7

77

BARD

FINAL REPORT

PROJECT NO. US-436-81

Response of Peach and Nectarine Germplasm to an Annual Top Removal Pruning System

W. Sherman, P. Spiegel-Roy, A. Erez

1987

24405

2uuo5 0

Final Progress Report Date December 10, 1986

BARD
P. O. Box 6
Bet Dagan, Israel

BARD N. of Proposal #US-436-81 (DSR No. 81233RF-6) (Univ. Acct. No. 124917324)

Title of Porposed Research - "Response of peach and nectarine germplasm to an annual top removal pruning system."

Name of Investigators
Principal Investigator: - Wayne B. Sherman
Cooperating Investigators: - P. Spiegal-Roy and Amnon Erez

Names and Addresses of Affiliated Institutions
Grantee Institution: University of Florida, Gainesville, FL 32611-USA
Cooperating Institution: Volcani Institute Agr. Res., Bet Dagn 50250-Israel

Project's starting date: 10/19/82

Type of Report: Initial ___ Comprehensive ___ Final X .

Signature

Wayne B. Sherman
Principal Investigator

Willard C. Marshall
Institutions Authorizing Official
Thomas E. Walsh
Director of Research

Carol A. Cook

Carol A. Cook
Grant Development Coordinator
IFAS Sponsored Programs

630.72 : 634.25 : 631.542 :

BAR/SHE 634.26 : 631.543.2 :

2nd copy 631.52

Table of Contents

Page

Abstract - BARD US-436-81

Clonal evaluations were made in Florida and Israel for determining adaptation to high density. In Florida, Flordagold, Fla. 9-9, Fla. 9-14, and Fla. 9-15N had significant yield on high density (1x3m), 16-month-old trees while the same clones at standard orchard spacing (4.5x6m) had no yield. Fruit size and soluable solids were slightly reduced on these trees at the high density as compared to the standard orchard spacing in the second fruiting at 28 months from planting (yields not comoparable due to frost damage).

In Israel, rooting capacity of 10 clones showed high variability for % rooted and survival. Self rooting would be more desirable as tree density greatly increases. Chilling was investigated in 9 clones and results were similar to that in Florida with 2 exceptions. A quadratic function seemed to link flower and vegetative bud break. Flower bud set of 10 clones in a high density planting was evaluated in the 2nd growing season and most clones produced high bud set, but 4 were especially prolific. Among 10 clones tested 9-7N, 9-15N, and 83-4 were the most promising for high density with annual top removal.

Approximately 225,000 hand pollinations during the 4 year grant period resulted in about 18,000 hybrid seedlings from which selections for early ripening, high fruit quality will be made. During the grant period some 78 new clonal selections were made which are propagated and being field tested. The significiant clones from this field test will be distributed to Israel for variety evaluation. Clones from previous cultivar tests are now propagated in Israel and 3 will be proposed for release in 1987-88 (Fla. 8-1, Fla. 82-9W, and Fla. 82-19). Others will be considered after further tests.

Improvements in the breeding procedure have been realized from effectiveness of preselection (selection in 18 month old seedlings). A 10-year analysis of the fruiting nursery indicated that selection was effective for chilling requirement, fruit development period, size, color, shape, and firmness. However, preselection for seedling chilling requirement based on seed chilling requirement was not effective in the chill range desired. Clones with a high flower bud set tended to produce precocious seedlings (H=0.55). A high degree of flower bud set in parents was a good indication that their progeny would have a high flower bud set. Chilling requirement was highly heritable (H=0.93). There was a positive relationship between earliness of autumn growth cessation and increased chilling requirement of the clone.

Attempts were made to increase the earliness and % success in germination of resecued peach embryos in order to increase the hybrid population size of earlier ripening seedlings for clonal selection. Media, tetcyclazide, paclobutrazol, gibberellin, hydrogen cyanamide, seed peeling, light vs dark during germination, and termperature were investigated in seed germination. Both media explored were about equal in effect. There were indications that tetcyclazide combined with GA_3 substationally increased seed germination in vitro. Paclobutrazol applied to trees and hydrogen cyanamide applied to seed had no highly beneficial effects on germination. GA_3 in media improved germiantion in nearly every experiment. Some beneficial effect of culturing the embryos in darkness was noted. Culturing seed with a late chilling (5°C) period increased % of large plantlets.

Research Objectives

1. Response of regrowth in high density with annual top removal and in standard orchard spacing.

1984

Flordagold, Sungem (Fla. 7-4N), and 5 clones from advanced selections (Fla. 8-2N, Fla. 8-6, Fla. 9-9N, Fla 9-15N, and Fla. 9-14) were propagated on Nemaguard rootstock and planted in January 1984 to a high density (5 replications of 6 trees each spaced 1 x 3 meters) and a standard orchard spacing (5 replications of 1 tree each spaced 6 x 4.5 meters). The 7 clones were chosen for this experiment from a preliminary screening of advanced selections and cultivars for adaptation to the annual top removal system. Comparisons of crop load (yield), fruit size, and soluable solids are being made in the 2 spacing systems.

1985

First yield on the high density was in May and early June 1985 (Table 1), but no yield occurred in the standard spaced orchard system because of pruning required to train the tree. Flordagold, Fla. 9-9N, Fla. 9-14, and Fla. 9-15N had significant commercial yield on the second leaf trees (16 months old). Fla. 8-2N, Fla. 8-6, and Sungem had yields that were not considered commercially significant. Top removal to 60cm was done in early June in the high density system for regrowth of 1986 crop.

1986

First yield following top removal the previous June in the high density system was in 1986. Fruit yield, size (diameter), and soluable solids were compared from the high density (Table 2) and standard orchard (Table 3) spacing systems. Fruit yield was reduced in both systems due to a late spring frost of -2°C on March 23. Damage was visually estimated to be more severe in the standard orchard system because trees were more compact and thus foliage more dense in the high density system thereby preventing heat loss. Only in marginal freeze conditions in very late March such as we experienced would be expected to result in yield differences between the 2 systems. Thus yield data between the 2 systems is not comparable for 1986. However, clones Fla. 9-9, Fla. 9-14, Fla. 9-15M and Flordagold were severely damaged in both systems. Fruit size and fruit soluable solids as measured by diameter and hand refractometer were smaller for all cultivars in the high density as compared to the standard orchard system.

Table 1. Yield and fruit size of 18-month-old peach trees in high density, 1985.

Clone	Harvest date	1		2		3		4		5		Clonal mean	
		Fruit weight[z] kg	Fruit size g	Fruit weight[z] kg	Fruit size g	Fruit weight[z] kg	Fruit size g	Fruit weight[z] kg	Fruit size g	Fruit weight[z] kg	Fruit size g	Fruit weight[z] kg	Fruit size g
Sungem Nect.	4/30	1.07	63	.15	50	.21	70	.30	50	.84	70	--	--
(Fla. 7-4N)	5/6	2.88	60	3.78	60	3.42	57	.15	50	1.48	57	--	--
Total/Avg.		3.95	62	3.93	55	3.63	64	.45	50	2.32	63	2.86	59
Fla. 8-2N	5/6	Very few fruit - not enough for records											
Fla. 8-6	5/14	1.92	80	2.28	91	4.15	83	1.62	90	7.43	94	3.48	88
Total/Avg.													
Fla. 9-15N	5/14	1.39	82	.26	65	1.19	70	1.88	75	2.33	75	--	--
	5/21	15.88	85	15.88	70	22.68	75	3.63	75	2.27	80	--	--
Total/Avg.		17.27	84	16.14	67	23.87	73	5.51	75	4.60	77	13.48	75
Fla. 9-9N	5/21	1.05	75	1.80	75	3.45	75	Missing data					
	5/24	5.44	70	19.50	75	9.53	75	Missing data					
Total/Avg.		6.49	73	21.30	75	12.98	75	--	--	--	--	13.59	74
Flordagold	5/21	4.37	115	3.89	105	6.75	95	4.37	95	4.14	115	--	--
	5/24	2.25	90	2.16	90	3.83	85	.51	85	.36	90	--	--
	5/28	1.62	90	1.35	90	2.16	90	.45	90	Missing data			
Total/Avg.		8.24	98	7.40	95	12.74	90	5.33	90	--	--	8.43	93
Fla. 9-14	6/7	7.65	85	4.48	80	5.67	90	Missing data					
	6/11	12.70	85	4.54	80	7.28	75	Missing data					
	6/17	7.28	85	9.07	85	12.70	80	Missing data					
Total/Avg.		17.63	85	18.09	82	15.65	82	--	--	--	--	17.12	83

[z]Yield per 6 trees 1 x 3 meters

Table 2. Yield, fruit size and soluble solids of 28 month-old peach trees in high density, 1986.

		Rep. 1[z]			Rep. 2			Rep. 3			Rep. 4			Rep. 5			Clonal mean		
Clone	Harvest date	Fruit yield (kg.)	Fruit diameter (cm.)	Soluble solids (%)	FY[w]	FD[x]	SS[y]	FY[w]	FD[x]	SS[y]	FY[w]	FD[x]	SS[y]	FY[w]	FD[x]	SS[y]	FY[w]	FD[x]	SS[y]
Fla. 8-2N	5/14	4.45	4.52	11.64	1.77	4.62	11.80	2.09	4.49	12.80	8.35	4.58	12.88	6.80	4.55	13.70	--	--	--
	5/16	26.17	4.55	11.08	19.05	4.62	12.80	9.48	4.52	14.24	11.88	4.51	12.60	9.25	4.55	12.00	--	--	--
	5/20	6.49	4.55	13.32	5.40	4.53	12.12	9.34	4.45	14.04	3.40	4.48	11.76	2.49	4.48	14.36	--	--	--
Total/Avg.		37.10	4.54	12.01	26.22	4.59	12.24	20.91	4.47	13.70	23.63	4.52	12.41	18.55	4.57	13.35	25.3	4.54	12.74
Fla. 9-9	6/6	28.62	4.79	11.36	24.77	4.62	12.92	29.85	4.85	11.76	20.14	4.88	12.36	13.24	5.22	13.56	23.3	4.87	12.39
Fla. 8-6	5/22	4.72	4.81	12.52	3.99	4.72	10.80	3.08	4.72	11.32	9.57	4.98	12.08	2.04	4.95	11.04	--	--	--
	5/26	2.13	4.61	13.16	5.67	4.78	11.64	3.72	4.79	13.76	5.44	4.78	13.28	4.08	4.86	13.08	--	--	--
	5/31	2.04	4.79	13.44	4.17	4.79	13.06	3.27	4.93	13.14	2.40	4.71	13.68	1.63	4.74	13.38	--	--	--
Total/Avg.		8.89	4.74	12.62	13.83	4.76	12.12	10.07	4.81	12.50	17.42	4.82	12.85	7.76	4.85	12.77	11.6	4.80	12.63
Fla. 9-15	5/26	2.77	4.95	11.20	3.04	4.80	11.48	2.13	4.83	11.76	1.00	4.65	12.88	--	--	--	--	--	--
	5/31	0.82	4.72	11.48	3.08	4.75	11.88	2.95	4.85	11.56	--	--	--	--	--	--	--	--	--
Total/Avg.		3.58	4.84	11.34	6.12	4.78	11.68	5.08	4.84	11.66	1.00	4.65	12.88	--	--	--	4.0	4.79	11.74
Sungem Nect.	5/14	2.63	5.11	9.76	5.17	5.03	11.54	7.98	4.85	10.26	1.00	4.84	10.14	6.80	5.03	9.18	--	--	--
	5/22	0.68	4.97	12.96	0.45	4.62	13.00	--	--	--	--	--	--	0.23	4.57	9.87	--	--	--
Total/Avg.		3.31	5.04	11.36	5.62	4.83	12.27	7.98	4.85	10.26	1.00	4.84	10.14	7.03	4.80	9.53	5.0	4.87	11.06
Flordagold	5/20	2.72	5.41	8.84	1.36	5.50	9.08	2.54	5.21	10.04	2.90	5.49	--	5.44	5.54	10.56	--	--	--
	5/26	9.66	5.35	8.72	4.76	5.30	9.12	4.35	5.00	9.96	1.81	5.07	10.36	4.08	5.04	11.24	--	--	--
	5/31	0.91	4.78	11.58	1.45	5.10	13.04	1.22	4.63	13.84	0.09	--	--	1.04	4.86	14.12	--	--	--
Total/Avg.		13.29	5.18	9.71	7.57	5.30	10.41	8.12	4.95	11.28	4.81	5.28	10.36	10.57	5.15	12.68	8.9	5.17	10.89
Fla. 9-14	6/13	7.08	5.26	9.52	4.72	5.17	9.76	14.20	4.89	9.76	4.67	4.98	10.36	13.15	5.37	10.04	8.8	4.14	9.89

[z] Yield per 6 trees 1 x 3 meters

[y] Soluable solids (%)

[x] Fruit diameter (cm.)

[w] Fruit yield (Kg)

Table 3. Yield, fruit size and soluble solids of 28 month-old peach trees in standard orchard spacing, 1986.

Clone	Harvest date	Rep. 1[z] Fruit yield (kg.)	Rep. 1[z] Fruit diameter (cm.)	Rep. 1[z] Soluble solids (%)	Rep. 2 FY[w]	Rep. 2 FD[x]	Rep. 2 SS[y]	Rep. 3 FY[w]	Rep. 3 FD[x]	Rep. 3 SS[y]	Rep. 4 FY[w]	Rep. 4 FD[x]	Rep. 4 SS[y]	Rep. 5 FY[w]	Rep. 5 FD[x]	Rep. 5 SS[y]	Clonal mean FY[w]	Clonal mean FD[x]	Clonal mean SS[y]
Fla. 8-2	5/14	1.50	5.02	14.34	3.20	4.95	14.08	0.66	4.80	12.60	1.32	4.78	15.54	2.68	4.78	14.48	--	--	--
	5/16	1.13	4.72	14.52	0.91	4.64	14.20	0.23	4.84	12.95	0.64	4.49	14.24	--	--	--	--	--	--
Total/Avg.		2.63	4.87	14.43	4.11	4.80	14.14	0.86	4.82	12.78	1.95	4.64	14.89	2.68	4.78	14.48	2.45	4.78	12.70
Fla. 9-9	6/6	0.41	4.71	14.10	0.18	4.97	14.60	1.54	5.29	13.38	1.41	5.42	13.52	2.36	5.12	12.72	1.18	5.10	13.66
Fla. 8-6	5/14	1.39	5.50	12.92	1.68	5.29	12.24	0.77	5.24	14.20	--	--	--	0.77	5.44	15.00	--	--	--
	5/20	0.73	5.05	13.48	0.68	5.78	12.44	0.23	5.72	13.30	0.23	5.40	13.75	0.36	5.32	13.80	--	--	--
	5/26	--	--	--	0.41	4.52	9.93	0.18	4.87	12.60	0.32	4.95	14.80	0.27	4.76	14.60	--	--	--
	5/31	--	--	--	--	--	--	--	--	--	0.32	5.24	13.40	0.09	5.16	14.60	--	--	--
Total/Avg.		2.54	5.28	13.20	2.77	5.03	11.54	1.18	5.28	13.37	0.86	5.70	14.00	1.50	5.17	14.50	1.80	5.19	12.80
Fla. 9-15	5/26	0.91	5.40	13.44	0.36	5.14	12.90	0.23	5.08	--	0.45	4.76	12.80	0.73	5.05	15.12	--	--	--
	5/31	1.45	5.30	13.48	--	--	--	0.32	5.24	13.27	1.18	4.81	14.00	0.09	5.72	15.60	--	--	--
Total/Avg.		2.36	5.35	13.46	0.36	5.14	12.90	0.55	5.16	13.27	1.63	4.79	13.40	0.82	5.39	15.36	1.15	5.17	13.83
Sungem Nect	5/14	1.04	5.13	10.58	--	--	--	0.27	5.72	13.90	0.91	4.66	12.14	1.90	4.95	14.28	--	--	--
	5/20	1.09	--	14.42	0.09	4.76	--	--	5.50	--	--	--	19.00	1.09	5.19	13.56	--	--	--
	5/22	2.18	5.42	12.60	0.23	5.40	10.50	0.68	5.00	14.20	0.64	5.16	14.64	--	--	--	--	--	--
Total/Avg.		4.31	5.28	12.53	0.32	5.08	10.50	0.95	5.41	14.05	1.55	4.91	15.26	2.99	5.07	13.92	0.85	5.15	13.79
Flordagold	5/20	0.36	5.48	12.36	--	--	--	0.68	5.53	12.20	--	--	12.82	0.32	5.72	12.55	--	--	--
	5/26	1.13	5.42	13.08	--	--	--	0.77	5.02	12.00	0.23	4.87	13.67	0.59	5.40	12.88	--	--	--
	5/31	--	--	--	--	--	--	0.18	5.40	10.60	--	4.76	14.20	--	--	--	--	--	--
Total/Avg.		1.50	5.45	12.72	--	--	--	1.63	5.32	11.60	0.23	4.82	13.56	0.91	5.56	12.72	0.85	5.29	12.69
Fla. 9-14	6/11	0.64	5.46	11.20	0.91	5.50	11.33	0.27	4.52	11.80	0.23	5.72	--	0.91	5.08	12.12	--	--	--
	6/16	2.72	5.31	10.44	0.45	5.08	10.20	1.59	4.62	11.44	0.91	5.72	10.90	0.34	5.08	11.00	--	--	--
Total/Avg.		3.36	5.39	10.82	1.36	5.29	10.77	1.86	4.57	11.62	1.14	5.72	10.90	1.25	5.08	11.56	1.80	5.21	11.20

[z] Based on 1 tree per rep-tree spacing 6.0 x 4.5 meters.
[y] soluable solids (%)
[x] Fruit diameter (cm)
[w] Fruit yield (kg.)

2. Clonal selection

Progress in low-chill peach and nectarine breeding was reported (Proc. Fla. State Hort. Soc. 97:320-322). Twenty advanced selections of peach and nectarine clones were compared with 7 cultivars. These selections and cultivars were characterized for chill requirement, days from bloom to maturity, and fruit quality. Two of these, Fla. 5-12 and Fla. 7-4N, have been released by the University of Florida as 'TropicSweet' and 'Sungem', respectively. Since the time of this publication some advanced selections have been deleted while additional advanced selections have been added for comparison (Table 4). From results of recent evaluation trials, some of these selections are expected to be named within 2 to 5 years. Clones Fla. 8-1, Fla. 82-9W, Fla. 82-19, Fla. 9-6N, Fla. 9-11N, and Fla. 9-15N currently appear to be the best candidates for naming.

Table 4. Characteristics of some promising peach and nectarine clones, Gainesville, Florida 19 82-86.

Clone	Estimated chill units	Fruit								Bacterial[x] Spot resistance
		FDP[z] (days)	Size (g)	Stone[y] freeness	Red overcolor (%)	Shape[x]	Firm[x]	Taste[x]	Flesh[x] browning	
Peach										
FlordaGrande	75	104	98	SF	60	8	7	7	10	10
Flordaprince	150	78	88	SC	80	9	8	7	8	4
Flordagold	325	88	89	SC	60	7	10	9	9	5
FlordaKing	400	68	92	SC	50	7	7	7	9	9
Desertred	175	89	101	SF	90	9	8	8	8	5
Fla. 1-8	350	97	115	SF	80	9	9	8	10	9
Fla. 8-1	200	69	72	SC	70	8	8	6	8	10
Fla. 81-12	300	79	130	SC	20	8	7	7	9	10
Fla. 82-3	275	71	75	SC	80	9	10	7	10	10
Fla. 82-7	200	80	100	SC	90	8	9	7	8	6
Fla. 82-9W	150	86	110	SC	80	9	9	9	9	8
Fla. 82-10	200	91	90	SC	70	10	8	8	8	8
Fla. 82-19	350	76	105	SC	60	8	10	8	10	9
Fla. 82-24W	150	96	112	F	50	8	8	8	9	10
Nectarine										
Sungem	425	70	82	SC	90	9	8	8	10	10
Fla. 8-2N	425	70	79	SC	70	9	8	8	9	10
Fla. 9-6N	225	89	87	SC	100	9	9	8	8	9
Fla. 9-11N	200	95	92	SC	100	9	9	8	8	9
Fla. 9-15N	275	88	97	SF	100	9	8	8	9	10
Fla. 81-6N	300	81	81	SC	100	8	8	8	9	10
Fla. 81-17N	200	79	76	SC	90	8	7	8	10	10
Fla. 82-23N	200	101	113	F	100	8	9	9	10	10

[z] FDP=Fruit development period.
[y] SC=Semicling, SF=semifree, and F=Free. All genetic freestone classes.
[x] Rating of 1=poorest or least desirable to 10=best or most desirable.

3. Improvements in the breeding procedure.

A. The genetics and methodology of the peach and nectarine breeding program were examined in order to improve the efficiency of producing high fruit quality, early ripening, low-chill cultivars. The effectiveness of preselection for chilling requirement, precociousness, fruit development period, fruit qualities, cold hardiness, and vigor were studied (Rodriquez, PhD dissertation and Mowrey, MS thesis).

B. Attempts to select for flower bud chilling requirement (CR) at the seed stage were made in 58 families obtained from crosses and open-pollination of low chill selections and cultivars of peach and nectarine from the Florida breeding program. A nonsignificant correlation (r=0.08) between midparent bud CR and family seed CR was obtained. A low significant correlation (r=0.21**) was obtained between individual seed CR and the CR of the resultant seedling. Seed coat removal had no effect on these correlations. Narrow sense heritability for bud CR as determined by parent-offsping regression was 0.50   0.06. The small range in CR of the seed and pollen parents, 300 to 450 and 200 to 400 chill units, respectively, may explain the low correlation values obtained. The data suggest that it is impractical to screen for seedling CR based on seed CR where the CR for climatic adaptability must be held within a range of less than 300 chill units (J. Amer. Soc. Hort. Sci. 110(5):627-630).

C. Flower bud set was evaluated in 18-month old peach and nectarine seedlings growing in a high density nursery system. Nonsignificant correlations between trunk diameter and flower bud set (-0.3) and between trunk diameter and percent fruiting plants (0.03) were found among 36 families from crosses or open pollination. Crosses with 'EarliGrande' (a light flower bud setter) consistently produced progeny with low bud set, as compared to crosses with Fla. 7-3 (a heavy flower bud setter). The percent of fruiting plants was high in families having Fla. 7-3 as a parent and in families derived from seed parents having a heavy flower bud set. These results indicate that clones with high flower bud set as mature trees tend to produce precocious seedlings. The estimate of narrow sense heritability by midparent-offspring regression for flower bud set in 18-month-old seedlings was 0.55 (Fruit Var. J. 40(1):8-12).

D. A 10-year analysis of the high-density nursery (HDN) in the breeding of low-chilling peach and nectarine cultivars indicated selection was effective during the first cropping year for chilling requirement, fruit development period, size, color, shape and firmness but not for crop load, which needs to be evaluated at normal spacing over several years. The HDN system effectively has advanced the breeding program by promoting short generation time, reducing labor and space, and allowing for rating of some characters within 2 years from seed (J. Amer. Soc. HortSci. 111(2):311-315).

E. A study was made on the feasibility of selection for cold hardiness, plant vigor, and flower bud set in young hybrid peach seedlings from a low chill breeding population. Variability occurred among families, pollen parents, and seed parents for cold hardiness, based on plant survival, among 4-month-old seedlings exposed to -10°C. The relationship between cold hardiness in juvenile and adult plants is not known. Variability was also found among 18-month-old seedlings for plant vigor and the red leaf allele was associated with reduced vigor compared to green leaf seedlings of similar genetic background. There was a positive relationship between the degree for flower bud set of parents and their progeny with a high heritability estimate for flower bud set in 18-month-old seedlings (HortSci. 21(4):938).

F. The University of Florida low chilling peach breeding program was studied for parental and progeny flower bud set and its relationship with progeny plant vigor. A significient correlation was found between parental and progeny flower bud set (r=0.65**) and between progeny flower bud set and stem diameter (r=0.40**). A high heritability estimate for flower bud set was obtained by regression of progeny on midparent means (Proc. Fla. State Hort. Soc. 99:in press).

G. The relationship between growth cessation under shortening daylengths and chilling requirement was investigated in a low-chill, young peach seedling population and in 6 low-chill peach cultivars. A positive correlation (r=0.32**) was found between growth cessation and chilling requirement in the seedling population, whereas, a negative correlation (r=0.58**) was found for the 6 cultivars. The 6 cultivars behaved in the manner that was expected; however, growth cessation in the seedlings was confounded by juvenility and vigor. Regression of individual progeny on their midparent values revealed that chilling requirement is highly heritable (h^2=0.93) (Fruit Var. J. 40(1):24-28).

4. In vitro and In vivo seed germination

A. Hydrogen cyanamide was investigated as a substitute for part or all of peach seed cold needs for germination. Peach clones used were Fla. 82-2 which ripens about 60 days from bloom and Sunlite which ripens about 90 days from bloom. Fla. 82-2 seed were harvested at fruit ripening, pits cracked for kernel removal and placed on a culture media, and matured for 4 weeks in vitro according to standard practices for germination. They were then removed from the media treated for 1,3 and 5 minutes at 0.025, 0.05%, and 0.1% hydrogen cyanamid and placed in either 7.5°C or 26°C (room temperature). There were 50 seed per treatment and 2 checks making 20 treatments. Sunlite nectarine seed were harvested at fruit ripening, pits cracked for kernal removal, and treated with hydrogen cyanamide at 0.05%, 0.1%, 0.25%, and 0.5% for 1,3, and 5 minutes. Treated seed were placed in moist perlite and either refrigerated (7.5°C) or kept at room temperature (26°C). There were 50 seed per treatment plus 2 checks for a total of 34 treatments.

Treatments of hydrogen cyanamide had no measurable effects on speeding up germination, and in fact, was toxic to the seed in proportion to the hydrogen cyanamide dosage.

B. The purpose of this research was to study the effects of embryo age, growth medium, and germination procedure on germination rates of ovule-cultured peach (<u>Prunus persica</u> (L.) Batsch) embryos. The effects of pollen source on embryo size were also studied.

There were no consistently significant differences in germination rates attributable to the effects of Knopos, Neal and Topoleski, or Stewart and Hsu ovule culture media. Germination rates in vitro compared to those in moist perlite were not significantly different. The embryos germinated in perlite were visibly weaker.

Interspecific crosses with almond tended to produce larger embryos than those produced by selfing, backcrossing, or outcrossing within peach. There were no consistent differences in embryo size when outcrossing was compared to inbreeding within <u>Prunus persica</u>.

The use of isozymes for peach X almond hybrid identification was studied and the PGM and PGD enzyme staining systems were found to verify the hybridity. (Chaparro, J. X. 1986. M.S. Thesis. Factors affecting embryo size and germination rates of ovule cultured peach embryos. Univ. of Florida.)

5. Germplasm Sent to Israel

Shipments of budwood representing promising peach and nectarine selections were made to Israel each year (Table 5). Clones not established will be reshipped as required for establishment. Clonal selections made in the last 2 grant years will be supplied to Israel as they prove worthy from Stage 2 (1st fruiting on budded trees) test.

Table 5. Clonal peach and nectarine sent to Israel from Florida through 1986.

Clone	Established Prior to 1983	Sent to quarantine 1983	1984	1985	1986
FlordaKing	x				
Sunripe	x				
Fla. 13-72 (Maravilha)	x				
Fla. 46A4	x				
Fla. K5E-15N	x				
Fla. K5E-142N	x				
Fla. 5-2 (Flordaprince)	x				
Fla. 5-5	x				
Fla. 5-14N	x				
Fla. 5-15N	x				
Fla. 6-4	x				
Fla. 6-6	x				
Fla. 7-1 (Flordagem)	x				
Fla. 7-4N (Sungem)	x				
Fla. 8-1	x				
Fla. 8-3N	x				
Fla. 8-5N	x				
Fla. 8-8N	x		x		
Fla. 9-1	x				
Fla. 3-2		x	x		
Fla. 7-11		x			
Fla. 8-2N		x			
Fla. 8-6		x	x		
Fla. 9-5N		x			
Fla. 9-6N		x	x		
Fla. 9-7N		x			
Fla. 9-8N		x			
Fla. 9-9N		x			
Fla. 9-10 (Desertred)		x			
Fla. 9-11N		x	x		
Fla. 9-12N		x			
Fla. 9-14		x			
Fla. 9-15N		x			
Fla. 83-4		x			
Fla. 83-5N		x			
Fla. 10-64 (FlordaGrande)		x			
Fla. 1-8		x			
Fla. 8-14		x			
Fla. 81-6N		x			
Fla. 81-12		x			
Fla. 81-27		x			

Table 5. (Continued)

Clone	Established Prior to 1983	Sent to quarantine 1983	1984	1985	1986
Fla. 82-7			x		
Fla. 82-8W			x		
Fla. 82-10			x		
Fla. 82-12			x		
Fla. 84-10N			x		
Fla. 84-14N			x		
Fla. M2-1			x		
Fla. M2-2			x		
Fla. M2-3			x		
Fla. M2-4N			x		
Fla. M2-7N			x		
Fla. M3-4			x		
Fla. 81-17N				x	
Fla. 82-2				x	x
Fla. 82-3				x	x
Fla. 82-9W				x	
Fla. 82-19				x	x
Fla. 82-21				x	x
Fla. 82-23N				x	x
Fla. 82-24W				x	
Fla. 9-20C					x
Fla. 82-6N					x
Fla. 84-12C					x
Fla. 86-30NC					x

Publications:

A. Thesis and Dissertations

1. Effectiveness of preselection for chilling requirement, precociousness, fruit development period, and fruit qualities in peach and nectarine (Prunus persica (L.) Batsch). PhD Dissertation. 1984. J. Rodriguez-Alcazar. Univ. of Fla. (Previously sent - see publications below.)

2. Preselection for precociousness, cold hardiness, chilling requirement, and vigor in peach and nectarine (Prunus persica (L.) Batsch). MS Thesis. 1985. B. D. Mowrey. Univ. of Fla. (Previously sent - see publications below.)

3. Factors affecting embryo size and germination rates of ovule cultured peach embryos. M.S. Thesis. 1986. J. X. Chaparro (attached).

B. Research Publications (attached).

1. Sherman, W. B., J. Rodriguez, and E. P. Miller. 1984. Progress in low-chill peaches and nectarines from Florida. Proc. Fla. State Hort. Soc. 97:320-322.

2. Rodriguez-A., J. and W. B. Sherman. 1985. Relationships between parental, seed, and seedling chilling requirement in peach and necatrine. J. Amer. Soc. Hort. Sci. 110(5):627-630.

3. Rodriguez-A., J. and W. B. Sherman. 1986. Relationship between parential flower bud set and seedling precocioiusness in peach and nectarine, P. persica (L.) Batsch. Fruit Var. J. 40(1):8-12.

4. Rodriguez-A., J., W. B. Sherman, and P. M. Lyrene. 1986. High density nursery system for breeding peach and nectarine; A 10 year analysis. J. Amer. Soc. Hort. Sci. 111(2):311-315.

5. Mowrey, B. D. and W. B. Sherman. 1986. Flower bud set and relationship to vigor in 18-month peach seedlings. Proc. Fla. State Hort. Soc. 99:(in press).

6. Mowrey, B. D. and W. B. Sherman. 1986. Relationship between autumn growth cessation and chilling requirement in peach. Fruit Var. J. 40(1):24-28.

7. Mowrey, B. D. and W. B. Sherman. 1986. Variability in cold hardiness, plant vigor and flower bud set in peach. HortScience 21(4):938. Abstr.

Reprinted from *Proc. Fla. State Hort. Soc.* 97:320-322. 1984.

PROGRESS IN LOW-CHILL PEACHES AND NECTARINES FROM FLORIDA[1]

W. B. SHERMAN, J. RODRIGUEZ AND E. P. MILLER
University of Florida, IFAS,
Fruit Crops Department,
Gainesville, FL 32611

Additional index words. Prunus persica (L.) Batsch, plant breeding, chilling requirement.

Abstract. **Eighteen peach and nectarine cultivars have been released from the University of Florida fruit breeding program. Only 'Flordaprince', 'Flordagold', and 'Flordaking' peaches and 'Sunfre' nectarine are currently recommended for commercial trial in Florida. Other cultivars and selections show promise in other areas of the world. Progress made in breeding for fruit with larger size, rounder shape, red over-color and earlier ripening has culminated in selections with high potential for becoming commercial cultivars. These selections and cultivars are characterized for chilling requirement, days from bloom to maturity, and fruit quality. Limited trials show promise of commercial success from central through north Florida.**

Low chilling peaches, *Prunus persica* (L.) Batsch, which originated in south China have been available to the plant breeder for many years. Pioneer breeding work to produce high fruit quality, low chilling peaches began in California in the early 1900's even before the problem of delayed foliation was recognized as a symptom of insufficient winter chilling (1). Peach breeding for low chill types was later initiated in South Africa prior to 1950, in Brazil in 1950, and in Florida in 1952 (2, 3). The nectarine gene was introduced into the Florida breeding program in 1956 (4).

The University of Florida has to date released 11 peach and 7 nectarine cultivars. These cultivars with their selection test numbers and date of official release are listed in Table 1 because many selections were publicly tested before release by the University of Florida and some have been distributed from original test sites with the cultivar name unknown. The dates for cultivar releases reflect the programs continuous activity. Some of these cultivars were never intended for commercial cropping. 'Sunripe' and 'Sunhome' nectarines and 'Flordawon' and 'Flordahome' peaches were for home gardens and 'Okinawa' was for a root-knot nematod (*Meloidogyne* spp.) resistant rootstock. Other cultivars have become obsolete. For example, 'Sungold', 'Sunrich', and 'Sunlite' nectarines and 'Flordared', 'Fordasun', and 'Flordabelle' peaches have either been replaced by superior cultivars or their fruit qualities are not sufficient to meet current market standards. Currently, 'Sunfre' nectarine and 'Flordagold', 'Flordaking', and 'Flordaprince' peaches are grown for commercial cropping in Florida and 'FlordaGrande' peach is grown in south Texas.

Florida peach and nectarine cultivars and selections have been tested with growers and experiment stations in Florida and in over 60 countries (7). Most cultivars and some selections have been found to be adapted to low chill areas representing most of the world's subtropics and tropical highlands. In fact, some selections discarded from our testing program have been propagated and named by others. One reason for this is that fruit standards in other countries often differ from those of U. S. markets where fruit size over 5 cm diameter is demanded, fruit overcolor and shape are critical, and high fruit firmness is mandatory. Further, there are often different genotype responses in other climates such as higher red overcolor in desert climates, lack of need for cold hardiness in buds and flowers in the absence of spring frosts, smoother fruit shape with uniformly cool winters, and larger fruit size with soils of higher water holding capacity. Florida selections which have been given cultivar names in other parts of the world have been made available to local nurserymen and growers but are not grown commercially in Florida because of serious defects (Table 2). Most of these cultivars have been used in our breeding program and some have been discarded because they have been replaced by superior selections.

The University of Florida peach and nectarine breeding

Table 1. Peach and nectarine cultivars named by the University of Florida and their selection number at the time of release.

Cultivar	Selection no.	Year released
Peach		
Okinawa	Seed Int.	1957
Flordawon	Fla. L1-58	1961
Flordaqueen	Fla. 4-26	1961
Flordahome	Fla. H97	1962
Flordasun	Fla. 16-33W	1964
Flordared	Fla. L27-12	1970
Flordabelle	Fla. W68-1	1970
Flordagold	Fla. 15-39	1976
Flordaking	Fla. 15-34	1978
Flordaprince	Fla. 5-2	1982
FlordaGrande	Fla. 10-64	1984
Nectarine		
Sunred	Fla. 68-72	1964
Sungold	Fla. Q303-4	1969
Sunrich	Fla. Q303-24	1971
Sunlite	Fla. 44-28	1975
Sunripe	Fla. 7E-62	1979
Sunfre	USDA C73-40	1982
Sunhome	Fla. 9-13NR	1985

Table 2. University of Florida selection numbers that have given cultivar names elsewhere and remarks on potential for commercial growing in Florida.

Selection number	Cultivar	Country where named	Remarks
Peaches			
Fla. L8-112	McRed	USA	Lacks firmness
Fla. 13-72	Maravilha	Brazil	Lacks size
Fla. 26-31	Flordabeauty	USA	Green ground color
Fla. 16-33	San Pedro	Argentina	Suture bulge
Fla. 2-2	Shermans Red	Australia	Lacks size
Fla. 3-1	Shermans Early	Australia	Lacks size and firmness
Fla. 1-3	Opodepe	Mexico	Long tip
Fla. 1-11	Rayon	Mexico	In evaluation
Fla. 7-1	Flordagem	Mexico	Lacks size and shape
Nectarines			
Fla. A5-107	K-gold	USA	Cracks badly
Fla. 19-19-375	Columbina	Brazil	Lacks firmness

[1]Florida Agricultural Experiment Stations Journal Series No. 5870. This research was supported by a grant from the United States-Israel (Binational) Agricultural Research and Development Fund (BARD).

Reprinted from Vol. 110(5), September 1985
Journal of the American Society for Horticultural Science
Alexandria, VA 22314

J. Amer. Soc. Hort. Sci. 110(5):627–630. 1985.

Relationships between Parental, Seed, and Seedling Chilling Requirement in Peach and Nectarine

Jorge Rodriguez-A. and Wayne B. Sherman
Department of Fruit Crops, IFAS, University of Florida, Gainesville, FL 32611

Additional index words. *Prunus persica*, breeding, genetics

Abstract. **Attempts to select for flower bud chilling requirement (CR) at the seed stage were made in 58 families obtained from crosses and open-pollination of low chill selections and cultivars of peach and nectarine [*Prunus persica* (L.) Batsch] from the Florida breeding program. A nonsignificant correlation (r = 0.08) between midparent bud CR and family seed CR was obtained. A low significant correlation (r = 0.21**) was obtained between individual seed CR and the CR of the resultant seedling. Seed coat removal had no effect on these correlations. Narrow sense heritability for bud CR as determined by parent-offspring regression was 0.50 ± 0.06. The small range in CR of the seed and pollen parents, 300 to 450 and 200 to 400 chill units, respectively, may explain the low correlation values obtained. The data suggest that it is impractical to screen for seedling CR based on seed CR where the CR for climatic adaptability must be held within a range of less than 300 chill units.**

Breeding fruit tree species for mild winter areas often requires use of germplasm exhibiting wide variation in chilling requirement (CR). Thus, selection for CR is necessary. Most temperate zone woody deciduous species require a certain amount of chilling to break dormancy. Their seeds also require moist chilling to germinate, the amount of which has been associated with the amount of chilling required for the buds (2, 7, 11, 12, 16, 18). Mechanisms controlling CR in buds and seeds may be similar (17). Significant positive correlations have been found between the CR of the seed for germination and the bud CR of the seed parent in apple (11), peach (2), and peach x almond hybrids (8), and between the seed CR and their midparent bud CR in almonds (7). This relationships suggests that screening for CR could be done at the seed stage by monitoring germination time during stratification to separate classes from low to high chilling (18). A low correlation was found in almond between bloom date and CR of the seeds from which they originated (8).

Time of bloom has been selected efficiently on the basis of leafing time in nonflowering juvenile apple seedlings (10, 14, 15). Early selection in apple is especially useful because the time between first or 2nd year leafing and first bloom may be several years. Screening for time of bloom of peach seedlings probably could be done during the first leaf stage in the nursery.

The frequency of peach and nectarine seedlings obtained with the proper CR for the Gainesville area (300–400 units CR) are obtained is about 50% to 60% of the total number of plants screened from most crosses made in the Florida breeding program. Determination of seedling CR classes by separating germinating seed into CR classes would allow the breeder to send seedlings to proper CR areas for growing, or to eliminate these seedlings before planting. The purpose of this study was to examine the potential of selecting for seedling CR based on time of seed germination during stratification in peach and nectarine.

Materials and Methods

Crosses and open-pollinated (OP) families from 16 selections and cultivars from the Univ. of Florida breeding program were used for this study. Two pollen parents, 'EarliGrande' (200 CR units) and clone Fla. 7-3 (400 CR units), were crossed to 16 seed parents ranging from 300 to 450 chilling units (Table 1). Crosses were made during February and March of 1982. Fruit from crosses and OP families were picked when ripe, and seed were removed and stratified at 5° to 6°C using standard procedures. Open-pollinated peaches are about 95% self-pollinated (6). An additional group of 10 families, including crosses and OP families, was included in this study, but their testae were removed. Previous reports indicate that germination inhibitors present in the testa lengthen the CR of the embryo (1, 2, 3, 4,

Received for publication 21 Dec. 1984. Florida Agr. Expt. Sta. J. Ser. No. 6095. This research was supported by a grant from the United States-Israel (Binational) Agr. Res. and Dev. Fund (BARD). The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 1. Florida low chill selections and cultivars used as seed parents.

Seed parent	Chilling requirements (units)
Fla. 3-4	375
Fla. 9-18	375
Fla. 5-20	325
Fla. 9-9	350
Fla. 7-11	375
Fla. 5-15	350
Fla. 9-16	325
Fla. 9-12	300
Fla. 5-14	350
Fla. 9-13	350
Fla. 8-6	350
Fla. 8-14	350
Flordagold	300
Sunripe	350
Sunlite	450
Fla. KE15	400

9). Seed were examined every 5 days once germination started. Individual seed were removed from stratification when the radicle reached a length of 2–2.5 cm, and the number of hours in stratification was recorded. One hour in the refrigerator was counted as a chilling unit. Germinating seed then were grown in a greenhouse until they reached a height of 25–30 cm.

The seedlings were planted in the field in late September of 1982 at 1 m between rows and 0.2 m within rows in a high density fruiting nursery (HDN) which was managed as reported previously (13). Seedlings were classified for their chilling requirement based on time of flower bud break in February and March of 1984. Cultivars of known chilling requirement were used as a reference. Chill unit requirements of parents had been estimated relative to each other based on time of flower bud break. Time of bloom under north central Florida conditions is mainly dependent on CR completion, rather than on differences among seedlings for heat unit accumulation; therefore, the data when more than 75% of the flower buds were open was considered a reliable index to seedling CR.

The Statistical Analysis System (SAS, Institute Cary, N.C.), provided computational procedures to run correlations, regressions, and contrast tests. The General Linear Models (GLM) procedure was used to obtain weighted regression analysis when a mid parent-offspring relationship was analyzed and the number of offspring was not the same in all families (5). Midparent-offspring regression was based on the relationship of midparent CR value and number of chill units necessary to obtain 80% germination of progeny based on those seed that germinated.

Results and Discussion

Relationship between midparent flower bud CR, Seed CR, and progeny mean CR. A low nonsignificant correlation (r = 0.08) was found between midparent flower bud CR and progeny CR in seed with testa intact (Table 2). The narrow range in midparent CR may explain the lack of significant correlation between midparent flower bud CR and progeny seed CR, a correlation found significant by other researchers (2, 11, 18). The mean chill unit requirement for germination in the 10 families was 2160 units and 2510 units for seed without and with the testa, respectively. Testa removal did not improve (r = −0.14) the relationship between midparent and progeny CR (Table 2). However, removal of the testa slightly reduced the time necessary to stratify. When 'Redhaven', a high chilling cultivar (950 chill units) was included in the analysis, the range in CR in the experiment was expanded, and a significant positive linear correlation between midparent flower bud CR and seed CR (family) was obtained (r = 0.43**). This finding sub-

Table 2. Relationship between midparent bud chilling requirement (CR) and amount of chilling for 80% germination in seed with and without testa in several Florida low chill peach and nectarine families.

Family	Midparent chilling units	Seed chilling units: With testa	Seed chilling units: Without testa
Fla. 5-20 x EG[z]	262	2448	2184
Fla. 9-9 x EG	275	2496	2280
Fla. KE 15 x EG	300	2496	2184
Fla. 9-12 OP	300	2400	---
Flordagold OP	300	2424	---
Fla. 5-15 OP	325	2712	2160
Fla. 9-16 OP	325	2448	---
Sunripe OP	350	2232	1872
Fla. 9-9 OP	350	2592	---
Fla. 3-4 OP	350	2664	---
Fla. 5-14 OP	350	2568	1944
Fla. 9-18 OP	375	2112	---
Sunlite OP	400	2784	2328
Fla. KE15 OP	400	2592	2136
Fla. KE15 x Fla. 7-3	400	2496	2472
Sunlite x Fla. 7-3	425	2496	1824
Redhaven OP[y]	950	3840	---
Correlation (r) with midparent CR		0.08[x] NS	0.14[w] NS

[z]EG = 'EarliGrande'.
[y]Not included in correlation analysis for the value shown.
[x]Correlation value for n = 16.
[w]Correlation value for n = 10.

Table 3. Midparent value of the flower bud chilling units of parental clones and progeny in some Florida low chill peach and nectarine families.

Cross	Midparent	Progeny mean	SD	Progeny range
Fla. 3-4 x EG[z]	275	310	86.7	175–475
Fla. 3-4 x Fla. 7-3[y]	375	402	42.5	300–475
Fla. 3-4 OP	350	360	65.2	150–475
Fla. 9-18 x EG	287	353	9.3	175–475
Fla. 9-18 x Fla. 7-3	387	423	45.8	350–475
Fla. 9-18 OP	375	398	62.7	275–475
Fla. 5-20 x EG	262	372	16.0	350–400
Fla. 5-20 x Fla. 7-3	362	355	48.8	250–450
Fla. 5-20 OP	325	355	30.8	300–400
Fla. 9-9 x EG	275	322	69.0	175–450
Fla. 9-9 x Fla. 7-3	375	403	43.5	275–475
Fla. 9-9 OP	350	363	22.9	250–450
Fla. 7-11 x EG	287	317	53.2	250–375
Fla. 7-11 x Fla. 7-3	387	354	84.2	175–475
Fla. 7-11 OP	375	348	93.5	100–450
Sunripe x EG	275	321	58.3	250–400
Sunripe x Fla. 7-3	375	368	51.3	275–475
Sunripe OP	350	380	25.5	350–450
Fla. 5-15 x EG	262	340	95.9	175–450
Fla. 5-15 x Fla. 7-3	362	359	76.3	175–450
Fla. 5-15 OP	325	375	97.0	175–475
Fla. 9-16 x EG	262	297	54.7	175–375
Fla. 9-16 x Fla. 7-3	362	395	51.3	250–475
Fla. 9-16 OP	325	384	33.7	350 450
Fla. KE15 x EG	300	391	70.6	175–475
Fla. KE15 × Fla. 7-3	400	390	95.3	175–475
Fla. KE15 OP	400	366	100.8	150–475
Sunlite x EG	325	359	57.3	250–475
Sunlite x Fla. 7-3	425	428	42.2	350–450
Sunlite OP	450	364	47.1	250–450
Fla. 9-12 x EG	250	304	89.1	100–450
Fla. 9-12 x Fla. 7-3	350	388	56.4	275–475
Fla. 9-12 OP	300	346	31.7	275–400
Correlation (r) with midparent		0.56**[x]		

[z]EG = 'EarliGrande' chilling req. = 200 units.
[y]Fla. 7-3 Chilling req. = 400 units.
[x]Correlation value for n = 33.

Table 4. Effect of pollen parent on seed chilling requirement (CR) for germination and resulting seedling CR in peach and nectarine.

Pollen sources contrasted	Estimated seed CR (units)[z]	F value	Estimated tree CR (units)[z]	F value
'EarliGrande'[y] vs. Fla. 7-3[x]	2172 vs. 2278	(2.91 NS)	355 vs. 377	(9.91**)
'EarliGrande' vs. OP	2172 vs. 2304	(1.86 NS)	335 vs. 366	(18.11**)
Fla. 7-3 vs. OP	2278 vs. 2304	(0.35 NS)	377 vs. 366	(9.59**)

[z]Average of 12 families per cross or OP.
[y]'EarliGrande' chilling requirement = 400 units.
[x]Fla. 7-3 chilling requirement = 200 units.
NS,**Nonsignificant (NS) and significant at $P = 0.01$ (**).

stantiates another study on peach (2) which indicated that it is difficult to separate clones that differ in less than 300 units of CR by observing the germination behavior of seed produced by the clones.

Table 5. Correlation between chilling requirement (CR) of seed and bud break in seedling and seed families in the Florida low chill peach and nectarine population.

Comparison	n	Correlation coefficient (r)
Mean seed CR (family) vs. family bud CR	36[z]	0.01 NS
Individual seed CR vs. individual seedling CR (with seed coat)	943[y]	0.21**
Individual seed CR vs. individual seedling CR (no seed coat)	226[y]	−0.08 NS

[z]Number of families.
[y]Number of seedlings.
NS,**Nonsignificant (NS) significant at $P = 0.01$ (**).

The range of midparent values for flower buds CR was between 262 and 450 chilling units (Table 3). There was a significant correlation ($r = 0.56$**) between midparent flower bud CR and the resulting seedling progeny, based on time of bloom in the field, suggesting that monitoring time of bloom of seedlings is more effective than monitoring seed germination behavior in attempting to predict flower bud chilling requirement.

Effects of CR of pollen parent on seed and resulting seedling bud CR. Because 2 pollen parents differing in chilling requirement (200 vs. 400 CR) were used in this study, it was possible to test whether the pollen parent flower bud CR was related to either the CR of the resulting seed or to the flower bud CR of the resulting seedling. The effect of pollen parent flower bud CR and the resulting seed CR was not significant, statistically, as compared to the significant pollen parent effect on seedling flower bud CR (Table 4). This lack of significance suggests that either our method for determining completion of rest in seed was ineffective or that seed and seedling bud chilling requirements have different genetic bases.

The regression of offspring on midparent means for flower bud chilling requirement provides an indication of additive gene action ($h^2 = 0.50 \pm 0.06$) controlling expression of this trait (Fig. 1). This value is conservative considering the range in CR of the material used. The inclusion of 'Redhaven' in the regression analysis inflated the h^2 to 0.75. Thus, parental flower bud CR is a good indicator of seedling progeny flower bud CR, but not of seed progeny CR. Seed CR and flower bud CR apparently are not as closely related as suggested previously (17).

Relationship between individual seed CR and corresponding seedling flower bud CR. When individual seed CR was compared to its corresponding seedling flower bud CR, a low significant correlation ($r = 0.21$**) was obtained (Table 5). Removal of the testa did not increase the correlation, although some increase was expected by removing the maternal influence of the seed coat. Indications that the role of the testa in germination is more of a physical nature than a chemical one can be drawn from data presented by several authors (1, 2, 7).

The low correlation values obtained in this study between seed CR and corresponding seedling flower bud CR agree with those obtained (8) in almond progenies. Thus, it appears that early selection among peach and nectarine seedlings for CR on the basis of CR for seed germination is not practical where the range in CR is less than 300 chill units.

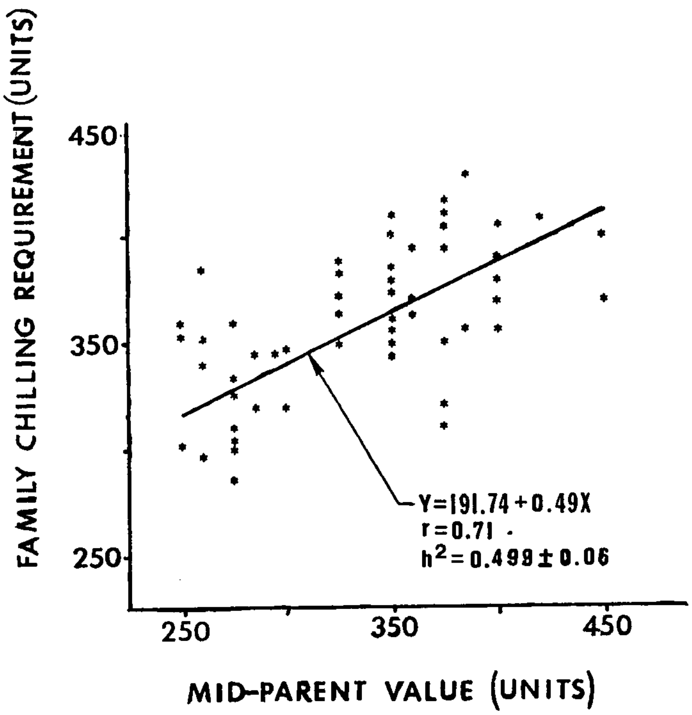

Fig. 1. Regression of offspring on mid-parent value for bud chilling requirement in some low chill peach and nectarine Florida selections.

Literature Cited

1. Bonamy, P.A. and F.G. Dennis, Jr. 1977. Abscicic acid levels in seeds of peach. II. Effects of stratification temperature. J. Amer. Soc. Hort. Sci. 102(1):26–28.
2. Chang, S. and D.J. Werner. 1984. Relationship of seed germination and respiration during stratification with cultivar chilling requirement in peach. J. Amer. Soc. Hort. Sci. 109(1):42–45.
3. Diaz, D.H. and G.C. Martin. 1972. Peach seed dormancy in relation to endogenous inhibitors and applied growth substances. J. Amer. Soc. Hort. Sci. 97(5):651–654.
4. Du Toit, H.J., G. Jacobs, and D.K. Stydom. 1979. Role of the various seed in peach and dormancy and initial seedling growth. J. Amer. Soc. Hort. Sci. 104(4):490–492.
5. Freund, R.J. and R.C. Littell. 1981. SAS for linear models. Cary, North Carolina: SAS Institute, Inc.
6. Hesse, C.O. 1975. Peaches, p. 285–335. In: J. Janick and J.N. Moore (eds.). Advances in fruit breeding. Purdue Univ. Press. West Lafayette, Ind.
7. Kester, D.E. 1969. Pollen effects on chilling requirement of almond-peach hybrids seeds. J. Amer. Soc. Hort. Sci. 94(3):318–321.
8. Kester, D.E., P. Raddi, and R. Asay. 1977. Correlation of chilling requirements for germination, blooming, and leafing within and among seedling populations of almond. J. Amer. Soc. Hort. Sci. 102:145–148.
9. Lipe, W.N. and J.C. Crane. 1966. Dormancy regulation in peach seeds. Science. 153:541–542.
10. Oppenheimer, C.H. and E. Slor. 1968. Breeding apples for a subtropical climate. Theor. Appl. Genet. 38:97–102.
11. Pasternark, G. and L.E. Powell. 1980. Chilling requirements of apple seeds from cultivars having low and high chilling requirements for shoot growth. HortScience 15(3):408. (Abst.)
12. Sanada, T., Y. Yoshida, and T. Hanniuda. 1982. Methods of seed storage in apple breeding 3. Differences in storage using early to late maturing cultivars and wild species. Bio. Abstr. 73.
13. Sherman, W.B., R.H. Sharpe, and J. Janick. 1973. The fruiting nursery: ultrahigh density for evaluation of blueberry and peach seedlings. HortScience. 8(3):170–172.
14. Tydeman, H.M. 1958. The breeding of late flowering apple varieties. Rpt. E. Malling Res. Sta. 1957.
15. Tydeman, H.M. 1964. The relation between time of leaf break and of flowering in apple seedlings. Rpt. E. Malling Res. Sta. 1963. p. 70–72.
16. Vegis, A. 1963. Climatic control of germination, bud break, and dormancy, p. 273. In: L.T. Evans (ed.). In environmental control of plant growth. Academic Press, New York.
17. Westwood, M.N. 1978. Temperate-zone pomology. W.H. Freeman and Co., San Francisco, Calif.
18. Westwood, M.N. and H.O. Bjornstad. 1968. Chilling requirements of dormant seeds of 14 pear species as related to their climatic adaptation. Proc. Amer. Soc. Hort. Sci. 92:141–149.

Fruit Varieties Journal 40(1):8-12 1986

American Pomological Society U. P. Hedrick award for research paper by a student: (1985 Second Place Award)

Relationship Between Parental Flower Bud Set and Seedling Precociousness in Peach and Nectarine, *Prunus persica* (L.) Batsch

JORGE RODRIQUEZ AND WAYNE B. SHERMAN

Abstract

Flower bud set was evaluated in 18-month old peach and nectarine *Prunus persica* (L.) Batsch seedlings growing in a high density nursery system. Nonsignificant correlations between trunk diameter and flower bud set (-0.3) and between trunk diameter and percent fruiting plants (0.03) were found among 36 families from crosses or open pollination. Crosses with 'EarliGrande' (a light flower bud setter) consistently produced progeny with low bud set, as compared to crosses with Fla. 7-3 (a heavy flower bud setter). The percent of fruiting plants was high in families having Fla. 7-3 as a parent and in families derived from seed parents having a heavy flower bud set. These results indicate that clones with high flower bud set as mature trees tend to produce precocious seedlings. The estimate of narrow sense heritability by midparent-offspring regression for flower bud set in 18-month-old seedlings was 0.55.

Seedlings of most woody plants pass through a juvenile phase during which they cannot be induced to flower. The delay in flowering caused by a long juvenile period may last several years and is one of the major problems limiting genetic advance under selection in most breeding programs (3). The juvenile phase can be shortened considerably in some species by controlling the environment and by various cultural practices (13). Apart from the effect that cultural practices have on the juvenile period, the within and between progeny differences are due to heredity. There appears to be genetic variability for precocity in fruits such as cherries (4), pears (10, 12), pecans (6), and apples (10). Breeding for precocity may not only increase breeding efficiency but may have an additional advantage in commercial production because of the general relationship between short juvenile period, early bearing of grafted trees (9), and high yield (6, 10). The objective of this research was to study the inheritance of flower bud set and its relationship to precociousness in low chilling peach and nectarine germplasm form the University of Florida breeding program.

Materials and Methods

Crosses using 'EarliGrande' (a light flower bud setter) and Fla. 7-3 (a heavy flower bud setter) as pollen parents were made in February and March of 1982. Twelve selections and cultivars with differing degrees of flower bud set were used as seed parents. The 12 open-pollinated families (op) were also included in this study because peaches are highly (95%) self-pollinated. The seedlings were planted in the field in late September of 1982 at 1 m between rows and .2 m within rows. Management of this high density nursery has been described (8).

When the seedlings were 18 months old flower bud set was rated on a scale of 1 to 10; 1 = the lowest or none to 10 = flower bud formation at most of the nodes of terminal branches.

Fruit Crops Department, IFAS University of Florida, Gainesville, FL. 32611
Florida Agricultural Experiment Station No.6617 This research was supported by a grant from the United States-Israel (Binational) Agricultural Research Development Fund (GARD).
Additional Index words. juvenility, breeding, genetics

Evaluations were made in February during bud swell. Parents which were in an adjacent block and managed as a commercial planting were also scored using the same criteria. Seedling vigor was evaluated as trunk diameter during bloom time, at a height of 0.5 m.

Flower bud set, trunk diameter, and percent of flowering plants were analyzed for correlations. Offspring-midparent values were regressed using a weighted regression procedure to obtain estimates of narrow sense heritability (h^2) for flower bud set (5).

Results and Discussion

Correlation of plant vigor and seedling flower bud set. The possibility that the length of the juvenile phase of a peach or nectarine seedling could be related to its vigor (as measured by trunk diameter) was investigated. The correlations between trunk diameter and flower bud set (r = 0.29) and between trunk diameter and percent of fruiting plants (r = 0.03) were nonsignificant, indicating that flower bud set has a major genetic component that is unrelated to plant vigor (Table 1). A negative correlation has been found in apple and pear between trunk diameter and length of the juvenile period (11). However, in another report no correlations were found between trunk diameter and the length of the juvenile period in pear progenies (7). Apple triploids and tetraploids tend to have longer juvenile periods than diploids even though they may be more vigorous and attain greater size at an earlier age (2). Thus the juvenile period appears to be negatively correlated with tree vigor only within a particular breeding lime. Amount of growth and length of the juvenile period in peach appear to be largely independent and selection for short juvenile period cannot be reliably based on trunk diameter.

The average number of fruiting plants per family is correlated with the average rating of flower bud set per family (0.39**). This indicates that seedlings which formed flower buds, had flower buds strong enough to set fruit. This also indicates that flower bud set evaluation can be made in the high density nursery during the first fruiting year.

Inheritance of flower bud set. The narrow sense heritability estimate for degree of flower bud set was 0.55 for the families under study and indicates mainly additive gene action (Fig. 1).

Table 1. Phenotypic correlation matrix among flower bud set, trunk diameter, and fruiting plants in Florida low chilling peach and nectarine seedlings.[z]

	Trunk diameter	% Fruiting plants
Flower bud set	-0.29 n.s.	0.39 **
Trunk diameter	——	0.03 n.s.

[z]Correlation between family means n = 36
n.s., ** = nonsignificant and significant at P = 0.01, respectively

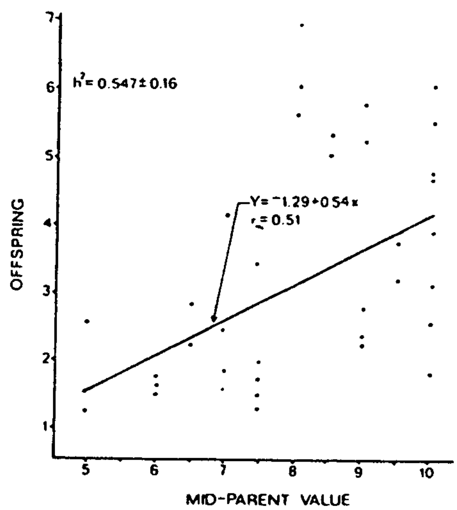

Figure 1. Midparent offspring regression for flower bud set in some Florida low chilling peach and nectarine families (scale used 1 to 10, with 10 being the highest flower bud set).

Table 2. Flower bud set of midparents and their offspring in some Florida low chilling peach and nectarine families.

Cross	Midparent value[z]	N	Progeny mean	SD	Progeny range
Fla. 3-4 OP[x]	10.0	27	5.5	1.8	3-9
Fla. 3-4 X EC[x]	7.5	30	2.0	0.9	1-4
Fla. 3-4 X 7-3	10.0	26	6.1	2.3	1-9
Fla. 5-14 OP	8.0	3	7.0	1.7	5-8
Fla. 5-14 X EG	6.5	16	1.8	1.4	1-6
Fla. 5-14 X 7-3	9.0	7	2.3	2.1	1-7
Fla. 5-15 OP	8.0	26	5.7	2.0	1-9
Fla. 5-15 X EG	6.5	16	2.3	2.7	1-5
Fla. 5-15 X 7-3	9.0	22	5.9	1.2	1-10
Fla. KE15 OP	10.0	19	1.8	0.9	1-3
Fla. KE15 X EC	7.5	16	1.5	0.6	1-3
Fla. KE15 X 7-3	10.0	22	4.8	2.3	1-9
Fla. 5-20 OP	5.0	20	2.6	1.7	1-7
Fla. 5-20 X EC	5.0	8	1.3	0.5	1-2
Fla. 5-20 X 7-3	7.5	28	3.3	1.7	1-7
Fla. 7-11 OP	7.0	22	4.1	2.3	1-7
Fla. 7-11 X EG	6.0	15	1.7	0.9	1-4
Fla. 7-11 X 7-3	8.5	23	5.4	2.4	1-10
Fla. 9-9 OP	10.0	49	2.6	1.6	1-9
Fla. 9-9 X EG	7.5	38	1.7	0.9	1-4
Fla. 9-9 X 7-3	10.0	42	4.7	2.0	1-9
Fla. 9-12 OP	8.0	12	6.1	1.3	4-8
Fla. 9-12 X EG	6.5	12	2.8	1.1	1-5
Fla. 9-12 X 7-3	9.0	18	5.4	2.6	1-9
Fla. 9-16 OP	10.0	29	3.7	2.5	1-9
Fla. 9-16 X EG	7.5	37	1.3	0.6	1-4
Fla. 9-16 X 7-3	10.0	50	3.1	1.7	1-8
Fla. 9-18 OP	9.0	11	2.4	1.7	1-6
Fla. 9-18 X EG	7.0	20	2.4	1.2	1-6
Fla. 9-18 X 7-3	9.5	26	3.2	2.1	1-10
Sunlite OP	7.0	35	1.7	1.1	1-6
Sunlite X EG	6.0	48	1.6	0.9	1-4
Sunlite X 7-3	8.5	31	5.2	2.1	1-10
Sunripe OP	9.0	28	2.7	1.0	1-5
Sunripe X EG	7.0	18	1.6	0.8	1-3
Sunlite X 7-3	9.5	21	3.8	1.8	1-7
EarliGrande	5.0				
Fla. 7-3	10.0				

[z]Evaluated in the scale 1 to 10, 10 being the highest bud set
[y]Bud set evaluated in 18 month-old seedlings
[x]EC = 'EarliGrande', OP = open-pollinated

This estimate is reliable for this population, but would be conservative where selection for precociousness has not been practiced. Some selection for precociousness has been done in this breeding population, in that plants not producing fruit either in their second or third leaf in the fruiting nursery have been discarded since 1975. This is evident in Table 2 which shows that the range of seed parents in relation to flower bud set goes from 5 to 10 in the scale used, while the flower bud set range in the offspring often ranges beyond one or both parents.

Influence of pollen parent on flower bud set. Crosses with 'EarliGrande' as male parent consistently produced progenies with lower flower bud set ratings (1.8) as compared with crosses involving Fla. 7-3 (4.0) (Table 3). This is expected if h^2 is at least moderately high because 'EarliGrande' is a light flower bud setter and Fla. 7-3 is a heavy bud setter. Furthermore, OP families (mostly self-pollinated) were significantly different from crosses performed with either male parent. These results confirm findings in other species (4, 6, 10, 12), in the sense that some crosses may produce progenies with half or twice the normal juvenile period.

This study suggests that the degree of bud set in mature trees influences the number of precocious seedlings in their offspring. Crosses between normal and dwarf genotypes with short internodes have been shown to produce precocious seedlings (Ralph Scorza, 1984 per. com.). Dwarf peaches have short internodes and are usually heavy bud setters, and short internodes in non-dwarf peaches are reported to be associated with heavy flower bud set (1).

Even through heavy flower bud set may not be critical to obtain adequate yields in mature orchards of peaches and nectarines, commercial yield may be advanced by 1 or 2 years in newly set orchards. Furthermore, the use of heavy flower bud setters as parents could be advantageous by producing higher percentages of progeny that fruit in 2 years from seed. Discarding seedlings that do not flower in their first year in the fruiting nursery will increase the percent of fruiting seedlings and would allow earlier selection for other characters. The high h^2 value obtained indicates that simple recurrent selection should lead to rapid progress in selecting for precociousness.

Table 3. Effect of pollen parents on flower bud set of their offspring in a population of low-chilling peach seedlings.

Contrast	Flower bud set rating[z]	F value
'EarliGrande vs Fla. 7-3	1.8 vs 4.1[y]	13.88**
Fla. 7-3 vs OP[x]	4.1 vs 3.4	26.39**
'EarliGrande' vs OP	1.8 vs 3.4	14 29**

[z]Scale 1 to 10, being 10 the highest bud set
[y]Average of 12 families per cross of OP family
[x]OP = open-pollinated family

Literature Cited

1. Blake, M. A. 1943. Classification of fruit bud development on peaches and nectarines and its significance in cultural practice. N. J. Agr. Exp. Sta. Bul. 706.
2. Brown, A. C. 1975. Apples. p. 3-37 In J. Janick and J. N. Moore (eds.) Advances in fruit breeding. W. Lafayette, Ind., Purdue Univ. Press.
3. Hansche, P. E. 1983. Response to selection. p. 154-171. In J. N Moore and J. Janick (eds.) Methods in fruit breeding. W. Lafayette Ind., Purdue Univ. Press.
4. Fogle, H. W. 1961. Inheritance of some fruit and tree characteristics in sweet cherry crosses. Proc. Amer. Soc. Hort. Sci. 78:76-75.
5. Freund, R. J. and R. C. Littell. 1981. SAS for linear models. Cary, North Carolina: SAS Institute, Inc.
6. Madden, G. D. 1968. Potential varieties for the Southeast through the USDA pecan breeding program. S.E. Pecan Growers Assn. 61:27-52.
7. Shen, D. S., Z. L. Li, S. Q. Zheng, H. Q. Chen and J. B. Lin. 1982. Study of problems in the correlations between growth and juvenility in hybrid seedlings of pear. Acta Hort. Sinica. 9(4):27-32.
8. Sherman, W. B., R. H. Sharpe, and J. Janick. 1973. The fruiting nursery: ultrahigh density for evaluation of blueberry and peach seedlings. HortScience. 8:170-172.
9. Visser, T. 1965. On the inheritance of juvenile period in apple. Euphytica. 14:125-134
10. Visser, T. 1976. A comparison of apple and pear seedlings with reference to the juvenile period. II. Mode of inheritance. Euphytica. 25:339-342.
11. Visser, T., J. J. Verhaehg, and D. P. DeVries. 1976. A comparison of apple and pear seedlings with reference to the juvenile period. I. Seedling growth and yield. Euphytica. 25:343-351.

12. Zielinski, Q. B. 1963. Precocious flowering of pear seedlings carrying the cardinal red color gene. J. Hered. 54:75-78.

13. Zimmerman, R. H. 1972. Juvenility and flowering in woody plants: a review. HortScience. 7:447-485.

Fruit Varieties Journal 40(1):12-17 1986

Reviewed Research Paper

In Vitro Propagation of Peach: I. Propagation of 'Lovell' and 'Nemaguard' Peach Rootstocks.[1]

ALI A. ALMEHDI AND DAN E. PARFITT[2]

Abstract

An improved tissue culture propagation medium was developed for in vitro multiplication of peach (*Prunus persica* L.) rootstocks 'Lovell' and 'Nemaguard. A 144-fold increase in number of shoots was achieved after 10 weeks with 26.7μM (6.0 mg l^{-1}) BA and 0.04μM (0.01 mg l^{-1}) IBA. Shoots continued to regenerate with subsequent subcultures. 20% of the shots rooted in the new medium without growth regulators at one half the recommended concentrations of KNO_3 and $(NH_4)_2SO_4$ plus 44.3μM (9 mg l^{-1}) IBA. Complete plants were transferred to soil, and grown with 100% survival. Explants taken from juvenile and mature plants did not differ significantly in their growth in the new medium.

Introduction

Seedling rootstocks have the potential disadvantage of genetic variation among them due to segregation that may lead to variability in the growth and performance of the scion cultivar. Improvement of rootstocks via incorporation of dominant genes through crossing, progeny testing and clonal rootstock propagation of selected progeny requires only one generation while rootstock propagation via seedling requires additional generations of breeding and selection to fix the genes and characters. Combinations of genes are also most conveniently maintained via vegetative propagation of clonal rootstocks, since recombination does not occur as would be the case for sexual reproduction. However, seedlings are presently used due to ease and economy of propagation.

Reports of *in vitro* peach propagation are numerous (1, 5, 9, 10, 11, 13, 15, 16). Media used in some studies (10, 12, 13, 15) have been limited to either MS or its close modifications. In addition, these media have not been demonstrated to be adequate for multiplication of more than few cultivars *in vitro*. Our study reports the development of a medium of *in vitro* multiplication of 'Lovell' and 'Nemaguard' and the continued regeneration of shoots without decline for up to 13 weeks. This study also reports the effects of 9 different media used on peach explants.

Materials and Methods

Actively growing shoots from juvenile and 14 year old peach plants

---

[1] This research was supported by USDA grant #81-CRSR-2-0732. The authors acknowledge Carol Calibro for typing and Carle Staub for media preparation and culture of explants. The use of trade names in this paper does not imply endorsement by the University of California of products named or criticism of similar ones not mentioned.

[2] Department of Pomology, University of California, Davis, CA 95616

Reprinted from Vol. 111(2), March 1986
Journal of the American Society for Horticultural Science
Alexandria, VA 22314

J. AMER. SOC. HORT. SCI. 111(2):311–315. 1986.

High-density Nursery System for Breeding Peach and Nectarine: A 10-year Analysis

Jorge Rodriguez-A., Wayne B. Sherman, and Paul M. Lyrene
Fruit Crops Department, University of Florida, Gainesville, FL 32611

Additional index words. fruit breeding, selection, chilling, juvenility

Abstract. **A 10-year analysis of the high-density nursery (HDN) in the breeding of low-chilling peach and nectarine [*Prunus persica* (L.) Batsch] cultivars indicated selection was effective during the first cropping year for chilling requirement, fruit development period, size, color, shape and firmness but not for crop load, which needs to be evaluated at normal spacing over several years. The HDN system effectively has advanced the breeding program by promoting short generation time, reducing labor and space, and allowing for rating of some characters within 2 years from seed.**

Rapid genetic advance in breeding of fruit trees is limited because of the relatively long juvenile period and the size of the plant (2). These factors hinder progress in breeding by imposing a limit on the number of plants that can be screened and by increasing the number of years that elapse before a breeding cycle can be completed. The following 2 approaches have been used to shorten the juvenile period: speeding up seedling growth to attain a minimum fruiting-size plant earlier than would be possible otherwise (9, 13) and breeding for short juvenile period (11, 12). Significant progress by breeding may require several generations.

Received for publication 12 Apr. 1985. Florida Agricultural Experiment Station Journal Series No. 6366. This research was supported by a grant from the United States–Israel (Binational) Agricultural Research Development (BARD) Fund. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

A desirable system of handling seedling populations should provide rapid advance from seed to fruiting to increase genetic gain per year, minimize nongenetic variation among seedlings, and be cost efficient. Two approaches to increase efficiency in screening seedling populations are: introducing dwarfing genes into the breeding population to reduce plant size (4) and using the high-density nursery (HDN) system, as described for fruiting seedlings by Sherman et al. (8), which increases the number of plants evaluated per unit area. The main objective of this study was to evaluate the HDN system for efficiency in peach and nectarine breeding. This system has been used by the Univ. of Florida breeding program for the last 10 years.

Materials and Methods

Seedlings in the HDN were established in the following manner. Seed were removed from the fruit in May, stratified and germinated in the greenhouse by August, and transplanted to the nursery in September at 15 to 20 cm apart within rows and 1 m between rows. Hybrid seedlings in HDN during the period 1975 through 1984 were used in this study. No data are available for 1980 due to freeze damage. Normal crops were obtained in the other years.

Seven traits were evaluated. Chilling requirement (CR), presented in chilling units, was estimated by rating spring budbreak of each seedling with standard clones of known CR. Crop load (CL), an indication of yielding capacity, was rated from 1 (no fruit set) to 10 (heaviest set); fruit were thinned by hand as needed to space them 15 to 20 cm apart. Fruit color (FC) was rated from 1 (yellow with no red color) to 10 (complete red overcolor). Fruit shape (FS) was rated from 1 (large suture bulge or pronounced tip) to 10 (round or slightly oblong with no suture bulge and the absence of pronounced tip). Fruit firmness (FF) was rated at the appearance of yellow ground color at time of commercial harvest and ranged from 1 (soft) to 10 (firm overall). Firmness mainly measures uniformity of ripening within each fruit but includes overall firmness. The general rating of this trait depends on firmness of several parts of the fruit, such as tip, suture, and shoulder. Fruit weight (FW) was obtained by weighing a representative sample of commercially ripe fruit. Fruit development (FDP) was the number of days elapsed between 50% bloom and first commercial harvest. Daily gain was calculated as the ratio FW/FDP.

Every year (except 1980), 10 to 30 selections were made from 3000 to 6000 hybrid seedlings fruiting in the HDN. Selections were June budded to root-knot nematode (*Meloidogyne* sp.) resistant rootstocks and planted the following winter in an adjacent block under commercial spacing and management. A minimum of 2 budded trees per selection was established in all instances.

Partial and multiple correlation analyses of data were made among traits and a regression analysis was fitted to generation means to estimate genetic gain (1). Analysis of variance components for the traits under study were obtained by using the procedure VARCOMP of the Statistical Analysis System (SAS Institute, Cary, N.C.) and the model Yijk = M + Ai + Bj + ABij + Eijk, where A = the effects of genotype (i = 1, 2, . . . 12), B = the effects of environment (years j = 1, . . . 10), and AB = genotype × year interaction that, in this instance, was confounded with E (error) because of lack of replications (k) within years.

Results and Discussion

Trait reliability. Correlations between traits evaluated in the HDN (stage 1) and the first fruiting of budded trees under simulated commercial field spacing (stage 2) are indicated in Table 1. Moderately high correlations were found for CR (r = 0.62**), FDP (r = 0.64**), and FW (r = 0.52**), and an intermediate level correlation for FC (r = 0.39**). Correlations were nonsignificant for FS, FF, and CL. When data were analyzed for correlation between stage 1 and the average of 2nd and 3rd year of fruiting in the field (stage 3) there was a slight correlation increase for CR (r = 0.62** vs. r = 0.73**), while FDP remained basically the same (r = 0.64**); however, FC decreased (r = 0.39** vs. r = 0.23), and FS, FF, and CL were again nonsignificant. The results indicate that evaluation for the statistically correlated traits can be made with reasonable accuracy in the fruiting nursery, in part because these traits have high heritability (h^2) values as compared to breeding populations of other fruit crops (3, 5–7, 10). Although ratings on desirable selections for FS and FF were not correlated between stages 1 and 2 and between 1 and 3, all ratings were consistently high,

Table 1. Phenotypic correlations between traits in peaches and nectarines evaluated in the high-density nursery (stage 1), during their 2nd year under commercial spacing (stage 2), and with an average of 2nd and 3rd year under commercial spacing (stage 3).

Characteristic	Correlation coefficients between stages		
	1[z] vs. 2	1 vs. 3[y]	2[x] vs. 3
Fruit development period (FDP)	0.64**	0.64**	0.92**
Chilling requirement (CR)	0.62**	0.73**	0.86**
Fruit weight (FW)	0.52**	0.82**	0.89**
Fruit color (FC)	0.39**	0.23	0.75**
Crop load (CL)	−0.10	0.18	0.49**
Fruit shape (FS)	0.11	0.28	0.63**
Fruit firmness (FF)	−0.16	012	0.81*

[z]Thirty-four clones evaluated.
[y]Thirty-three clones evaluated.
[x]Seventy-two clones evaluated.
**Significant at 1% level.

suggesting that valid ratings were made in stage 1. Evaluations in stages 2 and 3 assured increased accuracy. Ratings for CL were not determined accurately in stage 1, but were more reliable in stages 2 and 3 (r = 0.49**). When the data were analyzed for correlations between stage 2 and stage 3, the repeatability for all traits was high, as expected (Table 1). Ratings on budded trees therefore are relatively consistent from year to year, even though they are subjective.

If repeatability is low, accuracy can be gained with repeated measurement; if high, little will be added with temporal replication of measurements (1). The latter could be true for CR, FDP, FW, and FC between stages 1 and 2. The fact that some correlations between stages (h^2 broad sense) were nonsignificant or low may imply that the expression of those traits is not adequate in stage 1 as may be true for CL. Young trees do not set fruit as well as old trees. Under strong competition in the fruiting nursery, this effect could be even more pronounced. Also, FF and FS are evaluated subjectively. Further, they are composed of several quantitative traits, such as the presence of tip, shoulders, and suture, which may lead to greater errors in evaluation. The increased reliability of these traits between stage 2 and stage 3 may be because more fruit are present on the trees, permitting the breeder to increase accuracy in evaluation.

Correlation coefficients reveal the relationship between randomly changing variables, but in this instance the same variable is evaluated at different stages. The fact that correlations for some variables were nonsignificant does not necessarily mean that the selection procedure is not efficient, either in identifying good genotypes or discarding those with low expectations. Instead, the low correlation may indicate limited range of variability in the selected population. A thorough assessment of HDN would require the testing in stage 2 of all the seedlings originally planted in stage 1. This kind of test was not possible in the present study.

Estimates of variance components for CR, FDP, CL, FC, FF, and calculated daily gain (Table 2) obtained for a random sample of selections and cultivars on budded trees during 1982, 1983, and 1984 indicate major genetic control of most of the traits, except for CL and daily fruit gain. CR is reported to be highly affected by environmental fluctuations (6); however, the data covering the period from 1982 to 1984 show that the effect of years was unimportant on CR for this population sample, perhaps because CR is evaluated by comparison to bloom time

10. Vileila-Morales, E.A., W.B. Sherman, C.J. Wilcox, and C.P. Andrews. 1981. Inheritance of short fruit development period in peach. J. Amer. Soc. Hort. Sci. 106(4):399–401.
11. Visser, T. 1964. Juvenile phase and growth of apple and pear seedlings. Euphytica 13:119–129.
12. Visser, T. 1976. A comparison of apple and pear seedlings with reference to the juvenile period. II. Mode of inheritance. Euphytica 25:339–342.
13. Zimmerman, R.H. 1972. Juvenility and flowering in woody plants: A review. HortScience 7:447–485.

Table 4. Correlation matrix among characteristics representing Florida germplasm for peach and nectarine.[z]

Trait	FDP	CL	FC	FW	FS	FF
Chilling requirement (CR)	−0.19**	−0.01	0.08	0.05	−0.05	−0.002
Fruit development period (FDP)		0.02	0.08	0.49**	0.20**	0.12*
Crop load (CL)			0.20**	−0.08	0.03	0.02
Fruit color (FC)				−0.21**	0.26**	0.13**
Fruit weight (FW)					0.07	0.14**
Fruit shape (FS)						0.12*
Fruit firmness (FF)						

[z]Number of paired observations = 389.
*,**Significant at 5% and 1% levels, respectively.

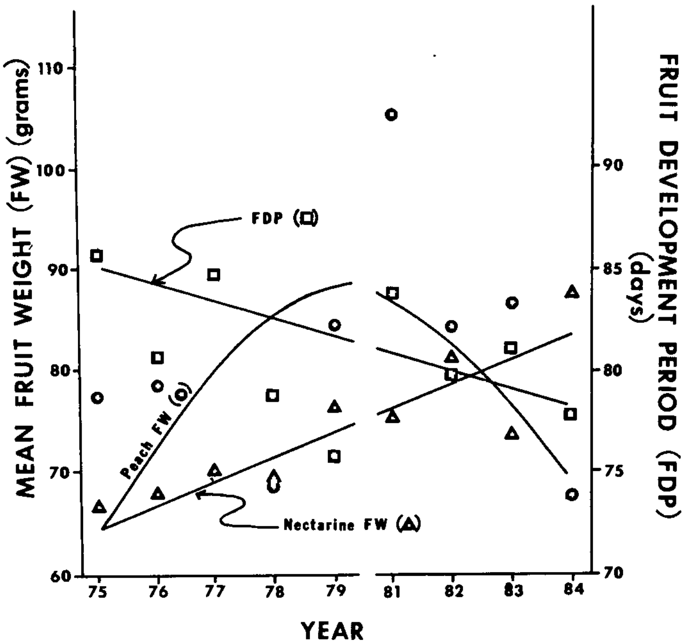

Fig. 1. Regression lines for yearly selection means for fruit weight and fruit development period on peach and nectarine selections made for large fruit size and early ripening.

parents, and emphasis was placed on selections with shortest FDP. The slope of the quadratic regression in peach shows that a FW gain of about 5 g per year was obtained through 1981, at which time size selection was relaxed in favor of short FDP. A linear model of FDP showed that the trend has been to decrease the number of days required for fruit maturation (Fig. 1). Thus, FDP among selection was reduced 6 days during this study. The relationship found between FDP and FW (Table 4) indicates, in general, that the shorter the FDP, the smaller the FW. This relationship probably is not due to a linkage of genes but is physiological in nature. It is clear that variation exists such that genetic progress can be obtained in FW in breeding peaches and nectarines with a reduced FDP.

Analysis of FW and FDP on the basis of daily gain (FW/FDP) was an attempt to eliminate the influence of FDP on FW. However, the results (data not shown) gave the same trends indicated in Fig. 1.

An evaluation for traits such as FC, FS, and FF indicates little change during the period examined for nectarines and peaches. Emphasis in selection was given to high ratings for these characters. Therefore, large rates of advancement cannot be shown, because less genetic variation exists among the selections than in the unselected hybrid seedling population.

Conclusion

We believe the HDN system is efficient for making genetic progress in peach and nectarine breeding. Commercial aspects (stage 3) of FDP, CF, FW, FC, FS, and FF were evaluated effectively in the HDN (stage 1). Commercial aspects of CL on young seedlings in the HDN could not be estimated. The advantages of the HDN system include maximum seedlings per unit area, thereby permitting reduced land, cultural operations, pesticides, and labor. In addition, the juvenile period is reduced in the HDN through rapidly attaining minimum plant size for flowering, and frost protection during bloom is permitted with overhead irrigation.

The use of HDN system results in selection for short juvenile period. Selections made in year 2 will be used as parents earlier than selections made in year 3. In addition, seedlings that do not fruit in 3 years are eliminated. Two seedlings from 1984 hybrids (May seed) had some flowers on 0.5m-high plants in Feb. 1985. Thus, it may be possible to reduce generation time to one to 2 years.

Literature Cited

1. Falconer, D.S. 1982. Introduction to quantitative genetics. Longman Group Ltd., London.
2. Hansche, P.E. 1983. Response to selection, p. 154–171. In: J.N. Moore and J. Janick (eds.). Methods in fruit breeding. Purdue Univ. Press, West Lafayette, Ind.
3. Hansche, P.E. and V. Beres. 1966. An analysis of environmental variability in sweet cherry. Proc. Amer. Soc. Hort. Sci. 88:167–172.
4. Hansche, P.E. and V. Beres. 1980. Genetic remodeling of fruit and nut trees to facilitate cultivar improvement. HortScience 15:710–715.
5. Hansche, P.E., V. Beres, and R.M. Brooks. 1966. Heritability and genetic correlations in the sweet cherry. Proc. Amer. Soc. Hort. Sci. 88:173–183.
6. Hansche, P.E., V. Beres, and H.I. Forde. 1972. Estimates of quantitative genetic properties of walnut and their implications for cultivar improvement. J. Amer. Soc. Hort. Sci. 97:279–285.
7. Hansche, P.E., C.O. Hesse, and V. Beres. 1975. Inheritance of fruit size, soluble solids, and ripening date in *Prunus domestica* cv. Agen. J. Amer. Soc. Hort. Sci. 100:522–524.
8. Sherman, W.B., R.H. Sharpe, and J. Janick. 1973. The fruiting nursery: Ultra high density for evaluation of blueberry and peach seedlings. HortScience 8:170–172.
9. Sherman, W.B. and P.M. Lyrene. 1983. Handling seedling populations, p. 66–73. In: J.N. Moore and J. Janick (eds.). Methods in fruit breeding. Purdue Univ. Press, West Lafayette, Ind.

Table 2. Estimates of mean square for traits in peaches and nectarines, evaluated during the period 1982–1984.

		Mean square (and percentage) for traits evaluated[z]															
Source	df	Fruit development period	(%)	Chill requirement	(%)	Fruit weight	(%)	Fruit color	(%)	Crop load	(%)	Fruit firmness	(%)	Daily gain[y]	(%)	Fruit shape	(%)
Year	2	14.5	(8)	697.0	(7)	166.7	(34)	0.5	(12)	0.1	(1)	0.0	(0)	0.04	(52)	0.1	(6)
Genotypes	10	158.4	(84)	9178.0	(87)	156.8	(32)	1.9	(42)	0.9	(12)	1.9	(79)	0.01	(16)	0.6	(31)
Error	20	14.4	(8)	685.6	(6)	164.5	(34)	2.1	(46)	7.3	(87)	0.5	(21)	0.02	(32)	1.3	(63)

[z]Evaluation made on 2 budded trees per selection, under commercial spacing (stage 3).
[y]Daily gain = fruit weight/days for fruit development.
[x]Error term contains year × genotype interaction.

in reference cultivars and a precise evaluation for CR was obtained. FDP also showed low genotype × year interaction (included low error), probably because this trait also involves CR completion as the beginning date. FW was consistent from year to year. FS and FF can be altered by mild winters increasing the number of pointed, large sutured fruit which ripen prematurely. FC is influenced most often by tree vigor in a particular year — the more vigorous, the less FC. CL is difficult to assess because of the many components that determine marketable yield and the large environmental effects on that trait in general. Daily gain (FW/FDP) involves a larger error term than that of other traits, probably because it includes 2 types of observations involving twice the error in evaluation plus the genotype × year interaction.

Evaluation stage and trait behavior. A comparison of stages reveals trends in the expression of some traits (Table 3). For instance, CR usually is rated higher in 2- or 3-year-old seedlings than in fruiting budded trees, presumably because young seedlings stop growth late in the fall, affecting the chilling accumulation process (300 vs. 279 chilling units). Young seedlings therefore begin growth later in the spring than do adult plants. FW is expected to increase in older trees because fruit is borne on larger-diameter twigs. Increased FW on budded compared with seedling trees is reflected in the data (92 vs. 84 g/fruit). No significant change occurred for other traits between seedling trees in the HDN and budded trees or between stages 2 and 3 of budded trees.

Table 3. Mean values and standard deviation (SD) for traits for selected clones of peach and nectarine evaluated in the high-density nursery (stage 1), first year under commecial spacing (stage 2), and an average for 2nd and 3rd year under commercial spacing (stage 3).

	Mean value ± SD		
Characteristic	Stage 1[z]	Stage 2[y]	Stage 3[x]
Fruit development period (days)	85 ± 13	88 ± 13	84 ± 13
Chilling requirement (chilling units)	300 ± 77	279 ± 87	286 ± 82
Fruit weight (g)	84 ± 20	91 ± 25	91 ± 17
Fruit color[w]	8.0 ± 2.0	7.7 ± 2.2	8.0 ± 1.7
Crop load[u]	7.1 ± 2.0	7.3 ± 2.3	7.2 ± 1.7
Fruit shape[v]	7.6 ± 1.2	7.3 ± 1.5	7.6 ± 1.3
Fruit firmness[t]	9.1 ± 0.9	8.1 ± 1.4	8.7 ± 1.3

[z]Seventy-two clones evaluated.
[y]Thirty-four clones evaluated.
[x]Thirty-three clones evaluated.
[w]Rated from 1 (yellow with no red color) to 10 (complete red overcolor).
[v]Rated from 1 (no fruit set) to 10 (heaviest set).
[u]Rated from 1 (large suture bulge or pronounced tip) to 10 (round or slightly oblong with no suture bulge and the absence of pronounced tip).
[t]Rated from 1 (soft) to 10 (firm overall).

Correlations among traits. Table 4 shows the phenotypic correlations of CR, FDP, CL, FC, FW, FS, and FF obtained for most of the selections made during the 1975–1984 period. Some statistically significant trends were evident, but none were high enough to use directly in selection for genetic advance. A small but significant negative correlation between CR and FDP was found ($r = -0.19^{**}$). This result was expected because, under Gainesville, Fla. conditions, plants with increased chilling requirement bloom later, and fruit therefore develop under higher temperatures and longer photoperiods than on plants with low chilling requirements. A moderately high correlation ($r = 0.49^{**}$) between FW and FDP was found, which indicates that the longer the fruit is on the tree the greater the physiological potential for larger FW. Low but significant positive correlations were obtained between FDP and FF ($r = 0.12^{**}$), FDP and FS ($r = 0.20^{**}$), and FS and FF. These values were expected because long FDP peaches are generally firmer and ship better than short FDP, which tend to have poor FS. A significant correlation between FS and FC ($r = 0.26^{**}$) was unexpected. When FS is rated high, the fruit probably are allowed to stay on the tree one or 2 days more (round fruit do not have prominent sutures or tips which have a tendency to become soft) during which time additional red overcolor develops. A negative correlation ($r = -0.21^{**}$) was found between FW and FC, indicating that large fruit tended to have less red overcolor.

Genetic advance in the HDN. One major goal of this program is to breed for early ripening peaches and nectarines. The analysis of the information for gain in FW and FDP was limited to those peaches and nectarines that ripen between 60 and 90 days after blooming. These data were obtained when selections were made to check efficiency of the HDN (8).

The slope of the linear regression shows a consistent increase in genetic advance for nectarines in fruit size from 67 g in 1976 to 84 g in 1984 (Fig. 1). This increase represents a genetic gain of 2.2 g/year in the period 1976–1984. The trend for peaches was different, with genetic gain increasing from 1975–1979 and then decreasing. This behavior may be explained by the fact that selections from 1980–1984 were consistently early, thereby affecting FW data. Further, many peach selections made in 1982–1984 were products of embryo rescue from early maturing seed

Fruit Varieties Journal 40(1):24-28 1986

Reviewed Research Paper

Relationship Between Autumn Growth Cessation and Chilling Requirement in Peach[1]

B. D. Mowrey and W. B. Sherman[2]

Abstract

The relationship between growth cessation under shortening daylengths and chilling requirement was investigated in a low-chill, young peach seedling population and in 6 low-chill peach cultivars. A positive correlation (r=0.32**) was found between growth cessation and chilling requirement in the seedling population, whereas, a negative correlation (r=-0.58**) was found for the 6 cultivars. The 6 cultivars behaved in the manner that was expected; however, growth cessation in the seedlings was confounded by juvenility and vigor. Regression of individual progeny on their midparent values revealed that chilling requirement is highly heritable (h^2=0.93).

Before deciduous woody plants enter dormancy they go through a series of changes that enable them to survive winter freezes. The first stage of acclimation is induced by a response to shortening daylengths which causes growth to cease (3,11). Many woody species have been shown to cease growth under short photoperiods (1,8,10,11,12,18,19,). Plants from higher latitudes generally exhibit this response under longer photoperiods than plants of the same species from lower latitudes.

Breeding improved cultivars of deciduous fruit tree species adapted to areas with low chilling units often requires use of high-chill germplasm as sources of desirable alleles. Progeny derived from crosses of adapted by unadapted genotypes show considerable variation for CR. Preselection for chilling requirement (CR) based on individual seedling growth cessation (GC) in the autumn, as suggested by Lammerts (9) would permit removal of seedlings that have an undesirable CR. These could then be sent to collaborators at the latitude of best adaptation for evaluation. This would result in greater precision in genetic studies since all seedlings of a progeny could be evaluated.

This study deals with the potential of selecting for CR on the basis of time of growth cessation in low CR peaches and nectarines. Our hypothesis was that sequence of growth cessation would show a negative relationship to CR (9).

Materials and Methods

The ability to pre-select for CR in peach by observing GC under shortening daylengths was investigated using 864 seedlings from 26 families and 6 cultivars at the University of Florida, Gainesville. The seedlings, which ranged from 125 to 475 chill units (CU), were produced by crossing 4 pollen parents with 19 seed parents (Table 1). The CR of the 6 cultivars ranged from 50 to 650 CU (Table 2). 'FlordaGrande', 'Maravilha' 'San Pedro', and 'Flordaking' all resulted from the University of Florida breeding program. 'Sunfre' was developed at USDA in Fresno, California and 'June Gold' was developed by Armstrong Nursery in California.

Crosses were made in January and February of 1983. Fruit were harvested in May and the seeds were removed and stratified. Resulting seedlings were planted in the fruiting

[1]Florida Agricultural Experiment Station J. Series No. 6504.

[2]Fruit Crops Dept., Univ. of Fla. Gainesville 32611. This research was supported by a grant from the United States-Israel (Binational) Agricultural Research Development Fund (BARD).

Table 1. Estimated chilling requirement (CR) and days to growth cessation (GC) after August 29 for some Florida low chilling peach and nectarine families.

Cross	Progeny CR mean	(chill units) range	Progeny GC (days) mean	range
FL 0-3 x FL 9-4	268	150 - 375	9.7	1 - 28
FL 0-4 x FL 7-7	286	250 - 375	15.5	7 - 21
FL 0-4 x FL 9-4	339	250 - 450	13.5	1 - 21
FL 1E-138 x FL 9-4	231	125 - 450	12.8	1 - 21
FL 3-4 x FL 0-2	248	125 - 350	13.9	1 - 42
FL 3-4 x FL 7-7	277	150 - 375	15.2	1 - 42
FL 3-4 x FL 9-4	298	250 - 350	16.2	1 - 28
FL 5-15 x FL 0-2	234	125 - 350	15.3	1 - 42
FL 5-15 x FL7-7	310	125 - 475	16.9	7 - 42
FL K5E-15 x FL 0-2	303	150 - 375	13.4	1 - 21
FL K5E-15 x FL 7-7	319	150 - 450	14.2	1 - 35
FL 5-18 x SH[z]	334	125 - 450	16.6	1 - 28
FL 5-19 x SH	357	250 - 450	11.9	1 - 42
FL 5-20 x SH	355	125 - 450	20.2	1 - 21
FL 7-11 x FL 0-2	341	275 - 375	28.9	14 - 42
FL 9-10 x FL 9-4	240	125 - 325	13.1	1 - 28
FL 9-11 x SH	278	150 - 350	15.4	1 - 35
FL 9-14 x FL 7-7	234	175 - 325	22.7	14 - 28
FL 9-14 x FL 9-4	259	150 - 350	12.2	7 - 21
FL 9-15 x FL 9-4	316	225 - 375	12.4	1 - 28
FL 9-15 x SH	294	175 - 425	15.3	1 - 35
FL 9-16 x FL 7-7	360	225 - 450	20.7	1 - 42
FL 9-16 x FL 9-4	341	275 - 450	13.1	1 - 21
FL 9-20 x FL 9-4	303	250 - 325	13.3	7 - 21
SR[y] x FL 9-4	329	275 - 425	17.7	1 - 21
SR x SH	342	275 - 450	14.9	1 - 28
		r = 0.32**		

[z]SH = Sunhome nectarine
[y]SR = Sunripe nectarine
**correlation value for n = 864, significant at 0.01 level

Table 2. Days to growth cessation (GC) after August 29 in 6 peach cultivars representing a range in chilling requirement (CR).

	CR Shoot	Days to GC A	B	C	D	E	Mean days to GC
FlordaGrande	50	15	22	22	22	33	23
Maravilha	225	22	15	22	25	15	20
San pedro	350	33	18	18	15	11	19
Flordaking	425	26	29	13	13	26	21
Sunfre	550	8	8	18	18	18	14
June Gold	650	8	8	8	8	8	8
				r = -0.58**			

**correlation value for n = 30, significant to 0.01 level.

nursery (16) in September 1983 and evaluated for GC in autumn 1984 and CR in spring 1985. Seedlings were visually rated for GC once a week starting August 30, 1984. Estimates were made for day of growth cessation. Three terminal shoots were observed on each seedling and GC was considered to have occurred when 2 of the shoots visually ceased producing leaves. Growth cessation was observed in all individuals before temperatures below 7°C occurred. The seedlings were classified as to CR by time of bloom in reference to cultivars of known CR. Reference cultivars used were 'Okinawa' 150 CU, 'Sunred' 250 CU, 'Early Amber' 350 CU, and 'Sunlite' 450 CU. Chilling requirement of the parents was also determined similarly. Time of peach bloom under north central Florida conditions is determined primarily by CR completion rather than difference in heat requirement. The range in bloom dates at Gainesville is mid-January to mid-March for peach cultivars of 100 to 650 CU, respectively. Peach cultivars of 200 to 400 CU bloom together in north Florida, cultivars of 400 to 600 CU bloom together in central Georgia, and all cultivars tend to bloom together in northern states where CR is met for each cultivar before heat units began accumulating in spring. The degree of lateness in bloom is this equated to the degree in inadequate chilling.

Growth cessation and CR in the 6 cultivars were determined in a similar manner as the seedlings. Trees of the 6 cultivars on a root-knot nematode resistant rootstock were 3 to 5 years old and uniform in vigor. They were given the same cultural practices. On August 13, 1984, 5 actively growing shoots approximately 2 m high and equidistant around a representative tree of each cultivar were selected and marked. Visual observations were made starting August 29 and the day of GC was estimated for each shoot.

The SAS computational package was used to obtain correlations and a regression (SAS Institute Inc., Cary NC). The CORR procedure (15) was used to determine the relationship between GC and CR in both seedlings and cultivars. The general linear model (GLM) procedure (5) was used to obtain the midparent-offspring regression coefficient which was used as an estimate of h^2 for CR (4). Since progeny population size differed between crosses, the regression was weighted by the number of seedlings per progeny.

Results and Discussion

Relationship Between GC and CR.

A low, but significant, positive correlation ($r = 0.32^{*}$) was found between GC and CR for individual seedlings in the populations. Thus, lower CR seedlings tended to terminate growth earlier than higher CR seedlings. This is opposite of the trend expected in peach and reported in other species (2, 12, 13, 17, 19,). Conversely, a significant negative correlation ($r = -0.58^{**}$) was found between CR and days to GC for the 6 cultivars. Thus, cultivars with a high CR tended to terminate growth earlier than cultivars with a low CR. This correlation is lower than the correlations of -0.89, -0.71, and -0.82 between GC and latitude of origin for 3 species of *Populus* (13).

Several explanations are plausible as to why the seedling population showed a trend opposite that found in budded trees and in mature seedlings of other species. The peach seedlings demonstrated considerable variation in vigor with stem diameters ranging from 4 to 26 mm. A significant positive correlation ($r = 0.43^{**}$) was found between stem diameter (SD) and GC with larger seedlings terminating growth later than smaller seedlings. A low, significant positive correlation ($r = 0.12^{**}$) between SD and CR was also found. Although the relationship between CR and vigor is unknown it is possible that this interaction is partially responsible for the trend observed. Since the seedlings were only 14 months old at GC evaluation many of them were juvenile or in the transition period between juvenile and adult. This may have had an effect on GC under decreasing photoperiods since juvenile deciduous plants are often more vigorous and exhibit delayed leaf drop as compared to adults.

The limited range of CR of the 6 cultivars may be responsible for the cultivar correlation obtained ($r = -0.58^{**}$) being lower than those reported in *Populus* (13). The range of CR for the 6 cultivars (50-650 CU) was about half of the range existing in peach (0-1150$^+$ CU). The 6 cultivars are adapted from 26 to 32 degrees latitude in the southeastern US, lowest to highest CR respectively, while the *Populus* examined (13) had a distribution range from 34 to 61 degrees latitude. It is possible that by examining a wider range of CR, a correlation of higher magnitude would be obtained. In fact, the cultivars, which had a wider CR range, showed a relationship between CR and GC that was more in line with what has been found in other species than the seedlings, which had a narrow CR range.

h^2 Estimate for CR.

The regression of progeny means on the mid-parent CR values gave a h^2 of 0.93 ± 0.14. This estimate was higher than the h^2 value of 0.49 obtained in another low CR peach population (14). We recognize these h^2 values are valid only for the population under study; however, both are high indicating that additive gene action is the primary component in CR inheritance. Our h^2 value for CR is similar to h^2 values for other CR related observations such as time of bloom in prune ($h^2 = 0.86$) (7) and time of leaf bud break in walnut ($h^2 = 0.96$) (6).

Conclusions

A negative relationship between CR and time of GC in the autumn was found for mature trees indicating that an estimate of CR could be made on the basis of time of GC in mature trees. However, the relationship was not evident in young seedlings and pre-selection of individual seedlings for CR by observing GC at the end of growing season was not feasible. Seedling juvenility and vigor had a larger influence on GC than the CR of the seedling. This technique might be partially effective for screening segregating populations derived from crosses of parents with large differences in CR, since the CR range would be much greater than the range used in this study.

The relationship between days to GC and CR found in the 6 cultivars has interesting implications for biannual peach production in tropical regions. Extremely low CR cultivars should continue growth and flower bud set throughout the year even under the relatively constant short photoperiods of the tropics.

The high h^2 estimate for CR in peach indicates that rapid progress is possible in breeding high chilling peach and possibly other deciduous species for subtropical latitudes, provided that a cross-compatible source of low-chill germplasm is available.

Literature Cited

1. Carpenter, S. B., M. J. Immel, and N. D. Smith. 1983. Effects of photoperiod on the growth and photosynthetic capacity of *Paulownia* seedlings. Catstanea 48:13-18.
2. Donselman, H. M. and H. L. Flint. 1982. Genecology of eastern red bud (*Cersis canadensis*). Ecology 63:962-971.
3. Downs, R. J. and H. A. Borthwick. 1956. Effects of photoperiod on the growth of trees. Bot. Gaz. 117:310-326.
4. Falconer, D. S. 1982. Introduction to quantitative genetics. London, England. Longman Group Limited.
5. Goodnight, J. H., J. P. Sall, and W. S. Sarle. 1982. The GLM procedure. p. 139-199. In: A. A. RAY (ed.) SAS user's guide Statistics. SAS Institute, Inc. Cary, N.C.

6. Hansch, P. E., V. Beres, and H. I. Forde 1972. Estimates of quantitative genetic properties of walnut and their implications for cultivar improvement. J. Amer. Soc. Hort. Sci. 97:279-285.

7. Hansche, P. E., C. O. Hesse, and V. Beres. 1975. Inheritance of fruit size, soluble solids, and ripening date in *Prunus domestica* cv Agen. J. Amer. Soc. Hort. Sci. 100:522-524.

8. Kocherzhenko, I. E. and T. K. Maiko. 1968. Photoperiodism and features of the anatomical structure of woody-plant saplings. Soviet Plant Physiol. 15:51-59.

9. Lammerts, W. E. 1943. Effects of photoperiod and temperature on growth of embryo cultured peach seedlings. Am. J. Bot. 30:707-711.

10. Nitsch, J. P. 1957. Growth responses of woody plants to photoperiodic stimuli. Proc. Amer. Soc. Hort. Sci. 70:515-525.

11. Nitsch, J. P. 1957 Photoperiodism in woody plants. Proc. Amer. Soc. Hort. Sci 70:526-544.

12. Nooden, L. D. and J. A. Weber. 1978 Environmental and hormonal control of dormancy in terminal buds of plants. p. 221-268. In:M. E. Clutter (ed.) Dormancy and developmental arrest. Academic Press, New York.

13. Pauley, S. S. and T. O. Perry. 1954. Ecotypic variation of the photoperiodic response of *Populus*. J. Arn. Arbor. 35: 167-187.

14. Rodriguez-Alcazar, Jorge. 1984. Effectiveness of preselection for chilling requirement, precociousness, fruit development period, and fruit qualities in peach and nectarine (*Prunus persica* (L.) Batsch). Doctoral Dissertation. University of Florida. Gainesville, Fla.

15. Sall, J. P. and D. M. Delong. 1982. The CORR procedure. p. 501-512. In: A. A. Ray (ed.) SAS user's guide: Basics. SAS Institute, Inc. Cary, N.C.

16. Sherman, W. B., R. H. Sharpe and J. Janick. 1973. The fruiting nursery: ultrahigh density for evaluation of blueberry and peach seedlings. HortScience 8:170-172.

17. Smitherberg, M. H. and C. J. Weiser. 1968. Patterns of variation among climatic races of red-osier dogwood. Ecology 49:495-505.

18. Van Huystee, R. B., C. J. Weiser and P. H. Li. 1967. Cold acclimation in *Cornus stolonifera* under natural and controlled photoperiod and temperature. Bot. Gaz. 128: 200-205.

19. Vince-Prue, D. 1975. Photoperiodism in plants. McGraw-Hill, London, England.

Proc. Fla. State Hort. Soc. 1986. Paper No. 64

Author's telephone No. (904)392-4711 KROME Section

Flower Bud Set and Relationship to Vigor in 18-Month Peach Seedlings

B. D. Mowrey and W. B. Sherman[1]

University of Florida, IFAS

Fruit Crops Department

Gainesville, FL 32611

Additional index words: breeding, juvenility, selection, *Prunus persica* (L.) Batsch

Abstract. The University of Florida low chilling peach breeding program was studied for parental and progeny flower bud set and its relationship with progeny plant vigor. A significient correlation was found between parental and progeny flower bud set (r=0.65**) and between progeny flower bud set and stem diameter (r=0.40**). A high heritability estimate for flower bud set was obtained by regression of progeny on midparent means.

Seedlings of tree fruit species pass through a juvenile period before they are able to flower. The juvenile period, a major barrier to genetic advancement, can be reduced by selecting and breeding (9) and by cultural practices that tend to increase seedling growth (6,10). Breeding for early flower bud set or a short juvenile period is the most effective means to increase genetic advance for characters under selection (3), because generation time is decreased.

Materials and Methods

The relationship between parental flower bud set and flower bud set in 18-month-old progeny was investigated in a seedling population from the

[1]Florida Agricultural Experiment Station Journal Series No. 6839 .
This research was supported by a grant from the United States - Israel (Binational) Agr. Res. Dev. Fund (BARD).

University of Florida low-chill peach and nectarine, [*Prunus persica* (L) Batsch], breeding program. The relationship between seedling vigor as determined by stem diameter and flower bud set was also investigated.

Crosses were made in January and February of 1983. Fruit were harvested in May and seed were removed and stratified. Resulting seedlings were planted in a high density fruiting nursery (7) in September 1983. The 864 seedlings studied represented 27 families derived from crossing 5 pollen parents and 18 seed parents. Progeny size varied from 15 to 35 seedlings. The parents were chosen because they varied greatly in flower bud set (Table 1).

Flower bud set was evaluated in January 1985 when the seedlings were 18 months old. Individual seedlings were given a rating from 1 to 10, 1 representing 10% or less and 10 representing 100% flower bud set (at least 1 per node) at the nodes of 3 randomly selected 30 cm terminal shoots. Seedlings could not be evaluated for fruiting due to heavy freeze damage to flower buds on January 20, 1985 (-12 C), but there is reason to believe degree of flower bud set is a good indication of fruiting potential, because a positive correlation exists between progeny mean flower bud set and number of fruiting seedlings per progeny (4). Flower buds were distinguished visually from vegetative buds by size, shape, and position. Parents were evaluated similarly for flower bud set on mature budded trees.

Stem diameter was used as an indicator of seedling vigor. Stem diameters was measured on each seedling in January 1985 to the nearest 0.5 mm 20 cm above the soil surface.

Results and Discussion

Correlation coefficients between seedling flower bud set with stem diameter and mean parental flower bud set were obtained using the CORR procedure of the SAS computational package (5). Heritability (h^2) of flower bud set was estimated by midparent-offspring regression (1). The general linear model (GLM) procedure was used to obtain the regression coefficient (2). Since progeny size differed among crosses the regression was weighted by the number of seedlings per progeny.

Midparent flower bud set ratings and corresponding flower bud set and stem diameter progeny means are presented in table 2. In general, there was good variability within mid-parent and progeny flower set ratings and within progeny item diameter means. A correlation (r=0.65**) was found between mean parental flower bud set and progeny flower bud set. Thus, seedlings derived from crosses of high flower bud set parents tended to have high flower bud set. High flower bud set fruit trees generally come into fruiting faster after budding than low flower bud set cultivars (6).

A heritability (h^2) estimate for flower bud set of 1.22 ± 0.29 was obtained from the mid-parent offspring regression. Although this estimate exceeds 1.0, it does indicate that the amount of flower bud set is controlled primarily by additive gene action. Thus, hybridization between parents with high flower bud set can be expected to result in progeny with high flower bud set.

A significant correlation (r=0.40**) was found in 18-month-old hybrid seedlings between plant vigor, as measured by stem diameter, and flower bud set. This relationship is similar to previous reports in apple and pear (8). This correlation may be attributed to the vigorous seedlings attaining a minimum plant height for ending the juvenility period earlier than weaker seedlings (10). It may be possible to preselect for short juvenile period in peach by roguing smaller seedlings from a progeny after the first-year's growth.

Selection of vigorous individuals in progenies resulting from inter-mating parents with a high degree of flower bud set should increase early flower bud set in resulting seedlings and increase precocity in peach budlings. Increased precocity would permit high yields early in the orchard life.

Literature Cited

1. Falconer, D. S. 1982. Introduction to quantitative genetics. London, England. Longman Group Ltd.
2. Goodnight, J. H., J. P. Sall, and W. S. Sarle. 1982. The GLM Procedure. p. 139-199. In; A. A. RAY (ed.) SAS user's guide: Statistics. SAS Inst., Inc., Cary, NC.
3. Hansche, P. E. 1983. Response to selection. p. 154-171. In: J. N. Moore and J. Janick (eds.) Methods in fruit breeding. Purdue Univ. Press, W. Lafayette, In.
4. Rodriguez J. and W. B. Sherman. 1986. Relationship between parental flower bud set and seedling precociousness in peach and nectarine. Fruit Var. J. 40:8-12.
5. Sall, J. P. and D. M. Delong. 1982. The CORR procedure. p. 501-512. In: A. A. Ray (ed.) SAS user's guide: Basics. SAS Institute, Inc. Cary, NC.
6. Sherman, W. B. and P. M. Lyrene. 1983. Handling seedling populations. p. 66-73. In: J N. Moore and J. Janick (eds.) Methods of fruit breeding. Purdue Univ. Press, W. Lafayette, In.
7. Sherman, W. B., R. H. Sharpe, and J. Janick. 1973. The fruiting nursery: ultra high density for evaluation of blueberry and peach seedlings. HortScience 8:170-172.
8. Visser, T. 1964. Juvenile phase and growth of apple and pear seedlings. Euphytica 13:119-129.
9. Visser, T. 1966. A comparison of apple and pear seedlings with reference to the juvenile period. II. Mode of inheritance. Euphytica 25:339-342.

Literature Cited (Cont.)

10. Zimmerman, R. H. 1972. Juvenility and flowering in woody plants: a review. HortScience 7:447-485.

Table 1. Flower bud set (FBS) on mature trees of parents in table 2.

Clone	FBS[z]
Fla. 0-2	10
Fla. 0-3	10
Fla. 0-4c	10
Fla. 1e-138	9
Fla. 3-4n	10
Fla. K5E-15n	7
Fla. 5-15n	9
Fla. 5-18	8
Fla. 5-19	8
Fla. 5-20	8
Fla. 7-7p	6
Fla. 7-11	10
Fla. 9-4	7
Fla. 9-6n	8
Desertred	10
Fla. 9-11n	10
Fla. 9-20	7
Fla. 9-14	9
Fla. 9-15n	10
Fla. 9-16	4
Sunripe	9
Sunhome	6

[z]FBS=10=100% to 1-10% or less of nodes possessing at least one flower bud.

Table 2. Mid-parent flower bud set ratings (FBS) and the corresponding flower bud set and stem diameter progeny means.

Cross		Mid-parent FBS[z]	Progeny FBS[z] mean	Progeny FBS[z] range	Progeny stem diameter mean (mm)
Fla. 0-3	x Fla. 9-4	8.5	2.1	1 - 7	13.3
Fla. 0-4c	x Fla. 7-7p	8.0	3.2	2 - 7	16.4
Fla. 0-4c	x Fla. 9-4	8.5	3.9	1 - 9	14.0
Fla. 1E-138	x Fla. 9-4	8.0	1.8	1 - 6	11.6
Fla. 3-4n	x Fla. 0-2	0.0	8.2	1 - 10	15.8
Fla. 3-4n	x Fla. 7-7	8.0	4.8	1 - 10	15.0
Fla. 3-4n	x Fla. 9-4	8.5	3.4	1 - 8	16.2
Fla. 5-15n	x Fla. 0-2	9.5	7.1	2 - 10	12.9
Fla. 5-15n	x Fla. 7-7p	8.0	4.3	1 - 10	15.4
Fla. K5E-15n	x Fla. 0-2	8.5	6.8	4 - 9	11.5
Fla. K5E-15n	x Fla. 7-7	6.5	3.3	1 - 7	12.2
Fla. 5-18	x Sunhome	7.0	3.1	1 - 7	13.0
Fla. 5-19	x Sunhome	7.0	1.4	1 - 6	12.2
Fla. 5-20	x Sunhome	7.0	3.2	1 - 7	12.3
Fla. 7-11	x Fla. 0-2	0.0	4.5	1 - 8	14.7
Desertred	x Fla. 9-4	8.5	1.4	1 - 5	11.1
Fla. 9-11n	x Sunhome	8.0	4.0	1 - 9	12.6
Fla. 9-14	x Fla. 7-7p	7.5	3.4	2 - 5	17.7
Fla. 9-14	x Fla. 9-4	8.0	1.9	1 - 5	13.1
Fla. 9-15n	x Fla. 9-4	8.5	2.1	1 - 6	13.0

Table 2. (Cont.) Mid-parent flower bud set ratings (FBS) and the corresponding flower bud set and stem diameter progeny means.

Cross		Mid-parent FBS[z]	Progeny FBS[z]		Progeny stem diameter mean (mm)
			mean	range	
Fla. 9-15n	x Sunhome	8.0	3.9	1 - 8	13.9
Fla. 9-16	x Fla. 7-7p	5.0	1.6	1 - 4	11.2
Fla. 9-16	x Fla. 9-4	5.5	1.4	1 - 4	10.8
Fla. 9-20c	x Fla. 9-4	7.0	1.3	1 - 2	13.7
Sunhome	x Fla. 9-6n	7.0	4.9	1 - 9	11.3
Sunripe	x Fla. 9-4	8.0	1.3	1 - 2	15.5
Sunripe	x Sunhome	7.5	3.5	1 - 6	10.9

[z]FBS = 10=100% to 1=10% or less of nodes possessing at least one flower bud.

Germination of early maturing genotypes *in vitro*

P. Spiegel-Roy

A series of experiments were performed in order to test and improve germination of early ripening genotypes *in vitro*.

Experiments with Maravilha peach (13-72) were performed, using embryo culture and the Murashige and Skoog medium. Results are summarized in Table 1.

Table 1. The effect of cold treatment (30 days) and gibberellin application on percentage of germination and proportion of rosetted plants with embryo culture of Maravilha peach

Treatment	With (+) or without (-) cold treatment	Germination %	Rosetted plants %
Check	-	0	-
Check	+	84	80
Gibberellin, 5 ppm	-	24	100
Gibberelling, 5 ppm	+	92	88
Gibberellin, 10 ppm	-	40	96
Gibberellin, 10 ppm	+	100	64
Gibberellin, 20 ppm	-	48	60
Gibberellin, 20 ppm	+	100	30
Gibberellin, 40 ppm	-	28	52
Gibberellin, 40 ppm	+	100	52

(Seeds collected and cultured 5.12.82).

The high percentage of rosetted plants may have been caused by the comparatively short chilling period (30 days at 4°C). However in the combination of 20 ppm of gibberellin GA_3 with cold treatment percentage of rosetted plants was lowest (20%) against 80% with seeds chilled but untreated with GA_3.

Further experiments conducted in 1983 again confirmed that the 20 ppm gibberellin resulted in high germination percentages (82% with Sunred nectarine, 80% with Maravilha). Gibberellin treatment at 30 ppm yilded somewhat higher germination rates than 20 ppm gibberellin (92%) with Maravilha. In later experiments (1984-1986) the effect of treating tress with antigibberellin (daminozide, paclobutrazol) on germination of cultured embryos of peach and nectarine was tested. In 1984, the effect of thiourea was also examined. 30 ppm GA_3 was included in the medium. (Murashige and Skoog) The experiment was performed with Maravilha peach. A tendency for higher germination rates with embryos derived from fruit of trees treated by spraying, with either thiourea or daminozide (at 2000 ppm concetration) was evident. Addition of GA_3 however to the medium depressed germination in embryos derived from fruit of trees treated with either thiourea or daminozide.

During 1985 further experiments were conducted; this time paclobutrazol (with and without addition of GA_3) was added to the medium. A new compound, tetcyclazide was also tried. The experiments were conducted with Earligrande (Texas) peach. Seed was extracted, peeled and placed in culture on 5/19/85, kept for 3 weeks at 4°C, and afterwards placed into a growth chamber at 25°C. All treatments were repeated with seed kept first in an incubator at 25°C, then peeled and left unchilled. With unchilled seed no treatment performed better than the check. Results with chilled seed are given in table 2.

Table 2. The effect of paclobutrazol and tetcyclazide and gibberellin on germination and development of embryos from peach cv. Texas _in vitro_*

M e d i u m	Number of embryos cultured	Shoot and roots	Roots only	Shoot only	Cotyledons open	Cotyledons green	Unchanged	Final Numb establishe
MS (Check	58	6	0	1	12	10	29	6
add. GA 30 ppm	52	5	1	2	5	6	33	5
add. PP333 50 ppm	39	21	1	7	5	2	3	21
add. PP333 100 ppm	49	11	1	12	8	13	4	13
add. PP50ppm + GA_3 30 ppm	40	18	0	15	4	0	3	27
add. PP100ppm + GA_3 30 ppm	48	24	0	16	3	3	2	24
Tetcyclazide 100ppm	17	8	1	6	1	1	0	10
Tetcyclazide 100ppm + GA_3 30ppm	17	14	0	2	0	0	1	16

* Seeds were extracted peeled and placed in culture ok 5/19/85, then kept for 3 weeks in cold chamber (4°C) and afterwards placed into growth chamber at 25°C.

Addition of paclobutrazol to the medium increased number of germinating and developing plants; tetcyclazide also gave favorable results.

Further experiments performed in 1985 showed again favorable results by inclusion of PP333 in the medium. Embryos were cultured in test tubes after 3 weeks in cold (4°C). Addition of 50 ppm PP333 in the medium increased germination to 54% compared to 10% in the control. Ev-n higher rates were achieved with the combination on PP333 and GA_3 in the medium. Results are summarized in Table 3.

Table 3. Percentage of plants established from *in vitro* culture of embryos in Texas cv.

Treatment	Perc. established
Check	10
GA_3 500 ppm	10
PP333 50 ppm	54
PP333 100 ppm	27
PP333 60 ppm + GA_3 50 ppm	68
PP333 100 ppm + GA_3 50 ppm	50
Tetcyclazide 100 ppm	50
Tetcyclazide 100 ppm + GA_3 30 ppm	94

Very high rates of germination were achieved with a combination of tetcyclazide and GA_3, but number of seeds used in this treatment was smaller than in other treatments. Again, the same treatments applied to unchilled seed, peeled 3 weeks after being maintained in an incubator at 25°C showed no gain in germination from addition of GA_3 or PP333 + GA_3 in the medium.

During 1986 experiments were conducted on conditions for embryo culture of 'Sunred' nectarine and 'Earligrande' peach. Two media were explored; 1) Stewart and Hsui, 2) Hough and Bailey with the addition of 30 ppm GA_3. Both media were solid media. Embryos were first cultured in 6% sugar. All seeds were peeled, except some lots of Earligrande. Earligrande fruits were recovered from a) orchard grown trees, b) 50 1 containers (volcanic tuff). Embryos were cultured in incubators at 26°C.

The gibberellin antagonist, paclobutrazol (2RS, 3ES)-d(4-chlorophenyl)-4.4, dimethyl-2 (lH-1,2,4-triazyl-1-yl)pentan-3-ol) was applied to both orchard grown and container grown 'Earligrande' as a ground application at the rates of 0, 15, 30, 300 mg per tree or pot. Applications were made during the last week of February. With Sunred only 0 and 1 g applications were made, on 2/23/86.

All lots were divided into two comparable parts. On 19/6; half of the embryos continued growth in 16 hr light in the incubator; the other lot was grown in darkness.

On 18/7 - half of both lots was transferred to 5°C, the other half was cultured at 26°C. The fresh medium used was Knopp with reduced sugar (2%) and half the quantity of K^+ and NH_4+. Results are summarized in table 4a. Peeling was performed in Earligrande orchard grown on half of the lot; results are given separately in table 5.

Table 4a. Effect of media, paclobutrazol treatment of trees and culture conditions on plantlet development from immature embryos of container grown Earligrande peach

Medium	Number embryos planted	Number plantlets	Number large plantlets
H&B + GA_3	66	55	10
S&H	72	60	17
PP333 0	38	31	2
" 15	33	32	9
" 30	32	29	13
" 300	35	25	3
Light	68	60	15
Darkness	70	59	12
5°C	67	59	21
26°C	71	[illegible]	[illegible]

Table 4b. Effect of media and paclobutrazol treatment of trees and culture conditions on plantlet development from immature embryos of field grown 'Earligrande' peach

Media	Number embryos planted	Number plantlets	Number large plantlets
H&B + GA_3	210	189	127
S&H	230	220	130
PP333 0 mg	125	123	89
" 15 mg	119	119	80
" 30 mg	116	116	85
" 300 mg	80	64	7
Light	213	204	113
Darkness	227	218	146
5°C	219	213	136
26°C	221	211	125

Table 5. Effect of media and paclobutrazol treatment of trees and culture conditions on plantlet development from immature embryos of 'Sunred' nectarine

Media	Number embryos planted	Number plantlets	Number large plantlets
H&B	69	66	32
S&H	92	88	51
PP333 0	77	76	44
" 50	83	81	41
Light	75	72	44
Dark	86	82	39
5°C	79	75	46
26°C	82	79	37

7/..

Table 6. The effect of late peeling (two months after seed culture), different media, paclobutrazol treatment, light and temperature on number of developing plantlets in Earligrande peach

Media	Number of seeds cultures	Number plantlets	Number large plantlets
H&B + GA_3	80	78	41
Stewart & Hsui	80	78	41
(PP333) Paclobutrazol 0	40	39	29
" " 15 mg	40	40	22
" " 30 mg	40	40	27
" " 300 mg	40	36	4
Light	80	78	32
Dark	80	78	50
5°C	80	79	47
26°C	80	76	35

Results with Earligrande embryo culture indicate better results with seed derived from field grown plants compared to seed from container grown plants. In both cases application of 300 mg paclobutrazol per tree or container had a deleterious effect on number of large plantlets and with seed from field grown trees also on percentage of plantlets obtained in culture. In contrast to results obtained during 1985, no beneficial effect of paclobutrazol applications (at the rate of 15 and 30 mg per tree or container) was noted, with the possible exception of a somewhat higher number of large plantlets from seed of container grown Earligrande' (table 4a.). Both media explored (Hough & Bailey, Stewart & Hsui) were about equal in their effect. As to the effect of dark vs 16 hr light applied one month after initiation of cultures, some beneficial effect of dark conditions was noted with embryos from field grown Earligrande. Chilling the cultures - performed only 2 months after the cultures were initiated resulted in a higher percentage of large plantlets with embryos from container grown 'Earligrande'. On the whole, results with embryo cultured from seed of field grown 'Earligrande' were satisfactory; percentage of large plantlets from seed of container grown 'Earligrande' was rather low and unsatisfactory.

Similar experiments were performed with 'Sunred' nectarine (table 5) paclobutrazol application was confined to a single variant (1 g) confronted with the control. No differences were found as to percentage of plantlets or percentage of large plantlets raised. Of all other comparisons made, the only difference found was a larger percentage of large plantlets from Stewart and Hsui medium compared to Hough and Bailey medium.

Lastly (table 6) a comparison of media and treatments was made with seed lots peeled only two months after culture, in either Hough and Bailey or Stewart and Hsui medium. Here again the main effect found was the deleterious effect of the high paclobutrazol application (300 mg per tree). Both culturing in the dark and chilling (5^oC) seemed to increase percentage of large plantlets.

In conclusion of experiments performed during several seasons, addition of GA_3 to media proved beneficial. Unchilled seed did not respond favourably to treatments. Additions of PP333 (paclobutrazol) and of a material used only in some experiments, tetcyclazide to the medium proved also interesting. In contrast, ground applications to trees during February of PP333 did not significantly increase percentage of germination. High rates of applications (300 mg PP333 per tree) proved deleterious. Seed from container grown trees did not perform as well as seed from field grown trees. Some beneficial effect of culturing the embryos in darkness was noted. Culturing in the dark and late chilling period (5^oC) of the embryos increased percentage of large plantlets in 'Earligrande' peach.

Bard project no. US - 436-81 "Response of peach and nectarine germplasm to an annual top removal pruning system"

Final Report

Amnon Erez
Institute of Horticulture The Volcani Center Bet Dagan Israel

Contents:

1. Establishment of imported plants from Florida.

During the period 1982 - 1985 a few shipments of new clones from Florida were obtained by the Israeli quarantine service and were grafted according to an agreed procedure in the Bsor experimental farm in the Northern negev on nemaguard rootstocks. Cuttings were taken for evaluation of the plant material in the winters of 1983/4 and 1985/6.

The cuttings were rooted according to Erez and Yablowitz (1983) and were either planted in the soil in Bet Dagan farm or grown in containers in volcanic tuff fertigated with a balanced nutrient solution (Nutricol 3 or Shefer- product of Deshanim Israel).

Evaluation of the rate of rooting took place in 1984 and 1985. Evaluation of the chilling requirements was carried out in 1985 and 1986 in potted plants chilled artificially for a predetermined time at 6^{0}C and grown in a greenhouse. Evaluation of the fruit characteristics were done in 1985 and 1986 in both field and container grown plants.

list of the clones on trial:

Table 1: Peach and nectarine cultivars obtained from Florida

Established Cvrs	Clones obtained in 1984		Clones obtained in 1985
5-2 (F. prince)	7-1 (F.Gem)	83-4	9-6N
13-72 (Maravilha)	82-N	9-12N	3-2
15-39 (F. Gold)	9-13N	7-11	9-11N
	9-8N	9-15N	9-14N
	9-7N		
	9-9N		
	9-10		

2. Rooting of hardwood cuttings.

Table2: Rooting capacity of hardwood cuttings of a few peach and nectarine clones.

Clone	% rooted & survived
9-8N	66
8-2N	4
9-12N	0
9-9N	77
9-13NR	56
9-7N	53
7-1	45
7-11	37
9-10	27
9-15N	21

Of the 10 clones checked 4 rooted well (survival over 50%) : 9-8N, 9-9N, 9-13NR, and 9-7N; four rooted moderately (survival 20 - 50 %) : 7-1(F. Gem), 7-11, 9-10 and 9-15N while 2 rooted poorly (survival 0 - 20%): 82-N and 9-12N.

3. Studies on the chilling requirement of the new clones.

The first clones planted in a meadow orchard system were those that rooted in spring 1984 They were planted with inrow spacings of 60 cm fertigated regularly. No. of replicates varied from 3 to 12 depending on the availability of the plants. Winter 1984/5 in Bet-Dagan was very mild what enabled to evaluate the adaptation of the various clones to such a climate. Stage of budbreak in the field is presented in Table 3.

Of the 9 clones compared the 3 most advanced were 9-10, Flordagem and 9-8N in both vegetative and floral buds. These clones coincided with bloom on older trees of Maravilha and Flordaprince. The next group in less advanced stage included: 9-15N, 9-9N, 7-11 and 9-13N. Delayed bud break occured with 8-2N (especially flower buds) and 9-7N. Comparison of these data to the semiqualitative data of W. Sherman (personal comunication)

Table 3: Bloom and leafing on 1- year-old trees of various Floridian clones raised from hardwood cuttings. (Bud break determined on Jan. 26 1985)

Clone	Bloom stage[a] (0-3)	Leafing stage[b] (0-3)
8-2N	0.5	1.0
9-13N	1.4	0.0
9-8N	1.5	1.3
9-7N	0.5	0.0
9-9N	1.1	0.6
9-15N	1.0	0.5
9-10	2.2	2.8
7-11	1.0	0.4
F. gem	1.9	1.5

[a]0= No swell; 1= Bud swell; 2= Initial bloom; 3= Full bloom.
[b]0=No bud break; 1=Green tip; 2= 2 cm growth; 3= 4 cm growth.

point to two discrepancies: 9-8N and 7-11 were rated by Sherman as having a higher chilling requirement than was observed in this study. It was thus seemed desireable to determine more accurately the actual chilling requirement of the various clones. This was done in the course of the next two seasons using potted plants. Mostly one year-old trees raised from hardwood cuttings were planted in spring in 10 l plastic bags filled with a mixture of volcanic tuff and peat moss and fertigated regularly. In early Autumn prior to the onset of active chilling, the plants were transferred to a cold room held at 6^{0}C for 10 or 21 days under an 8 hrs photoperiod. Later the trees were transferred to a greenhouse, heated during 1985/6 but not in 1986/7 and bud break was evaluated separately for flower and lateral vegetative buds. Data for these two years is presented in figures 1 and 2 respectively.

The data obtained in 1985 (Fig 1) confirmes the field observations that 7-11 and 9-8N require less chilling that was supposed previously. These data were confirmed in the following year (Fig 2). Furtheremore, it seems that the clones 3-2 and 9-11N require more chilling than was supposed previously. The relative chilling requirements of the clones tested in comparison to commercially grown cultivars is shown in Figures 3 and 4 for 1985/6 and 1986/7 respectively. The following clones ar...

require about 240 hrs of continuous chilling: Flordaprince, and to a lesser degree 9-8N. Higher chilling requirement of about 360 chilling hrs was shown by 3-2, 9-10, 9-12N, 9-15N, 9-6N, 9-9N, and 7-11. The clones: 13-72, 9-13N, 83-4 and 9-7N require more chilling.
A quadratic function seems to link flower and vegetative bud break as can be seen from figure 5.

4. Bud set in the new clones.

Flower bud set (formation) was evaluated first in the end of the 2nd growing season in plants planted in Bet-Dagan in spring 1984.
Flower buds were produced to a high degree in most of the clones but especially prolific were: 7-11, 9-15N, F. Gem and 9-7N. The low flower bud set was found in 9-8N.
In 1986 all clones were headed back after the first harvest in May. The level of bud set was determined in January 1987 (Fig 6). Again, 9-8N is the poorer setter followed by moderate flower bud setters: 9-7N, 9-10, and 9-13N. Better still were 7-11, F. Gem, 9-15N, and 9-9N. The best one was F. Prince.

5. Evaluation of the fruit characteristics of the new clones.

Peach and nectarine fruit was picked from trees grown in the meadow orchard or in the containers. Only few fruits per tree were collected. Time of harvest mean average fruit weight as well as TSS were recorded. The data obtained is summarized in Table 5

Table 5: Fruit characteristics obtained with trees grown from cuttings in Bet Dagan

Clone	Harvest date	Fruit wt. (g)	TSS (%)	Remarks
F. Prince	5/13	98.0	7.5	
Maravilha	5/11	89.0	9.7	
8-2N	5/23	51.9	-	Elongated
9-13NR	5/22	63.1	8.9	Elongated
9-8N	5/18	88.1	12.9	
9-9N	5/23	71.0	8.6	Pointed tip
9-7N	5/28	73.4	16.3	
9-15N	5/23	70.5	10.5	
7-11	5/29	66.0	9.5	
83-4	5/25	107.1	12.1	

The very first fruit can not represent the fruit of the bearing tree as it ripens later and is smaller than the typical fruit of the mature tree. With these reservations in mind it seems that 9-8N,9-7N and 83-4 are the more interesting clones among the tested group. A wider group will be evaluated only in 1987.

6. Future prospects.

The clones obtained and tested in the course of the duration of this project were found to be a very valuable plant material. Quite a few clones were shown to have a very low chilling requirement and a very high level of bud set after heading back. Among the clones tested it seems that 9-7N, 9-15N and 83-4 are more promising as interesting material for meadow orchards and other similar systems. The cooperation strengthened by the project will hopefully continue so that further evaluation of new clones from Sherman's breeding work in Florida will be carried out after termination ot this work.

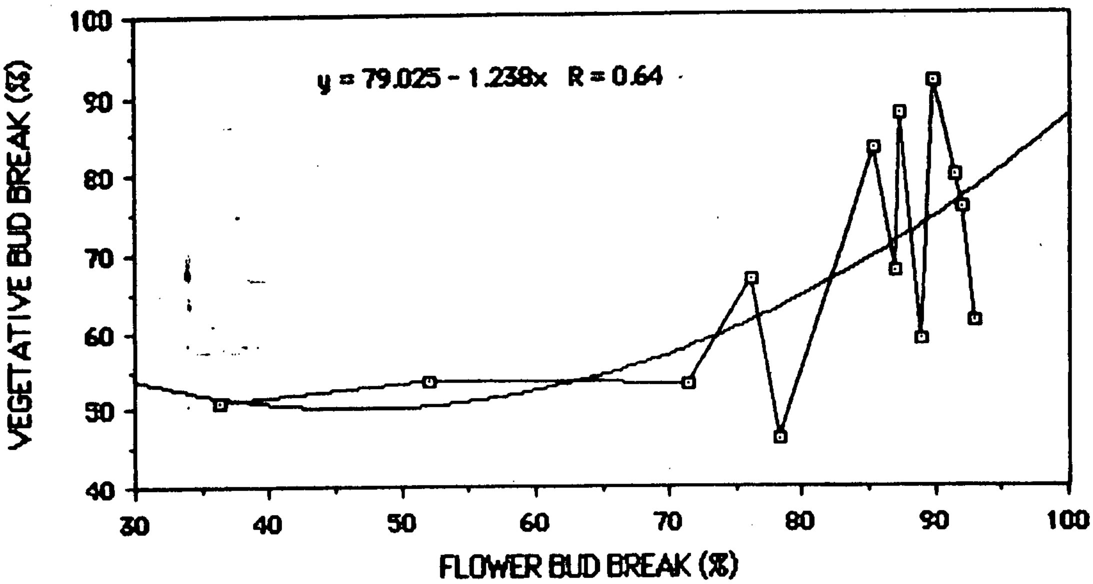

FIG. 5: COMPARISON OF VEGETATIVE AND FLOWER BUD BREAK IN VARIOUS PEACH CLONES

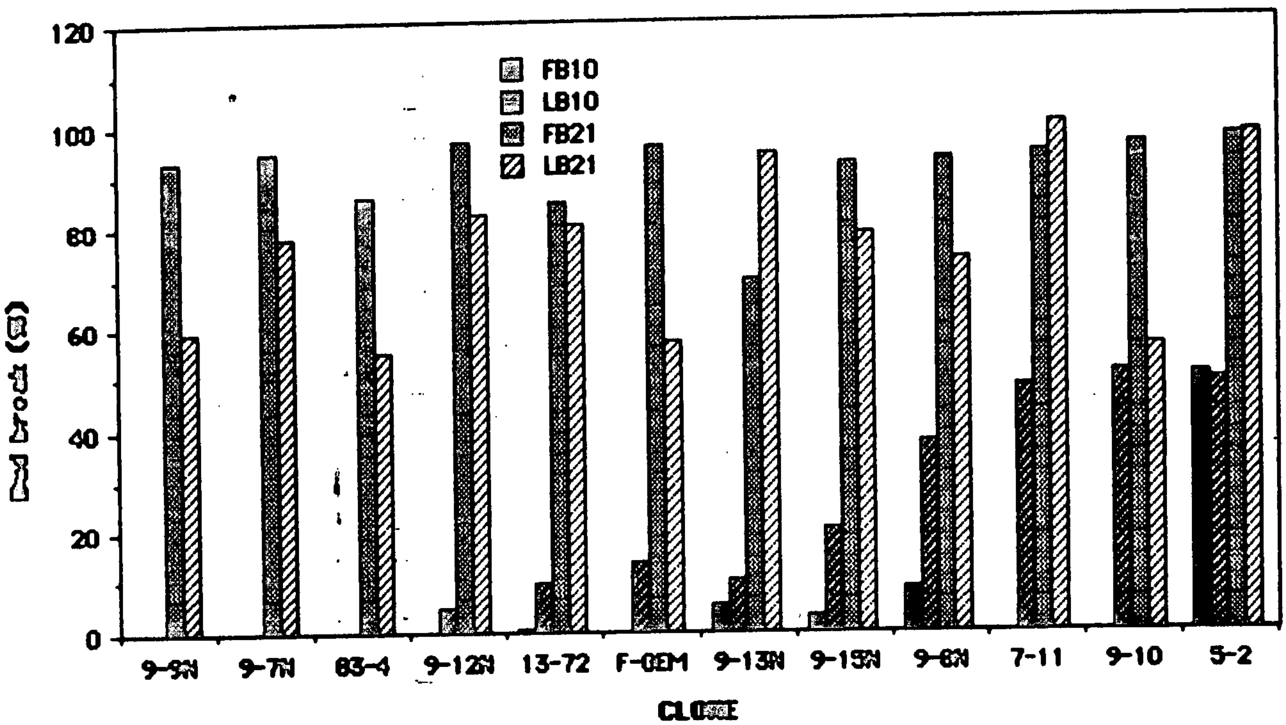

FIG. 3: EFFECT OF EXPOSURE TO 10 OR 21 DAYS AT 6C ON BUD BREAK IN VARIOUS PEACH CLONES

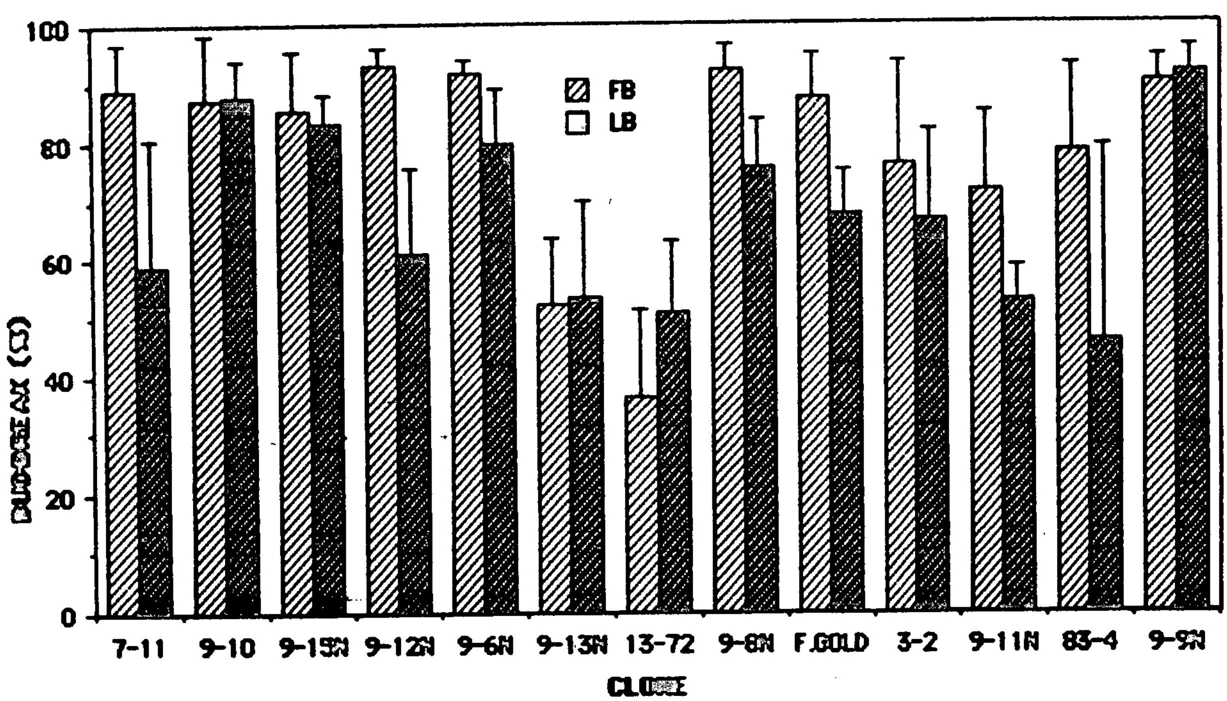

Fig. 4 EFFECT OF EXPOSURE TO 10 DAYS AT 6C ON BUDBREAK IN VARIOUS PEACH CLONES

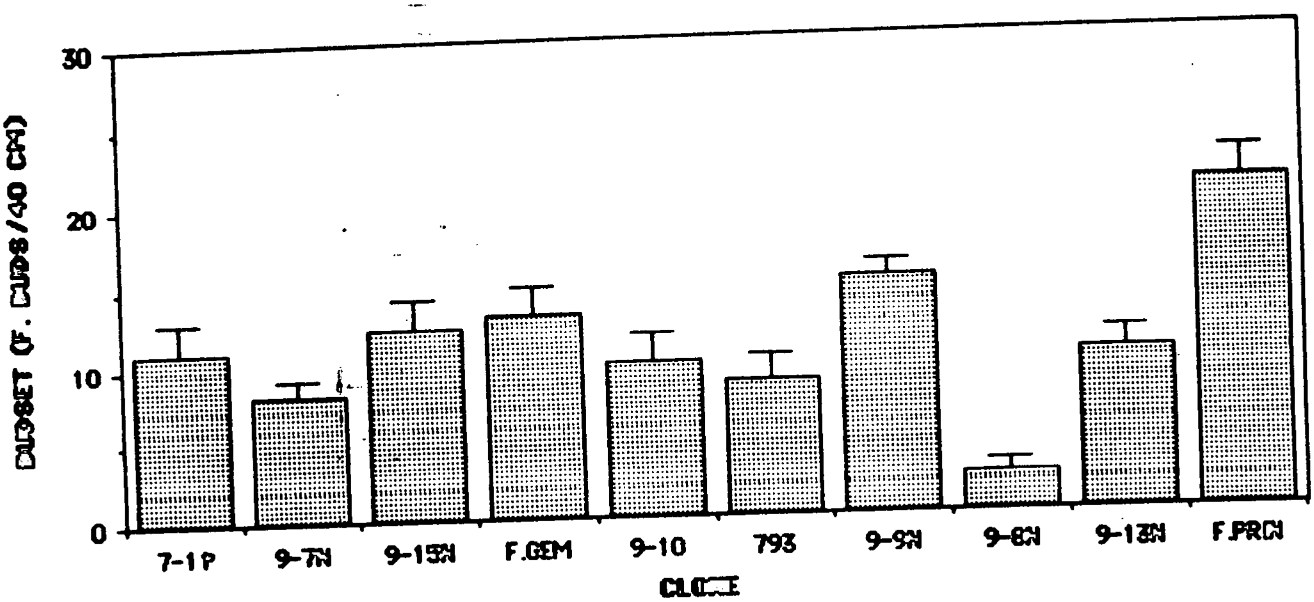

FIG. 6: BUD SET ON VARIOUS PEACH CLONES IN RESPONSE TO TOP REMOVAL

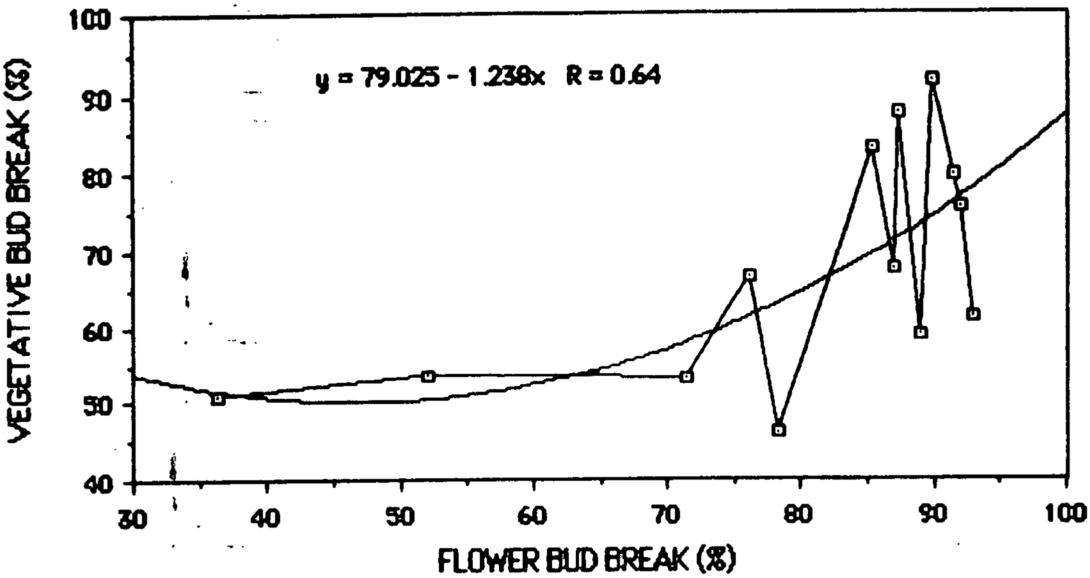

FIG. 5: COMPARISON OF VEGETATIVE AND FLOWER BUD BREAK IN VARIOUS PEACH CLONES