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ANNUAL REPORT

Project No. 92-K19 - Noninfectious Bud-failure

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Interpretive Summary

Studies dealing with various aspects of the noninfectious bud-failure project have been carried out in this project for a number of years. These have dealt primarily with inheritance and breeding, epidemiology within individual varieties, and physiology of symptoms. We have now attained a broad understanding of the problem, its biological nature, factors that determine its distribution and methods of control. Although information has been provided regularly concerning this work, we are now achieving progress in the scientific publication of the research results that provide the rationale for the direction of the work. Four scientific publications have been completed (see Publications List at end of report) and a schedule of additional publications has been made.

We have now essentially attained field control of the BF problem in 'Nonpareil' as well as other varieties by the clonal selection of nursery sources. This result has been achieved through the cooperative efforts of this project, individual nurseries, and the Foundation Plant Materials Service (FPMS) of the University of California. This material is combined with other projects involving the selection of "virus-free", "true-to-type" nursery material which will be eligible for distribution through the Registration and Certification program of the California Dept. of Agriculture. Individual sources have been tested for horticultural value in the Regional Variety Trials, the subject of a different project.

The situation with the 'Carmel' variety is not as satisfactory and additional time will be required to make appropriate selections that can be considered reliable for low BF production. The prognosis is good that this objective can be attained but at present growers can expect to find some BF trees appearing in their orchards in the immediate future.

The primary unit of selection for low BF-potential is the

individual tree. The problem is how to identify such desirable source trees to be used to produce a new clonal selection from a population of other orchard trees which do not have symptoms but still have sufficient BF-potential to produce progeny with symptoms. "Single tree" progeny tests are the only way at present to make this separation. A biochemical or genetic method of measuring BF-potential would be extremely useful for this purpose. There is currently some progress in this direction in another project and material in these studies will be made available for experimentation. Growers should realize, however htat it is is impossible to predict whether a simple biochemical or genetic index for BF-potential will be found.

The "single tree" vegetative progeny tests described in this project have only produced the first year of results. We expect to obtain data again in 1993 but a third year (1994) should be obtained to be able to apply the prediction techniques developed with the epidemiological model described in this project.

objectives:

1. (Kester and Gradziel) to establish clonal source selections of different almond varieties with low BF-potential, freedom from virus, and trueness to type.
2. (Kester and Gradziel). To establish the pattern of variability of BF-potential within Carmel and Nonpareil.
3. (Shackel and Kester) To determine the effect of management parameters (growth and vigor, and irrigation regime) on the expression and rate of development of BF in young orchards of Carmel and Nonpareil propagated from sources with different potentials for BF.
4. (Kester and Gradziel) To test the potential for stabilizing BF-potential at a given level for scion orchard management.
5. (Gradziel and Kester). To test the utilization of genetic progeny testing for BF-potential (parallel to vegetative progeny testing) in relative BF resistance.
6. To provide a summarized record of the research and development information generated in this project in both the scientific and grower oriented literature on almond.

Project No. 1: SOURCE SELECTION OF PROPAGATING MATERIAL FOR ALMOND VARIETIES.

Procedures: Beginning in 1988, tests were started on single tree source selections of various almond varieties to determine their eligibility to be planted in the Foundation Orchard (FPMS) and eventual released through the Registration and Certification program. The procedures include virus testing, establishing trueness-to-variety in the Foundation trees and progeny testing in commercial orchards (Kern and Fresno Cos.) to observe BF production

and trueness-to-type. Individual sources were recommended from a meeting with nursery and FPMS personnel. Virus tests were carried out by FPMS and an eligibility list determined. Those selections which tested negative were established at the Foundation Plant Materials Service (FPMS) orchard at UC Davis. In addition, progeny trees were propagated by Burchell Nursery and planted in commercial orchard sites in Kern and Fresno Cos. Trees have been examined each spring for BF symptoms.

Results: Prior to this time, individual clonal selections items have been available of the following varieties: Nonpareil (various sources), Mission, Ne Plus Ultra, Peerless, Sonora, Padre, Thompson. Newer selections of additional important varieties made in 1988 and 1989 have completed virus testing and eligible material were propagated into the Foundation orchard at UC Davis. Preliminary trueness-to-type tests have been made and should be largely completed in 1993: Varieties include Butte, Price, additional Mission. Virus-"free", heat-treated sources of Fritz, Ruby and additional Nonpareil were produced in 1991 and trees have been planted in the FPMS orchard but trueness-to-type observations are not complete.

Carmel results are shown in Table 1.

Table 1. Clonal Selection for low BF-potential in Carmel

Source	Tree	BF in:			Trees with severe BF
		1990	1991	1992	
ID	no.	%	%	%	no.
			1989 planting		
114-3	13	0	0	23	1
114-4	13	0	0	18	1
114-2	14	0	0	4	0
114-1	13	0	0	9	0
114-6*	13	0	0	0	0
114-5	13	0	0	0	0
			1990 planting		
Delta-2	40		0	0	0
Delta-7	40		0	0	0
Delta-13*	38		0	0	0
Wells-4*	44		0	30	0
Wells-9*	21		0	0	0
114-3	41		0	0	0

*virus infected; not in FPMS

Conclusions: Source selections for most of the important commercial non-patented almond varieties which are eligible for Registration and Certification by commercial nurseries will be completed by the end of 1993. There are a few exceptions, the most notable will be Carmel. Except for Carmel, essentially all of the selections also

show low potential for BF, including Nonpareil.

Project No. 2. VARIABILITY OF BF-POTENTIAL IN CARMEL AND NONPAREIL

Procedures: Two separate parts of this project have been followed. In Part I, a complete pedigree of the propagation material that currently makes up the commercial nursery sources of Carmel was analyzed to determine patterns of variability. In Part II, progeny trees produced by representative budwood collections from eleven different commercial nurseries were propagated. The origin of each tree was maintained throughout the propagation procedure from source to progeny tree in the orchard. The resulting trees were planted in a commercial orchard in northwest Kern Co. and BF symptoms recorded in March 1992. In addition, two other unpedigreed sources were planted as were a number of separate Nonpareil sources.

Results:

Part I. An analysis of the pedigree for Carmel has been completed and provides a background for the variability in BF-potential present in this variety. Results from this analysis are in the publications listed under objective 6.

Part II. Progeny test results were obtained from source blocks of twelve commercial nurseries. Fifteen separate sources were provided which included traditional "source orchards", "scion orchards", "a nursery increase block" and "single tree clones". From this material almost 3000 Carmel nursery trees were planted in February 1991. No source tree sampled showed BF symptoms. Evaluations of BF in March 1992 included ratings from slight (BF=1) to very severe (BF = 4). An equal number of Nonpareil nursery trees of different sources were also provided.

Principal results obtained from evaluations in March 1992 can be summarized as follows:

1. The percentages of BF trees produced from different sources after one year ranged from 0 to 49.5 (Table 2).

The overall level may be higher than normal because 1992 was a year of high BF expression apparently resulting from the long hot period through fall 1991. This range in percentage paralleled the average ratings of BF severity.

2. Individual trees within source blocks constituted the most important source of BF variability. Since this was only the first year, we should expect that additional BF progeny from additional source trees will appear next spring (1993). Although much variability occurred within individual budsticks and among

different budsticks there was no single overriding pattern. Instead there was a generally uniform distribution in which the numbers of BF trees produced per stick and sticks/tree was closely associated with the total BF-potential of that tree.

3. The pedigree analysis indicated that the large number of BF trees showing up in recent years and confirmed by the test may be due in part to the five consecutive scion generations that sources represent. On the other hand, differences among source orchards also have to be due to other specific conditions associated with a particular orchard including such factors as history, site location, tree vigor and rootstock.

3. BF was produced in eight 'Nonpareil' trees (2400 total) of three sources (nine total) after the first year test. Two FPMS clonal sources were used by three of these nurseries with no BF trees evident.

Table 2. BF IN PROGENY ORCHARDS OF CARMEL

Source	Sticks /tree	Progeny trees total	with BF			Individual source trees Total	Contributing to BF:	
	no.	no.	%	ave.	sig.	no.	no.	%
P1	5	290	49.1	1.21	A	10	10	100
P2	3	325	21.0	0.59	B	16	8	50
P3	5	235	18.9	0.49	B	7	3	43
P4	5	325	10.5	0.215	C	13	5	38
P5	-	100	10.0		C	-	-	-
P6	2-5	80	10.0	0.16	C	8	2	25
P7	1	238	7.5	0.16	C	25	4	16
P8	2	297	6.0	0.17	C	21	5	24
P9	1	215	5.0	0.10	C	25	7	28
P10	5	236	5.0	0.12	C	10	2	20
P11	-	297	3.3			-	-	-
P12	5	234	1.7	0.02	C	10	4	40
P13	2	96	0.0(1)			20	0	0
P14	7	31	0.0			1	0	0

(1) high loss of nursery trees may obscure results

Conclusions:

Short term prospects: BF trees can be expected to continue to appear in commercial orchards of 'Carmel' because of the wide range of BF-potential among current source and absence of quick methods to identify problem trees in any one source.

a) Nursery improvement may come from:
    1) elimination of some sources and avoidance of specific trees within sources identified in this

study
2) expansion of "single tree progeny tests" by individual nurseries

b) Orchard development for 'Carmel' by growers will require:
1) annual surveys of young orchards for BF trees
2) a systematic program to replace affected trees

Long term prospects: Selection for low BF-potential propagation sources of Carmel appears to be good because of the wide range of variability in BF-potential (horizontal variation) shown among individual trees of different sources. In order to exploit this variation we need not only to be able to measure the BF-potential of individual source trees but also to manage them to prevent buildup of BF-potential (vertical variation). Procedures include:

a). development and extension of "single tree progeny test" to upgrade individual orchard sources
b). clonal selection and stabilization of individual source trees in scion orchards as has been done with 'Nonpareil' (will take time)
c). need for "biochemical marker" or other procedure to identify low BF-potential rapidly

Project No. 3. IRRIGATION EFFECTS IN RELATION TO BF-POTENTIAL

Procedure. The plant materials selected for this study included 'Nonpareil' and 'Carmel' trees specifically selected to have "low", "medium" and "high" BF-potential. Three levels of water stress ("dry", "medium and "wet" treatments) were imposed as well as two levels of nitrogen application ("low" and "high"). Trees were planted at Wolfskill Experimental orchards in February 1991. Readings for BF were taken in March 1992.

Results. a. The overall percentages for BF after one year were 0 (low), 2 (medium) and 99 (high) for 'Nonpareil' and 2 (low), 35 (medium) and 99 (high) for 'Carmel'. These results confirm the principle that BF potential in progeny trees is directly proportional to the BF potential of the specific source. Differences do exist and predicted BF production in the progeny can occur.

b. Irrigation treatments resulted in a dramatic and linear response of tree growth, with trunk cross-sections varying between 25 and 60 cm^2 after 2 years in the dry and wet treatments, respectively. For Carmel and Nonpareil trees propagated from known BF sources, water stress did not influence the overall percentage of trees exhibiting BF, but did clearly influence the severity of BF symptoms expressed. BF symptoms (evaluated in spring, 1992) were more severe as the severity of water stress increased. Since all trees in the wet treatment had much more extension growth throughout the season than the corresponding trees in the dry treatment, these results suggest that it may be possible to

minimize the effect of BF by continuation of tree growth into the cooler weather following midsummer. BF symptoms will be further evaluated in 1993.

Project No. 4. STABILIZATION AND MANAGEMENT OF BUDWOOD SOURCE BLOCKS TO CONTROL BF-POTENTIAL.

Procedures: Trees from the same sources as described under objective 3 were planted separately (March 1991) and BF determined in the different trees in spring 1992. In the meantime, buds had been collected from the top of each plant in January and were then budded at the base of shoots in March. The tops of the trees were pruned back to the same location at the base.

Results. Shoots from both the pruned branches and the buds grew during 1992 and will be evaluated for BF symptoms next spring. The process will be repeated in consecutive years. We expect that the BF-potential in the original tree will be stabilized at the initial level but BF-potential in the grafted branches will change over time.

Project No. 5. SEEDLING PROGENY TESTS OF BF-POTENTIAL

Part I. Peach x almond hybrid crosses.

Procedure. Crosses were made in spring 1989 between Peach Selection 40A-17 x various almond varieties. Seedling progeny were planted at close planting at Wolfskill Experimental Orchards in winter 1989-90. Observations of BF in the progeny were made in March 1991 and again in march 1992.

Results: For the second year, severe BF+ individuals were present in the F_1 progeny produced when different almond varieties were crossed with 40A-17 peach. The results reported in 1991 are confirmed. The relative percentages of BF in these progeny has been considered to indicate relative overall BF susceptibility of the almond parent. In these tests, 'Jordanolo', 'Carmel' and 'Sonora' showed highest percentages; 'Nonpareil', 'Merced', and 'Monterey' were intermediate. 'Price'and 'Butte' were low or absent. Despite this ratings, clonal sources which show low BF-potential exist for 'Jordanolo', 'Sonora' and 'Nonpareil'. We should expect the same prospect eventually for 'Carmel'.

Part II. Almond clonal selections of different varieties x Nonpareil BF crosses.

Procedure. Test crosses were made in the same manner in spring 1989 and again in spring 1990. Seedlings were planted in 1989-90 and 1990-91.

Results. Up to now the seedlings have been too young to show results except that one tree with severe BF appeared in spring 1992 in the progeny of 'Nonpareil BF' x 'Jordanolo'. Observations will

again be made in spring 1993.

Project No. 6. PUBLICATION OF SCIENTIFIC RESULTS.

Drafts of two scientific papers describing patterns of BF development in 'Nonpareil' and 'Carmel' (1) and the variability of BF within 'Nonpareil' (2) have been completed and are to be to be sent to journals in January 1993. Similarly, drafts of two papers describing variability of BF in 'Carmel', as described in this report, are being reviewed and after revision will be sent to journals also in January (3,4). Articles on source selection and genetic disorders in almond have been prepared to be published in the forthcoming Almond Manual. An article describing selection for low BF-potential was prepared for the nursery industry and an abstract was publish in the IAB Newsletter in August (5).

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