judge internal color. Marsh grapefruit from Lindcove, South Coast, and Limoneira were very similar in flesh color through May, but by July fruit from Lindcove was darker than fruit from the coastal locations.

Redblush grapefruit from both interior locations was well colored throughout the season, while only very pale red coloration developed at the coastal locations (graph 4). Redblush developed the darkest red pigmentation of flesh at Lindcove in July. With grapefruit there were no apparent flesh texture effects of climate except for granulation by July at Thermal.

Grapefruit juice composition

Throughout most of the season, juice percentage of grapefruit varied only slightly between climatic zones: between 41 and 46% for Redblush, and between 39 and 47% for Marsh. Highest juice percentage was at Thermal with Redblush and at South Coast with Marsh; second highest was at South Coast with Redblush and at Thermal with Marsh. Lowest juice percentage with Marsh was at Lindcove; Redblush juice content was about the same at Lindcove and Limoneira. In July juice percentage of grapefruit at Thermal dropped to an average of 25% as the fruit became badly granulated.

There was little difference in taste ratings between Marsh and Redblush. Average taste ratings for both varieties combined are shown in graph 5. Results indicate that superior juice quality cannot be attained at the two cooler climatic zones. By July, grapefruit from Thermal was excessively overripe and granulated.

Solids-acid ratios for Marsh grapefruit are shown in graph 6. Solids-acid ratios for Redblush were almost identical to those for Marsh.

Ascorbic acid (vitamin C) content of grapefruit juice did not vary greatly between climatic zones. Coastal grown grapefruit contained slightly larger quantities of ascorbic acid.

The results of these studies show that, except for pigmentation, Marsh and Redblush grapefruit are commercially identical in physical and chemical characteristics.

Lemon size, shape, rind

Like the other varieties studied, lemons produced larger fruit in the warmer climatic zones, as shown in graph 3. Lemons also tended to be slightly more elongate when grown in the warmer interior climatic zones.

Lemons grown in the interior climatic zones were more yellow, while coastal-grown fruit was greener at each picking date. Color break from green to yellow was rapid and continuous from late October to mid-late January; lemons grown at Thermal changed color more rapidly from late October to early December than during the following six weeks.

Rind texture of lemons varied only slightly between climatic zones. As with grapefruit, lemons from Lindcove were coarsest, and those from the coastal climatic zones were smoothest.

Lemon rind thickness was strongly influenced by climate. Fruit grown at the two coastal locations had the thickest rind, with South Coast lemons having thicker rind than Limoneira fruit. Lemons from Thermal had the thinnest rind, while Lindcove lemons were intermediate between desert and coastal fruit in rind thickness. Average lemon rind thickness in mm for all samplings in all seasons was 4.9 at Limoneira, 5.5 at South Coast, 4.5 at Lindcove, and 3.7 at Thermal.

Flesh characteristics

Lemon flesh color varied only slightly between climatic zones. Lemons produced at the two coastal locations were lightest in flesh color; Thermal lemons were the darkest yellow color internally, while Lindcove fruit was intermediate in flesh color. There were no observed effects of climatic differences on flesh texture of lemons.

Lemon juice composition

Juice percentage of lemons increased from coast to interior. Average juice percentages for all harvests in all seasons were 31.2% for Limoneira, 33.2% for South Coast, 38.4% for Lindcove, and 43.2% for Thermal. This trend may be caused, at least in part, by the tendency of coastal fruit to have thicker rind than interior grown lemons.

Solids-acid ratios for lemons are shown in graph 6; figures for the two lemon varieties have been combined, since differences between these varieties were not significant. Lemon juice from coastal lemons contained more ascorbic acid (vitamin C) than interior grown lemons.

E. M. Nauer is Specialist; J. H. Goodale is Senior Nurseryman; L. L. Summers is Staff Research Associate; and Walter Reuther is Professor of Horticulture and Horticulturist, Department of Plant Sciences, University of California, Riverside. R. L. Blue, D. C. Elfving, Jan Moore, C. N. Roistacher, and R. L. Wagner assisted with this research.

BUD FAII

Noninfectious bud failure (BF) affects certain almond varieties and has become increasingly widespread in recent years.

Symptoms are produced by failure of vegetative buds (particularly on middle and terminal portions of shoots) to grow in the spring. This is followed by vigorous wide-angled growth from surviving buds. In some trees, particularly when other symptoms are severe, bands of roughened bark appear on some branches. As this pattern of bud failure develops, BF trees develop wild, disoriented growth patterns and hence the disorder is frequently called "crazytop."

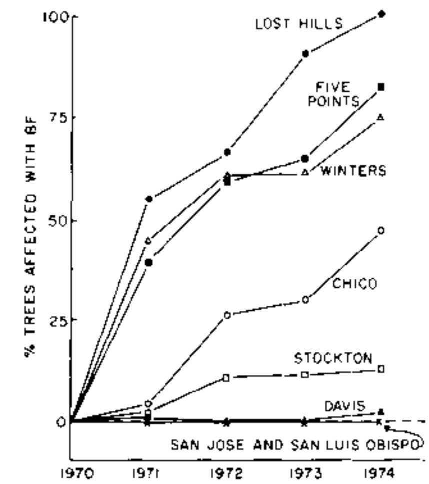
Early work on the BF problem developed the concept of increased BF incidence with successive vegetatively propagated generations. At that time BF was attributed to a genetic disorder with unstable characteristics. Since then, observations suggest that environmental conditions affect the stability and expression of BF. Vegetative propagation is done on the premise that plants propagated from a common parent remain the same, but this premise is not fulfilled in the BF disorder. In other cases where variations have occurred after vegetative propagation, the problem has most often been attributable to environmental influences, virus infections or mutations. However, variability of noninfectious BF cannot, at present, be directly accounted for by any one of these factors. This series of articles adds further information on the nature of BF and discusses selection for freedom from BF within the Nonpareil variety. It documents the impact of environment on BF potential and expressions and provides data on yield reduction due to BF. Finally, it outlines a system of management decisions for orchardists faced with almond trees affected with BF.

LURE IN ALMONDS

Variability of bud failure in Nonpareil almonds

D. E. KESTER · RACHID HELLALI · R. N. ASAY

DEVELOPMENT OF BF IN TESTS WITH NONPAREIL ALMONDS AT SELECTED LOCATIONS IN CALIFORNIA



THIS ARTICLE REPORTS the results of a series of experiments begun in 1969 to separate the effects of propagation source, nursery location and orchard location on the incidence of noninfectious bud failure (BF) in Nonpareil almond. The experiments were stimulated by the observation that high summer temperatures were associated with a high incidence of bud failure.

Shown in the graph on page 12 are average effective July temperatures for test orchard locations, as well as other almond growing areas. A single symptomless Nonpareil tree was used to insure that buds initially had the same BF potential. This particular source tree, identified hereafter as Farnham Nonpareil, was growing in the Foundation Plant Material Service (FPMS) orchard at Davis.

Budsticks were supplied to four commercial nurseries, which propagated trees by June and fall budding. The trees were then planted at eight orchard sites in California, with 150 or 250 trees per site.

Orchard location

The graph (above) shows the incidence of BF-affected trees at the end of each growing season during a four-year period at each orchard site. By spring 1974, the amount varied from none at San Luis Obispo and San Jose, to a few trees with mildly affected shoots at Davis, slightly more at Stockton, somewhat more at Chico, and increasing amounts at Winters, Five Points, and Lost Hills. As the numbers affected per plot increased, the severity of the symptoms was greater and the age when symptoms appeared was earlier. Within each plot BF intensity varied among the individual trees. In essentially all affected trees in the Stockton plot symptoms were limited to limbs exposed to the sun on the south side of the tree.

The graphs show July temperatures at different locations in California and the 1974 percentages of BF in the test plots. Summer temperature levels, based on both day and night conditions parallel the differences found in BF in the orchard sites studied. Temperature levels correlate with BF distribution and severity. It was concluded that the incidence of BF was directly related to the location of the orchard and that the percentages of BF in the eight locations indicated the effect of the environment on BF expression and on BF potential. Such information can be a guide to relative BF potential at a given locality in California.

Nursery location

Significant differences in the incidence of BF developing later in the orchard were found to occur in trees propagated for this experiment by the different nurseries. These differences, along with results of other propagation tests, showed that although changes in BF potential could develop in the nursery row, other factors such as growth conditions in the nursery, methods of nursery handling, and pruning at transplanting might offset these differences. It was concluded that nursery location alone was not a determining factor in BF development, if suitable propagation material was used.

Propagation source

The initial experiment to study the effect of environment on BF constituted a performance test of the BF potential in the bud source tree used. This source, Farnham Nonpareil, had been selected for freedom from known viruses and had no visual symptoms of BF. However, its potential to produce BF trees was high, since up to 100% of the trees propagated from it produced BF in some plots.

Performance tests have been made or are underway comparing trees propagated and grown at a single nursery and orchard location but differing in the source. These tests have mostly been made at the West Side Field Station in Fresno County and have shown that wide differences in BF potential exist in various propagation sources. One test involved source trees selected as candidates for the California Registration and Certification program. The source trees, after having indexed negatively on the virus indicator host range prescribed, are maintained at the FPMS orchard at Davis. They represent the single tree sources whose BF potential should fall within a narrow range, whether high or low. Test plantings were made in 1971 and 1972 and a new planting established in 1974 in Kern County. No BF has yet appeared in trees originating from these source trees, whereas adjacent trees of Farnham Nonpareil planted for comparison produced trees with 40 to 60% BF.

In another test trees from various commercial sources are compared with single tree FPMS sources. These originated either from randomly collected buds from nursery trees or as young nursery trees. This test was not made to monitor commercial sources but to learn how trees originating from separate Nonpareil propagation sources in California differ when tested side by side in a single location. In general these trees represent multiple tree sources (in contrast to single tree sources) with random selection by nurserymen.

In part of this test, five groups of trees from different sources in central California (middle of the Sacramento Valley to northern San Joaquin Valley) were grown. Three of these have produced no BF to date and two have a very low incidence (5%). Another part of this test used four nursery sources, one from the Central Valley, two from the northern San Joaquin Valley, and one from the southern San Joaquin Valley. The two from the northern San Joaquin Valley produced little or no BF, but the source trees from the other two locations produced significant BF.

A survey was made in 1971 in commercial orchards near Wasco in the southern San Joaquin Valley to determine if high BF levels similar to those of the Farnham Nonpareil in that area were shown by trees from other Nonpareil sources. High BF incidence was found in other commercial Nonpareil orchards comparable to that produced by Farnham Nonpareil in the test plots in those areas. Usually such trees came from nursery stock grown in the southern part of the San Joaquin Valley. In contrast, however, other orchards in the same area, some up to 10 years of age, did not show significant numbers of BF trees (less than 5%). The trees examined came from nursery stock originating in central California.

Seasonal changes

Evidence was obtained that changes in BF potential occurred in developing shoots during the growing season. For example, buds on the base of shoots, which were laid down early in the previous spring, tend to remain alive, whereas those produced on the center or apical part of the shoot, laid down later in the spring or summer, often in a second flush of growth, are the ones that fail. Buds on very late season growth generally survive. This pattern suggests that exposure of the growing shoot to higher temperature in midsummer is associated with failure. Buds appear to fail in June, July, or August, depending on the location, year, and level of BF potential, although BF symptoms do not become apparent until the following spring.

In severely affected trees in areas with high summer temperatures, symptoms of bark cracking, discoloration of shoots and decreased bud size may appear at the end of the summer. In most cases, flower buds are not normally affected and high percentage fruit set may result on BF trees, even when few leaves are present.

BF and temperature

Direct evidence of a temperature effect has been obtained by growing almond plants at high (80/100°F night/day) and low (65/75°F) temperatures in the greenhouse. Farnham Nonpareil and Jordanolo trees originating from normal and BF source trees were tested through four consecutive propagation cycles using adjoining buds on the same budstick to produce trees to test at each temperature. Almost all plants of both varieties from BF source trees grown at cool temperatures have grown normally. However, when such plants were transplanted to the experimental orchard at Winters, symptoms returned, indicating that permanent recovery had not occurred.

Plants originating from normal Nonpareil trees grown at high temperatures have gradually developed mild BF symptoms. No plant of this propagation line has developed BF symptoms at the cool temperature. Jordanolo plants from the normal source tree have remained normal at both high and low temperatures, indicating that the source plant had a lower BF potential and that temperature injury as such was not involved in this test.

Conclusions

A picture emerges from these studies that can account for the distribution of BF within the almond industry in California. Expansion of almond production and nursery propagation into the southern and western parts of the San Joaquin Valley from Merced south as well as in some parts of the Sacramento Valley has been accompanied by increasing incidence of BF. Significant changes in temperature patterns occur between Modesto and Merced and between Davis and Winters, Woodland, and Yuba City and farther north. With time, progressive increases in BF potential have apparently occurred in trees in these sensitive areas. Changes would be unrecognizable in the tree until such time as symptoms appear, a process that may require many years. However, symptomless trees with BF potential used as propagation source may produce BF in these progeny orchards sometimes at a relatively young age. The BF problem may be accentuated when a relatively few source trees are used to furnish buds for propagation. The risk is increased if source trees are selected in areas where high levels of BF potential prevail and when selection is not accompanied by performance tests. Although there is some possibility that an inexperienced propagator may fail to recognize a tree with BF symptoms, symptomless trees with significant BF potential pose a far greater danger for spread.

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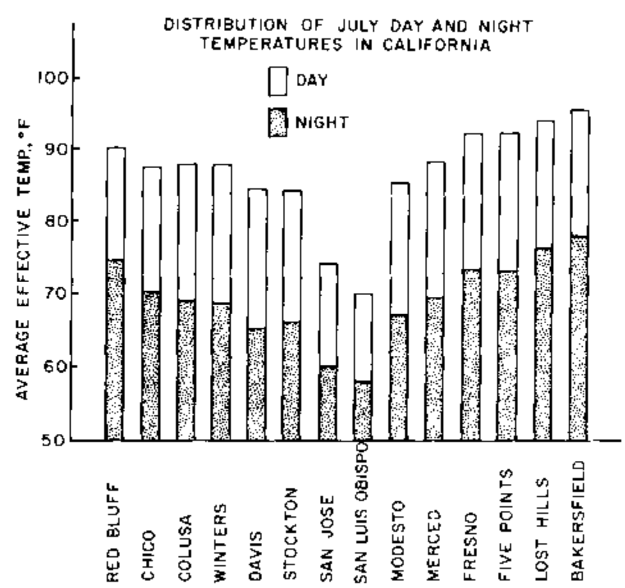

Effective night = mean minimum + $\left(\frac{\text{Max-min}}{4}\right)$ Effective day = mean maximum − $\left(\frac{\text{Max-min}}{4}\right)$