Almond Board Research Conference - December 6, 1977

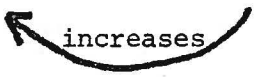
Subject: Project 77-K4. Part I. Noninfectious bud-failure

Project Leader: Dr. Dale E. Kester, U.C.D.

Other Personnel: R.A. Asay, Hellali Rachid, Warren Willig, Leah Tabachnik, Dr. J. Lin, and Dr. George Martin

The key relationship in this project is the following:

Expression of BF character = "Genetic" susceptibility - variety "clone" + Environment (location) - temperature - other?



I. Noninfectious bud-failure (BF):

The concept we have is that BF is expressed as a susceptibility to high temperature. This susceptibility not only varies among trees (and thus propagation sources) but can change with time from low susceptibility to high susceptibility. Susceptibility does not decrease once developed, but BF (although present) may not be expressed at low temperature.

The object of the research is to study separately the 2 factors: genetic susceptibility (potential) and environment under conditions in orchards, controlled temperature chambers and test tubes. The ultimate goals are: a) to identify BF-resistant (and/or BF-free) clones of 'Nonpareil' and other varieties and/or b) to learn to manipulate the environment to control expression.

The main features of this years program were as follows:

1. An anatomical and physiological study of the developing buds on BF plants has been made by graduate student Hellali Rachid, (assisted by Dr. J. Lin and G. Martin).

RESULTS: Anatomically a spectrum of differences among buds from BF trees is found, ranging from seemingly normal, but apparently failing, to reduction in size to severe necrosis in the growing point. Physiological studies are still in progress.

2. An irrigation experiment has been started to determine if water stress can affect BF development and expression.

3. In a controlled growth chamber, BF plants exposed to five weeks at high temperature, in one experiment, were killed to the bud union and in another, only the buds were killed.

4. Inheritance studies of BF susceptibility from almond varieties in almond x peach hybrid crosses have continued. Data is being obtained but is not complete.

5. Methods of growing shoot tips and callus in test tubes have been developed. Differences have been found between tissue from normal and BF plants in growth on one medium and in high temperature susceptibility on another medium. The results should be considered preliminary.

Subject: Project 77-K4. Part II. Variety Evaluations

Project Leader: Dr. Dale E. Kester, U.C.D.

Other Personnel: R.A. Asay, Jim Doyle. Many other persons including U.C. Extension and other organizations are cooperating and will be listed in final report.

As in Part I, the key relationship of this project is also the following:

Expression of the variety (yield, quality and performance) = Genetic potential - variety - "clone" - rootstock + Environment < Location + Management

A. Variety evaluations:

1. The basis for Regional Variety Trials is to compare directly different varieties in the same orchard environment and to compare this performance with that in other locations and under different management. These plots exist in Kern County (1974), Colusa County (1975), Butte County (1976) and in the San Joaquin County (this winter). Activities this year in these plots were:

a. First crop samples were obtained at plots in Kern County and Colusa County.

b. Virus indexing tests were started to aid in evaluating performance.

c. Cross-pollination tests were made among commercial varieties as part of a continuing program to establish specific incompatible groups.

2. Sampling has continued for selections growing at UCD and Kearney Field Station plus miscellaneous grower samples.

B. Evaluations of shell hardness and tightness of seal:

Shell hardness and tightness of the seal are considered to be major factors in NOW resistance. Their expression directly results from the relationship stated above. Understanding their relationship in its effect on shell hardness is the key towards the effective evaluation of new varieties for this character and towards understanding the causes of variations that have been observed in shell hardness within the same variety.

1. About 250 nut samples have been collected to compare the same variety from various sources ("clones"), locations and growing conditions, with emphasis on 'Mission'.

2. Shell character of varieties in Kern plot will be compared to those in Colusa plot (in cooperation with Dr. Ed Soderstrom, who will examine hull character).

Shell hardness and tightness of seal has been observed to vary widely both within and between samples of the same variety. The basic relationship appears to be that softer and more open shells will result from increase in vigor and decrease in crop density. Increased nut size and change in shape and appearance are associated with softer shells.

December 29, 1977

Project No.: 77-K

Tree Research: Part 1. Noninfectious bud-failure
Part 2. Variety evaluation

Prepared by: D. E. Kester, Department of Pomology, University of California, Davis, CA 95616

Objectives

Part 1. The overall objectives are to understand better how BF affects the basic physiology of the almond tree, BF expression and distribution and production of symptoms, how it is affected by environment (primarily temperature) and how the control of BF is transmitted in both vegetative and seed propagation. Specifically, this year we expected:

a. to establish more clearly the cellular events in the buds as symptoms develop on BF trees in the orchard and in growth chambers;

b. to develop the test tube culture techniques to compare BF susceptibility of shoots and callus tissue in relation to temperature;

c. to examine orchard temperature microclimates and its possible modification; and

d. to continue seed transmission studies.

Part 2.

1. To coordinate the establishment and management of Regional Variety Trial (RVT) orchards, including a new plot in San Joaquin County in cooperation with San Joaquin Delta College.

2. To continue to evaluate selection block material pending future release of varieties.

3. To continue to investigate variety and environmental factors affecting variability in shell hardness and sealing properties as a basis for NOW resistance.

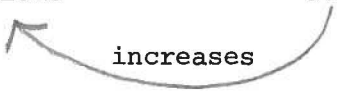
Interpretive Summary

Part 1. Noninfectious bud-failure (BF):

The concept we have is that BF is expressed as a susceptibility to high temperature. This susceptibility not only varies among trees (and thus propagation sources), but can change with time from low susceptibility to high susceptibility. Susceptibility does not decrease once developed, but BF (although present) may not be expressed at low temperature.

The key relationship in this project can be expressed as the following:

Expression of BF character	=	"Genetic" susceptibility - variety - "clone"	+	Environment (location) - temperature - other?



The main features of this years program were as follows:

1. An anatomical and physiological study of the developing buds on BF plants has been made by graduate student Hellali Rachid, (assisted by Dr. J. Lin and G. Martin). RESULTS: Anatomically a spectrum of differences among buds from BF trees is found, ranging from seeming normality, but apparent failure, to reduction in size, to severe necrosis in the growing point. Physiological studies are still in progress, but also show significant differences between buds from BF trees and from symptomless trees in levels of growth hormones, suggesting their possible use to monitor changes in BF susceptibility.

2. An irrigation experiment has been started to determine if water stress can affect BF development and expression.

3. In a controlled growth chamber, BF plants exposed to five weeks at high temperature, in one experiment, were killed to the bud union and in another, only the buds were killed. Differences in growth hormone levels were found in normal vs. BF buds again suggesting an application to measure BF susceptibility.

4. Inheritance studies of BF susceptibility from almond varieties in almond x peach hybrid crosses have continued. Data is being obtained but is not complete.

5. Methods of growing shoot tips and callus in test tubes have been developed. Differences have been found between tissue from normal and BF plants in growth on one medium and in high temperature susceptibility on another medium. The results should be considered preliminary, but also point to the use of the technique to measure BF susceptibility.

Part 2. Variety evaluation:

The key relationship of this project is also the following:

Expression of the variety (yield, quality and performance)	=	Genetic potential - variety - "clone" - rootstock	+	Environment	Location + Management

A. Variety evaluations:

1. The basis for Regional Variety Trials is to compare directly different varieties in the same orchard environment and to compare this performance with that in other locations and under different management. These plots exist in Kern County (1974), Colusa County (1975), Butte County (1976) and in the San Joaquin County (this winter). Activities this year in these plots were:

a. First crop samples were obtained at plots in Kern County and Colusa County.

b. Virus indexing tests were started to aid in evaluating performance.

c. Cross-pollination tests were made among commercial varieties as part of a continuing program to establish specific incompatible groups.

2. Sampling has continued for selections growing at UCD and Kearney Field Station plus miscellaneous grower samples.

B. Evaluations of shell hardness and tightness of seal:

Shell hardness and tightness of the seal are considered to be major factors in NOW resistance. Their expression directly results from the relationship stated above. Understanding their relationship in its effect on shell hardness is the key towards the effective evaluation of new varieties for this character and towards understanding the causes of variations that have been observed in shell hardness within the same variety.

1. Nut samples were collected to compare the same variety from various sources ("clones"), locations and growing conditions, with emphasis on 'Mission'.

2. Shell character of varieties in Kern plot were compared to those in Colusa plot.

Shell hardness and tightness of seal has been found to vary widely both within and between samples of the same variety. The basic relationship appears to be that softer and more open shells will result from increase in vigor and decrease in crop density. Increased nut size and change in shape and appearance are associated with softer shells. Thus, evaluation of shell characteristics of different varieties in relation to NOW resistance depends on conditions under which the nuts are produced.

PROGRESS REPORT

Part 1. Noninfectious bud-failure

Project 1. Anatomical and physiological changes in buds of normal, symptomless, and BF plants (Hellali, Rachid; Dr. J. Lin; Dr. George Martin; D. E. Kester).

Procedure

Two kinds of studies have been made. One involves sampling buds at 2-week intervals beginning in April of one year and continuing through the season until the following February. Part of the buds were preserved and later examined through a microscope. Others were measured and weighed both for fresh and dry weight. Another part of the samples was freeze dried and analyzed for abscisic acid and gibberellin.

The other study included growing small plants by budding from normal, symptomless and BF plants and placing them in growth chambers for 5 and 10 weeks. Buds were then analyzed for the same constituents as described above and also examined microscopically for internal damage.

Results

Part of the anatomical results were reported a year ago. The study has continued and the information obtained provides a more complete picture of what occurs in the development of symptoms than we have had. Bud development had a different pattern in the severely affected BF plant than in symptomless plants. Buds from "normal" plants grow slowly in size until June and then develop bud scales. Elongation continues slightly during summer, stops in fall and winter, and starts to grow again in late December when chilling is completed. Buds on severely BF buds, on the other hand, followed a similar pattern in spring as those on normal plants, but were smaller in size. However, buds failed to elongate in summer, but did elongate somewhat in winter and later. Internal damage on the growing points could be identified by August and September. Differences in the growth hormones, abscisic acid (ABA, a growth inhibitor), and gibberellin (a growth promoter) also occurred. In a growth chamber, normal plants grown at high temperatures produced high concentrations of ABA, whereas the BF plant did not. The results suggest that ABA is a key factor in BF-resistance and its analysis could be used to monitor BF-susceptibility. Possibly it could act as a "protecting" substance. These hypothesis need to be tested extensively in the next phase of the investigation.

Results are being published in a thesis and in several technical papers.

Project 2. Orchard tests to measure environment effects and BF-susceptibility.

Procedure

Procedures were described previously, but include, on the one hand, growing trees in different environments propagated from a single source, and, on the other hand, growing trees of different sources in a single environment.

Results

Environmental studies continue to show that BF develops at different rates in different locations with a high correlation between BF incidence and higher summer temperatures.

The several new FSPMS clones of 'Nonpareil' being tested at West Side Field Station continue to show resistance.

Project 3. Test tube cultures.

Procedure

This procedure was described in some detail in 1976 report. It briefly consists of isolating individual shoot tips and establishing these in a sterile culture where they are supplied with necessary nutrients. The callus cultures involve placing pieces of stem onto a culture medium in a test tube or Petri dish, such that a mass of callus cells develop on the small "explant" from which new masses of cells are transferred to new media about every 4 weeks.

Results

During the last half of 1977, the work had to be discontinued because of severe contamination problems. A new set of materials is being started in December-January. Prior to the time of discontinuation, small shoots of almond could be grown in culture if a growth regulator chemical, benzyladenine, was added to the medium. At 1 gram/liter many lateral shoots developed such that the mass of shoots could be divided periodically to multiply the cultures. At a lower concentration (0.1 mg/l) the shoot elongated.

Callus cultures grew well in culture, but their growth depended on the kind of medium. In a highly nutritious medium, callus from BF plants outgrew that from normal. It is hypothesized that this difference in behavior represents the difference in BF susceptibility which is expressed by higher growth rate.

In a less nutritious medium, callus from the two sources grew similarly, but the callus from BF plants was very sensitive to high temperatures. It is hypothesized that these differences can be used directly to measure BF-susceptibility and BF-expression.

Project 4. Irrigation effects.

Procedure

The two plots of 'Nonpareil', one at Winters (with symptoms) and one at Davis (few or no symptoms) were divided into 3 subplots, a) irrigated; b) nonirrigated; and c) single irrigation in July. Soil moisture is measured every 2 weeks with a neutron probe to a 9 feet depth. Ratings for BF will be made during the coming spring.

Results

No results have yet been obtained in terms of BF symptoms. However, effects on fruit growth were measured and are reported separately.

Project 5. Inheritance studies.

Procedure

Crosses are made, seedling plants are grown in a greenhouse and then they are transplanted to the orchard at WEO, Winters during the following spring. Plants are scored in the following spring for BF symptoms. It has been found to be better to leave plants in for at least 2 years evaluation.

During past spring, crosses were made with 2 peach parents. One is the early blooming variety 40A-17 previously used, from which pollen is taken to place onto the flowers of almond variety to be tested. The other is virus-free J.H. Hale, a late blooming pollen sterile peach, which was used for seed, pollen to be taken from the almond variety to be tested.

Results

Table 1 shows results of crosses for this year and shows probably most significantly the advantage of location of seed tree at Winters as compared to Davis. Results at Davis were poor, partly because of frost, part perhaps due to other weather conditions. The two BF trees used as seed parents showed high % set, but also a high % of shriveled kernels. These abnormalities did not appear when the cross was made the other way and may reflect an effect of the BF seed parent on quality.

Seed germination this year was much more consistent and successful with the J.H. Hale crosses as compared to the 40A-17 crosses. The advantages of making test crosses to J.H. Hale trees located at Wolfskill Experiment Station, Winters, is shown.

More data on the BF transmission from crosses of previous years has been obtained, but is incomplete.

Table 1. Seed production from crosses made Spring 1977

Location of seed tree	Seed parent	x	Pollen parent	% set	No. of seeds	
Davis	Wells Nonpareil	x	40A-17:4-6-19	6.3	41	9 % shriveled frost
Winters	BF Nonpareil	x	"	20.0	378	34% shriveled
Winters	Merced BF	x	"	17.4	192	32% shriveled
Davis	Mission 3-67	x	"	0.8	10	
Davis	1-69	x	"	0.2	2	frost, poor pistils
Davis	5-33	x	"	0.3	4	
Davis	2-62	x	"	2.1	22	frost?
Winters	J.H. Hale Peach	x	Wells Nonpareil	12.5	92	
Winters	"	x	BF Nonpareil	13.5	78	
Winters	"	x	FSPMS Jordanolo	12.2	125	
Winters	"	x	BF Jordanolo	10.5	93	
Winters	"	x	Mission	10.3	82	

Project 6. Modification of orchard microclimate (with Robt. Brewer, Coop. Extension, Kearney FS; Lyndon Brown, Coop. Extension, Kings County; and Marvin Gerdts, Coop. Extension, KFS).

Procedure

Overhead sprinkling system was installed over a block of trees, at the West Side Field Station, Five Points which included severely BF trees of 'Nonpareil'. The objective was to determine if one could reduce summer temperature and thus reduce BF symptoms. This project was part of another program to reduce bud temperature in January to delay bloom.

Results

The system was installed in the spring, but because of poor water quality problems during the drought period, it was considered too risky to put water on the trees in this manner.

Discussion

The concept we have is that BF is expressed as sensitivity to high temperatures. However, a distinction must be made between inherent BF susceptibility and BF-expression (symptoms). BF susceptibility has been shown to vary among trees of a susceptible variety. BF susceptibility also increases with time under specific stress conditions. We have identified sources of 'Nonpareil' that differ in their inherent BF susceptibility and are using plants propagated from these sources to study environmental stress conditions in orchards, growth chambers, and test tubes in relation to BF.

During the past year or more seasonal changes in the anatomy and physiology of buds on BF plants in the orchard have been studied. These reveal fundamental differences between a nonaffected plant and a BF plant in growth, size, and internal damage in the bud. Differences exist between BF and normal plants in specific hormone levels in relation to seasonal patterns. A correlation between low levels of a natural hormone abscisic acid (ABA) and BF susceptibility has been found which suggests that ABA content might be used as a "biochemical marker" for BF susceptibility. In a limited preliminary experiment, a "normal" plant exposed to high temperatures in a growth chamber produced high levels of a naturally occurring inhibitor, abscisic acid, whereas a plant from a BF plant did not.

Methods of growing shoot tips and callus in test tubes have been developed. In the work so far, tissue from BF plants has been found to grow more rapidly than that from normal plants on an enriched growing medium and to grow equally, but be more sensitive to high temperature on a less nutritious medium. Increased growth activity was observed to be associated with increased activity of specific enzymes, particularly peroxidase.

Inheritance studies are a key part of the investigation because it may be the only real way we can identify whether or not a particular plant or variety is "carrying" an inherent BF factor. This part of the program has been hampered by difficulty in consistently getting large enough seedling populations to study and in difficulty in accurately measuring or diagnosing BF in individual

plants. Thus, the results this year with J.H. Hale as a seed parent and the studies of internal characteristics of BF plants are particularly significant in their application to the inheritance phase of the project.

Thus, the several seemingly separate phases of this investigation are being brought together in more basic understanding of the problem with the current development of tools to apply directly to the ultimate goal of eliminating BF susceptible plants.

Part II. Variety Evaluation

Project 1. Regional variety trials (RVT)

Procedure. Layout of plots and the varieties and selections included have been previously described. This year nut samples were collected from the Kern County plot and Colusa plot to provide duplicate samples of the same variety in two locations. Each sample was further divided and 1 part given to Dr. Ed Soderstrom for tests of hull resistance to NOW.

Tests for Prunus ringspot virus (PRSV) were made to provide needed information on evaluating performance. The test is made by placing several buds from test trees into 'Shirofugen' cherry shoots. Infected plants produce severe gumming at the bud within 4-6 weeks.

Results. 1. The status of each of the plots is as follows:

Kern County - Samples were collected this year for the first time on part of the plot and grower harvested the remainder.

Colusa County - Samples were collected this year for first time. A new planting was made for trees of UC and USDA selections as well as a rootstock trial.

Butte County - Plot was too young to produce nuts this year. The 1976 planting is being replaced because of poor survival. Trees are being propagated by Sierra Gold Nursery for planting winter 1977-78. Cost was borne by California State University, Chico.

San Joaquin County - Trees have been propagated and will be planted in winter 1977-78. This is a completely new planting and will include some varieties not present in other plots.

2. Virus testing. The following results were obtained: - = negative, + = positive, 0 = not tested.

	Colusa	Kern
Butte	-	-
Carmel	-	-
Carrion	+	+
Fritz	+	+
Granada	-	-
Harvey	+	+
Money tree	+	-
Merced	0	+
Norman	-	+
Price	+	+

	Colusa	Kern
Profuse	0	+
Ripon	0	+
Robson	+	+
Ruby	0	+
Thompson	-	0
Nonpareil	-	-
Mission	-	-
Ne Plus Ultra	0	+

Project 2. Cross-pollination tests. (D. Kester, R. N. Asay, Marvin Gerdts, and Jim Doyle)

Procedure. Hand-pollination tests were made among various commercial varieties to establish cross-pollination requirements and to identify incompatibility groups. Tests at the Kern County plot were made by Jim Doyle and Marvin Gerdts and involved bagging flowering shoots and applying pollen to the blossoms when open. Other tests were made at Davis by D. Kester and R. N. Asay and involved emasculation of flowers and hand application of pollen.

Results. Some frost occurred at Davis and some bag tearing occurred at the Kern plot. Nevertheless, a pattern of data has resulted. However, because the data is not complete and certain combinations need to be repeated the data will not be presented in this report.

Project 3. Shell characteristics.

Procedure. Hand harvested and hand-hulled nut samples were collected and crack-out tests were run on twenty-five nut samples. Tests included the a) sealing property, as measured by air leakage in cc/min in the seal meter (see 1976 report for details), and by visual observations on shell seal, and b) kernel size, nut size, and shelling percentage as obtained in our standardized evaluation procedures.

Air leakage of individual nuts was recorded with a programmed hand computer which automatically produced means, standard deviations and distributions.

Results. The purpose of the 1976 and 1977 studies was to examine the variability in shell characteristics within samples, between samples of the same variety and between samples of different varieties. The 1976 procedures included extensive seal meter tests, but details were not reported last year.

Table 1, presents the seal meter tests of samples tested in 1976 along with other data on that sample obtained during a crack-out test. No seal meter tests have yet been made on 1977 samples. Table 2, compares selected data from the Kern plot and the Colusa County plot in 1977. Table 3, presents similar data for various grower selections from samples collected in 1977, but segregated by location where collected.

The general observations reached are as follows:

1. Seal meter tests give a precise method of measuring the tightness of the shell in any one sample and is particularly useful to show variability. Thus, the value of a variety may be based not only on the mean value, but how many individuals are poorly sealed, i.e., with a seal meter value above a certain level. The variability is expressed as the standard deviation and range in Table 1.

2. There is a close correlation between seal meter value, the shelling %, and the % of nuts with visible openings. Examination of where the air stream escaped from nuts under water revealed that an imperfect suture seal was the usual case. Thus, visual observation is an acceptable procedure for rapid evaluation and can eliminate the necessity for using the time consuming seal meter test on obviously poorly sealed varieties (Table 1).

3. There is a correlation between reduced nut size and the hardness and amount of shell as measured by shelling % and sealing characteristics. This relationship occurs both within variety samples and between variety samples. A variety with a high count/oz invariably has a harder, more tightly sealed shell. This can account for the hard shells of 3-5 W (sample no. 4) or 3-63E (sample no. 24).

4. The relationship between smaller sizes and harder shells is particularly true among samples of the same variety collected from different locations, in different years, with different ages on different rootstocks and with different nutritional levels. Table 2 compares the characters of number, size, % kernel and % sealed shells for the same varieties for the 2 plots in Kern County and Colusa County. This is the first crop for both plots so that the yield density was relatively low and we recognize from previous experience that nuts will be somewhat atypical of the variety. Trees of the Kern plot are in very favorable soil and climatic conditions and are growing very vigorously. Trees at the Colusa County plot are growing in much less favorable soil, and are growing well, but less vigorously. Nuts produced from the different varieties in the Kern plot were significantly larger in size, had higher shelling percentages, poorer sealed shells, and higher natural worm infestation.

5. The difference in shell was particularly noticeable with the normally hard shelled 'Mission' variety where 4 separate propagation-clones were compared. Typical hard-shelled nuts (shelling % 42-49) were produced at Colusa, whereas soft shelled, larger nuts with atypical appearance were produced in the Kern plot.

During past 2 years various samples of 'Mission' have been collected and evaluated to determine if "genetic strains" or environmental factors could account for variations in shell type that have been reported. Although the investigation is not complete, the evidence points to the conclusion that variations in shell type can be accounted for by natural variations due to nongenetic causes. Thus, soft-shell and off-type nuts are associated with low crop density and high vigor. This situation can occur with young trees just coming into bearing. Tendency toward soft shell has been observed on the 'Peerless' variety this year. These "off-type" nuts can occur with bearing trees where crop density is decreased below a certain level or where severe pruning and dehorning occurs (as in a scion orchard). However, this does not rule out the possibility that low production due to "genetic strain" or a virus may subsequently produce "off-type" nuts.

A relationship between crop density and rootstock on the kind of shell has been found in a test orchard at the West Side Field Station, (Fresno County). Data for 1976 is presented in Part V, Table 1. Fig. 1 includes 1976 and 1977 data, but similar results have been obtained in previous years in this plot originally established in 1966. 'Mission' trees on 51-263 and almond rootstocks produced relatively good crops and the nuts were hard shelled and well sealed. Trees on 'Lovell' peach have invariably had reduced crop density apparently from excess boron in the soil. When crop density was below a certain level (e.g., about 3000 nuts/acre) the nuts were soft shelled and poorly sealed. Trees on the vigorous peach-almond hybrid RS also produced soft shells and poorly sealed nuts even with relatively good crop.

In 1977, the crop density on all trees in this plot was very high, nut size was much smaller than previously, and the shells were harder and shelling percentages lower than 1976. Nevertheless, a difference among the shelling percentage of trees on different rootstocks occurred.

In contrast, 'Mission' trees at Davis on different rootstocks have not shown significant differences.

6. Data has obtained from samples of 'Nonpareil' and 'Mission' collected from trees which have had different nitrogen treatments (Table 4). This was part of an orchard experiment in Butte County in progress for several years by Warren Micke and Clem Meith.

In 'Nonpareil', there was a direct relationship between increase in nitrogen application with increase in nut size (both weight and linear dimension) increase in shelling percentage and a decrease in the percent of well sealed shells. 'Mission' nuts showed a similar relationship, increasing size (at least up to the 2 lb. rate), but increasing the shelling percentage. All 'Mission' nuts, however, were well sealed.

This data is consistent with the pattern described that shelling percentage, nut size, and sealing properties of shell is a direct function of the vigor of the tree.

7. Variety evaluations for NOW resistance in terms of shell hardness depends on making comparisons within a single reasonably uniform environment which itself must be evaluated by including specific varieties as standards. For example, in Table 2, 'Nonpareil' and 'Mission' are used as standards. Essentially, all the varieties in the test resemble 'Nonpareil' more closely than they do 'Mission' and do not look promising for NOW resistance. However, this 1977 data should not be considered completely reliable for these varieties because of their age and can over estimate susceptibility. Nevertheless, Granada, Price, and Robson appeared to have consistently higher worm counts than others.

Among the other selections, the group from LeGrand, California appear to show some resistance. If, however, one compares the overall values of nut size for this location compared to those from Stanislaus, Colusa, or Kern, one must suspect that, with the exception of 'Ripon', the characteristics of the varieties at this location may greatly under estimate their potential NOW susceptibility. Using 'Butte' as an indicator variety for the separate plots, kernel size (no/oz) ranges from 45, to 31 to 30 to 21 with corresponding shelling percentages of 41, 59, 47, and 69. These comparisons underscore the fact that testing locations and procedures to obtain appropriate samples is equally if not more important than the methods of evaluating for NOW resistance.

Publications

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Table 1. 1976 data on shell evaluation of almond varieties.

Variety	Rootstock	Seal meter tests: Seal meter cc/min	Seal meter tests: % 100 or more	Crack-out test: % sealed	Crack-out test: Shelling %	Crack-out test: No./ oz.
I. UCD Selection						
1. Milow		6 ± 8	0			
2. Mission 1-65 /		6 ± 2	0	100	42	21
3. 4-81W		24 ± 8	0	100	48	45
4. 3-5W		29 ± 12	0	100	50	36
5. 1-69		58 ± 32	8	100	55	23
6. 3-52W		60 ± 151	12	100	53	24
7. 5A-3		95 ± 81	36	100	56	28
8. NPU	/ alm	96 ± 128	24	100	50	17
9. 2-62		108 ± 220	16	84	59	23
10. 1-46		158 ± 129	56	100	50	24
11. NPU	/ Lov	180 ± 180	48	80	54	19
12. Smelling		193 ± 145	72	98	59	16
13. 13-1		249 ± 198	84	100	54	24
14. Vesta	/ nema	294 ± 231	72	76	53	19
15. Nonpareil	/ nema	355 ± 279	80			
16. 25-26		383 ± 301	64	80	52	25
17. Milow	/ alm	494 ± 365				
18. Nonpareil	/ nema	516 ± 295	88	25	63	22
19. Nonpareil	/ alm	547 ± 237	100			
20. Nonpareil	/ Pa 2-16-8-63	640 ± 252	96	44	67	53
21. Nonpareil	/ alm	688 ± 216	100			
II. Wolfskill Experiment Station (Winters)						
22. Marcona		17 ± 10	0	100	32	21
23. Peerless		24 ± 16	0	100	36	30
24. 3-63E		31 ± 55	-	100	45	36
25. 3-24E		82 ± 132	6	100	48	36
26. Long IXL		122 ± 99	12	100	52	28
27. Davey		135 ± 163	9	84	51	27
28. NPU	/ nema	210 ± 177	17	84	60	20
29. Drake		259 ± 252	16	60	42	27
30. Spencer		487 ± 241	23	60	53	20
31. Merced		503 ± 233	25	25	64	25
III. Butte County - Nitrogen test plot (Micke, Meith)						
32. Nonpareil 0		376 ± 260	18			
33. Nonpareil 4		508 ± 341	21			
34. Nonpareil 8		534 ± 270	22			
IV. Davis rootstock block						
35. Mission	/ Lov peach	1 ± 2	0			
36. Mission	/ Lov peach	4 ± 4	0			
37. Mission	/ PA 2-16-2	6 ± 2	0			
38. Mission	/ alm	6 ± 3	0			
39. Mission	/ 1-8-2 peach	6 ± 4	0			
40. Mission	/ 3-11-1 peach	6 ± 6	0			
41. Mission	/ alm	7 ± 4	0			
42. Mission	/ PA 2-16-8	8 ± 5	0			

Table 1. (con't)

Variety	Rootstock	Seal meter tests: Seal meter cc/min	Seal meter tests: % 100 or more	Crack-out test: % sealed	Crack-out test: Shelling %	Crack-out test: No./ oz.	Nuts/tree
V. West Side Field Station, Five Points (Fresno County)							
43. Mission	/ 51-263	11 ± 22	0				4204
44. Mission	/ Lovell	12 ± 16	0				4908
45. Mission	/ 51-263	15 ± 25	3				4300
46. Mission	/ alm	28 ± 46	3				5797
47. Mission	/ Lov	39 ± 81	5				4976
48. Mission	/ alm	42 ± 84	4				6178
49. Mission	/ alm	48 ± 128	0				4830
50. Mission	/ alm	51 ± 102	6				4501
51. Mission	/ PA	155 ± 195	10				2731
52. Mission	/ PA	198 ± 279	8				1461
53. Mission	/ PA	221 ± 207	18				5374
54. Mission	/ Lov	337 ± 303	18				2392

Table 2. 1977 nut evaluation in relation to shell characteristics of samples of orchard plot.

Variety	Colusa County Plot				Kern County Plot			
	No/ oz	% kernel	% sealed	% worm	No/ oz	% kernel	% sealed	% worm
Nonpareil 2-70	28	63	48	8	22	72	28	0
4-72	29	62	56	24	24	71	28	0
5-72	26	66	68	8	18	77	8	8
7-72	28	64	56	8	22	69	28	0
Com.	24	66	44	8	-	-	-	-
Mean	27	64	54	10	21.5	72	23	2
Mission 1-65	25	42	100	0	22	64	100	0
2-71	25	49	88	4	20	56	48	0
5-67	26	46	96	0	19	60	100	0
Com.	26	43	100	0	19	60	100	0
Mean	25.5	45	96	1	20	60	87	0
Butte	31	59	72	12	21	69	24	8
Carmel	21	62	64	4	-	-	-	-
Carrion	23	64	44	12	-	-	-	-
Fritz	25	68	24	12	-	-	-	-
Granada	30	58	76	4	28	68	0	40
Harvey	26	66	24	8	26	72	0	4
Jordanolo	18	66	36	4	19	74	12	0
Milow (12-38)	32	67	88	12	-	-	-	-
Money Tree	20	67	8	4	24	77	0	4
Ne Plus Ultra	21	64	16	16	18	74	72	0
Norman	32	70	16	0	28	78	8	20
Peerless 1-65	23	42	100	0	-	-	-	-
2-70	20	42	96	0	-	-	-	-
Price	28	65	40	20	22	68	4	28
Robson	25	62	48	8	21	75	24	28
Thompson	24	71	24	4	25	68	24	12
Ripon	-	-	-	-	25	56	100	0
Vesta	25	53	72	4	22	68	20	0
5A-3	28	66	72	4	26	71	36	12
5A-20	21	76	24	8	21	77	16	4
Mean for plot	27.0	63.5	45.2	6.6	24.5	66.7	23.3	8.4

Table 3. 1977 comparison of shell character in almond varieties in relation to location of plot.

Location	Variety	No/ oz	% kernel	% sealed	% worm	
I. Le Grand	Butte	45	41	100	0	
	Le Grand	41	60	76	0	
	Madera	30	43	80	8	
	Mono	33	42	100	0	
	Planada	31	39	44	4	
	Ripon	42	47	92	8	
	Ruby	38	44	100	0	
	Self-set	31	53	56	0	
	Tioga	44	47	100	4	
	Tokyo	25	53	84	20	
	Wawona	36	52	100	8	
	Yosemite	32	46	100	0	
II. Stanislaus	Butte	30	47	48	12	
	Carmel	25	57	80	0	
	Carmel	27	57	40	0	
	Carmel	21	71	76	0	
	Carmel	23	61	84	0	
	Carmel	20	66	100	0	
	Carrion	31	49	88	8	
	Cressey	25	68	56	4	
	Grace	30	51	44	4	20% doubles
	Janice	25	65	68	0	
	Monarch	22	52	96	4	
	Monterrey	21	53	100	0	28% doubles
	Norman	30	60	80	0	
	Oriole	27	65	64	0	
	Price	25	61	60	0	
	Ruby	25	49	84	4	
	Sauret #1	27	69	12	0	
	Sauret #2	27	63	52	0	
	Tardy Texas	26	43	100	0	
	Thompson	23	69	56	12	

Table 4. Relationship between nitrogen treatment and size, shelling %, and shell character of 'Nonpareil' and 'Mission'. (From samples obtained by W. Micke and C. Meith, Butte County).

Variety	Nitrogen treatment	Grams	Size No./oz	% kernel	% shells well sealed	Size (cm) length	width	thickness
Nonpareil	0 lbs	1.01	28	57	72	2.23	1.35	0.81
	1 "	1.15	25	62	44	2.34	1.37	0.89
	2 "	1.15	25	66	44	2.30	1.36	0.90
	4 "	1.30	22	72	40	2.33	1.33	0.88
	8 "	1.40	20	75	32	2.36	1.38	0.94
Mission	0 lbs	0.95	30	43	100	1.82	1.18	0.91
	1 "	0.97	29	47	100	1.86	1.27	0.96
	2 "	1.01	28	49	100	1.84	1.25	0.98
	4 "	1.00	29	49	100	1.84	1.24	0.99
	8 "	1.00	28	51	100	1.85	1.25	0.99