of the sample. In this study the largest portion was always found as size 3 (5/8- to 6/8-inch). To determine firmness, one reading was taken on the largest cheek of each fruit with a type 00 Durameter.[1] This instrument reads on a scale from 0 to 100, with 100 equal to 4 ounces of force.

A 2.5 mm diameter plunger extends 3.0 mm from the base of the instrument. When the cheek of a fruit is placed against the instrument base, the reading shows the amount of plunger retraction into the base. The fruit skin is not punctured as a result of this operation.

In 1968 fruit firmness was also recorded in the field twice weekly from the start of final fruit swell to several weeks after normal harvest.

Fruit Color.--Fruit used for firmness plus 15 additional fruit selected at random from the fruit in size 3 (5/8- to 6/8-inch) were used to determine color. A 1/4-inch disc of epidermal tissue was cut from the largest cheek of each fruit. The 25 discs were placed in 25 ml of 0.5% oxalic acid solution. These samples were held in 40° F dark storage until color equalization occured (one week minimum). Samples were later removed from storage, filtered and made up to 50 ml volume with 0.5% oxalic acid. The absorbance of the pigment solution was determined at 515 mu with a Beckman DU spectrophotometer.

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[1]Manufactured by: Shore Instrument and Mfg. Co., Inc., Jamaica, N. Y.

Soluble Solids.--The 25 fruit selected for fruit color measurement were macerated and a juice sample was read on an Abbe' refractometer. No soluble solids were determined in 1968.

Respiration.--Respiration was measured in an oxygen-carbon dioxide gas analyzing respirometer (27) referred to as APRIL[2] in 1966 and 1967 on not less than 300 grams of fruit harvested weekly during the harvest season. In 1967 a comparison of the respiration of treated and untreated fruit was also measured, beginning in mid June through late harvest.

pH and Total Acidity.--In 1968 pH and total acidity were determined on treated fruit from one orchard. Fifty grams of pitted fruit was homogenized with 50 ml of distilled water. pH was determined and the solution was titrated to pH 8.0 with 0.1N NaOH.

## Fruit Removal Force (FRF)

The FRF was measured in 1967 and 1968 beginning as soon as the fruit could be separated from the pedicel and continued throughout the harvest season. Twenty fruit were measured at random around each tree at approximately a 5- to 7-foot height. In 1967 these measurements were recorded weekly. In 1968, 10 fruit per tree were measured twice

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[2]Automatic Photosynthetic Respiration Integrating Laboratory, Horticulture Department, Mich. State Univ.

weekly for several weeks after normal harvest. A Hunter push-pull mechanical force gauge,[3] model L-1000-M, was used for all measurements.

## Fruit Growth

In 1968 fruit growth was measured twice weekly on 10 fruit randomly selected per tree. Diameter measurements were made on these fruits perpendicular to the suture line. Measurements were made from June 1 through several weeks after normal harvest.

## Mechanical Harvesting Experiments

In 1967 a mechanical harvesting experiment was established at Location 1. Fruit treated at 0, 2,000 and 4,000 ppm were harvested at three intervals during the harvest period, starting at the earliest commercial harvest date for Alar treatments, one week later, and two weeks after the second harvest.

In 1968 similar experiments were conducted at Location 1 using 0, 2,000 and 4,000 ppm, and at Location 3 using 0 and 4,000 ppm. Harvesting began at earliest commercial harvest date for the Alar treatments. Two harvests, spaced two weeks apart, were made at Location 1, while three weekly mechanical harvests were made at Location 3. Fruit firmness

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[3]Manufactured by: Hunter Spring, Div. of Ametek, Inc., Hatfield, Pennsylvania.

measurements were made before and after mechanical harvesting. A self-propelled Friday Harvester[4] was used to harvest fruit mechanically.

Processing Evaluations

In 1967 representative 25-pound lots of each treatment replicate were placed in separate tanks and soaked in running water for 4 hours. After soaking, all fruit was removed and passed over the sorting belt. Cull fruit, stems, etc. were removed and their weight recorded. Sound fruit from each lot was collected, weighed, pitted and reweighed. The pitted fruit was then allowed to drain 5 minutes, all juice was collected and juice loss was determined. Pits were collected from each lot, drained 10 minutes and weighed.

Canning.--Twelve ounces of pitted fruit was placed in a #303 can, covered with boiling water, exhausted for 6 to 7 minutes, sealed and processed for 10 minutes at 210° F.

Freezing.--Twelve ounces of pitted fruit was placed in a #303 can, the fruit was completely covered with cold 40% sucrose syrup, sealed and frozen at -10° F.

Storage.--Nine months later, 2 cans of each treatment replicate were assembled. Frozen treatments were thawed at 70° F for 2-1/2 hours, and canned samples were

[4]Manufactured by Friday Tractor Co., Hartford, Michigan.

tested for vacuum. All fruit samples were evaluated as follows:

Drained Weight.--Cans were opened and drained weights were recorded after a 2-minute drain period.

Soluble Solids.--Soluble solids of the juice was determined with an Abbe' refractometer, Model 3L.

pH and Total Acidity.--Five ml of juice was added to 50 ml of distilled water. pH was determined, and the solution was titrated to pH 8.0 with 0.1N NaOH. Acidity was calculated as percent malic acid.

Color.--Color of drained fruit was measured by reflectance, using a Hunterlab Color and Color Difference Meter,[5] model D25, and a Gardner Automatic Color Difference Meter, Model Al.[6] A 2-inch appature was used in the Gardner, and a 4-inch appature was used in the Hunter. Juice color was determined by mixing 25 ml of juice with 25 ml of 0.5% oxalic acid. The solution was filtered and absorbancy was determined at 515 mu on a Beckman DU spectrophotometer.

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[5]Manufactured by Hunter Associates Laboratory, Fairfax, Va.

[6]Manufactured by Gardner Laboratories Inc., Bethesda 14, Md.

Firmness.--Firmness was determined with the Instron Shear Press,[7] model TTBM, using 150 grams of fruit in a Kramer shear box #C322. A 100 kg load scale was used for canned fruit and 250 kg scale for frozen fruit. A 10 cm/1 cm ratio of screw to chart drive travel was used for all measurements.

## Residue Analysis

Residue analyses[8] were determined on treated fruits in 1967 and 1968. The analysis procedure used was similar to that described by Ryugo (81). Fruit was harvested for analysis at the optimum time for commercial harvest.

## Mineral Nutrient Composition

Tissue analysis of leaf, fruit and pit were made in 1966. All tissue samples were collected when the fruit was in the optimum condition for commercial harvest. Nitrogen was determined by a modified Kjeldahl method, potassium by flame spectrophotometer, and P, Ca, Mg, Mn, Fe, Cu, B, Zn and Al were determined by photoelectric spectrometer. Preparation and procedures followed were the same as those described by Kenworthy (54).

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[7]Manufactured by Instron Corp., Canton, Mass.

[8]Analysis was determined on samples taken from research plots by Hazleton Labs Inc., Falls Church, Va. in 1967; Syracuse University Res. Corp., Syracuse, N. Y. in 1968. Analysis costs paid for by the UNIROYAL Chemical Co., Naugatuck, Conn.

## Fresh and Dry Weight of Fruit

Fresh weight and dry weight comparisons were made on pitted lots of 10 fruit from each treatment in 1966. Fruit samples were collected at optimum commercial harvest date.

## Terminal Shoot Growth and Node Count

The terminal shoot growth and number of nodes per shoot were recorded for 10 shoots selected randomly at a 5- to 7-foot height. These measurements were made during the dormant season following treatments applied in the 1966 and 1967 growing season.

## Bud Initiation

Counts were made on the number of vegetative and flower buds found on 20 terminal shoots randomly selected at a 5- to 7-foot height. Records were taken for the 1966 and 1967 treatments and the counts were made the spring following the year of treatment.

# RESULTS AND DISCUSSION

Spring and fall Alar application results will be discussed separately. Detailed results of all experiments conducted are given in the Appendix. The results given here are selected from the Appendix tables to illustrate the type of response observed with Alar treatment. Variations in response will be discussed later. All table numbers containing an "A" indicate Appendix tables.

## Spring Alar Applications

Fruit Color.--Fruit color of tart cherries was significantly enhanced by Alar applications at the time of the first and second harvests (Table 1). At the time of first harvest, all Alar concentrations showed a significant increase in fruit color. However, only concentrations of 2,000 and 4,000 ppm maintained this increase through the second harvest. In this experiment, all differences disappeared by the third harvest.

The color enhancing ability of Alar at 4,000 and 8,000 ppm was evident in Figure 1 and Figure 2, respectively. Both concentrations showed a significant color enhancement during the first two weeks of harvest. This increase was

Table 1.--Effect of various Alar concentrations on fresh fruit color at selected harvest dates in 1966, location 1.[1]

| Alar Concentration (ppm) | Fruit Color (Absorbance, 515 mu) Weekly Harvest 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| 0 | 0.89 | -3 | 1.20 | -2 | 1.52 | |
| 1000 | 1.07 | +1 | 1.24 | | 1.48 | |
| 2000 | 1.15 | +1 | 1.52 | +1 | 1.42 | |
| 4000 | 1.17 | +1 | 1.50 | +1 | 1.51 | |
| | | ** | | * | | N.S. |

[1]From Appendix Table 1A.

**Indicated orthogonal comparison significant at 1% level.

*Indicated orthogonal comparison significant at 5% level.

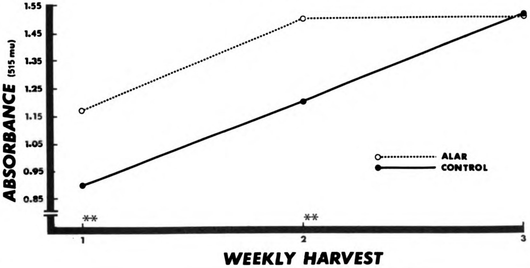
N.S. Not significantly different.

Figure 1.--Fresh fruit color as effected by 4,000 ppm Alar at selected harvest dates in 1966, location 1 (from Appendix Table 1A).

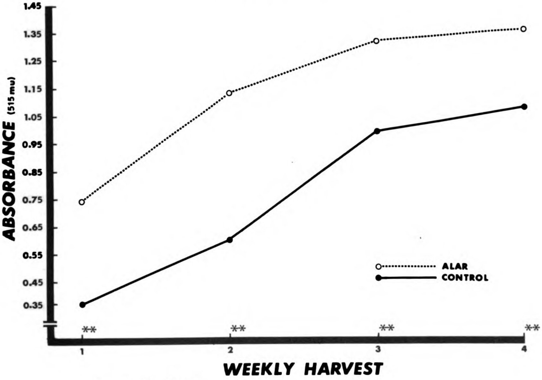
Figure 2.--Fresh fruit color enhancement resulting from 8,000 ppm Alar treatment at selected harvest dates in 1968, location 3 (from Appendix Table 5A).

FIGURE 1

**FRUIT COLOR**




**FRUIT COLOR**




** Significantly different at the 1% level.

FIGURE 2

equivalent to a 1-week and 1-1/2-week advancement in color formation, as compared to untreated fruit in Figure 1 and Figure 2 respectively. With 4,000 ppm (Figure 1) all color difference disappeared by the last harvest. However, at 8,000 ppm (Figure 2) significant color differences continued to be evident in later harvests although the difference in actual values was somewhat less. Appendix Tables 1A through 5A show a variation in the length of duration of the color enhancement found with Alar. However, in most experiments the enhancement was sufficient, at the beginning of the harvest season, to advance the date at which harvesting could begin when higher concentrations of Alar were applied.

The color enhancement effect of Alar was evident in the processed product as well as in fresh fruit (Table 2).

Table 2.--Fruit color of processed fruit as effected by 4,000 ppm Alar.[1] (aL/bL Ratio)[2]

| Alar Concentration (ppm) | Fruit Color (aL/bL Ratio) | | | | | |
|---|---|---|---|---|---|---|
| | Frozen | | | Canned | | |
| | Harvest | | | Harvest | | |
| | 1 | 2 | 3 | 1 | 2 | 3 |
| 0 | 1.95 | 2.59 | 3.09 | 0.85 | 1.44 | 1.99 |
| 4000 | 2.76 | 3.05 | 2.90 | 1.41 | 2.08 | 2.28 |
| | * | N.S. | N.S. | * | * | N.S. |

[1]From Appendix Table 9A.

[2]Hunter Color Difference Meter readings.

*Values significantly different at the 5% level.

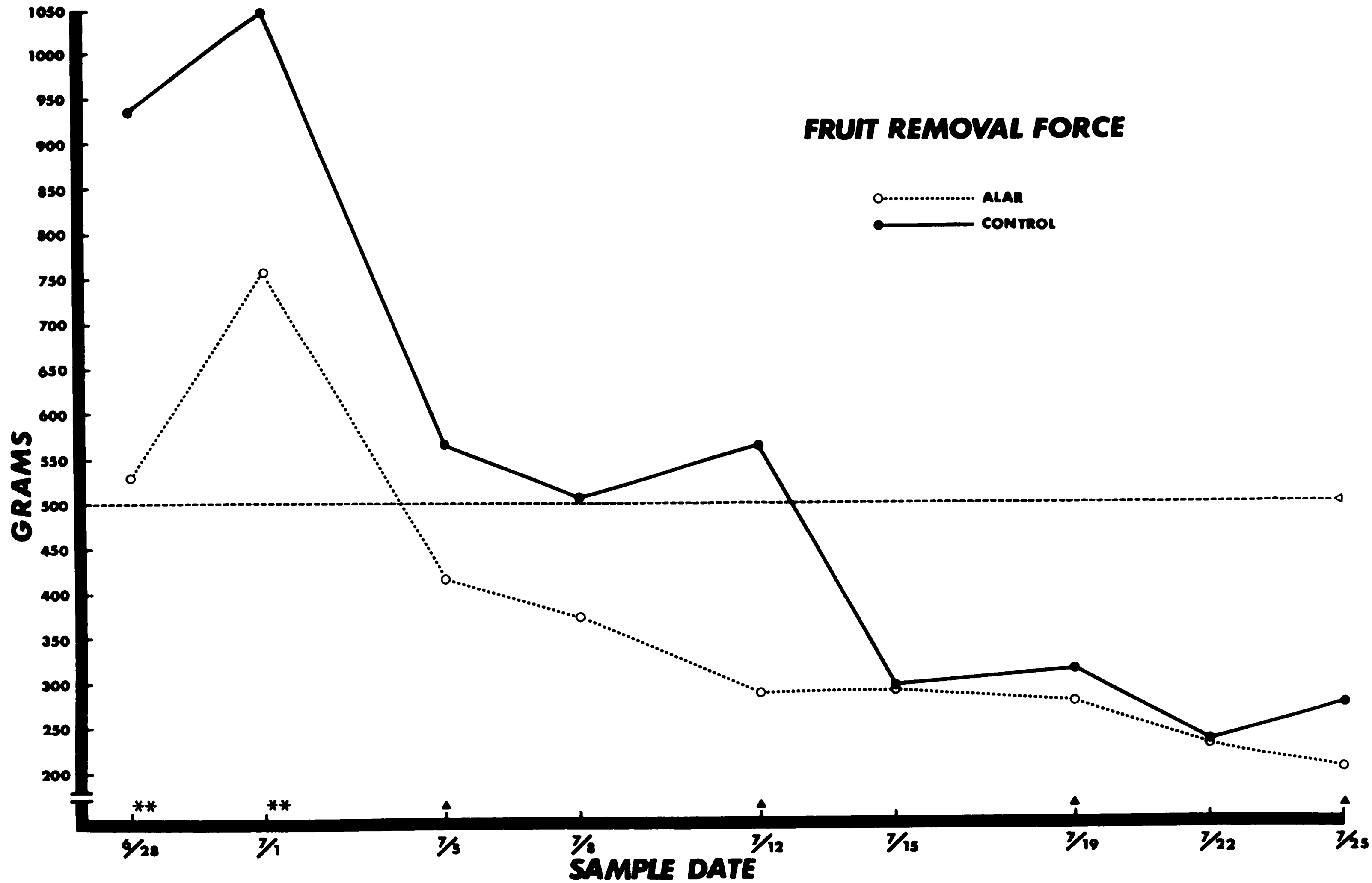
N.S. Values not significantly different.

Both canned and frozen fruit showed a significant increase in red color at the first harvest. Canned fruit had significantly more color at the second harvest, while frozen fruit showed only a trend in favor of increased color at the second harvest. All color differences, of processed fruit, diminished by the last harvest date. The results of this experiment supported the results of experiments conducted on fresh fruit color in Table 1 and Figure 1.

Fruit Removal Force (FRF).--The force required to separate the fruit from its pedicel was reduced as a result of Alar application (Figure 3). Significant differences in FRF were detected the week prior to the start of commercial harvest (sample times 1 and 2). Substantial differences remained evident during the first 1 and 1/2 weeks of commercial harvest (sample times 3, 4 and 5). These differences disappeared at the later sample times. The force differences shown at the first two mechanical harvesting dates (sample times 3 and 5) were observable under field conditions both by the force required to remove the fruit by hand and by the ease with which the fruit was removed machanically.

Based on the comparison of fruit removal forces with the observed ease of mechanically harvesting fruit, 500 grams would appear to be the maximum "average per tree" force at which the fruit may be removed by machanical harvesting on a commercial basis. In this experiment, Alar

Figure 3.--"Fruit removal force" in relation to Alar application at 4,000 ppm in 1967, location 1. (From Appendix Table 11A)




** Significantly different at the 1% level.
▲ Weekly mechanical harvests.
◁ Commerical mech. harv. practical below line.

FIGURE 3

advanced the possible start of machnical harvesting 1 and 1/2 weeks.

Fruit Firmness.--The firmness of fresh fruit, which was hand-harvested and cooled, was significantly improved at all harvest dates when Alar was applied (Table 3). All concentrations had a significant ability to increase firmness. However, 4,000 ppm showed a consistently greater ability to improve firmness over that of lower concentrations. In this experiment, Alar treated fruit harvested late was firmer at all concentrations than untreated fruit harvested at the start of the harvest period.

Table 3.--Firmness of hand-picked fruit as influenced by Alar concentrations at selected harvest dates in 1966, location 1.[1]

| Alar Concentration (ppm) | Firmness[2] Harvest 1 | | | 2 | | | 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 49.9 | -3 | | 48.7 | -3 | | 47.1 | -3 | |
| 1000 | 53.1 | +1 | -2 | 49.9 | +1 | -1 | 52.0 | +1 | -1 |
| 2000 | 56.5 | +1 | +1 | 52.9 | +1 | -1 | 52.8 | +1 | -1 |
| 4000 | 57.6 | +1 | +1 | 55.3 | +1 | +2 | 55.1 | +1 | +2 |
| | | ** | ** | | ** | ** | | ** | ** |

[1]From Appendix Table 14A.

[2]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

**Orthogonal comparison significant at 1% level.

Mechanical harvesting causes tart cherries to soften. The results of an experiment designed to test the influence of Alar on resisting this softening is shown in Table 4. The only significant improvement in the firmness of Alar fruit on the tree was at the first harvest while Alar fruit that was mechanically harvested showed significantly greater firmness at all harvest dates. This change in treatment

Table 4.--Effect of Alar at 4,000 ppm on firmness of attached and mechanically harvested fruit at selected harvest dates in 1967, location 1.[1]

| | Alar Concentration (ppm) | Firmness[2] | | |
|---|---|---|---|---|
| | | Fruit Attached To Tree | Mechanically Harvested Fruit | |
| Harvest 1 | 0 | 55.6 | 53.2 | * |
| | 4000 | 61.2 | 61.3 | N.S. |
| | | * | * | |
| Harvest 2 | 0 | 51.5 | 41.3 | * |
| | 4000 | 53.4 | 53.4 | N.S. |
| | | N.S. | * | |
| Harvest 3 | 0 | 47.0 | 43.6 | * |
| | 4000 | 47.7 | 46.9 | N.S. |
| | | N.S. | * | |

[1]From Appendix Table 18A.

[2]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

*Values significantly different at the 5% level.

N.S. Values not significantly different.

differences between fruits attached to the tree and those mechanically harvested was a result of the firmness lost by untreated fruit as a result of mechanical harvesting. Control fruits lost a significant amount of firmness as a result of mechanical harvesting at each harvest date. The Alar treated fruit did not lose any significant amount of firmness as a result of mechanical harvesting, at any of the harvest dates.

The results of an experiment conducted to compare the change in the treatment differences in fruit firmness when measured on the tree, after mechanical harvesting, and after cooling the fruit which had been mechanically harvested are shown in Table 5. Alar treated fruit was significantly firmer at all times of measurement. However, the least amount of difference was evident with fruits attached to the tree. This supported the minimal differences found in Table 4 with fruit attached to the tree. Apparently, the effect of Alar on fruit firmness is partly the result of increased resistance to softening such as may occur in mechanical harvesting.

An experiment designed to measure fruit softening as associated with maturation on the tree was initiated one week prior to the start of commercial harvest and continued one week after commercial harvest had ceased (Appendix Table 31A and 33A). The results of this experiment indicated that the firmness response to Alar continued to

Table 5.--Effect Alar at 4,000 ppm on fruit firmness at various stages in the harvesting operation in 1968, location 3. (Mean of all harvests)[1]

| Alar Concentration (ppm) | Firmness[2] | | |
|---|---|---|---|
| | On Tree | After Mechanical Harvesting | After Cooling In Air |
| 0 | 52.1 | 38.2 | 44.0 |
| 4000 | 57.9 | 47.7 | 51.2 |
| Diff. | 5.8 | 9.5 | 7.2 |
| | * | * | * |

[1]From Appendix Table 22A.

[2]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

*Values significantly different at 5% level.

persist beyond the normal harvest season. Observations made on the fruit 3 weeks after the end of commercial harvest showed fruit deterioration to the point where no difference in firmness were evident.

The improved firmness found in the fresh fruit was sufficient to promote increased texture of the processed product (Tables 6 and 7). The compaction and shear force values of the frozen processed product were significantly higher when the fruit has been treated with Alar. These differences were evident at all harvest dates.

Table 6.--Compaction force of frozen processed fruit as influenced by 4,000 ppm Alar at selected harvest dates in 1967, location 1. (Kg force/gm. fruit)[1]

| Alar Concentration (ppm) | Compaction Force (kg/gm fruit) Harvest 1 | 2 | 3 |
|---|---|---|---|
| 0 | 0.51 | 0.39 | 0.30 |
| 4000 | 0.70 | 0.51 | 0.43 |
| | ** | * | * |

[1]From Appendix Table 23A.

**Values significantly different at 1% level.

*Values significantly different at 5% level.

Table 7.--Shear force of processed fruit as influenced by 4,000 ppm Alar at selected harvest dates in 1967, location 1. (Kg force/gm fruit)[1]

| Alar Concentration (ppm) | Shear Force (kg/gm fruit) Frozen Harvest 1 | 2 | 3 | Canned Harvest 1 | 2 | 3 |
|---|---|---|---|---|---|---|
| 0 | 1.01 | 0.83 | 0.67 | 0.11 | 0.18 | 0.28 |
| 4000 | 1.32 | 1.12 | 0.98 | 0.12 | 0.22 | 0.47 |
| | * | * | * | N.S. | N.S. | * |

[1]From Appendix Table 24A.

*Values significantly different at 5% level.

N.S. Values not significantly different.

The exposure, during the processing operations, of fruit for canning to cooking reduced fruit texture and removed some of the treatment differences exhibited in the frozen product (Table 7). The loss of texture as a result of cooking made the compaction and shear peak identical. Significantly greater forces were required to shear canned Alar-treated fruit at the last harvest date, while no differences were apparent in the earlier harvests.

Fruit Size.--The data collected by the use of the mechanical sizer, which measured minimum diameter of the fruit, are shown in Appendix Tables 25A through 29A. These size data are inconclusive due to wide variations and opposing results and thus will not be presented in the thesis body. These variations could be the result of measurement error, large tree variability or differential tree response to Alar. However, later data measured by other means will show some rather decisive effects of Alar on fruit size.

The number of pitted, Alar treated fruit required per 12 ounces (#303 can) remained extremely uniform throughout the harvest season in the processing experiment (Table 8). The uniformity of number of fruit per 12 ounces with Alar fruit was in sharp contrast to the decreasing number of untreated fruit required per 12 ounces. Apparently, this difference resulted from the continued enlargement

Table 8.--Fruit size as effected by 4,000 ppm Alar at selected harvest dates in 1967, location 1. (No. of fruit per 12 ounces)[1]

| Alar Concentration (ppm) | Fruit Size (No./12 oz.) | | |
|---|---|---|---|
| | Harvest | | |
| | 1 | 2 | 3 |
| 0 | 115 | 100 | 93 |
| 4000 | 115 | 115 | 114 |
| | N.S. | * | ** |

[1]From Appendix Table 30A.

*Values significantly different at the 5% level.

**Values significantly different at the 1% level.

N.S. Values not significantly different.

of untreated fruit which occurs normally after fruit maturity is reached. Alar appeared to almost entirely prevent this enlargement as shown by the consistency in the number of fruit per can throughout the harvest season.

Further proof that Alar controlled fruit growth is shown in the fruit growth curve (Figure 4). The Alar treatment caused an accelerated increase in fruit enlargement which resulted in a more rapid final swell of the fruit. This provided a larger fruit earlier. Fruit treated with Alar, also, showed an greater reduction in the rate of fruit enlargement, as maturity was reached compared to

Figure 4.--Fruit growth as altered by Alar at 4,000 ppm, 1968, location 1. (From Appendix Table 31A)

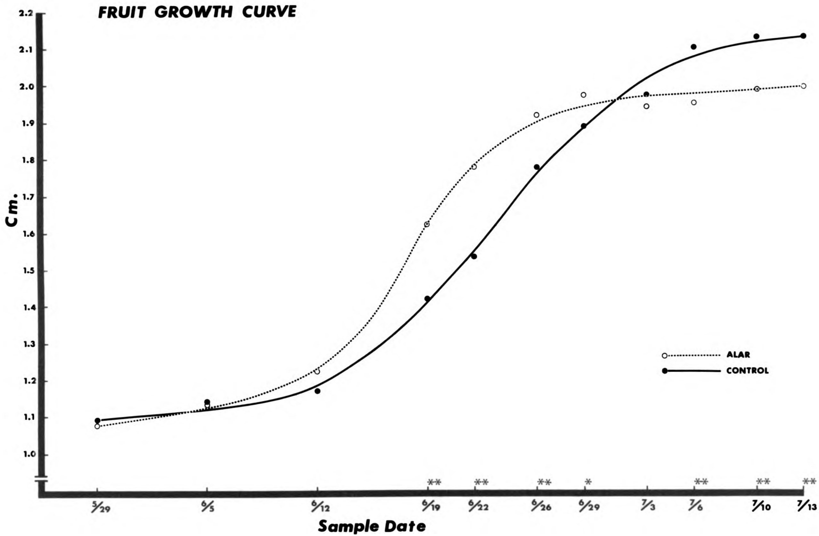

FRUIT GROWTH CURVE
Cm.
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
ALAR
CONTROL
** ** ** * ** ** **
5/29
6/5
6/12
6/19
6/22
6/26
6/29
7/3
7/6
7/10
7/13
Sample Date

FIGURE 4

untreated fruit. This provided a more uniform size of fruit throughout the harvest season and fewer larger-sized fruit which could result from continued enlargement as with the untreated fruit. Data in the curve supported the results shown in Table 8.

Fruit Acidity.--All concentrations of Alar significantly reduced the acidity of the fruit (Table 9). This reduction in fruit acidity persisted throughout the entire harvest season.

Fruit Respiration.--Alar treatment caused a significant reduction in metabolic activity measured as $CO_2$ evolved per 24 hours (Table 10). The respiratory quotient of treated fruit was significantly reduced, which indicates that Alar may have altered the use of metabolic pathways in the fruit. These differences were evident throughout the harvest season (Table 35A and 36A). A fruit respiration curve obtained using treated and untreated fruit measured over a longer period indicated an overall reduction in respiration and respiratory quotient for treated fruit (Table 37A).

Terminal Shoot Growth.--All concentrations of Alar significantly reduced terminal shoot growth the year it was applied (Table 11). There was a significant decrease in shoot growth as Alar concentration was increased the first year. When the same trees were treated the following year, 1,000 ppm resulted in a similar reduction; 2,000 ppm reduced

Table 9.--Fruit acidity as related to Alar concentration at selected harvest dates in 1968, location 3. (Percent malic acid)[1]

| Alar Concentration (ppm) | Fruit Acidity (Percent Malic Acid) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Harvest | | | | | | | |
| | 1 | | 2 | | 3 | | 4 | |
| 0 | 2.02 | +3 | 1.61 | +3 | 1.21 | +3 | 1.07 | +3 |
| 2000 | 1.63 | -1 | 1.36 | -1 | 1.00 | -1 | 0.85 | -1 |
| 4000 | 1.78 | -1 | 1.33 | -1 | 0.97 | -1 | 0.79 | -1 |
| 8000 | 1.74 | -1 | 1.26 | -1 | 0.96 | -1 | 0.78 | -1 |
| | | ** | | ** | | ** | | ** |

[1]From Appendix Table 34A.

*Orthogonal comparison significant at the 1% level.

Table 10.--The influence of Alar on fruit respiration, location 1. (Mean of all harvests)[1]

| Alar Concentration (ppm) | Fruit Respiration | | | |
|---|---|---|---|---|
| | $CO_2$/24 Hrs. | | R.Q./24 Hrs.[2] | |
| 0 | 625 | +2 | 1.10 | +2 |
| 2000 | 454 | -1 | 1.02 | -1 |
| 4000 | 420 | -1 | 0.92 | -1 |
| | | * | | ** |

[1]From Appendix Tables 35A and 36A.

[2]Respiratory quotient = $CO_2/O_2$ ratio.

*Orthogonal comparison significant at 5% level.

**Orthogonal comparison significant at 1% level.

Table 11.--Terminal shoot growth as effected by Alar (Percent of control)[1]

| Alar Concentration (ppm) | 1966 1 Yr. Application | | | 1967 2 Yrs. Application | |
|---|---|---|---|---|---|
| 0 | 100 | +1 | | 100 | +1 |
| 1000 | 90 | -1 | -1 | 89 | |
| 2000 | 78 | -1 | 0 | 98 | |
| 4000 | 59 | -1 | -1 | 64 | -1 |
| | | * | * | | * |

[1]From Appendix Table 40A.

*Orthogonal comparison significant at 5% level.

growth only 2% as compared to 22% the previous year; and 4,000 ppm reduced growth 36% versus 41% the first year. Thus, Alar had less ability to reduce growth the second year and, as a result, only the highest concentration was significantly effective.

<u>Shoot Internode Length</u>.--Alar significantly reduced the internode lehgth when applied to trees at 2,000 and 4,000 ppm (Table 12). As was the case with shoot growth, internode length was significantly reduced only by the applications of 4,000 ppm when the same trees were retreated the following year. In most experiments, the number of nodes per shoot were only slightly reduced as a result of Alar applications (Table 41A).

Table 12.--Internode length as effected by Alar. (Percent of control)[1]

| Alar Concentration (ppm) | 1966 | | 1967 | |
|---|---|---|---|---|
| | 1 Yr. Application | | 2 Yrs. Application | |
| 0 | 100 | +2 | 100 | +1 |
| 1000 | 97 | | 98 | |
| 2000 | 82 | -1 | 104 | |
| 4000 | 70 | -1 | 67 | -1 |
| | | * | | ** |

[1]From Appendix Table 42A.

*Orthogonal comparison significant at 5% level.

**Orthogonal comparison significant at 1% level.

<u>Bud Initiation</u>.--Experiments conducted in 1966 showed some enhancement of flower bud initiation when 2,000 and 4,000 ppm of Alar were applied (Table 13). In 1967 all Alar concentrations significantly enhanced flower bud initiation when the same trees were retreated (Table 13). When the first-year application experiment was repeated in 1967, all Alar concentrations significantly increased flower bud initiation (Table 43A). The apparent difference in the ability of Alar to influence flower bud initiation between 1966 and 1967 may have been due to climatic conditions or crop load. Field observations in the spring of 1967 and 1968 indicated

that the Alar treatment of the previous year enhanced flower opening by 2 to 3 days.

Table 13.--Flower bud initiation as influenced by Alar. (Percent of control)[1]

| Alar Concentration (ppm) | 1966 | | 1967 | |
|---|---|---|---|---|
| | 1 Yr. Application | | 2 Yrs. Application | |
| 0 | 100 | -1 | 100 | -3 |
| 1000 | 91 | | 120 | +1 |
| 2000 | 110 | | 117 | +1 |
| 4000 | 133 | +1 | 123 | +1 |
| | | * | | * |

[1]From Appendix Table 43A.

*Orthogonal comparison significant at the 5% level.

Residue Analysis.--There were inconsistent Alar responses between locations in 1966 and 1967. Table 14 shows the residue values obtained from fruit in 1967. Location 2 had only 1/2 to 2/3 the residue found in location 1. Similar decreases in response were evident in the data obtained from Location 2 in 1966. Thus, the lack of response at location 2 may have been associated with lower residual Alar levels if a valid inference can be drawn on 1966 results from 1967 residues.

Table 14.--Alar residue present at optimum harvest date in fruit treated one year. (Alar residue in ppm)[1]

| Alar Concentration (ppm) | 1967 Location 1 | 1967 Location 2 | 1968 Mean of 4 Locations |
|---|---|---|---|
| 0 | 0.1 | 0.2 | 0.3 |
| 1000 | 8.4 | 5.9 | --- |
| 2000 | 20.0 | 11.0 | --- |
| 4000 | 38.0 | 17.5 | 18.5 |
| 8000 | 75.5 | 58.0 | 49.2 |

[1]From Appendix Table 45A.

The explanation loses some validity when residue values for 1968 are considered (Table 14). These are the mean values of four locations, all of which showed a "typical" response to Alar treatment. The 1968 values compare more closely to Location 2 in 1967, which did not respond, than to Location 1, which did respond. Many climatic factors, both at the time of application and during the growing season, as well as variations in analytical method, may have contributed to the observed differences in response and residue.

In 1967 location 1 did not respond well to Alar applications as shown in the fruit color and firmness response. The response was less than that found at the same location in 1966. The only logical explanation which might account for this difference in response is that the crop was extremely light. This did not allow for good random selection of samples, since the entire crop load from each tree was needed to obtain a sufficient sample size. The small amount of fruit on the trees might also account for the higher residue values found at that location.

A variation in Alar response between years and locations is clearly evident and there is no clear cut explanation which would account for this. One can only guess as to the effect of crop load, climatic variations and other factors which might play a role in the observed variations in Alar response.

The mean residue value of all samples from each application rate is shown in Table 45A. These mean residue values showed a linear relationship to concentrations applied (Figure 5). The overall mean residue expressed as percent of application rate was 0.75%.

Nutrient Composition of Leaves, Fruit and Pit.--No differences were found in nutrient composition of fruit or pit. Therefore, only mean nutrient values are reported in Table 51A. There were no deficiencies or excesses evident in the orchards. Kenworthy (56) showed that fruit color increased as leaf K decreased. Thus, the lower K level found at Location 2 may explain why little Alar color response was observed. The only effect of treatment on leaf

Figure 5.--Mean residue values of all samples taken at the various Alar application concentrations in 1967 and 1968. (From Appendix Table 45A)

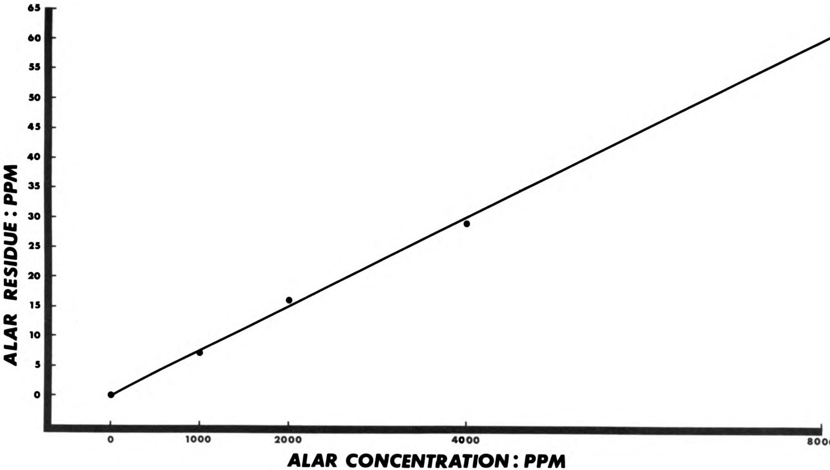

65
60
55
50
45
40
35
30
25
20
15
10
5
0
ALAR RESIDUE : PPM
0
1000
2000
4000
8000
ALAR CONCENTRATION : PPM

FIGURE 5

composition was with leaf nitrogen. There was a trend toward increasing leaf nitrogen as concentration of Alar increased. This trend was significant at one location. This condition may have been a result of a reduced utilization of nitrogen when growth was restricted with Alar.

"No Response" Parameters.--No differences were found in soluble solid content and percent dry weight of fresh fruit or in drained weight and acidity of processed fruit as a result of Alar treatment. Therefore, no data are presented on these parameters.

Related Responses.--The enhancement of fruit color and reduction in fruit removal force early in the harvest season indicated that Alar caused a marked advancement in fruit maturity. This conclusion was supported by the enhancement of final fruit swell caused by Alar. Reduced fruit acidity and fruit respiration were also indicative of more mature fruit. However, the differences in acidity, respiration and respiratory quotient continued throughout the harvest season.

The effect of Alar on fruit acidity may be either a direct effect of Alar or a secondary response related to fruit maturity. Differences in fruit respiration and respiratory quotient may have resulted from Alar causing an alteration in the use of metabolic pathways within the tissues which in turn resulted in changes associated with earlier maturity and increased anthocyanin biosynthesis.

The precise mode of action of Alar is not known. However, the increased firmness and resistance to softening resulting from Alar applications would appear to be best explained as a direct effect of the chemical since no relationship of the increased firmness to advanced fruit maturity is indicated. The influence of Alar on uniformity of fruit size and reduced vegetative growth also deserve some explanation. Other researchers have attributed the vegetative response to reduced cell division and earlier terminal bud formation. It would seem logical to conclude that the control of cell size might be a factor in fruit size uniformity.

The increase in flower bud initiation resulting from Alar treatment may be attributed to either the direct effect of Alar or a secondary response resulting from reduced growth.

## Fall Alar Applications

Fruit Color.--Fall Alar applications delayed red color formation in fruits early in the harvest season (Table 46A). Since the first harvest data was timed to coincide with the earliest possible commercial harvest of fruit treated in the spring with Alar, control fruit was still immature at this time. Fruit treated with Alar in the fall was not different from control fruit at first harvest, therefore both were immature. A trend toward decreased fruit color with increasing Alar concentration of fall application was evident at the second harvest with a significant reduction shown at 8,000 ppm.

Fruit Firmness.--Alar applications applied in the fall at high concentrations resulted in higher firmness values at the first two harvest dates (Table 47A). This firmness increase coincided with reduced color formation. These data confirm the field observation that fall application of Alar delayed fruit maturity the following year. This delay can be partly attributed to an observed delay of 2 or 3 days in dormant bud break and flower opening.

Fruit Size.--Fruit size was significantly reduced by fall Alar applications (Table 48A and 49A). There was a decrease in the percent of fruit in size #3* and a related increase in the amount of small fruit (size #2). These differences were significant throughout the harvest season at the 4,000 and 8,000 ppm concentrations.

Terminal Shoot Growth and Internode Length.--All concentrations of Alar applied in the fall were effective in significantly reducing shoot growth and the following year (Table 50A). However, these reductions were of less magnitude than those which resulted from spring applications. There was no reduction in the number of nodes per

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*Size #3 has approximately 125 fruit per 500 grams; this size of fruit is preferred by cherry processors.

shoot. The total growth reduction resulted from significant reductions in internode length (Table 50A).

Bud Initiation.--Alar applied in the fall caused a significant increase in flower bud formation at all concentrations tested (Table 50A). The early October application time was approximtely 4 months after flower bud initiation is normally considered to begin. These data suggested that flower bud initiation can occur very late in the season and still result in "apparent" complete floral differentiation and development.

Related Responses.--The increase in fruit firmness and decrease in fruit color early in the harvest season from Alar treatment applied the previous fall indicated a delay in fruit maturity. A corresponding decrease in fruit size would be expected. However, the continuation of this size reduction throughout the harvest season indicated something more than a maturity response. Data related to vegetative growth and bud initiation indicated a response similar to spring applications of Alar with differences only in the relative magnitude of the response.

## Future Research and Recommendations

The findings presented in this thesis suggest that the tart cherry responds to Alar application in many ways. However, these data leave many points unproven and raise several new questions, especially with respect to practical use of the chemical.

Since all research applications of Alar were made with a high pressure sprayer, wetting the tree to the drip point, a program involving speed sprayer applications at concentrated spray rates used commercially must be undertaken to insure adequate response under commercial application conditions.

Future research on different times of application might prove beneficial, particularly the use of two applications of 1,000 or 2,000 ppm spaced at some time interval. It is possible that Alar applications will be beneficial only when sufficient foliage is present for adequate absorption of the chemical and that applications close to harvest time run the risk of causing high residue and may not have a sufficient interval in which to cause a response. Related research on fruit quality to evaluate factors such as bruising, scalding, cracking, wind damage and fruit drop might prove useful.

Detailed research to confirm the results on flower initiation, particularly with fall applications, would be beneficial. This should involve the changes in response which may occur with variations in yearly climatic conditions and crop load, as well as data collected to confirm the observed influences on bloom dates. The cause of increased flower initiation has yet to be worked out.

The long range effects of continued Alar application on the yield and maintenance of fruiting wood as it relates to growth reduction and increased flower initiation must be studied. Will the increase in the number of nodes bearing flowers and the reduction in shoot length cause sufficient reduction in spur numbers as to adversely affect the total fruiting potential and eventually reduce fruit yield? Does the increased denseness caused by shorter internode length shift the bearing surface more toward the outside of the tree? Does this denseness influence spur life? Can higher levels of nitrogen overcome the effect of Alar? These are all questions which need to be resolved.

The fruit in the center of the tree is the last to color. If these fruit had sufficient color, harvesting could, in some cases, begin at an earlier date. One suggestion, proposed in talking with growers, was to apply Alar only to the center of the tree. If color were the only problem, and not fruit removal force, this would achieve an earlier harvest date with less residue and for less cost. Since cost is a relevant issue, research on this point might prove useful.

A program of processed product evaluation involving products ready for consumption needs to be conducted to evaluate the usefulness of the firmness increase found with Alar treatment.

Present research indicates that Alar may be used on tart cherries as follows: Alar should be applied at the rate of 4,000 ppm, covering the tree to the drip point, at two weeks after full bloom. On mature trees, this requires approximately 400 gallons of water per acre (16 pounds of Alar per acre). This will allow harvesting operations to begin one week earlier. Before a grower proceeds with Alar application, several questions must be resolved: 1) Should all his orchards be treated or only that acreage which can be harvested in one week? 2) Will a processing plant be open to receive the fruit? 3) Should the same trees be treated in successive years or should alternate sites be used to prevent continued growth reduction on the same trees?

When Alar is cleared for use, it should be tried on a limited scale by each grower to be sure that Alar will respond under his conditions and fit into his operation, since some variation in response between locations was noted. If a good response is obtained at 4,000 ppm, the grower may find that a suitable response can be obtained at 2,000 ppm under his conditions, thus reducing application costs.

# SUMMARY

Field experiments were conducted on the use of Alar on Montmorency tart cherries in 1966 through 1968 to determine its usefulness in extending the harvest season and improving cherry quality. Treatments involved both spring and fall applications at concentrations ranging from 1,000 to 8,000 ppm.

Spring applications of Alar significantly increased fruit color early in the harvest season. This increase continued through most of the season when Alar was applied at the higher concentrations. Fruit removal froce was significantly reduced early in the harvest season by all Alar concentrations. These two effects were sufficient to advance the possible starting date of commercial mechanical harvesting one week.

Alar significantly reduced acidity of fresh fruit throughout the entire harvest season. Fruit respiration and the respiratory quotient were significantly reduced during the entire harvest period. Significant increases in fruit firmness were evident in fruit hanging on the tree, handpicked fruit and mechanically harvested fruit. Alar treated fruit showed a significant ability to resist softening when mechanically harvested. Both the color and firmness increases found in the fresh fruit were significantly evident in the processed product.

Alar treatment caused fruits to go through an accelerated final swell and, in one case, resulted in a more uniform size of fruit throughout the harvest season because of the reduced amount of fruit size enlargement which occurred with delayed harvest.

Trees treated with Alar showed significantly reduced shoot growth and internode length. These trees, also, showed a significantly greater amount of flower bud initiation.

Fall Alar applications significantly reduced fruit color early in the harvest season and resulted in a corresponding increase in fruit firmness which indicated delayed fruit maturity. Fruit size was significantly decreased during the entire harvest season. Trees treated in the fall showed reduced shoot growth and internode length and increased flower bud initiation.

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# APPENDIX TABLES

Table 1A.--Fruit color as influenced by Alar application, 1966.[1]

| | Location #1 | | | | Location #2 | | |
|---|---|---|---|---|---|---|---|
| | Conc. | ABS. | | | Conc. | ABS. | |
| Harvest 1 | 0 | 0.89 | -3 | | 0 | 0.98 | |
| | 1000 | 1.07 | +1 | | 1000 | 1.19 | |
| | 2000 | 1.15 | +1 | | 2000 | 0.94 | |
| | 4000 | 1.17 | +1 | | 4000 | 1.12 | |
| | | | 1% | | | | N.S. |
| Harvest 2 | 0 | 1.20 | -2 | | 0 | 1.33 | -1 |
| | 1000 | 1.24 | | -1 | 1000 | 1.54 | |
| | 2000 | 1.42 | +1 | 0 | 2000 | 1.56 | |
| | 4000 | 1.50 | +1 | +1 | 4000 | 1.72 | +1 |
| | | | 1% | 5% | | | 1% |
| Harvest 3 | 0 | 1.52 | | | 0 | 2.07 | |
| | 1000 | 1.48 | | | 1000 | 1.92 | |
| | 2000 | 1.42 | | | 2000 | 1.70 | |
| | 4000 | 1.51 | | | 4000 | 2.05 | |
| | | | N.S. | | | | N.S. |
| Mean of All Harvests | | | | | | | |
| | 0 | 1.20 | | | 0 | 1.46 | |
| | 1000 | 1.26 | | | 1000 | 1.55 | |
| | 2000 | 1.33 | | | 2000 | 1.40 | |
| | 4000 | 1.40 | | | 4000 | 1.63 | |
| | | | N.S. | | | | N.S. |

[1]Treatments applied to trees one year.

Table 2A.--Fresh fruit color as a result of one year's Alar application, 1967.

| | Location #1 | | | Location #2 | | | |
|---|---|---|---|---|---|---|---|
| | Conc. | ABS. | | Conc. | ABS. | | |
| Harvest 1 | 0 | 0.70 | | 0 | 0.45 | -4 | |
| | 1000 | 0.75 | | 1000 | 0.72 | +1 | |
| | 2000 | 0.80 | | 2000 | 0.67 | +1 | |
| | 4000 | 0.84 | | 4000 | 0.73 | +1 | |
| | 8000 | 0.81 | | 8000 | 0.76 | +1 | |
| | | | N.S. | | | 1% | |
| Harvest 2 | 0 | 1.05 | | 0 | 0.57 | -4 | |
| | 1000 | 1.01 | | 1000 | 0.73 | +1 | -1 |
| | 2000 | 1.05 | | 2000 | 0.68 | +1 | -1 |
| | 4000 | 1.05 | | 4000 | 0.65 | +1 | -1 |
| | 8000 | 1.00 | | 8000 | 0.81 | +1 | +3 |
| | | | N.S. | | | 1% | 5% |
| Harvest 3 | 0 | 1.14 | | 0 | 0.79 | -1 | |
| | 1000 | 1.03 | | 1000 | 0.88 | | |
| | 2000 | 1.12 | | 2000 | 0.80 | | |
| | 4000 | 1.02 | | 4000 | 0.73 | | |
| | 8000 | 1.07 | | 8000 | 0.94 | +1 | |
| | | | N.S. | | | 5% | |
| Harvest 4 | 0 | 1.15 | | 0 | 0.80 | | |
| | 1000 | 1.14 | | 1000 | 0.92 | | |
| | 2000 | 1.08 | | 2000 | 0.84 | | |
| | 4000 | 1.09 | | 4000 | 0.88 | | |
| | 8000 | 1.11 | | 8000 | 0.89 | | |
| | | | N.S. | | | N.S. | |
| Mean of All Harvests | | | | | | | |
| | 0 | 0.98 | | 0 | 0.65 | -4 | |
| | 1000 | 1.01 | | 1000 | 0.81 | +1 | |
| | 2000 | 1.00 | | 2000 | 0.75 | +1 | |
| | 4000 | 1.00 | | 4000 | 0.75 | +1 | |
| | 8000 | 1.00 | | 8000 | 0.85 | +1 | |
| | | | N.S. | | | 5% | |

Table 3A.--Fresh fruit color as a result of two year's Alar application, 1967.[1]

| | Location #1 | | | Location #2 | | |
|---|---|---|---|---|---|---|
| | Conc. | ABS. | | Conc. | ABS. | |
| Harvest 1 | 0 | 0.70 | -1 | 0 | 0.45 | -3 |
| | 1000 | 0.89 | | 1000 | 0.78 | +1 |
| | 2000 | 0.66 | | 2000 | 0.62 | +1 |
| | 4000 | 0.95 | +1 | 4000 | 0.66 | +1 |
| | | | 5% | | | 1% |
| Harvest 2 | 0 | 1.05 | -1 | 0 | 0.57 | -3 |
| | 1000 | 1.08 | | 1000 | 0.67 | +1 |
| | 2000 | 1.14 | | 2000 | 0.81 | +1 |
| | 4000 | 1.30 | +1 | 4000 | 0.68 | +1 |
| | | | 5% | | | 1% |
| Harvest 3 | 0 | 1.14 | | 0 | 0.79 | -3 |
| | 1000 | 1.24 | | 1000 | 1.02 | +1 |
| | 2000 | 1.09 | | 2000 | 0.91 | +1 |
| | 4000 | 1.10 | | 4000 | 0.90 | +1 |
| | | | N.S. | | | 1% |
| Harvest 4 | 0 | 1.15 | | 0 | 0.80 | |
| | 1000 | 1.31 | | 1000 | 1.00 | |
| | 2000 | 1.12 | | 2000 | 0.84 | |
| | 4000 | 1.20 | | 4000 | 0.75 | |
| | | | N.S. | | | N.S. |
| Mean Over All Harvests | | | | | | |
| | 0 | 1.01 | | 0 | 0.65 | |
| | 1000 | 1.13 | | 1000 | 0.87 | |
| | 2000 | 1.00 | | 2000 | 0.79 | |
| | 4000 | 1.14 | | 4000 | 0.75 | |
| | | | N.S. | | | N.S. |

[1]Treatments applied two successive years.

Table 4A.--Effect of Alar on fresh fruit color, 1968, (mechanical harvesting experiment).

| | Location #1 | | |
|---|---|---|---|
| | Conc. | ABS. | |
| Harvest #1 | 0 | 0.50 | -4 |
| | 2000[1] | 0.88 | +1 |
| | 2000[2] | 0.90 | +1 |
| | 4000[1] | 0.84 | +1 |
| | 4000[2] | 1.10 | +1 |
| | | | 5% |
| Harvest #2 | 0 | 1.06 | |
| | 2000[1] | 1.21 | |
| | 2000[2] | 1.42 | |
| | 4000[1] | 1.12 | |
| | 4000[2] | 1.27 | |
| | | | N.S. |
| Mean of All Harvests | 0 | 0.78 | -2 |
| | 2000[1] | 1.05 | |
| | 2000[2] | 1.16 | +1 |
| | 4000[1] | 0.98 | |
| | 4000[2] | 1.18 | +1 |
| | | | 1% |

| | Location #3 | | |
|---|---|---|---|
| | Conc. | ABS. | |
| Harvest #1 | 0 | 0.89 | -1 |
| | 4000[1] | 1.38 | +1 |
| | | | 5% |
| Harvest #2 | 0 | 1.45 | -1 |
| | 4000[1] | 1.93 | +1 |
| | | | 5% |
| Harvest #3 | 0 | 1.29 | -1 |
| | 4000[1] | 1.64 | +1 |
| | | | 5% |
| Mean of All Harvests | 0 | 1.21 | -1 |
| | 4000[1] | 1.64 | +1 |
| | | | 5% |

[1]Alar applied one year.

[2]Alar applied two successive years.

Table 5A.--Fresh fruit color as affected by Alar, 1968, Location #3.

| | Conc. | ABS. | | |
|---|---|---|---|---|
| Harvest #1 | 0 | 0.35 | -3 | |
| | 2000 | 0.61 | +1 | -2 |
| | 4000 | 0.88 | +1 | +1 |
| | 8000 | 0.74 | +1 | +1 |
| | | | 1% | 5% |
| Harvest #2 | 0 | 0.60 | -3 | |
| | 2000 | 0.99 | +1 | |
| | 4000 | 0.99 | +1 | |
| | 8000 | 1.13 | +1 | |
| | | | 1% | |
| Harvest #3 | 0 | 0.99 | -3 | |
| | 2000 | 1.33 | +1 | |
| | 4000 | 1.38 | +1 | |
| | 8000 | 1.32 | +1 | |
| | | | 1% | |
| Harvest #4 | 0 | 1.08 | -3 | |
| | 2000 | 1.34 | +1 | |
| | 4000 | 1.31 | +1 | |
| | 8000 | 1.36 | +1 | |
| | | | 1% | |
| Mean of All Harvests | 0 | 0.75 | -3 | |
| | 2000 | 1.07 | +1 | |
| | 4000 | 1.14 | +1 | |
| | 8000 | 1.14 | +1 | |
| | | | 1% | |

Table 6A.--Effect of Alar on color of processed fruit, "L" reading on color difference meter.

| | Frozen | | | Canned | | |
|---|---|---|---|---|---|---|
| | Conc. | L Reading | | Conc. | L Reading | |
| Harvest #1 | 0 | 26.6 | +1 | 0 | 38.0 | +1 |
| | 4000 | 20.5 | -1 | 4000 | 29.7 | -1 |
| | | | 1% | | | 1% |
| Harvest #2 | 0 | 20.5 | +1 | 0 | 28.8 | +1 |
| | 4000 | 16.3 | -1 | 4000 | 24.2 | -1 |
| | | | 1% | | | 1% |
| Harvest #3 | 0 | 14.8 | | 0 | 23.4 | +1 |
| | 4000 | 13.1 | | 4000 | 21.6 | -1 |
| | | | N.S. | | | 5% |
| Mean of All Harvests | | | | | | |
| | 0 | 20.6 | +1 | 0 | 30.0 | +1 |
| | 4000 | 16.6 | -1 | 4000 | 25.2 | -1 |
| | | | 5% | | | 5% |

Table 7A.--Effect of Alar on color of processed fruit, "aL" reading on color difference meter.

| | Frozen | | | Canned | | |
|---|---|---|---|---|---|---|
| | Conc. | aL Reading | | Conc. | aL Reading | |
| Harvest #1 | 0 | 25.9 | | 0 | 15.2 | |
| | 4000 | 28.8 | | 4000 | 18.3 | |
| | | | N.S. | | | N.S. |
| Harvest #2 | 0 | 28.0 | | 0 | 18.8 | |
| | 4000 | 26.0 | | 4000 | 20.1 | |
| | | | N.S. | | | N.S. |
| Harvest #3 | 0 | 23.8 | | 0 | 18.6 | |
| | 4000 | 20.6 | | 4000 | 18.0 | |
| | | | N.S. | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 25.9 | | 0 | 17.5 | |
| | 4000 | 25.1 | | 4000 | 18.8 | |
| | | | N.S. | | | N.S. |

Table 8A.--Effect of Alar on color of processed fruit. "bL" reading on color difference meter.

| | Frozen | | | Canned | | |
|---|---|---|---|---|---|---|
| | Conc. | bL Reading | | Conc. | bL Reading | |
| Harvest #1 | 0 | 13.3 | +1 | 0 | 17.9 | +1 |
| | 4000 | 10.5 | -1 | 4000 | 13.0 | -1 |
| | | | 1% | | | 1% |
| Harvest #2 | 0 | 10.8 | +1 | 0 | 13.0 | +1 |
| | 4000 | 8.5 | -1 | 4000 | 9.7 | -1 |
| | | | 5% | | | 1% |
| Harvest #3 | 0 | 7.7 | | 0 | 9.4 | +1 |
| | 4000 | 7.3 | | 4000 | 7.9 | -1 |
| | | | N.S. | | | 5% |
| Mean of All Harvests | | | | | | |
| | 0 | 10.6 | | 0 | 13.4 | |
| | 4000 | 8.8 | | 4000 | 11.8 | |
| | | | N.S. | | | N.S. |

Table 9A.--Effect of Alar on color of processed fruit, aL/bL ratio from color difference meter.

| | Frozen | | | Canned | | |
|---|---|---|---|---|---|---|
| | Conc. | aL/bL Ratio | | Conc. | aL/bL Ratio | |
| Harvest #1 | 0 | 1.95 | -1 | 0 | 0.85 | -1 |
| | 4000 | 2.76 | +1 | 4000 | 1.41 | +1 |
| | | | 5% | | | 5% |
| Harvest #2 | 0 | 2.59 | | 0 | 1.44 | -1 |
| | 4000 | 3.05 | | 4000 | 2.08 | +1 |
| | | | N.S. | | | 5% |
| Harvest #3 | 0 | 3.09 | | 0 | 1.99 | |
| | 4000 | 2.90 | | 4000 | 2.28 | |
| | | | N.S. | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 2.54 | | 0 | 1.43 | -1 |
| | 4000 | 2.90 | | 4000 | 1.92 | +1 |
| | | | N.S. | | | 5% |

Table 10A.--Juice color of processed fruit as influenced by Alar.

| | Frozen | | | Canned | | |
|---|---|---|---|---|---|---|
| | Conc. | ABS. | | Conc. | ABS. | |
| Harvest #1 | 0 | 0.23 | | 0 | 0.29 | -1 |
| | 4000 | 0.36 | | 4000 | 0.52 | +1 |
| | | | N.S. | | | 5% |
| Harvest #2 | 0 | 0.51 | | 0 | 0.58 | -1 |
| | 4000 | 0.65 | | 4000 | 0.97 | +1 |
| | | | N.S. | | | 1% |
| Harvest #3 | 0 | 0.85 | | 0 | 1.26 | -1 |
| | 4000 | 1.25 | | 4000 | 1.49 | +1 |
| | | | N.S. | | | 5% |
| Mean of All Harvests | | | | | | |
| | 0 | 0.53 | | 0 | 0.71 | -1 |
| | 4000 | 0.75 | | 4000 | 1.00 | +1 |
| | | | N.S. | | | 1% |

Table 11A.--"Fruit removal force" as influenced by Alar, 1967, Location #1.

| | Sample Time | Conc. | Grams | |
|---|---|---|---|---|
| | 1 | 0 | 937 | +2 |
| | | 2000 | 518 | -1 |
| | | 4000 | 528 | -1 |
| | | | | 5% |
| | 2 | 0 | 1044 | +2 |
| | | 2000 | 626 | -1 |
| | | 4000 | 757 | -1 |
| | | | | 5% |
| Mechanical Harvesting 1 | 3 | 0 | 567 | |
| | | 2000 | 434 | |
| | | 4000 | 415 | |
| | | | | N.S. |
| | 4 | 0 | 505 | |
| | | 2000 | 347 | |
| | | 4000 | 373 | |
| | | | | N.S. |
| Mechanical Harvesting 2 | 5 | 0 | 564 | |
| | | 2000 | 263 | |
| | | 4000 | 287 | |
| | | | | N.S. |
| | 6 | 0 | 297 | |
| | | 2000 | 230 | |
| | | 4000 | 292 | |
| | | | | N.S. |
| | 7 | 0 | 313 | |
| | | 2000 | 211 | |
| | | 4000 | 277 | |
| | | | | N.S. |
| | 8 | 0 | 236 | |
| | | 2000 | 248 | |
| | | 4000 | 232 | |
| | | | | N.S. |
| Mechanical Harvesting 3 | 9 | 0 | 273 | |
| | | 2000 | 200 | |
| | | 4000 | 204 | N.S. |
| Mean of All Sample Times | | 0 | 528 | |
| | | 2000 | 342 | |
| | | 4000 | 374 | |
| | | | | N.S. |

Table 12A.--"Fruit removal force" as influenced by Alar, 1968 (mechanical harvesting experiment).

| | Location #1 | | |
|---|---|---|---|
| | Conc. | Grams | |
| Harvest #1 | 0 | 799 | +4 |
| | 2000[1] | 501 | -1 |
| | 2000[2] | 510 | -1 |
| | 4000[1] | 429 | -1 |
| | 4000[2] | 474 | -1 |
| | | | 1% |
| Harvest #2 | 0 | 351 | |
| | 2000[1] | 317 | |
| | 2000[2] | 323 | |
| | 4000[1] | 336 | |
| | 4000[2] | 278 | |
| | | | N.S. |
| Mean of All Harvests | 0 | 575 | +4 |
| | 2000[1] | 409 | -1 |
| | 2000[2] | 416 | -1 |
| | 4000[1] | 383 | -1 |
| | 4000[2] | 376 | -1 |
| | | | 1% |

| | Location #3 | | |
|---|---|---|---|
| | Conc. | Grams | |
| Harvest #1 | 0 | 484 | +1 |
| | 4000 | 287 | -1 |
| | | | 1% |
| Harvest #2 | 0 | 459 | +1 |
| | 4000 | 319 | -1 |
| | | | 5% |
| Harvest #3 | 0 | 363 | |
| | 4000 | 273 | |
| | | | N.S. |
| Mean of All Harvests | 0 | 435 | +1 |
| | 4000 | 293 | -1 |
| | | | 5% |

[1]Alar applied one year.

[2]Alar applied two successive years.

Table 13A.--Effect of Alar on "fruit removal force," 1968 (grams of force).

| | Location #3 | | | | |
|---|---|---|---|---|---|
| | Concentration | | | | |
| Sample Time | 0 | | 2000 | 4000 | 8000 |
| 1 | 1343 | ** | 968 | 976 | 841 |
| 2 | 857 | ** | 754 | 773 | 508 |
| 3 | 651 | | 623 --- | 728 --- | 648 --- |
| 4 | 509 | * | 388 | 437 | 380 |
| 5 | 532 --- | * | 421 | 354 | 391 |
| 6 | 426 | | 320 | 346 | 310 |
| 7 | 450 | ** | 289 | 296 | 315 |
| 8 | 450 | ** | 258 | 251 | 339 |
| 9 | 352 | | 284 | 245 | 292 |
| 10 | 361 | | 241 | 239 | 248 |
| Overall Sample Times | 593 | * | 455 | 464 | 427 |

*Control significant from mean of all treatments at 5% level.

**Control significant from mean of all treatments at 1% level.

---FRF reduced to 500 gms.; commercial harvest possible.

Table 14A.--Fresh fruit firmness as enhanced by Alar application, 1966[1]

| | Location #1 | | | | Location #2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Conc. | Firmness[2] Reading | | | Conc. | Firmness Reading | | |
| Harvest 1 | 0 | 49.9 | -3 | | 0 | 49.2 | -3 | |
| | 1000 | 53.1 | +1 | -2 | 1000 | 51.4 | +1 | -1 |
| | 2000 | 56.5 | +1 | +1 | 2000 | 50.5 | +1 | +2 |
| | 4000 | 57.6 | +1 | +1 | 4000 | 52.6 | +1 | +2 |
| | | | 1% | 1% | | | 5% | 1% |
| Harvest 2 | 0 | 48.7 | -3 | | 0 | 48.3 | -3 | |
| | 1000 | 49.9 | +1 | -1 | 1000 | 49.7 | +1 | -1 |
| | 2000 | 52.9 | +1 | -1 | 2000 | 50.9 | +1 | -1 |
| | 4000 | 55.3 | +1 | +2 | 4000 | 51.4 | +1 | +2 |
| | | | 1% | 1% | | | 5% | 5% |
| Harvest 3 | 0 | 47.1 | -3 | | 0 | 48.9 | -3 | |
| | 1000 | 52.0 | +1 | -1 | 1000 | 49.4 | +1 | -1 |
| | 2000 | 52.8 | +1 | -1 | 2000 | 50.6 | +1 | -1 |
| | 4000 | 55.1 | +1 | +2 | 4000 | 52.5 | +1 | +2 |
| | | | 1% | 1% | | | 5% | 1% |
| Mean of All Harvests | | | | | | | | |
| | 0 | 48.6 | -3 | | 0 | 48.8 | -1 | |
| | 1000 | 51.6 | +1 | -1 | 1000 | 50.1 | | |
| | 2000 | 54.0 | +1 | 0 | 2000 | 50.6 | | |
| | 4000 | 56.0 | +1 | +1 | 4000 | 52.1 | +1 | |
| | | | 1% | 1% | | | 5% | |

[1]Treatments applied to trees one year.

[2]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 15A.--Fresh fruit firmness as enhanced by Alar application, 1967[1]

| | Location #1 | | | | Location #2 | | |
|---|---|---|---|---|---|---|---|
| | Conc. | Firmness[2] Reading | | | | Firmness Reading | |
| Harvest 1 | 0 | 53.7 | -1 | | 0 | 47.5 | |
| | 1000 | 51.4 | | | 1000 | 47.7 | |
| | 2000 | 53.3 | | | 2000 | 49.4 | |
| | 4000 | 52.7 | | | 4000 | 48.9 | |
| | 8000 | 56.0 | +1 | | 8000 | 53.0 | |
| | | | 5% | | | | N.S. |
| Harvest 2 | 0 | 48.2 | -3 | | 0 | 47.9 | |
| | 1000 | 48.3 | | | 1000 | 48.5 | |
| | 2000 | 51.2 | +1 | | 2000 | 47.9 | |
| | 4000 | 52.6 | +1 | | 4000 | 48.7 | |
| | 8000 | 50.8 | +1 | | 8000 | 51.2 | |
| | | | 5% | | | | N.S. |
| Harvest 3 | 0 | 47.7 | | | 0 | 49.1 | |
| | 1000 | 46.9 | | | 1000 | 48.9 | |
| | 2000 | 48.4 | | | 2000 | 49.6 | |
| | 4000 | 49.2 | | | 4000 | 49.3 | |
| | 8000 | 50.9 | | | 8000 | 51.6 | |
| | | | N.S. | | | | N.S. |
| Harvest 4 | 0 | 46.2 | | | 0 | 44.9 | |
| | 1000 | 45.8 | | | 1000 | 45.5 | |
| | 2000 | 48.1 | | | 2000 | 45.3 | |
| | 4000 | 47.4 | | | 4000 | 44.7 | |
| | 8000 | 48.3 | | | 8000 | 46.4 | |
| | | | N.S. | | | | N.S. |
| Mean of All Harvests | | | | | | | |
| | 0 | 48.9 | -3 | | 0 | 47.3 | -1 |
| | 1000 | 48.1 | | | 1000 | 47.6 | |
| | 2000 | 50.2 | +1 | -1 | 2000 | 48.0 | |
| | 4000 | 50.5 | +1 | -1 | 4000 | 47.9 | |
| | 8000 | 51.5 | +1 | +2 | 8000 | 50.3 | +1 |
| | | | 1% | 1% | | | 5% |

[1]Treatments applied to trees one year.

[2]Firmness reading on scale of 0 to 100, 100 equal to 4 oz. of force.

Table 16A.--Fresh fruit firmness as enhanced by Alar application, 1967[1]

| | Location #1 | | | Location #2 | | |
|---|---|---|---|---|---|---|
| | Conc. | Firmness[2] Reading | | Conc. | Firmness Reading | |
| Harvest 1 | 0 | 53.7 | | 0 | 47.5 | |
| | 1000 | 51.1 | | 1000 | 47.4 | |
| | 2000 | 53.1 | | 2000 | 43.7 | |
| | 4000 | 52.8 | | 4000 | 45.6 | |
| | | | N.S. | | | N.S. |
| Harvest 2 | 0 | 48.2 | -1 | 0 | 47.9 | |
| | 1000 | 47.8 | | 1000 | 47.5 | |
| | 2000 | 48.8 | | 2000 | 47.9 | |
| | 4000 | 50.6 | +1 | 4000 | 49.0 | |
| | | | 5% | | | N.S. |
| Harvest 3 | 0 | 47.7 | -2 | 0 | 49.1 | |
| | 1000 | 47.6 | | 1000 | 48.8 | |
| | 2000 | 51.0 | +1 | 2000 | 48.0 | |
| | 4000 | 50.8 | +1 | 4000 | 48.9 | |
| | | | 5% | | | N.S. |
| Harvest 4 | 0 | 46.2 | | 0 | 44.9 | -1 |
| | 1000 | 46.8 | | 1000 | 43.2 | |
| | 2000 | 47.4 | | 2000 | 44.5 | |
| | 4000 | 46.0 | | 4000 | 49.3 | +1 |
| | | | N.S. | | | 5% |
| Mean of All Harvests | | | | | | |
| | 0 | 48.9 | -2 | 0 | 47.3 | |
| | 1000 | 48.3 | | 1000 | 46.7 | |
| | 2000 | 50.1 | +1 | 2000 | 46.0 | |
| | 4000 | 50.1 | +1 | 4000 | 48.2 | |
| | | | 1% | | | N.S. |

[1]Treatments applied two successive years.

[2]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 17A.--Fresh fruit firmness as enhanced by Alar application, 1968, Location #3

| | Conc. | Firmness[1] Reading | | |
|---|---|---|---|---|
| Harvest #1 | 0 | 52.2 | -2 | |
| | 2000 | 53.5 | | |
| | 4000 | 58.3 | +1 | |
| | 8000 | 58.1 | +1 | |
| | | | 1% | |
| Harvest #2 | 0 | 50.9 | -3 | |
| | 2000 | 55.9 | +1 | -2 |
| | 4000 | 59.3 | +1 | +1 |
| | 8000 | 59.5 | +1 | +1 |
| | | | 1% | 1% |
| Harvest #3 | 0 | 46.9 | -3 | |
| | 2000 | 50.5 | +1 | -2 |
| | 4000 | 54.6 | +1 | +1 |
| | 8000 | 54.8 | +1 | +1 |
| | | | 1% | 1% |
| Harvest #4 | 0 | 43.7 | -3 | |
| | 2000 | 51.0 | +1 | -2 |
| | 4000 | 52.9 | +1 | +1 |
| | 8000 | 55.4 | +1 | +1 |
| | | | 1% | 1% |
| Mean of All Harvests | 0 | 48.4 | -3 | |
| | 2000 | 52.7 | +1 | -2 |
| | 4000 | 56.2 | +1 | +1 |
| | 8000 | 56.9 | +1 | +1 |
| | | | 1% | 5% |

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 18A.--Effect of Alar on firmness of mechanically harvested fruit, 1967, Location 1.

| | Hand Harvested[3] | | Mechanically Harvested | | |
|---|---|---|---|---|---|
| | Conc. | Firmness[1] | Conc. | Firmness | Hand vs. Mech.Harv. |
| Harvest 1 | 0 | 55.6 A[2] | 0 | 53.2 A | 5% |
| | 2000 | 55.8 A | 2000 | 57.9 B | N.S. |
| | 4000 | 61.2 B | 4000 | 61.3 C | N.S. |
| | | 5% 5% | | 5% 5% 5% | |
| Harvest 2 | 0 | 51.5 | 0 | 41.3 A | 5% |
| | 2000 | 52.4 | 2000 | 53.6 B | N.S. |
| | 4000 | 53.4 | 4000 | 53.4 B | N.S. |
| | | N.S. | | 5% 5% | |
| Harvest 3 | 0 | 47.0 | 0 | 43.6 A | 5% |
| | 2000 | 46.7 | 2000 | 45.7 B | N.S. |
| | 4000 | 47.7 | 4000 | 46.9 B | N.S. |
| | | N.S. | | 5% 5% | |
| Mean of | 0 | 51.4 A | 0 | 46.0 A | 1% |
| All | 2000 | 51.6 A | 2000 | 52.4 B | N.S. |
| Harvests | 4000 | 54.1 B | 4000 | 53.9 C | N.S. |
| | | 1% 1% | | 1% 1% 1% | |

Mean of Hand and Mechanically Harvested

| Harvest #1 | | Harvest #2 | | Harvest #3 | |
|---|---|---|---|---|---|
| Conc. | Firmness | Conc. | Firmness | Conc. | Firmness |
| 0 | 54.4 A | 0 | 46.4 A | 0 | 45.3 |
| 2000 | 56.9 A | 2000 | 53.0 B | 2000 | 46.2 |
| 4000 | 61.3 B | 4000 | 53.4 B | 4000 | 47.3 |
| | 1% 1% | | 1% 1% | | N.S. |

Mean of All Harvests for Hand and Mechanically Harvested

| Conc. | Firmness |
|---|---|
| 0 | 48.9 A 1% 1% |
| 2000 | 52.0 1% B 5% |
| 4000 | 54.0 1% 5% C |

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

[2]Number followed by letters are significantly different from unlettered numbers at indicated significance level.

[3]Firmness measured immediately upon removal of fruit from the tree.

Table 19A.--Effect of Alar on firmness of mechanically harvested fruit, harvest #3, Location 1, 1967.

| Hand Harvested | | | Mechanically Harvested | | | Harvested and Soaked 2 Hrs. | | |
|---|---|---|---|---|---|---|---|---|
| Conc. | Firmness[3] | | Conc. | Firmness | | Conc. | Firmness | |
| 0 | 45.1 | A[4] | 0 | 38.0 | A | 0 | 48.5 | A |
| 4000 | 50.6 | | 4000 | 44.1 | | 4000 | 53.1 | |
| | | 1% | | | 1% | | | 1% |

Table 20A.--Effect of Alar fruit firmness on tree at location 2, 1967.

| Harvest #3 | | | Harvest #4 | | |
|---|---|---|---|---|---|
| Conc. | Firmness | | Conc. | Firmness | |
| 0[1] | 44.1 | A | 0[1] | 46.8 | A |
| 1000[1] | 46.4 | A | 1000[1] | 48.6 | A |
| 2000[1] | 48.1 | 5% | 2000[1] | 49.6 | A |
| 4000[1] | 48.9 | 5% | 4000[1] | 51.9 | 5% |
| 1000[2] | 47.1 | A | 1000[2] | 50.5 | A |
| 2000[2] | 47.6 | A | 2000[2] | 49.2 | A |
| 4000[2] | 46.8 | A | 4000[2] | 50.6 | A |
| 8000[2] | 52.5 | 1% | 8000[2] | 54.4 | 1% |

Firmness of Mechanically Harvested Fruit, Location 2, 1967

| Conc. | Firmness | | Conc. | Firmness | |
|---|---|---|---|---|---|
| 0[1] | 37.7 | A | 1000[2] | 42.1 | A |
| 1000[1] | 40.8 | A | 2000[2] | 40.4 | A |
| 2000[1] | 42.7 | 5% | 4000[2] | 41.1 | A |
| 4000[1] | 42.0 | A | 8000[2] | 45.1 | 1% |

[1]Treatments applied two successive years to trees.

[2]Treatments applied one year to trees.

[3]Firmness reading on scale of 0 to 100, 100 equals 4 oz. force.

[4]Numbers followed by letters are significantly different from unlettered numbers at indicated significance level.

Table 21A.--Alar's influence on the firmness of mechanically harvested fruit, Location #1, 1968.

| | | FIRMNESS[3] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | On Tree | | | After Mech. Harv. | | In Lab | |
| | Conc. | Firmness | | | Firmness | | Firmness | |
| Harvest 1 | 0 | 51.4 | -2 | | 43.2 | -4 | 53.9 | -4 |
| | 2000[1] | 52.5 | | | 50.3 | +1 | 58.3 | +1 |
| | 2000[2] | 52.2 | | | 59.7 | +1 | 56.8 | +1 |
| | 4000[1] | 54.0 | +1 | | 49.9 | +1 | 58.6 | +1 |
| | 4000[2] | 54.5 | +1 | | 51.4 | +1 | 58.1 | +1 |
| | | | 5% | | | 1% | | 1% |
| Harvest 2 | 0 | 45.0 | -4 | | 37.0 | -4 | 47.4 | -4 |
| | 2000[1] | 52.0 | +1 | -1 | 41.5 | +1 | 52.0 | +1 |
| | 2000[2] | 56.0 | +1 | +1 | 38.5 | +1 | 51.8 | +1 |
| | 4000[1] | 51.5 | +1 | -1 | 41.5 | +1 | 53.6 | +1 |
| | 4000[2] | 55.0 | +1 | +1 | 40.0 | +1 | 52.7 | +1 |
| | | | 1% | 1% | | 1% | | 1% |
| Mean of All Harvests | | | | | | | | |
| | 0 | 48.2 | -4 | | 40.1 | -4 | 50.6 | -4 |
| | 2000[1] | 52.7 | +1 | -1 | 45.9 | +1 | 55.2 | +1 |
| | 2000[2] | 54.1 | +1 | +1 | 44.1 | +1 | 54.2 | +1 |
| | 4000[1] | 52.8 | +1 | -1 | 45.7 | +1 | 56.1 | +1 |
| | 4000[2] | 54.8 | +1 | +1 | 45.7 | +1 | 55.4 | +1 |
| | | | 1% | 1% | | 1% | | 1% |

[1]Alar applied to trees one year.

[2]Alar applied two successive years.

[3]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 22A.--Alar's influence on the firmness of mechanically harvested fruit, 1968, Location #3.

| | | FIRMNESS[1] | | | | | |
|---|---|---|---|---|---|---|---|
| | | On Tree | | Mech. Harv. | | In Lab | |
| | Conc. | Firmness | | Firmness | | Firmness | |
| Harvest 1 | 0 | 50.4 | -1 | 37.6 | -1 | 47.2 | |
| | 4000 | 56.8 | +1 | 44.2 | +1 | 53.2 | |
| | | | 5% | | 5% | | N.S. |
| Harvest 2 | 0 | 52.9 | -1 | 39.5 | -1 | 44.6 | -1 |
| | 4000 | 58.5 | +1 | 50.1 | +1 | 53.2 | +1 |
| | | | 5% | | 5% | | 5% |
| Harvest 3 | 0 | 52.9 | -1 | 37.6 | -1 | 40.3 | -1 |
| | 4000 | 58.4 | +1 | 48.8 | +1 | 47.3 | +1 |
| | | | 5% | | 1% | | 5% |
| Mean of All Harvests | | | | | | | |
| | 0 | 52.1 | -1 | 38.2 | -1 | 44.0 | -1 |
| | 4000 | 57.9 | +1 | 57.7 | +1 | 51.2 | +1 |
| | | | 5% | | 5% | | 5% |

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 23A.--Effect of Alar on compaction force of processed frozen fruit.

| Compaction Force Kg/gm (Frozen Fruit) | | | |
|---|---|---|---|
| | Conc. | Kg/gm | |
| Harvest 1 | 0 | 0.51 | -1 |
| | 4000 | 0.70 | +1 |
| | | | 1% |
| Harvest 2 | 0 | 0.39 | -1 |
| | 4000 | 0.51 | +1 |
| | | | 5% |
| Harvest 3 | 0 | 0.30 | -1 |
| | 4000 | 0.43 | +1 |
| | | | 5% |
| Mean of All Harvests | 0 | 0.40 | -1 |
| | 4000 | 0.54 | +1 |
| | | | 5% |

Table 24A.--Effect of Alar on shear force of processed fruit.

| | Kg Shear Force/Gm Fruit | | | | | |
|---|---|---|---|---|---|---|
| | Frozen | | | Canned | | |
| | Conc. | Kg Shear | | Conc. | Kg Shear | |
| Harvest 1 | 0 | 1.01 | -1 | 0 | 0.11 | |
| | 4000 | 1.32 | +1 | 4000 | 0.12 | |
| | | | 5% | | | N.S. |
| Harvest 2 | 0 | 0.83 | -1 | 0 | 0.18 | |
| | 4000 | 1.12 | +1 | 4000 | 0.22 | |
| | | | 5% | | | N.S. |
| Harvest 3 | 0 | 0.67 | -1 | 0 | 0.28 | -1 |
| | 4000 | 0.98 | +1 | 4000 | 0.47 | +1 |
| | | | 5% | | | 5% |
| Mean of All Harvests | | | | | | |
| | 0 | 0.84 | -1 | 0 | 0.19 | -1 |
| | 4000 | 1.14 | +1 | 4000 | 0.27 | +1 |
| | | | 5% | | | 5% |

Table 25A.--Fruit size related to Alar application, percent of fruit in size #3[1], 1966[2]

| | Location 1 | | | Location 2 | | |
|---|---|---|---|---|---|---|
| | Conc. | % of Sample | | Conc. | % of Sample | |
| Harvest 1 | 0 | 62.6 | -2 | 0 | 87.1 | |
| | 1000 | 54.3 | | 1000 | 68.1 | |
| | 2000 | 75.2 | +1 | 2000 | 77.2 | |
| | 4000 | 79.1 | +1 | 4000 | 87.1 | |
| | | | 1% | | | N.S. |
| Harvest 2 | 0 | 80.6 | -2 | 0 | 86.3 | |
| | 1000 | 82.6 | | 1000 | 82.0 | |
| | 2000 | 84.3 | +1 | 2000 | 87.2 | |
| | 4000 | 88.7 | +1 | 4000 | 91.4 | |
| | | | 5% | | | N.S. |
| Harvest 3 | 0 | 79.2 | -2 | 0 | 87.4 | |
| | 1000 | 75.3 | | 1000 | 79.2 | |
| | 2000 | 86.3 | +1 | 2000 | 64.5 | |
| | 4000 | 84.6 | +1 | 4000 | 67.9 | |
| | | | 1% | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 74.1 | -2 | 0 | 86.9 | |
| | 1000 | 70.7 | | 1000 | 76.4 | |
| | 2000 | 82.0 | +1 | 2000 | 77.0 | |
| | 4000 | 84.1 | +1 | 4000 | 82.1 | |
| | | | 1% | | | N.S. |

[1]Preferred size--125 fruit per 500 grams.

[2]Treatment applied to trees one year.

Table 26A.--Fruit size related to Alar application, percent of fruit in size #3[1], 1967[2].

| | Location 1 | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Conc. | % of Sample | | | Conc. | % of Sample | | |
| Harvest 1 | 0 | 93.0 | | +1 | 0 | 83.4 | | +1 |
| | 1000 | 81.1 | | -1 | 1000 | 61.1 | | |
| | 2000 | 94.6 | | | 2000 | 86.3 | | |
| | 4000 | 91.9 | | | 4000 | 85.7 | | |
| | 8000 | 89.9 | | | 8000 | 59.9 | | -1 |
| | | | | 5% | | | | 5% |
| Harvest 2 | 0 | 91.5 | | +1 | 0 | 45.0 | -3 | |
| | 1000 | 79.6 | | -1 | 1000 | 49.9 | | |
| | 2000 | 92.4 | | | 2000 | 83.3 | +1 | +1 |
| | 4000 | 95.1 | | | 4000 | 71.0 | +1 | +1 |
| | 8000 | 93.5 | | | 8000 | 55.4 | +1 | -2 |
| | | | | 5% | | | 5% | 5% |
| Harvest 3 | 0 | 83.9 | -2 | +2 | 0 | 66.0 | +1 | +1 |
| | 1000 | 71.9 | | -1 | 1000 | 31.2 | -1 | |
| | 2000 | 76.4 | | -1 | 2000 | 79.6 | | |
| | 4000 | 90.7 | +1 | | 4000 | 74.6 | | |
| | 8000 | 93.5 | +1 | | 8000 | 42.5 | | -1 |
| | | | 1% | 5% | | | 1% | 5% |
| Harvest 4 | 0 | 81.8 | -3 | | 0 | 57.1 | +2 | |
| | 1000 | 84.7 | | | 1000 | 29.4 | -1 | |
| | 2000 | 92.3 | +1 | | 2000 | 63.3 | | |
| | 4000 | 86.9 | +1 | | 4000 | 74.3 | | |
| | 8000 | 90.7 | +1 | | 8000 | 39.1 | -1 | |
| | | | 5% | | | | 1% | |
| Mean of All Harvests | | | | | | | | |
| | 0 | 87.5 | | | 0 | 62.9 | | |
| | 1000 | 79.3 | | | 1000 | 42.9 | | |
| | 2000 | 88.9 | | | 2000 | 78.1 | | |
| | 4000 | 91.2 | | | 4000 | 76.4 | | |
| | 8000 | 91.9 | | | 8000 | 49.2 | | |
| | | | N.S. | | | | N.S. | |

[1]Preferred size of fruit--125 fruit per 500 grams.

[2]Treatments applied to trees one year.

Table 27A.--Fruit size related to Alar application, percent of fruit in size #3[1], 1967[2].

| | Location 1 | | | Location 2 | | |
|---|---|---|---|---|---|---|
| | Conc. | % of Sample | | Conc. | % of Sample | |
| Harvest 1 | 0 | 93.0 | | 0 | 83.4 | +2 |
| | 1000 | 91.5 | | 1000 | 79.3 | -1 |
| | 2000 | 94.5 | | 2000 | 61.9 | -1 |
| | 4000 | 97.7 | | 4000 | 92.0 | |
| | | | N.S. | | | 5% |
| Harvest 2 | 0 | 91.5 | | 0 | 65.9 | |
| | 1000 | 84.5 | | 1000 | 67.3 | |
| | 2000 | 94.5 | | 2000 | 62.2 | |
| | 4000 | 90.9 | | 4000 | 79.0 | |
| | | | N.S. | | | N.S. |
| Harvest 3 | 0 | 83.9 | | 0 | 66.0 | +1 |
| | 1000 | 82.1 | | 1000 | 59.0 | |
| | 2000 | 83.3 | | 2000 | 30.8 | -1 |
| | 4000 | 93.2 | | 4000 | 66.2 | |
| | | | N.S. | | | 1% |
| Harvest 4 | 0 | 81.8 | -2 | | 0 | 57.1 |
| | 1000 | 84.9 | | 1000 | 48.2 | |
| | 2000 | 90.4 | +1 | 2000 | 39.1 | |
| | 4000 | 91.4 | +1 | 4000 | 58.3 | |
| | | | 5% | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 87.5 | | 0 | 68.1 | |
| | 1000 | 85.8 | | 1000 | 63.4 | |
| | 2000 | 90.7 | | 2000 | 48.5 | |
| | 4000 | 93.3 | | 4000 | 73.9 | |
| | | | N.S. | | | N.S. |

[1]Preferred size--125 fruit per 500 grams.

[2]Treatments applied two successive years.

Table 28A.--Fruit size related to Alar application, percent of fruit in size #4, Location 1.

| | Conc. | 1966[1] % of Sample | | | 1967[1] % of Sample | | | 1967[2] % of Sample | |
|---|---|---|---|---|---|---|---|---|---|
| Harvest 1 | 0 | 30.9 | +2 | -1 | 4.3 | | -1 | 4.3 | |
| | 1000 | 43.0 | | +1 | 11.4 | | +1 | 7.7 | |
| | 2000 | 18.4 | -1 | | 1.1 | | | 3.6 | |
| | 4000 | 13.7 | -1 | | 1.4 | | | 0.6 | |
| | 8000 | ---- | | | 0.2 | | | --- | |
| | | | 5% | 5% | | | 5% | | N.S. |
| Harvest 2 | 0 | 4.2 | | | 6.5 | | | 6.5 | |
| | 1000 | 10.4 | | | 11.2 | | | 13.2 | |
| | 2000 | 2.3 | | | 4.9 | | | 3.6 | |
| | 4000 | 4.4 | | | 1.1 | | | 6.7 | |
| | 8000 | ---- | | | 0.5 | | | ---- | |
| | | | N.S. | | | N.S. | | | N.S. |
| Harvest 3 | 0 | 11.6 | | | 14.6 | +2 | | 14.6 | +1 |
| | 1000 | 19.8 | | | 19.9 | | | 17.5 | |
| | 2000 | 9.0 | | | 19.6 | | | 15.6 | |
| | 4000 | 4.8 | | | 4.6 | -1 | | 4.2 | -1 |
| | 8000 | ---- | | | 1.2 | -1 | | ---- | |
| | | | N.S. | | | 1% | | | 5% |
| Harvest 4 | 0 | ---- | | | 7.4 | | | 7.4 | |
| | 1000 | ---- | | | 12.2 | | | 14.4 | |
| | 2000 | ---- | | | 6.1 | | | 6.3 | |
| | 4000 | ---- | | | 9.6 | | | 3.9 | |
| | 8000 | ---- | | | 3.4 | | | ---- | |
| | | | | | | N.S. | | | N.S. |
| Mean of All Harvests | | | | | | | | | |
| | 0 | 15.6 | +2 | -1 | 8.2 | +1 | | 8.2 | |
| | 1000 | 24.4 | | +1 | 13.7 | | | 13.2 | |
| | 2000 | 9.9 | -1 | | 7.9 | | | 7.3 | |
| | 4000 | 7.7 | -1 | | 4.2 | | | 3.8 | |
| | 8000 | ---- | | | 1.3 | -1 | | ---- | |
| | | | 1% | 1% | | 5% | | | N.S. |

[1]Treatments applied to trees one year.

[2]Treatments applied two successive years.

Table 29A.--Fruit size related to Alar application, 1968, Location #3.

| | % Size #3 | | | % Size #4 | | |
|---|---|---|---|---|---|---|
| | Conc. | % of Sample | | Conc. | % of Sample | |
| Harvest 1 | 0 | 78.2 | | 0 | 10.3 | |
| | 2000 | 71.4 | | 2000 | 18.0 | |
| | 4000 | 80.8 | | 4000 | 17.3 | |
| | 8000 | 66.7 | | 8000 | 16.5 | |
| | | | N.S. | | | N.S. |
| Harvest 2 | 0 | 80.2 | | 0 | 5.8 | -1 |
| | 2000 | 77.8 | | 2000 | 5.9 | -1 |
| | 4000 | 76.8 | | 4000 | 21.7 | +3 |
| | 8000 | 87.3 | | 8000 | 3.1 | +1 |
| | | | N.S. | | | 1% |
| Harvest 3 | 0 | 78.0 | | 0 | 17.9 | |
| | 2000 | 73.0 | | 2000 | 24.6 | |
| | 4000 | 63.0 | | 4000 | 36.6 | |
| | 8000 | 79.5 | | 8000 | 15.9 | |
| | | | N.S. | | | N.S. |
| Harvest 4 | 0 | 84.6 | | 0 | 11.3 | |
| | 2000 | 75.1 | | 2000 | 24.2 | |
| | 4000 | 81.6 | | 4000 | 15.1 | |
| | 8000 | 81.8 | | 8000 | 11.6 | |
| | | | N.S. | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 80.2 | | 0 | 11.3 | |
| | 2000 | 74.4 | | 2000 | 18.2 | |
| | 4000 | 75.6 | | 4000 | 22.7 | |
| | 8000 | 78.8 | | 8000 | 11.8 | |
| | | | N.S. | | | N.S. |

Table 30A.--Fruit size as effected by 4,000 ppm Alar.

| Number of Fruit per #303 Can (12 oz.) 1967, Location #1 | | | |
|---|---|---|---|
| | Conc. | No. of Fruit | |
| Harvest 1 | 0 | 114.8 | |
| | 4000 | 115.3 | |
| | | | N.S. |
| Harvest 2 | 0 | 100.4 | -1 |
| | 4000 | 115.1 | +1 |
| | | | 5% |
| Harvest 3 | 0 | 92.7 | -1 |
| | 4000 | 114.5 | +1 |
| | | | 1% |
| Mean of All Harvests | | | |
| | 0 | 102.6 | |
| | 4000 | 114.9 | |
| | | | N.S. |

Table 31A.--Fruit diameter and firmness as influenced by Alar, 1968, Location 1.

| Harvest | Conc. | Fruit Diameter (Cm) | | Harvest | Conc. | Fruit[1] Firmness | |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 1.09 | | 1 | 0 | ---------- | |
| | 4000 | 1.07 | | | 4000 | ---------- | |
| | | | N.S. | | | | |
| 2 | 0 | 1.14 | | 2 | 0 | ---------- | |
| | 4000 | 1.13 | | | 4000 | ---------- | |
| | | | N.S. | | | | |
| 3 | 0 | 1.17 | | 3 | 0 | ---------- | |
| | 4000 | 1.22 | | | 4000 | ---------- | |
| | | | N.S. | | | | |
| 4 | 0 | 1.42 | | 4 | 0 | ---------- | |
| | 4000 | 1.62 | | | 4000 | ---------- | |
| | | | 1% | | | | |
| 5 | 0 | 1.53 | | 5 | 0 | ---------- | |
| | 4000 | 1.78 | | | 4000 | ---------- | |
| | | | 1% | | | | |
| 6 | 0 | 1.78 | | 6 | 0 | 65.1 | |
| | 4000 | 1.92 | | | 4000 | 62.9 | |
| | | | 1% | | | | N.S. |
| 7 | 0 | 1.89 | | 7 | 0 | 54.6 | |
| | 4000 | 1.97 | | | 4000 | 57.5 | |
| | | | 5% | | | | N.S. |
| 8 | 0 | 1.97 | | 8 | 0 | 52.8 | |
| | 4000 | 1.94 | | | 4000 | 54.9 | |
| | | | N.S. | | | | N.S. |
| 9 | 0 | 2.10 | | 9 | 0 | 50.4 | |
| | 4000 | 1.95 | | | 4000 | 53.5 | |
| | | | 1% | | | | N.S. |
| 10 | 0 | 2.13 | | 10 | 0 | 48.4 | |
| | 4000 | 1.98 | | | 4000 | 53.4 | |
| | | | 1% | | | | 5% |
| 11 | 0 | 2.13 | | 11 | 0 | 48.0 | |
| | 4000 | 1.99 | | | 4000 | 50.9 | |
| | | | 1% | | | | N.S. |
| 12 | 0 | 2.05 | | 12 | 0 | 53.0 | |
| | 4000 | 1.96 | | | 4000 | 54.0 | |
| | | | 5% | | | | N.S. |
| Mean of All Harvests | 0 | 1.70 | | Mean of All Harvests | 0 | 53.2 | |
| | 4000 | 1.71 | | | 4000 | 55.3 | |
| | | | N.S. | | | | 5% |

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 32A.--Fruit diameter as influenced by Alar, 1968 (Cm)

| | Location #3 Concentration | | |
|---|---|---|---|
| Harvest | 0 | 4000 | 8000 |
| 1 | 1.00 | 0.93 | 0.92 |
| 2 | 1.03 | 1.01 | 1.00 |
| 3 | 1.13 | 1.11 | 1.10 |
| 4 | 1.22 | 1.26 | 1.16 |
| 5 | 1.27 | 1.45** | 1.31 |
| 6 | 1.48 | 1.70** | 1.59* |
| 7 | 1.55 | 1.84** | 1.71** |
| 8 | 1.70 | 1.89** | 1.82* |
| 9 | 1.80 | 2.01** | 1.78 |
| 10 | 2.01 | 1.99 | 1.93 |
| 11 | 2.10 | 2.03 | 1.95** |
| 12 | 2.10 | 2.03 | 1.98* |
| 13 | 2.13 | 2.11 | 2.02* |
| 14 | 2.14 | 2.16 | 1.96** |
| Over All Harvests | 1.71 | 1.76* | 1.66* |

*Significance from control at 5% level.

**Significance from control at 1% level.

Table 33A.--Fruit firmness[1] as influenced by Alar (on tree), 1968.

| Harvest | Location 3 Concentration 0 | 2000 | 4000 | 8000 | Sign. Level |
|---|---|---|---|---|---|
| 1 | 74.7 ** | 61.1 | 64.0 | 59.5 | |
| 2 | 61.9 ** | 54.2 | 57.0 | 55.6 | |
| 3 | 53.9 * | 55.6 -1 | 56.5 -1 | 59.1 +2 | 1% |
| 4 | 51.9 ** | 54.0 -2 | 57.9 +1 | 57.0 +1 | 1% |
| 5 | 47.7 * | 51.6 -1 | 52.2 -1 | 54.4 +2 | 5% |
| 6 | 55.1 ** | 57.4 -1 | 59.4 -1 | 62.4 +2 | 1% |
| 7 | 53.4 ** | 58.1 | 57.3 | 58.8 | |
| 8 | 52.4 ** | 58.1 | 57.9 | 58.9 | |
| 9 | 51.5 ** | 57.3 | 57.4 | 57.6 | |
| 10 | 51.6 ** | 54.8 -1 | 55.5 -1 | 57.1 +2 | 5% |
| Over All Harvests | 55.6 -1 | 56.2 | 57.5 | 58.0 +1 | 5% |

*Control significantly different from mean of other treatments at 5% level.

**Control significantly different from mean of other treatments at 1% level.

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 34A.--Fruit acidity in relation to Alar application, Location 3, 1968.

| | pH | | | % Malate | | |
|---|---|---|---|---|---|---|
| | Conc. | pH | | Conc. | % Malate | |
| Harvest 1 | 0 | 3.50 | | 0 | 2.02 | +3 |
| | 2000 | 3.48 | | 2000 | 1.63 | -1 |
| | 4000 | 3.53 | | 4000 | 1.78 | -1 |
| | 8000 | 3.50 | | 8000 | 1.74 | -1 |
| | | | N.S. | | | 1% |
| Harvest 2 | 0 | 3.70 | -2 | 0 | 1.61 | +3 |
| | 2000 | 3.80 | +1 | 2000 | 1.36 | -1 |
| | 4000 | 3.80 | +1 | 4000 | 1.33 | -1 |
| | 8000 | 3.80 | +1 | 8000 | 1.26 | -1 |
| | | | 1% | | | 1% |
| Harvest 3 | 0 | 3.80 | -3 | 0 | 1.21 | +3 |
| | 2000 | 4.10 | +1 | 2000 | 1.00 | -1 |
| | 4000 | 4.10 | +1 | 4000 | 0.97 | -1 |
| | 8000 | 4.10 | +1 | 8000 | 0.96 | -1 |
| | | | 1% | | | 1% |
| Harvest 4 | 0 | 4.05 | -3 | 0 | 1.07 | +3 |
| | 2000 | 4.25 | +1 | 2000 | 0.85 | -1 |
| | 4000 | 4.20 | +1 | 4000 | 0.79 | -1 |
| | 8000 | 4.25 | +1 | 8000 | 0.78 | -1 |
| | | | 1% | | | 1% |
| Mean of All Harvests | | | | | | |
| | 0 | 3.76 | -3 | 0 | 1.48 | +3 |
| | 2000 | 3.91 | +1 | 2000 | 1.21 | -1 |
| | 4000 | 3.91 | +1 | 4000 | 1.22 | -1 |
| | 8000 | 3.11 | +1 | 8000 | 1.19 | -1 |
| | | | 5% | | | 1% |

Table 35A.--The influence of Alar on fruit respiration (respiratory quotient), 1966.

| | Location 1 | | | | Location 2 | | |
|---|---|---|---|---|---|---|---|
| | Conc. | R.Q./ 24 Hrs. | | | Conc. | R.Q./ 24 Hrs. | |
| Harvest 1 | 0 | 1.11 | +2 | | 0 | 1.45 | |
| | 1000 | ---- | | | 1000 | 1.53 | |
| | 2000 | 1.02 | -1 | | 2000 | 1.53 | |
| | 4000 | 0.98 | -1 | | 4000 | 1.13 | |
| | | | 1% | | | | N.S. |
| Harvest 2 | 0 | 1.10 | +2 | | 0 | 1.35 | |
| | 1000 | ---- | | | 1000 | 1.17 | |
| | 2000 | 1.01 | -1 | +1 | 2000 | 1.18 | |
| | 4000 | 0.86 | -1 | -1 | 4000 | 1.07 | |
| | | | 1% | 1% | | | N.S. |
| Mean of All Harvests | | | | | | | |
| | 0 | 1.10 | +2 | | 0 | 1.40 | |
| | 1000 | ---- | | | 1000 | 1.34 | |
| | 2000 | 1.02 | -1 | | 2000 | 1.35 | |
| | 4000 | 0.92 | -1 | | 4000 | 1.09 | |
| | | | 1% | | | | N.S. |

Table 36A.--The influence of Alar on fruit respiration ($CO_2$ Evolution), 1966.

| | Location 1 | | | Location 2 | | |
|---|---|---|---|---|---|---|
| | Conc. | $CO_2$/ 24 Hrs. | | Conc. | $CO_2$/ 24 Hrs. | |
| Harvest 1 | 0 | 679.6 | +2 | 0 | 746.6 | |
| | 1000 | ----- | | 1000 | 867.0 | |
| | 2000 | 487.4 | -1 | 2000 | 917.4 | |
| | 4000 | 479.4 | -1 | 4000 | 770.8 | |
| | | | 5% | | | N.S. |
| Harvest 2 | 0 | 570.8 | _2 | 0 | 604.8 | |
| | 1000 | ----- | | 1000 | 554.4 | |
| | 2000 | 420.4 | -1 | 2000 | 558.8 | |
| | 4000 | 360.0 | -1 | 4000 | 604.8 | |
| | | | 5% | | | N.S. |
| Mean of All Harvests | | | | | | |
| | 0 | 625.2 | +2 | 0 | 675.7 | |
| | 1000 | ---- | | 1000 | 710.7 | |
| | 2000 | 453.9 | -1 | 2000 | 738.1 | |
| | 4000 | 419.7 | -1 | 4000 | 687.8 | |
| | | | 5% | | | N.S. |

Table 37A.--The influence of Alar on fruit respiratory curve, 1967, Location 1.

| Harvest | Conc. | $CO_2$/24 Hrs. | | Conc. | R.Q./24 Hrs. | |
|---|---|---|---|---|---|---|
| 1 | 0 | 762.6 | | 0 | 0.91 | |
| | 4000 | 742.8 | | 4000 | 0.86 | |
| | | | N.S. | | | N.S. |
| 2 | 0 | 711.4 | | 0 | 0.99 | |
| | 4000 | 675.0 | | 4000 | 0.84 | |
| | | | N.S. | | | N.S. |
| 3 | 0 | 642.6 | | 0 | 0.93 | +1 |
| | 4000 | 569.4 | | 4000 | 0.75 | -1 |
| | | | N.S. | | | 1% |
| 4 | 0 | 488.0 | | 0 | 0.93 | |
| | 4000 | 492.8 | | 4000 | 0.89 | |
| | | | N.S. | | | N.S. |
| 5 | 0 | 399.2 | | 0 | 0.96 | |
| | 4000 | 368.2 | | 4000 | 0.94 | |
| | | | N.S. | | | N.S. |
| 6 | 0 | 381.6 | | 0 | 0.99 | |
| | 4000 | 332.8 | | 4000 | 0.96 | |
| | | | N.S. | | | N.S. |
| 7 | 0 | 400.2 | | 0 | 1.05 | |
| | 4000 | 326.2 | | 4000 | 1.04 | |
| | | | N.S. | | | N.S. |
| 8 | 0 | 334.0 | +1 | 0 | 0.93 | |
| | 4000 | 236.4 | -1 | 4000 | 0.90 | |
| | | | 5% | | | N.S. |
| 9 | 0 | 321.8 | | 0 | 1.00 | |
| | 4000 | 328.4 | | 4000 | 1.06 | |
| | | | N.S. | | | N.S. |
| Mean of | | | | | | |
| All | 0 | 493.5 | +1 | 0 | 0.96 | +1 |
| Harvests | 4000 | 452.4 | -1 | 4000 | 0.92 | -1 |
| | | | 5% | | | 5% |

Table 38A.--The influence of Alar on fruit respiration ($CO_2$ Evolution), 1967.

| | Location 1 | | | Location 2 | | |
|---|---|---|---|---|---|---|
| | Conc. | $CO_2$/ 48 Hrs. | | Conc. | $CO_2$/ 48 Hrs. | |
| Harvest 1 | 0 | 1148.0 | | 0 | 699.8 | |
| | 1000 | 963.5 | | 1000 | 669.5 | |
| | 2000 | 1078.1 | | 2000 | 667.3 | |
| | 4000 | 1096.1 | | 4000 | 707.7 | |
| | | | N.S. | | | N.S. |
| Harvest 2 | 0 | 845.0 | | 0 | 608.4 | |
| | 1000 | 978.5 | | 1000 | 616.9 | |
| | 2000 | 744.9 | | 2000 | 597.0 | |
| | 4000 | 868.6 | | 4000 | 618.1 | |
| | | | N.S. | | | N.S. |
| Harvest 3 | 0 | 881.8 | | 0 | 567.4 | |
| | 1000 | 836.4 | | 1000 | 549.1 | |
| | 2000 | 905.3 | | 2000 | 509.2 | |
| | 4000 | 823.8 | | 4000 | 599.1 | |
| | | | N.S. | | | N.S. |
| Harvest 4 | 0 | 966.8 | | 0 | ----- | |
| | 1000 | 921.9 | | 1000 | ----- | |
| | 2000 | 899.4 | | 2000 | ----- | |
| | 4000 | 873.5 | | 4000 | ----- | |
| Mean of All Harvests | | | | | | |
| | 0 | 960.4 | | 0 | 625.2 | |
| | 1000 | 919.5 | | 1000 | 611.8 | |
| | 2000 | 873.4 | | 2000 | 591.2 | |
| | 4000 | 804.7 | | 4000 | 641.6 | |
| | | | N.S. | | | N.S. |

Table 39A.--The influence of Alar on fruit respiration, respiratory quotient, 1967.

| | Location 1 | | | | Location 2 | | |
|---|---|---|---|---|---|---|---|
| | Conc. | R.Q./48 Hrs. | | | Conc. | R.Q./48 Hrs. | |
| Harvest 1 | 0 | 0.98 | | | 0 | 1.40 | |
| | 1000 | 0.90 | | | 1000 | 1.53 | |
| | 2000 | 0.90 | | | 2000 | 1.40 | |
| | 4000 | 0.88 | | | 4000 | 1.25 | |
| | | | N.S. | | | | N.S. |
| Harvest 2 | 0 | 1.20 | +2 | | 0 | 1.63 | |
| | 1000 | 1.13 | | | 1000 | 1.58 | |
| | 2000 | 1.03 | -1 | | 2000 | 1.65 | |
| | 4000 | 1.02 | -1 | | 4000 | 1.51 | |
| | | | 1% | | | | N.S. |
| Harvest 3 | 0 | 1.41 | +1 | | 0 | 2.09 | |
| | 1000 | 1.30 | | | 1000 | 1.84 | |
| | 2000 | 1.33 | | | 2000 | 1.84 | |
| | 4000 | 1.14 | -1 | | 4000 | 1.90 | |
| | | | 1% | | | | N.S. |
| Harvest 4 | 0 | 1.58 | +3 | | 0 | | |
| | 1000 | 1.37 | -1 | +1 | 1000 | | |
| | 2000 | 1.42 | -1 | +1 | 2000 | | |
| | 4000 | 1.24 | -1 | -2 | 4000 | | |
| | | | 1% | 1% | | | |
| Mean of All Harvests | | | | | | | |
| | 0 | 1.29 | +3 | | 0 | 1.70 | +1 |
| | 1000 | 1.17 | -1 | +1 | 1000 | 1.65 | |
| | 2000 | 1.16 | -1 | +1 | 2000 | 1.63 | |
| | 4000 | 1.07 | -1 | -2 | 4000 | 1.55 | -1 |
| | | | 1% | 1% | | | 5% |

Table 40A.--Terminal shoot growth* as effected by Alar.

1966[1]

| Location 1 | | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | | Conc. | Length | % of Control | |
| 0 | 10.85 | 100.0 | +3 | | 0 | 4.65 | 100.0 | |
| 1000 | 9.75 | 89.9 | -1 | -1 | 1000 | 4.80 | 103.2 | |
| 2000 | 8.45 | 77.9 | -1 | 0 | 2000 | 4.70 | 101.1 | |
| 4000 | 6.40 | 59.0 | -1 | +1 | 4000 | 3.90 | 83.9 | |
| | | | 5% | 5% | | | | N.S. |

1967[1]

| Location 1 | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | Conc. | Length | % of Control | |
| 0 | 7.00 | 10.00 | +3 | 0 | 5.40 | 100.0 | +3 |
| 1000 | 5.55 | 79.3 | -1 | 1000 | 3.35 | 62.0 | -1 |
| 2000 | 3.60 | 51.1 | -1 | 2000 | 4.50 | 83.3 | -1 |
| 4000 | 3.45 | 49.3 | -1 | 4000 | 3.80 | 70.4 | -1 |
| | | | 1% | | | | 5% |

1967[2]

| Location 1 | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | Conc. | Length | % of Control | |
| 0 | 7.00 | 100.0 | +1 | 0 | 5.40 | 100.0 | +3 |
| 1000 | 6.20 | 88.6 | | 1000 | 4.95 | 91.7 | -1 |
| 2000 | 6.85 | 97.9 | | 2000 | 3.00 | 55.6 | -1 |
| 4000 | 4.50 | 64.3 | -1 | 4000 | 3.70 | 68.5 | -1 |
| | | | 5% | | | | 5% |

*Expressed in inches.

[1]Treatment applied to trees one year.

[2]Treatment applied two successive years.

Table 41A.--Number of nodes per shoot at effected by Alar.

| 1966[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location 1 | | | | Location 2 | | | | |
| Conc. | Number of Nodes | % of Control | | Conc. | Number of Nodes | % of Control | | |
| 0 | 12.45 | 100.0 | | 0 | 7.30 | 100.0 | | |
| 1000 | 11.65 | 93.6 | | 1000 | 6.70 | 91.8 | | |
| 2000 | 11.75 | 94.4 | | 2000 | 7.80 | 106.8 | | |
| 4000 | 10.30 | 82.7 | | 4000 | 6.70 | 91.8 | | |
| | | | N.S. | | | | N.S. | |
| 1967[1] | | | | | | | | |
| Location 1 | | | | Location 2 | | | | |
| Conc. | Number of Nodes | % of Control | | Conc. | Number of Nodes | % of Control | | |
| 0 | 12.85 | 100.0 | +1 | 0 | 12.20 | 100.0 | | |
| 1000 | 12.35 | 96.1 | | 1000 | 11.15 | 91.4 | | |
| 2000 | 11.40 | 88.7 | | 2000 | 11.25 | 92.9 | | |
| 4000 | 10.40 | 80.9 | -1 | 4000 | 11.50 | 94.3 | | |
| | | | 5% | | | | N.S. | |
| 1967[2] | | | | | | | | |
| Location 1 | | | | Location 2 | | | | |
| Conc. | Number of Nodes | % of Control | | Conc. | Number of Nodes | % of Control | | |
| 0 | 12.85 | 100.0 | | 0 | 12.20 | 100.0 | +3 | |
| 1000 | 11.60 | 90.3 | | 1000 | 11.70 | 95.9 | -1 | +2 |
| 2000 | 12.15 | 94.6 | | 2000 | 9.80 | 80.3 | -1 | -1 |
| 4000 | 12.45 | 96.9 | | 4000 | 9.60 | 78.7 | -1 | -1 |
| | | | N.S. | | | | 1% | 1% |

[1]Treatments applied to trees one year.

[2]Treatments applied two successive years.

Table 42A.--Internode length* as effected by Alar.

1966[1]

| Location 1 | | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | | Conc. | Length | % of Control | |
| 0 | .87 | 100.0 | +3 | | 0 | .64 | 100.0 | |
| 1000 | .84 | 96.6 | -1 | +2 | 1000 | .72 | 112.5 | |
| 2000 | .71 | 81.6 | -1 | -1 | 2000 | .61 | 95.3 | |
| 4000 | .61 | 70.1 | -1 | -1 | 4000 | .58 | 90.6 | |
| | | | 5% | 5% | | | | N.S. |

1967[1]

| Location 1 | | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | | Conc. | Length | % of Control | |
| 0 | .54 | 100.0 | +3 | | 0 | .44 | 100.0 | +3 |
| 1000 | .45 | 83.3 | -1 | +2 | 1000 | .30 | 68.2 | -1 |
| 2000 | .32 | 59.3 | -1 | -1 | 2000 | .40 | 90.9 | -1 |
| 4000 | .33 | 61.1 | -1 | -1 | 4000 | .33 | 75.0 | -1 |
| | | | 1% | 1% | | | | 5% |

1967[2]

| Location 1 | | | | Location 2 | | | |
|---|---|---|---|---|---|---|---|
| Conc. | Length | % of Control | | Conc. | Length | % of Control | |
| 0 | .54 | 100.0 | +1 | 0 | .44 | 100.0 | +2 |
| 1000 | .53 | 98.1 | | 1000 | .42 | 95.5 | |
| 2000 | .56 | 103.7 | | 2000 | .31 | 70.5 | -1 |
| 4000 | .36 | 66.7 | -1 | 4000 | .39 | 88.6 | -1 |
| | | | 1% | | | | 5% |

*Expressed in inches.

[1]Treatments applied to trees one year.

[2]Treatments applied two successive years.

Table 43A.--Bud initiation (percent flower buds) as influenced by Alar.

| 1966[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location 1 | | | | Location 2 | | | | |
| Conc. | Flower Buds | % of Control | | Conc. | Flower Buds | % of Control | | |
| 0 | 47.4 | 100.0 | -1 | 0 | 74.8 | 100.0 | -2 | +1 |
| 1000 | 43.1 | 90.9 | | 1000 | 58.7 | 78.5 | | -1 |
| 2000 | 52.2 | 110.0 | | 2000 | 84.3 | 112.7 | +1 | |
| 4000 | 63.0 | 132.9 | +1 | 4000 | 83.0 | 111.0 | +1 | |
| | | | 5% | | | | 1% | 1% |

| 1967[1] | | | | 1967[2] | | | |
|---|---|---|---|---|---|---|---|
| Location 1 | | | | Location 1 | | | |
| Conc. | Flower Buds | % of Control | | Conc. | Flower Buds | % of Control | |
| 0 | 68.5 | 100.0 | -3 | 0 | 68.5 | 100.0 | -3 |
| 1000 | 81.5 | 119.0 | +1 | 1000 | 81.9 | 119.6 | +1 |
| 2000 | 84.0 | 122.6 | +1 | 2000 | 80.4 | 117.4 | +1 |
| 4000 | 80.2 | 117.1 | +1 | 4000 | 84.4 | 123.2 | +1 |
| | | | 5% | | | | 5% |

[1]Treatment applied to trees one year.

[2]Treatment applied two successive years.

Table 44A.--Effect of Alar on leaf nitrogen content.

| Location 1 | | | Location 2 | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Conc. | % N | | Conc. | % N | | |
| 0 | 2.13 | | 0 | 2.37 | -3 | |
| 1000 | 2.20 | | 1000 | 2.34 | +1 | -1 |
| 2000 | 2.33 | | 2000 | 2.59 | +1 | 0 |
| 4000 | 2.39 | | 4000 | 2.69 | +1 | +1 |
| | | N.S. | | | 5% | 5% |

Table 45A.--Alar residue analysis.*

| 1967, Location 1 | | | |
|---|---|---|---|
| 1 Yr. Application | | 2 Yrs. Application | |
| Conc. | PPM | Conc. | PPM |
| 0 | 0.1 | 0 | 0.1 |
| 1000 | 8.4 | 1000 | 7.8 |
| 2000 | 20.0 | 2000 | 22.0 |
| 4000 | 38.0 | 4000 | 54.0 |
| 8000 | 75.5 | | |

| 1967, Location 2 | | | |
|---|---|---|---|
| 1 Yr. Application | | 2 Yrs. Application | |
| Conc. | PPM | Conc. | PPM |
| 0 | 0.2 | 0 | 0.2 |
| 1000 | 5.9 | 1000 | 7.2 |
| 2000 | 11.0 | 2000 | 11.5 |
| 4000 | 17.5 | 4000 | 24.0 |
| 8000 | 58.0 | | |

| 1968, Mean of Locations | |
|---|---|
| Conc. | PPM |
| 0 | 0.6 |
| 4000 | 18.5 |
| 8000 | 49.2 |

| Mean of All Years | | |
|---|---|---|
| Conc. | PPM | % of Application Rate |
| 0 | 0.3 | 0.0 |
| 1000 | 7.0 | 0.70 |
| 2000 | 16.1 | 0.81 |
| 4000 | 28.8 | 0.72 |
| 8000 | 60.7 | 0.76 |
| | | Mean: 0.75% |

*Compliments of UNIROYAL Chemical Company

Table 46A.--Fresh fruit color as influenced by fall Alar application.

| Fall Alar Applications (Location 1), 1966 | | | |
|---|---|---|---|
| Harvest | Conc. | ABS. | |
| 1 | 0 | 0.70 | |
| | 2000 | 0.57 | |
| | 4000 | 0.65 | |
| | 8000 | 0.65 | |
| | | | N.S. |
| 2 | 0 | 1.05 | +1 |
| | 2000 | 0.88 | |
| | 4000 | 0.92 | |
| | 8000 | 0.79 | -1 |
| | | | 5% |
| 3 | 0 | 1.14 | |
| | 2000 | 1.07 | |
| | 4000 | 1.23 | |
| | 8000 | 1.11 | |
| | | | N.S. |
| 4 | 0 | 1.15 | |
| | 2000 | 1.20 | |
| | 4000 | 1.09 | |
| | 8000 | 1.17 | |
| | | | N.S. |
| Mean of All Harvests | 0 | 1.01 | |
| | 2000 | 0.93 | |
| | 4000 | 0.97 | |
| | 8000 | 0.92 | |
| | | | N.S. |

Table 47A.--Fresh fruit firmness as enhanced by fall Alar applications.

| Fall Alar Applications (Location 1), 1966 | | | | |
|---|---|---|---|---|
| Harvest | Conc. | Firmness[1] Reading | | |
| 1 | 0 | 53.7 | -1 | |
| | 2000 | 51.8 | | |
| | 4000 | 53.1 | | |
| | 8000 | 55.5 | +1 | |
| | | | 5% | |
| 2 | 0 | 48.2 | -2 | |
| | 2000 | 49.9 | | |
| | 4000 | 50.9 | +1 | -1 |
| | 8000 | 55.7 | +1 | +1 |
| | | | 1% | 1% |
| 3 | 0 | 47.7 | | |
| | 2000 | 47.7 | | |
| | 4000 | 49.1 | | |
| | 8000 | 48.1 | | |
| | | | N.S. | |
| 4 | 0 | 46.2 | | |
| | 2000 | 46.1 | | |
| | 4000 | 46.4 | | |
| | 8000 | 45.7 | | |
| | | | N.S. | |
| Mean of All Harvests | 0 | 48.9 | -2 | |
| | 2000 | 48.8 | | |
| | 4000 | 49.8 | +1 | -1 |
| | 8000 | 51.2 | +1 | +1 |
| | | | 1% | 1% |

[1]Firmness reading on scale of 0 to 100, 100 equals 4 oz. of force.

Table 48A.--Fruit size related to fall Alar application. Percent of fruit in size #3.

| Fall Alar Applications (Location #1), 1966 | | | | |
|---|---|---|---|---|
| Harvest | Conc. | % of Sample | | |
| 1 | 0 | 87.5 | +2 | |
| | 2000 | 84.0 | | |
| | 4000 | 75.7 | -1 | |
| | 8000 | 64.4 | -1 | |
| | | | 1% | |
| 2 | 0 | 93.0 | +3 | |
| | 2000 | 90.2 | -1 | +1 |
| | 4000 | 80.5 | -1 | 0 |
| | 8000 | 75.5 | -1 | -1 |
| | | | 1% | 1% |
| 3 | 0 | 83.9 | +2 | |
| | 2000 | 82.3 | | |
| | 4000 | 76.0 | -1 | +1 |
| | 8000 | 64.5 | -1 | -1 |
| | | | 1% | 5% |
| 4 | 0 | 81.8 | +2 | |
| | 2000 | 83.6 | | |
| | 4000 | 71.8 | -1 | |
| | 8000 | 67.2 | -1 | |
| | | | 1% | |
| Mean of All Harvests | 0 | 87.5 | +2 | |
| | 2000 | 84.0 | | |
| | 4000 | 75.7 | -1 | |
| | 8000 | 64.4 | -1 | |
| | | | 1% | |

Table 49A.--Fruit size related to fall Alar application. Percent of fruit in size #2.

| Fall Alar Applications (Location 1), 1966 | | | | |
|---|---|---|---|---|
| Harvest | Conc. | % of Sample | | |
| 1 | 0 | 2.7 | -3 | |
| | 2000 | 8.8 | +1 | -1 |
| | 4000 | 17.2 | +1 | 0 |
| | 8000 | 22.9 | +1 | +1 |
| | | | 1% | 1% |
| 2 | 0 | 2.0 | -3 | |
| | 2000 | 6.3 | +1 | -1 |
| | 4000 | 17.3 | +1 | 0 |
| | 8000 | 43.9 | +1 | +1 |
| | | | 1% | 1% |
| 3 | 0 | 1.4 | -3 | |
| | 2000 | 5.2 | +1 | -1 |
| | 4000 | 15.6 | +1 | 0 |
| | 8000 | 28.0 | +1 | +1 |
| | | | 1% | 1% |
| 4 | 0 | 10.4 | -1 | |
| | 2000 | 4.8 | | -1 |
| | 4000 | 12.1 | | 0 |
| | 8000 | 22.6 | +1 | +1 |
| | | | 1% | 1% |
| Mean of All Harvests | 0 | 4.1 | -2 | |
| | 2000 | 6.3 | | -1 |
| | 4000 | 15.6 | +1 | 0 |
| | 8000 | 29.4 | +1 | +1 |
| | | | 1% | 1% |

Table 50A.--Growth responses as effected by Fall Alar application.

Fall Alar Application (Location 1), 1966

Shoot Growth[1]

| Conc. | Length | % of Control | |
|---|---|---|---|
| 0 | 7.00 | 100.0 | +3 |
| 2000 | 5.30 | 75.7 | -1 |
| 4000 | 5.55 | 79.3 | -1 |
| 8000 | 5.30 | 75.7 | -1 |
| | | | 5% |

Number of Nodes

| Conc. | No. of Nodes | % of Control | |
|---|---|---|---|
| 0 | 12.85 | 100.0 | |
| 2000 | 12.55 | 97.7 | |
| 4000 | 13.00 | 101.2 | |
| 8000 | 12.65 | 98.4 | |
| | | | N.S. |

Internode Length[1]

| Conc. | Length | % of Control | |
|---|---|---|---|
| 0 | .54 | 100.0 | +3 |
| 2000 | .42 | 77.8 | -1 |
| 4000 | .42 | 77.8 | -1 |
| 8000 | .42 | 77.8 | -1 |
| | | | 5% |

Present Flower Bud Initiation

| Conc. | % Flower Buds | % of Control | |
|---|---|---|---|
| 0 | 68.5 | 100.0 | +3 |
| 2000 | 87.5 | 127.7 | -1 |
| 4000 | 80.1 | 116.9 | -1 |
| 8000 | 81.0 | 118.2 | -1 |
| | | | 5% |

[1]Expressed in inches.

Table 51A.--Mean nutritional composition of leaf, fruit and pit tissues from orchards at Location 1 and 2.

| | Leaf | | Fruit | | Pit | |
|---|---|---|---|---|---|---|
| | Location | | Location | | Location | |
| Element | 1 | 2 | 1 | 2 | 1 | 2 |
| N% | 2.26 | 2.49 | 0.98 | 0.76 | 0.85 | 1.05 |
| K% | 1.75 | 0.95 | 1.82 | 1.21 | 0.44 | 0.33 |
| P% | 0.31 | 0.18 | 0.17 | 0.12 | 0.36 | 0.31 |
| Na ppm | 383 | 360 | 355 | 402 | 378 | 340 |
| Ca% | 1.08 | 2.21 | 0.07 | 0.10 | 0.18 | 0.20 |
| Mg% | 0.44 | 0.58 | 0.06 | 0.07 | 0.17 | 0.15 |
| Mn ppm | 45 | 74 | 9 | 10 | 20 | 19 |
| Fe ppm | 196 | 157 | 36 | 27 | 70 | 46 |
| Cu ppm | 15 | 153 | 2 | 6 | 23 | 23 |
| B ppm | 28 | 29 | 8.3 | 12 | 15 | 17 |
| Zn ppm | 24 | 36 | 13 | 15 | 22 | 19 |
| Al ppm | 142 | 257 | 261 | 159 | 53 | 28 |

ERRATA

1. Page 68, line 11, <u>froce</u> should read <u>force</u>.

2. Page 71, reference 19, <u>Concard</u> should read <u>Concord</u>.
   <u>labrusia</u> should read <u>labrusca</u>.

3. Page 78, reference 96, <u>Aer</u>. should read <u>Amer</u>.