PROJECT NO. 75-L

COOPERATOR

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PROJECT: Almond Variety Evaluation

I. Objectives and Goals

The project has two principal goals. One is produce information in which specific current or prospective almond varieties can be compared. For this purpose, variety test plots exist or are being established to evaluate environments and cultural adaptation. Objective data from such plots are needed on various tree and nut characteristics significant to production. This would provide information by which variety judgments of the industry can be more effectively made.

The second main goal is to obtain a better understanding of the biological basis of specific characteristics, including such factors, as pollen compatibility, N O W resistance, and harvesting capabilities. This information would provide a basis for precise selection criteria.

II. Abstract of Work In Progress

New orchard test plots are being established in Kern County, Colusa County and Butte County. These supplement existing test plots at Davis and Fresno. In the latter, preliminary evaluations are nearing completion on current UC and USDA selections. Information on cross-compatibilities of these current selections with 'Nonpareil' and 'Mission' was obtained this year. Large differences among varieties to N O W resistance were demonstrated in controlled feeding tests.

Investigation of biological basis for N O W resistance emphasized again the importance of the shell characteristics and possibly the volume of the hull. Studies on ripening factors of detached fruits provided evidence that ethylene is directly involved in "triggering' ripening processes of abscission layer formation and dehiscence.

III. Experimental

A. Evaluation of USDA & UC almond selections potentially useful as new varieties.

Procedure: Potential candidate varieties selected from seedling populations in the breeding programs of the University of California and USDA have been planted in test orchards at Davis (Department of Pomology) and Fresno (Kearney Field Station) with some trees at Winters, West Side Field Station (Fresno, CA) and in scattered orchard plots in private orchards.

In the primary plots at Davis and Fresno 2 trees per variety have been propagated, planted, managed and harvested along with standard varieties. Plantings were made in 1966, 67, 70, 71 and 74. Data has been obtained on yield, tree characters and tree behavior, harvest and nut characteristics.

Results: Data obtained so far, has only been partially summarized and the work on all the 1975 samples has not be completed as of this report. Nevertheless, it has been possible to reduce the initial number of untested selections from more than 50 to 7 for the 1966 and 1967 planting group. Attention is now centering on the group planted 1970 and later. Tentative selection was made from this list in 1974.

Discussion: It is expected that the 1975 results will terminate a large part of this phase of testing and specific selections will be placed into larger orchard tests. The remainder will either be eliminated or placed into an appropriate place as breeding stock.

B. Pollination Testing

Procedure: Pollen compatibility of potential new varieties with 'Nonpareil' and 'Mission' was tested by cross pollination by hand. Pollen was collected from such varieties and placed on emasculated 'Nonpareil', 'Tardy Nonpareil' and 'Mission' flowers. Counts of nuts setting were made at 6 weeks and again near harvest. One or 2 replications of about 100 flowers were used for each test cross.

An alternate procedure that has been utilized in certain experiments has involved microscope examination of pollen tubes in macerated styles stained with lacmoid. Pollen tubes can be directly observed by the differential staining.

Results: Eleven selections were cross-compatible with 'Nonpareil' and 2 were cross-incompatible. All but one were cross-compatible with 'Mission'. Rain and cool weather on March 8 and later adversely affected set in those tests made later in the blooming season.

Pollen tube analysis confirmed the self-fertility of certain experimental varieties but also showed that there were differences among them in the degree of self-fertility. An interaction of temperature and time on pollen tube growth in the style in different combinations of selfing and crossing was found and would affect the orchard behavior of these plants.

Discussion: Although the orchard tests were able to detect incompatible combinations, difficulty in obtaining consistent results because of environmental hazards was clearly shown. This emphasizes the potential value of studying pollen tubes directly in the style under controlled environmental conditions. New modifications of the test developed in England and now used in Spain should be utilized in the future.

C. Evaluations of Varieties for N O W Susceptibility

Two tests were made to determine the ability of N O W larvae to invade the hull, shell and kernel of specific almond varieties, that varied in shell and hull characteristics and different times.

VARIETY - EXPERIMENT 1

Procedure: Three replications of 25 whole fruits each (hull, shell and kernel) were placed in glass jars covered with cheesecloth. Five egg cases of N O W, supplied by Dr. Leo Caltagirone, U.C.B., were placed on each nut. Fruits were divided into 2 groups, one immature (stage 3-5) and a second near mature (stage 6-8). Numbers of worms infesting the hull, shell and kernel were determined after about 4 weeks. All fruits were treated with Botran prior to the test to control growth of microorganisms, particularly *Botrytis*. Control however, was only partially successful.

Results: A summary of data on variety comparisons is shown in Table I, but has not been subjected to statistical analysis. However, inspection of results shows a range in % kernel infestation with 'Nonpareil' highest (59%) and 'Peerless' essentially zero. The percent infestation was closely related to "% sealed nuts" with some exceptions. 'Merced' had less infestation than expected but was very severely affected by fungi which appeared to affect results. The infestation in the unsealed nuts over-all varieties was much greater than that in sealed nuts with the exception of 3-63E. The fact that some amounts of infestation did develop in "sealed nuts" may be due to inability to classify accurately shell seal.

Infestation in the hull, as distinct from the kernel, also showed a range in values from high to low that was broadly associated with kernel infestation, over-all % infestation, and number of worms per jar. Hull weight appeared to be a factor in susceptibility but needs to be evaluated more critically. Evidently the "feeding value" of the fruit as provided by both exposed kernels and the hull may be important in over-all infestation.

TIMING - EXPERIMENT 2

Procedure: 'Nonpareil' and 'Texas' fruits were sampled twice during the season after the start of "hull-split". At each time fruits were divided into 2 groups, classes 3-5 and 6-8. One set was washed with 3 changes of running water for 10 minutes and then allowed to dry overnight (see Section D). Five cases of N O W eggs were added to each fruit of a set of 25 per treatment. For each treatment another set was tested without eggs to establish the level of natural infestation. Two replications were used for each treatment. Worm infestations were determined after 1 month.

Results: (Table 2) Natural infestation was essentially zero in these trials. N O W larva invaded 'Nonpareil' hulls and kernels in significant amounts with greater incidence at the later harvest and in the more mature nuts. This pattern is associated with greater opening of the shell with advancing maturity. On the other hand, infestation was less in the more mature hulls probably because of their drier condition.

'Mission' kernels showed very low infestation in any sample. The only ones affected were a few unsealed nuts at the September 12 harvest. However, infestation of the hull was also very reduced.

Discussion: Opening of the shell on 'Nonpareil' is shown to be a major factor in N O W infestation. Resistance of 'Mission' in these samples can be attributed to the well sealed shell but the characteristics of the hull must also play a part.

D. Detached Fruits

Studies on the relationship between almond "ripening" and ethylene was started in 1973 on the suggestion and assistance of the late Dr. Maxie. During the first year, the following results were obtained:

1. Detached 'Nonpareil' and 'Mission' fruits can ripen off the tree in an enclosed container, as measured by changes in dehiscence (splitting) and abscission layer formation (fruit removal force).

2. High turgor (moisture) appeared important for dehiscence.

3. Ethylene production was associated with both processes.

4. Microorganisms on the fruit were a complicating factor on this study and contributed to the respiration and ethylene evolution.

The 1974 experiments involved methods to control fungi by chilling, washing with water, and treatment with fungicide (Clorox, Botran). In these studies, all treatments delayed or inhibited ripening (abscission and dehiscence) and reduced ethylene and CO_2 evolution in comparison to untreated control. The purpose of the 1975 study was to separate effects of fungicide treatments on ripening and on presence of microorganism. Only the 1975 results will be given here.

Procedure: Enough fruits of 'Nonpareil' and 'Mission' were collected for each test to provide 2 replications of 50 fruits each. These were placed into glass jars fitted with tubing such that moist air could be moved through the jar and samples of escaping gas could be collected for measurements of ethylene and carbon dioxide. Fruit removal force (FRF) was measured on the attachment of the stem and dehiscence graded on a scale of 1-8 (see elsewhere) before and after the test. Evolution of the microflora was also made.

Results: The following results can be reported as occurring under these experimental conditions.

1. Ethylene can produce abscission layer formation and initiate dehiscence. However, the latter process is less sensitive to ethylene and may require either higher concentrations or other conditions to complete the process.

2. Prior to about the end of June, abscission layer formation and dehiscence cannot take place.

3. By mid-July fruit can initiate both processes in response to ethylene, in both 'Nonpareil' and 'Mission'. Through August fruits become increasingly sensitive to ethylene (or are increasingly capable of initiating these processes).

4. Microorganisms on the fruit can produce enough ethylene to initiate "ripening" responses in the almond fruits in the enclosed conditions of this experiment. Control of fungi can reduce this effect although a direct inhibition by Botran cannot be ruled out. The ability to offset "ripening" responses decreased with development time.

5. Respiration of the fruit and ethylene evolution was directly correlated to "ripening" response.

Discussion: These results provide evidence that ethylene is directly involved in both abscission layer formation and dehiscence in the almond fruit but to different degrees. They also show that the responsiveness of the fruit changes with advancing development. These results were obtained on detached fruits under artifical conditions and need to be tested with intact fruits in the orchard. However, the implications are that the ethylene phenomenon should be explored further.

E. Orchard Plots

Procedure: Plots have been established to provide orchard tests of new unreleased almond selections and new varieties not extensively grown. Plots have been selected to represent differing climatic areas in California. These plots involve one row of either 'Nonpareil' and 'Mission' paired with a row of test varieties.

Test varieties are planted either as one complete row of about 20 trees of one item, or as random trees within the row (Colusa). Trees have been propagated by commercial nurseries under conditions such that all trees in the plot have the same propagation and handling.

Choice of varieties has been made by consultation among UC, (Pomology and Extension) grower representatives of the area, and other individuals directly involved as in the Chico plot (see below).

Results: Three plots have been established in the following areas.

Location	Date Established	Nursery Propagation	Remarks
Kern Co., (Kernal Farming Corp.)	June 1974	Dave Wilson Nursery	Includes rootstock tests and FPMS selections
Colusa Co., (Nickels Estate)	April 1975	Fowler Nursery	Includes FPMS selections
Butte Co., (Calif. State Univ., Chico)	scheduled for Spring 1976	Sierra Gold Nursery	

In addition separate plots involving both varieties and rootstocks were established in Fresno County at the Kearney Field Station and the West Side Field Station in Spring 1975 to study particular combinations. These were established by Marvin Gerdts and Lyndon Brown (Extension Service).

Discussion: Possibility of a fourth plot has been discussed but no commitment has been made.

Publications:

Kester, D. E. and R. A. Asay. Almonds, pp. 387-419. In: Advances in Fruit Breeding, Janick and Moore, editors. Prudue University Press. 1975.

Table 1. Infestation of hulls, shells and kernels of various almond varieties after forced feeding with N O W. August - September 1975.

	Overall Infestation		Infested	Worms Per	Unsealed	Infestation		Sealed	Infestation		Average Hull
	Kernel	Hull	Nuts	Jar	No.	Hull	Kernel	No.	Hull	Kernel	Weight
	%	%	%	No.	%	%	%	%	%	%	gms.
Nonpareil*	59	63	84	89	85	12	29	15	4	9	2.50
Drake	50	52	70	81	96	9	16	4	0	0	4.70
Vesta*	38	50	66	48	74	14	22	26	10	3	4.96
La Prima	37	47	62	103	40	12	27	60	11	12	3.55
3-24E	34	39	52	66	20	27	53	80	10	26	2.22
Ne Plus Ultra	31	46	62	61	50	16	24	50	9	3	2.64
5A-3*	29	41	54	62	46	21	39	56	11	4	2.17
5A-20*	29	35	46	37	50	8	21	50	5	4	2.28
Milow	26	30	40	70	44	14	18	56	2	6	1.91
Merced*	26	42	56	50	96	14	19	6	11	0	2.91
3-63E	15	36	46	46	22	12	3	78	9	10	1.74
CP 5-58	13	27	36	34	18	15	22	82	6	2	4.08
Thompson*	8	20	26	31	14	11	17	88	6	2	2.33
Mission	8	14	18	17	13	10	25	87	1	0	2.87
Ballico	4	6	8	6	8	0	17	92	1	0	2.28
Peerless	<1	44	58	42	2	0	0	98	19	0	3.28
Mean:	25	37				12	22		8	5	

*Fungus attack

Table 2. N O W infestation of 'Nonpareil' and 'Mission' fruits in relation to maturity of the fruit.

	August 14 Harvest		August 29 Harvest	
GROUP I - N O W Eggs Added				
Nonpareil	Class 3-5	Class 6-8	Class 3-5	Class 6-8
Mean % Sealed	18	54	2	5
Kernels Infested (overall %)	21	27	31	45
Sealed %	7	18	0	<1
Unsealed %	24	40	8.2	10.5
Hulls Infested %	43	33	56	38
Sealed %	33	18	10	50
Unsealed %	46	51	56	81
	September 12 Harvest		September 29 Harvest	
Texas				
Mean % Sealed	98	97	100	100
Kernels Infested (overall %)	3	3	0	0
Sealed %	0	0	0	0
Unsealed %	100	100	0	0
Hulls Infested (overall %)	3	6	0	4
Sealed %	2	3	0	4
Unsealed %	0	2	-	-
GROUP II - No N O W Eggs Added (Natural Infestation)				
Nonpareil				
Kernel Infested %	0	0	0	1
Hull Infested %	0	0	0	1
Mission				
Kernel Infested %	0	0	0	0
Hull Infested %	1	3	1	2

Table 3. Fruit development and maturity stages at beginning of experiments with detached fruits.

Ripening Class		Nonpareil 6/27	Nonpareil 7/18	Nonpareil 8/12	Nonpareil 8/19	Nonpareil 9/2	Mission 7/14	Mission 8/4	Mission 8/22	Mission 9/12
		Date of Harvest:					Date of Harvest:			
Unsplit	1	100/7 (1)	100/9	26/10			100/12	100/13	100/12	32/10
Starting to split	2			42/10	24/9					44/8
↓	3			8/7	18/7	5/1				14/6
	4			12/6	24/5	4/1				10/6
Open	5			10/4	26/2	18/3				
↓	6			2/6	8/3	44/3				
	7					10/2				
Dry	8					6/1				
Ave. F.R.F. for sample		7	9	9	5	3	12	13	12	8
Fresh Wt.: gms.										
Fruit		15.1	18.6	20.8	22.0	12.6	10.5	13.9	11.7	12.0
Kernel		2.10	2.26	2.39	2.39	1.88	1.58	1.81	1.83	1.69
Dry Wt.:										
Kernel		0.49	0.95	1.45	1.53	1.52	0.55	0.99	1.17	1.17
% H_2O:										
Kernel		76.6	58.0	39.4	35.8	19.2	65.2	45.3	36.2	31.1

(1) above line: % in class

below line: means pull-force in lbs. (F.R.F.)

Table 4. Fruit Removal Force (F.R.F.) of almond fruit, stem attachments of detached fruits.

Nonpareil

Date of Collection:	June 27	July 21	Aug. 12
Beginning of Experiment:	7.16 ± 2.69	8.60 ± 3.12	8.59 ± 2.99
Untreated			
Unwashed	(combined samples of all treatments 7.57 ± 2.40)	4.45 ± 1.93	(discontinued due to contamination)
Washed (1)		6.43 ± 2.51	
Botran (2)		7.82 ± 3.05	
Ethylene treated (3)			
Unwashed	↓	3.19 ± 1.25	↓
Washed		2.07 ± 0.85	
Botran		3.51 ± 1.61	

Texas

Date of Harvest:	July 16	Aug. 6	Aug. 25	Sept. 15
Beginning of Experiment:	12.29 ± 3.10	13.06 ± 2.31	11.58 ± 1.86	8.13
Untreated				
Unwashed	8.44 ± 3.19	2.70 ± 0.87	1.47 ± 0.62	no measurements
Washed	8.87 ± 2.12	2.60 ± 0.90	1.57 ± 0.65	
Botran	9.72 ± 2.37	5.97 ± 2.35	1.85 ± 0.72	
Ethylene treated				
Unwashed	2.31 ± 0.93	1.80 ± 0.69	1.33 ± 0.69	↓
Washed	2.48 ± 0.87	2.14 ± 0.78	1.27 ± 0.56	
Botran	2.34 ± 1.02	2.13 ± 0.70	1.39 ± 0.61	

(1) Running water, 3 changes at 10 minutes each

(2) 0.125% solution

(3) 2 ppm, 48 hours

Table 5. Percentages of unsplit almond fruits remaining after 2 weeks of assimilated ripening conditions.

Nonpareil

Date of Collection:	June 27	July 21	Aug. 12
Beginning of Experiment:	100	100	26
Untreated			
Unwashed	100	32	no measurements
Washed	↓	51	
Botran	↓	58	
C_2H_4 Treated	↓		↓
Unwashed	↓	14	↓
Washed	↓	15	↓
Botran	↓	24	↓

Mission

Date of Collection:	July 16	Aug. 4	Aug. 25	Sept. 15
Beginning of Experiment:	100	100	100	32
Untreated				
Unwashed	96	41	21	no measurements
Washed	97	40	32	
Botran	100	85	48	
C_2H_4 Treated				↓
Unwashed	95	73	33	↓
Washed	91	84	34	↓
Botran	91	87	58	↓