Project Number: 84-I8
Project Leader: J. M. Labavitch
Project Title: Almond Development

LABAVITCH

ANNUAL REPORT TO ALMOND BOARD - 1984

PROJECT NO. 84-I8
TREE AND CROP RESEARCH, ALMOND DEVELOPMENT

OBJECTIVES

To develop information about various aspects of almond fruit development:

(1) The role of ethylene in embryo sac development and fruit set (Weis, Polito and Labavitch).

(2) The role of ethylene in control of almond fruit maturation and application of this information for orchard practice (Weis and Labavitch).

INTERPRETIVE SUMMARY

Ethylene is a gas that is produced by many plants at various times in their development. This gas acts as a plant hormone in that its presence in or around the plant serves to regulate plant behavior. Project 84-I8 is designed to test whether the production of ethylene by almond flowers and/or fruits plays a role in regulating fruit set and/or nut maturation. A large portion of the work done this year was performed to confirm findings of work done in 1983.

1. Work in spring 1984 showed a clear correlation between successful pollination of 'Nonpareil' almond flowers and the production of ethylene by these flowers. These data confirm 1983 findings that ethylene production by excised almond pistils increases with application of compatible pollen and that this increase parallels embryo sac development. Preliminary work done to develop a system for aseptic almond ovule culture showed some promise for future refinement as an experimental system to test the implications of this correlation.

2. Work in the summer of 1983 indicated that treatments of full size almond fruit with ethylene gas (3 parts per million) or with a commercially-available ethylene-releasing chemical (ethephon, 5 ppm) would accelerate hull split and abscission. The results suggested also that the nut itself normally produces ethylene in order to regulate these processes. This year's work generally confirmed these observations. In addition, an experimental ethylene-releasing chemical, CGA 15281, was tested and results (in terms of acceleration of hull-split) suggested potential value in regulation of fruit split and/or abscission.

EXPERIMENTAL PROCEDURES (all work carried out in the UC Davis orchard)

1. 'Nonpareil' flowers in the "popcorn" stage were emasculated and either cross-pollinated ('Mission' pollen) or left unpollinated. Samples of pistils were taken daily and enclosed in glass tubes in order to measure ethylene production (gas chromatography).

Ovules were aseptically removed from unpollinated 'Nonpareil' flowers and cultured on various media. Samples were removed from culture at daily intervals and prepared for microscopic examination (preservation and embryo sac development).

2. Methods for gassing almond fruit clusters with ethylene were similar to those used in 1983, except that a lower dosage of ethylene was used (1 ppm). Treatments were begun on June 27 and ran for 18 days. Weekly spray applications were made on developing 'Nonpareil' almond fruits using a variety of chemicals beginning on July 5. Applications were made either with hand-held sprayers or a 5-gallon backpack sprayer and care was taken to thoroughly wet fruit surfaces. Spray materials used in hand-held sprayers were:

   a. Silver thiosulfate (2 mM) in water or in a 0.1% water solution of Tween 20.

   b. 10 mM aminooxyacetic acid (AOA) in water or in a 0.1% water solution of Tween 20.

   c. Naphthaleneacetic acid (NAA) at 10 ppm in water or in a 0.1% water solution of Tween 20.

   d. Water.

   e. Tween 20 in water (0.01%, 0.05%, 0.1%)

Backpack sprayer applications included:

   a. Ethephon (1, 5, and 20 ppm in water).

   b. 10 ppm CGA 15281 in water.

The effects of spray treatments on nut dehiscence were assessed twice weekly, except in the case of the tree sprayed with CGA 15281, which was assessed every 2 days. All treatments were compared to control groups of nuts that had received no spray treatments.

A similar test of the effects of CGA 15281 was begun on July 24 with the spraying of trees of 'Mission' variety.

RESULTS

1. Beginning on the fourth day after pollination a divergence in the amount of ethylene produced by excised pistils could be seen when cross- and non-pollinated flowers were compared (Figure 1). Levels of ethylene produced by non-pollinated pistils remained low and constant, while ethylene emanation from cross-pollinated pistils rose steeply during the period of day 5 to day 9.

2. 'Nonpareil' almonds treated with 1 ppm ethylene in an air stream began to split (Figure 2) and abscise (Figure 3). Samples treated with constant ethylene did not reach a state of 100% hull-split because several fruits dropped without splitting. Samples treated

with ethylene for 1 day out of 3 also matured more rapidly than "air-treated" or unbagged nuts in terms of split, but did not show an increased rate of drop over controls during the 18 days of treatment. When samples which had been air-treated were switched to ethylene treatment their development was also accelerated.

Because 1983 results suggested that the wetting agent Tween 20 could accelerate almond maturation on its own, tests with 3 concentrations of this agent were made. This year we observed no significant accelerations of maturation compared to nuts sprayed with water and untreated controls.

In 1983 spray treatments of almond fruits with STS (which blocks plant responsiveness to ethylene), AOA (which inhibits plant ethylene production), and NAA (which generally retards abscission of plant organs) tended to delay nut maturation. These results suggested to us that ethylene production by almond fruits was a normal controlling aspect of nut maturation. In 1984 only the retarding effects of AOA and NAA were seen (and these effects were not seen when these agents were applied in Tween 20 solutions). Earlier application of these materials to larger test samples will be made in 1985 in order to more adequately test the impressions given by the 1983 results.

Ethephon and CGA 15281 treatments of 'Nonpareil' almond fruits appeared to result in some acceleration of split, but when CGA 15281 was applied to 'Mission' fruits, no difference from controls was seen. This later test may have been affected by the fact that these same trees had been sprayed with an experimental growth retardant, PP333, earlier in the spring.

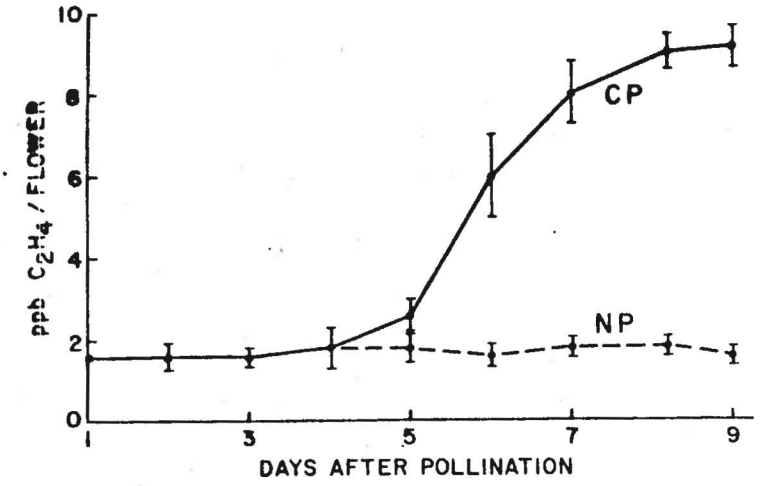

Figure 1. Ethylene production by cross-pollinated (CP) and nonpollinated (NP) pistils explanted from flowers of 'Nonpareil' almond.

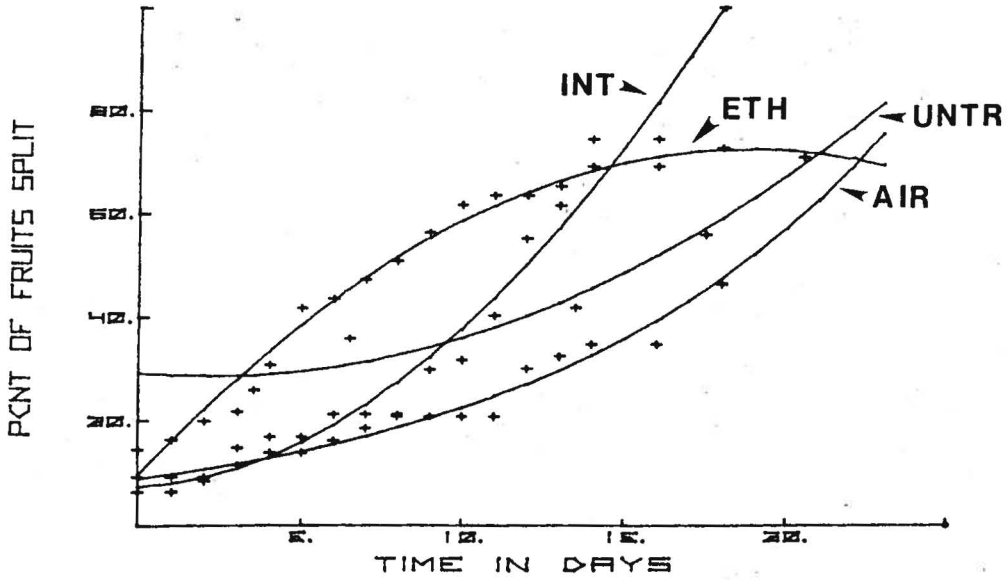

Figure 2. Time-course of dehiscence of almond fruits enclosed in plastic bags and gassed with air (AIR), 1 part per million ethylene (ETH), and ethylene (1 ppm) for 1 day followed by 2 days of air, alternating (INT). Unbagged fruits (UNTR) were also examined.

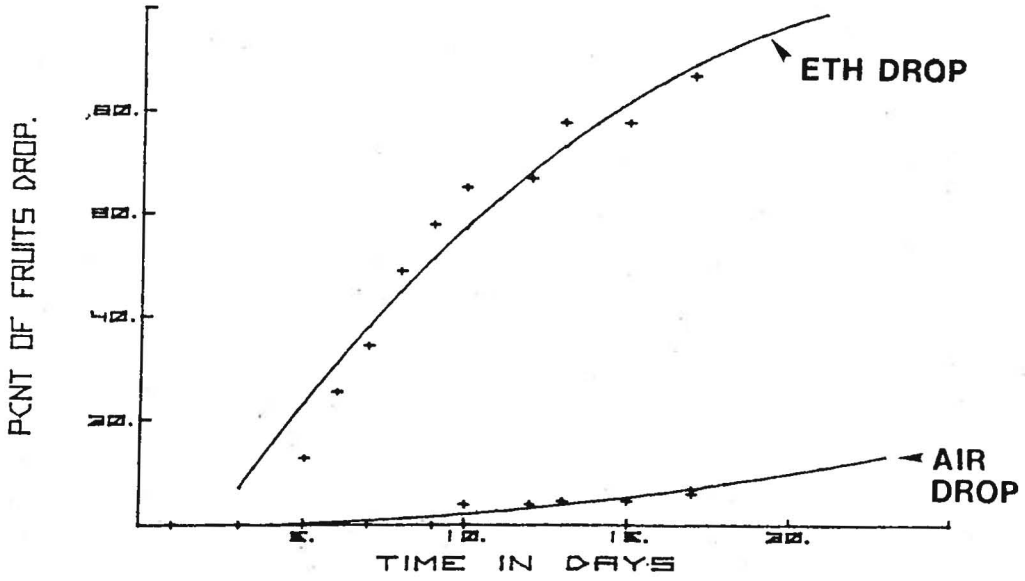

Figure 3. Time-course of abscission of bagged air- and ethylene-gassed almond fruits.

DISCUSSION

1. Ethylene production by flowers has often been correlated with pollination, petal senescence, and flower drop. ACC (1-aminocyclopropane-1-carboxylic acid), the substance which is converted to ethylene in plant tissues, was found on almond pollen during our 1983 research period. ACC could contribute to a rapid production of ethylene by floral tissues (as it does in carnations). The later emanation of ethylene by explanted pistils (Figure 1) may also contribute to floral senescence. However, because more ethylene is produced following cross-pollination, which was seen in 1983 to lead to the enhancement of embryo sac development and, presumably, fruit growth, it seems more likely that the later-produced (5 days post-pollination) ethylene contributes to fruit set and development rather than floral degeneration. The refinement of a system for tissue culture of almond ovules may allow further investigation of the involvement of ethylene in fruit development without the complications inherent in "field research".

2. The data shown in Figures 2 and 3 confirm 1983 findings that the almond fruit is responsive to ethylene gas at fairly low concentrations. Data from 1983 and 1984 spray treatments showed inconsistencies that may be due to year-to-year weather and orchard variations, differences among treatment starting dates that were too late in terms of % hull split, and inadequate sample sizes. However, these data indicate that the ethylene-releasing chemicals ethephon and CGA 15281 (at concentrations much lower than those usually employed in orchards) can also promote nut maturation. Our results do not clearly implicate ethylene in endogenous control of dehiscence and abscission. However, AOA and NAA (which inhibit normal ethylene production) appear to slow maturation. Although additional testing is necessary, these results do suggest that fruit ethylene production does play a part in regulating dehiscence and abscission. If 1985 results confirm this suggestion it may be possible to influence these developmentally-important events by influencing the production of ethylene by almond fruits or manipulating ethylene levels in the orchard.

PUBLICATIONS

A paper on objective '1' is being submitted for presentation at the Annual International Symposium on Growth Regulators In Fruit Production in September, 1985.

A second paper, on objective '2', will be submitted for presentation at the annual American Horticultural Society meetings in Virginia in July-August, 1985.