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Project No. 84-K11 - Tree and Crop Research
Bud Failure and Nonproductivity Disorders in Almonds

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Objectives

Noninfectious bud-failure (BF): (1) To identify the BF factor (or the absence of the BF factor) in source-clones and/or varieties though a combination of biochemical, seedling progeny, and vegetative progeny tests. (2) To determine the effect of nutritional, plant source, and stress factors (moisture, temperature) on cells and shoot tips form BF plants in culture. (3) To continue field observations on BF distribution within varieties and sources. (4) To determine the inheritance patterns of BF factors in F1 and F2 hybrid populations of almond, almond x peach, and other almond species incorporating such factors such as dwarfness, thin, hard, shells (for NOW resistance), and productivity.

Genetic induced nonproductivity (BMS): (1) To continue field observations on BMS affected plants as needed, particularly in progeny trees of 'Nonpareil' and 'Fritz'.

Virus bud-failure/calico (with Dr. George Nyland): (1) To establish patterns of pollen transmission from calico affected plants in the Regional Variety Trial Plots. (2) To determine virus effects on productivity.

Interpretive Summary: A. Noninfectious bud-failure (BF).

The concept of bud-failure developed under this project is that the disorder is caused by a genetic factor found in specific varieties, manifested under environmental stress after a period of gradual or rapid induction, and expressed more rapidly in some trees and sources than others. Research has emphasized understanding the problem and its distribution in order to devise strategies for predicting the potential for bud-failure in different varieties, different sources within varieties, different years, different locations, and different conditions of management.

Objective 1.

(a) Seedling progeny. Most direct identification of the BF factor in a particular almond variety has been its transmission to offspring in almond x peach (particular varieties) crosses to produced severely BF and roughbark (RB) individuals. A number of such progeny from both F1 and F2 crosses are being studied. Detection has been facilitated by the high summer inductive temperatures in 2 of the past 3 years. Likewise, the high inductive temperature of the 1984 summer has set the stage for very pronounced symptoms in Spring 1985.

We have extended the F1 progeny tests of additional symptomless 'Nonpareil' sources and find, as before, that up to 50 percent of offspring with particular early blooming peach varieties show severe BF and roughbark (RB) after the first or second growing season. Similar results come from 'Titan' and 'Carmel', but not

from 'Padre', 'Butte', or 'Price'. BF offspring did not appear within progeny of symptomless, or affect 'Nonpareil' when crossed with certain other peach varieties, in particular, a genetic dwarf peach. However, when we grow the F2 generation from these symptomless F1 trees through the third year, we find segregation of severe BF in the next generation in expected ratios conforming to our original hypothesis. This indicates that the BF factor is transmissable through consecutive seedling generationas even though it does not express itself (at least in the time period of the observations). Further it suggests to us that the original proposal of screening out the BF genotypes by breeding may be valid. We are examining these symptomless individuals for other characteristics that would make them potential parents in future breeding projects (see below).

(b) Vegetative progeny tests. Annual records of BF percentages have now been recorded in a number of experimental tests since early 1970's to establish patterns of BF development and to compare production of BF trees from different source orchards, source trees, and source clones of 'Nonpareil'. The basic pattern of development show a gradual shift (or induction) in the BF potential with time but at different rates depending upon propagation source. After observations next spring we hope to compile this information for publication. Nevertheless, this information along with the inheritance information indicates that all 'Nonpareil' sources do have a BF potentiality, but that some selection can be made among sources.

(c) Biochemical. The exact nature of the heritable BF factor continues to be elusive. Specific biochemical tests have now precluded the hypothesis that an organism of the viroid type is a causal agent. Prelminary work has been started to establish protein differences between symptomless and affected BF tissue.

One of the most productive avenues of research has been the fingerprinting of particular enzyme systems in which variation occurs in their isozyme patterns as measured through electrophoresis. These variants are inherited and can be used as genetic markers to identify specific varieties, to establish parental origins, and (when enough systems are brought into use) to map the chromosomal system. The significance to this problem is to detect linage to another trait or character, such as BF, (or to some desirable trait) which could then be detected routinely even in the seed in a breeding program. It should be clear, however, that these currently known systems will not differentiate among different BF levels in the same variety. So far we have identified five genetic isozyme markers in more than 75 varieties. Their analysis has provided direct experimental evidence that essentially all of our recent varieties are offspring of 'Nonpareil' and mostly 'Mission', and that the appearance of BF in various varieties is from inheritance of the parental 'Nonpareil' (see Project 84-LA11).

Such isozyme linkage studies of BF and specific isozymes are particularly important in connection with the peach x almond progeny described. A beginning has been made to identify markers in these progeny in cooperation with Dr. Dan Parfitt and Dr. S. Arulsekar of the Plant Germplasm Center, Davis.

Objective 2. Culture of shoots and cells.

Almond cells arising from both symptomless (normal) and affected BF plants have been grown in culture for several years to provide a system where we could duplicate the field tests in the laboratory and eventually maintain source plants of specific varieties under controlled environmental conditions. Lou Fenton (graduate student) is completing a study on their response to culture showing that the cells from BF plants differ from the cells from symptomless plants in growing much more rapidly and having somewhat different responses to temperature. We have begun to study in more detail the effect of media modification and artificial stress (with polyethylene glycol) on the growth of the two types of cells. We find that various sources of nitrogen have an effect. Likewise, the preliminary results with PEG indicate that the cells from symptomless plants tend to slow down in growth (go dormant?) whereas those from BF plants do not and appear more sensitive to stress.

Shoot tip cultures of normal and BF 'Nonpareil', normal and BF 'Harpareil', and normal and BF 'Jordanolo' have been established in aseptic culture, but contamination problems have limited the extent of the work this year.

Objective 3. Field observations.

Orchard observations have continued with 'Carmel', with different varieties in the RVT and other plots, and the studies referred to above. The pattern shows that both site and source are important and that gradual buildup of BF potential is taking place in the high summer temperature areas, and that certain years are particularly signficant. This means that although source progeny might well be compared for BF potential in high temperature site areas, the location of the source orchard itself should be located in relatively low temperature growing areas to avoid this induction process.

Lou Fenton (graduate student) has under development a computer model to define the change in BF potential with time under different temperature regimes. The data comes from published information (Kester and Asay, 1978) in which BF percentages have been obtained for different years and different plot locations in California of 'Nonpareil' trees with uniform potential for producing BF. This model plots the rate of progress that might be expected in different locations depending upon the level of BF potential in the source material. By using degree day data from the IPM temperature bank, the importance of particular temperatures and the period during the year when they occur may also be assessed. We hope to extend the model to define the variability pattern more precisely and to identify other factors that affect the induction process.

Objective 4. Inheritance of BF.

Considerable data has been obtained on the distribution of BF offspring in particular seedling populations of almond x almond, almond x peach (F1), almond x peach (F2), and almond x almond species. These are now being examined in conjunction with another project funded from other sources which is examining these progeny for yield and production factors, as well as nut characteristics; e.g., shell resistance to worm damage. Considerable data has been obtained but analysis has not been completed.

Earlier in the report the BF inheritance in almond x peach (F1 and F2) populations has been described. One of the objectives has been to select breeding lines or individual seedling plants that lack the BF factor and which have other useful horticultural traits that could then be used as germplasm for future breeding programs. In the almond peach populations we have identified four different aspects of growth habits, and the time required for them to develop in young plants. These include: a) terminal shoot (TS), b) current season lateral (CSL), c) short spurs (SS), and d) lateral shoots (LS). The TS and TS1 growing habit with flowers on longer terminal shoots develops during the second growing season with bloom in the third spring. SS and LS grow from lateral buds on terminal shoots and require an additional year to develop. In the F2 population flowering on TS began this spring, and flowering on SS is developing for next year. Data on fruiting and other characteristics have been obtained but have not been analyzed.

In another test started several years ago, BF 'Nonpareil' was used in a series of crosses with various almonds in conjunction with parallel crosses with peach. The theory was that by using a severly affected 'Nonpareil' one could shorten the time at which a BF offspring could be detected and eliminated. The concept seems to hold in that BF almond offspring were produced with some progeny, but the percentage so far is low and apparently cannot identify enough of the probable BF offspring to be useful as compared to almond x peach progeny. These progeny will be continued through next spring to take advantage of the high temperature induction period of this year. Some individual progeny have failed to develop BF offspring indicating that their genetic background is conductive to low BF development even the factor is present.

The indivudal parents listed include some germplasm materials originating from late blooming, semi-dwarfed, high producing, almond species. Other progeny from this material involving other parents than BF 'Nonpareil' have also been grown, and offspring examined as having potential for commercial use and with some possiblity of having resistance to BF.

(B and C) Field studies and observations were made but will not be included.