water loss and further studies should be conducted to examine this relationship. Satisfactory yields on mature trees and adequate consumer acceptance implies that the late maturing cultivars, 'Bosc' and 'Anjou,' could be grown and marketed through the present distribution system.

Literature Cited

1. Embree, C. G., A. D. Crowe and H.-Y. Ju. 1986. Yield patterns over 5 years for Clapp's Favorite, Bartlett, Flemish Beauty, Bosc and Anjou pears in 25 year old orchard. Kentville Research Station Annual Report. 1986.
2. Bligh, R. D. L. 1949. Pear growing in the Annapolis Valley. Can. Dept. Agric. Publ. 824.
3. Mellenthin, W. M., P. M. Chen and S. B. Kelly. 1980. Low oxygen effects on dessert quality, scald prevention and nitrogen metabolism of 'd'Anjou' pear fruit during long-term storage. J. Amer. Soc. Hort. Sci. 105:522-527.
4. Wang, C. Y. and Mellenthin, W. M. 1975. Effect of short-term high CO_2 treatment on storate of d'Anjou pear. J. Amer. Soc. Hort Sci. 100:492-495.

Fruit Varieties Journal 42(3)79-85 1988

Inbreeding and Co-ancestry of Low Chill Short Fruit Development Period Freestone Peaches and Nectarines Produced by the University of Florida Breeding Program

RALPH SCORZA, W. B. SHERMAN, AND G. W. LIGHTNER[2]

Abstract

Inbreeding coefficients and coefficients of coancestry were calculated for low chill requiring, short fruit development period (FDP) peaches released from the University of Florida (UF) breeding program. Inbreeding was relatively low for most cultivars as were coefficients of coancestry for most parental combinations. The UF cultivars represent a diverse pool of germplasm with potential for commercial production or for extending the genetic base of breeding programs in the tropical highlands and subtropics.

The peach (*Prunus persica* (L.) Batsch) is self fertile and naturally self pollinates. It is considered tolerant of inbreeding, and open pollination usually results in less than 5% outcrossing (2, 4, 5). The peach's natural tolerance of inbreeding and the repeated use of germplasm of high fruit quality has led to the development of a limited germplasm base for the major freestone cultivars grown in the eastern U.S. The relatively narrow range of variation in disease, insect, cold, and other stress resistance has been cited as a function of this limited genetic base (8).

Since the early 1950's the University of Florida (UF), Gainesville, Florida, has developed a breeding program for the production of low chill requiring, short fruit development period (FDP) peaches. Low chill requirement is not desirable for peaches grown in the major temperate zone production areas due to the tendency of low chill genotypes to bloom during warm periods that can occur in late winter. Thus, the character was generally not available in germplasm in most other U.S. breeding programs. A short FDP (<100 days) is important in Florida because fruit must be harvested before

Table 1. Inbreeding coefficients of peach and nectarine cultivars from the University of Florida breeding program.

Cultivar	Parentage	Inbreeding Coefficient Case I	Case II
Columbina(N)[1]	Sunlite op	.008	.500
Desertred	FLA 3-4 X FLA 5-9	.081	.162
Flordabearty	F 2-678 op	0	.609
Flordabelle[2]	[(Southland X Hawaiian) op] X Flordawon	.063	.500
•Flordagold[2]	RioGrande op	0	.500
•FlordaGrande[2]	(Flordasun X Springtime) X FLA 5-58	.192	.277
Flordahome[2]	(PI 146130 X P. davidiana) op 2X[3]	0	.500
•Flordaking[2]	FLA 9-67 X Early Amber	.188	.250
•Flordaprince[2]	FLA 27 X Maravilha	.030	.117
Flordaqueen[2]	(Southland X Jewel) op	0	.500
Flordared[2]	(Southland X Hawaiian) op 4X[3]	0	.750
Flordasun[2]	L 1-15 X Springtime	0	0
Flordawon[2]	(Southland X Hawaiian) op 2X[3]	0	.750
Hermosillo	FLA 5-5 X FLA 3-4	.021	.049
KGold (N)	FLA 4-65 X FLA 68-50	.020	.078
Maravilha	Sunred X (FLA 14-32 op)	.008	.063
McRed	F 62-77 op	0	.781
Okinawa	Unknown (seed importation-rootstock)	0	0
Opedepe	Flordabelle X FV 9-266	.041	.109
Rayon	FLA 16-61 X KGold	.039	.156
San Pedro	Flordasun X Springtime	.250	.250
Shermans Early	LFA 9-33 X FLA 10-48	.018	.098
Shermans Red	Sunred X Springbrite	.020	.066
Sundowner (N)[2]	(Sunred X Columbina) op	0	.547
Sungold (N)[2]	NJ 5107397 X (Okinawa X Panamint)	0	0
Sunhome (N)[2]	(KGold X FLA 1-59) X Sunred	0	.553
•Sunland (N)[2]	FLA 3-4 X Armking	0	0
Sunlite (N)[2]	(Okinawa X Panamint) X NJN 21	0	0
Sunrich (N)[2]	NJ 5107397 X (Okinawa X Panamint)	0	0
Sunred (N)[2]	[Panamint X (Southland X Hawaiian F_2)] op	0	.500
Sunripe (N)[2]	(Flordawon X Merril Princess) op	.254	.406
•TropicSweet[2]	FLA 46-95 X KGold	.023	.094
	Mean inbreeding	.039	.286
Cultivar Grouping			
6 elite UF cultivars (indicated by •)	"	.072	.206
Eastern Freestone peaches	"	.039	.156
30 selected Eastern Freestone peaches[4]	"	.103	.244

1 (N) = nectarine.
2 Official releases by IFAS, Univ. of Fla. Others given clonal names elsewhere.
3 Number of times self pollinated.
4 Inbreeding coefficients of cultivars with incomplete pedigrees calculated as zero instead of being excluded from calculation as in Scorza *et al.*, 1985 (8).

the rainy season begins in early June. This character is not usually found in low chill seed introductions as short FDP is related to lack of seed germination from immature embryos (4). Thus, short FDP was introduced from early-ripening U.S. temperate zone genotypes. The UF breeding program has developed cultivars from crosses involving low chill requiring seedlings introduced by the ealry Spanish settlers in the southern U.S., imported germplasm from Okinawa, south China, and South and Central American, and from improved temperate zone U.S. germplasm.

While the UF produced cultivars may be genetically distinct from the cultivars grown in the more northern areas of the U.S. selection for low chill requirement, short FDP, and high fruit quality may have produced a germplasm base as restricted as that of the more northern cultivars. Since UF cultivars are being tested in over 51 countries and grown commercially in 8 (7), a narrow genetic base would have widespread impact in terms of genetic vulnerability. The following study was undertaken to investigate the extend of inbreeding in the cultivars released by the UF peach and nectarine breeding program.

Materials and Methods

Procedures for the development of the pedigree tracing program, inbreeding, and coefficient of coancestry analyses have been previously outlined (8). Briefly, a pedigree data file was created and the SAS procedure INBREED calculated inbreeding coefficients. The PEDIT program sorted records from the oldest to the most recent generation. Two data files were created for the study, the first, case I, was based on pedigrees using 'J.H. Hale' as the progeny of unknown parents and 'Elberta' and 'Belle' as the offspring of unrelated, unknown pollinizers of 'Chinese Cling.' Open pollinations in case I were assumed due to outcrossing to unrelated males. The second data set, case II, incorporated assumptions which would give higher inbreeding coefficients. Assumptions were based on undocumented but probable pedigrees resulting from uncontrolled pollinations. In this case 'J.H. Hale' was assumed to result from self polination of 'Elberta.' 'Elberta' was the offspring of 'Chinese Cling' X 'Early Crawford.' 'July Elberta' was considered to be an open pollinated seeding of 'Elberta.' All "open pollinations" in case II were assumed to be the result of selfing, except for male sterile genotypes. Progeny from open pollinations of male sterile cultivars were assumed to result from outcrossing to unknown males. Parents of unknown origin in cases I and II, were assumed to be unrelated and non-inbred. It was also assumed that selection carried out by the breeding program in segregating seedling populations had not altered the probabilities of identity by descent of alleles. The PEACHPED program traced pedigrees.

Results and Discussion

Inbreeding coefficients of cultivars for case I were low except for 'Florda-Grande,' 'Flordaking,' 'San Pedro,' and 'Sunripe' (Table 1). If the assumptions for case II are considered, ie, the maximum amount of inbreeding possible given our knowledge of probable pedigrees, many cultivars have coefficients greater than 0.125, the inbreeding coefficient for half sibs. Some notable exceptions with low inbreeding coefficients for case II include 'Flordasun,' 'Hermosillo,' 'K Gold,' 'Maravilha,' 'Okinawa,' 'Opedepe,' 'Shermans Early,' 'Shermans Red,' 'Sungold,' 'Sunland,' 'Sunlite,' 'Sunrich,' and 'TropicSweet.' The mean inbreeding coefficient of UF peach cultivars (.039 case I; .286 case II) (Table 1.) is identical for case I and higher for case II than the mean inbreeding of eastern US freestone peaches (.039 case I; .156 case II) (8). The assumption that all open pollination resulted in selfing

Table 2. Coefficients of coancestry of University of Florida peach and nectarine cultivars.

Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
														Case I																		
1. Columbina	500	197	018	012	008	009	---	011	021	016	008	007	008	144	024	024	010	063	017	020	007	013	021	130	078	010	134	250	078	020	014	020
2. Desert Red		541	020	014	016	011	---	014	024	099	017	099	099	161	086	028	010	063	019	052	009	016	026	056	086	020	150	206	086	028	014	052
3. Flordabeauty			500	050	028	021	---	033	037	033	051	017	033	045	039	029	037	---	062	053	009	035	060	010	---	011	010	035	---	023	026	042
4. Flordabelle				532	021	019	---	141	084	030	035	015	282	054	030	019	021	---	286	156	008	085	028	007	---	008	007	024	---	015	079	032
5. Flordagold					500	019	---	020	014	014	024	015	014	017	014	011	014	---	028	021	015	018	021	004	---	004	004	016	---	007	010	016
6. Flordagrande						596	---	130	014	255	017	255	012	053	020	012	009	---	096	022	284	158	094	006	008	006	006	017	008	014	007	017
7. Flordahome							500	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
8. Flordaking								594	073	020	025	104	032	070	026	016	014	---	131	138	146	119	069	007	007	008	007	022	007	016	014	025
9. Flordaprince									515	190	026	011	025	057	040	267	015	063	058	091	007	080	086	040	024	042	013	041	024	140	013	032
10. Flordared										500	024	063	020	018	020	013	014	---	029	030	032	033	019	005	---	005	005	016	---	010	011	022
11. Flordaqueen											500	014	024	029	025	022	028	---	046	036	009	025	035	007	001	007	007	032	001	013	018	028
12. Flordasun												500	010	042	016	010	077	---	077	018	375	165	075	005	006	005	005	014	006	011	006	014
13. Flordawon													500	021	020	013	014	---	155	041	005	026	019	005	---	005	005	016	---	010	131	022
14. Hermosillo														511	091	030	020	047	064	090	055	097	086	043	052	021	135	100	052	029	018	059
15. K Gold															510	042	014	---	032	275	014	029	051	023	032	081	074	047	032	068	011	267
16. Maravilha																504	013	063	024	034	008	022	141	070	032	071	015	047	032	254	009	029
17. McRed																	500	---	034	021	004	014	027	004	---	004	004	020	---	007	015	018
18. Okinawa																		500	---	---	---	032	---	016	125	016	032	125	125	---	---	---
19. Opedepe																			521	100	101	088	074	009	003	009	009	034	003	017	055	035
20. Rayon																				520	012	087	044	016	016	046	041	039	016	044	019	155
21. SanPedro																					625	145	103	005	009	005	005	013	009	011	003	010
22. Shermans Early																						509	055	008	011	010	008	027	011	020	012	026
23. Shermans Red																							510	070	019	072	014	042	019	260	018	039
24. Sundowner																								500	028	036	038	073	028	130	005	015
25. Sungold																									500	016	047	157	250	032	012	020
26. Sunhome																										500	015	020	016	134	004	044
27. Sunland																											500	080	047	017	006	041
28. Sunlite																												500	157	039	028	039
29. Sunrich																													500	032	012	020
30. Sunred																														500	006	040
31. Sunripe																															627	105
32. Tropic Sweet																																512
Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

Table 3. Coefficients of coancestry of University of Florida peach and nectarine cultivars.

Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Case II																																
1. Columbina	750	349	074	063	063	041	---	046	078	063	071	045	063	236	063	102	086	125	060	063	036	050	075	422	164	088	208	500	164	094	074	067
2. Desert Red		590	118	108	191	070	---	075	091	108	090	078	108	221	131	104	122	078	096	119	063	078	096	228	120	114	180	286	120	108	009	116
3. Flordabeauty			809	274	231	132	---	155	173	274	211	160	274	145	160	163	321	---	229	217	104	172	207	129	024	161	042	074	024	184	174	184
4. Flordabelle				750	219	137	---	324	246	313	188	172	688	158	157	141	235	---	442	391	102	262	145	110	016	137	037	063	016	157	242	180
5. Flordagold					782	151	---	151	123	219	157	164	219	113	110	110	242	---	198	164	137	151	142	086	039	123	034	063	039	110	104	153
6. Flordagrande						621	---	190	079	192	110	305	137	100	076	073	127	---	181	106	315	214	155	062	023	078	023	041	023	083	090	091
7. Flordahome							750	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
8. Flordaking								631	150	168	117	186	262	122	093	286	141	---	248	240	195	200	136	073	022	089	026	046	022	101	118	106
9. Flordaprince									559	168	117	097	215	120	120	324	143	094	165	199	061	166	175	172	049	187	041	078	049	266	098	117
10. Flordared										875	188	391	313	119	157	141	235	---	223	235	221	239	145	110	016	137	037	063	016	157	149	180
11. Flordaqueen											750	125	188	100	102	117	235	---	168	145	094	121	129	090	024	100	033	071	024	110	117	121
12. Flordasun												516	172	104	092	086	149	---	190	132	391	238	153	072	022	090	026	045	022	098	102	109
13. Flordawon													875	143	157	141	235	---	410	328	102	213	145	110	016	137	037	063	016	157	289	180
14. Hermosillo														529	134	101	136	063	135	154	097	145	144	172	083	110	150	174	083	108	095	117
15. K Gold															539	129	117	---	115	348	060	102	134	129	039	242	088	063	039	196	074	321
16. Maravilha																532	139	125	113	135	059	102	246	254	073	263	051	102	073	407	079	115
17. McRed																	899	---	235	176	106	148	176	102	032	127	040	086	032	117	199	164
18. Okinawa																		500	---	---	---	032	---	063	125	063	047	125	125	---	---	---
19. Opedepe																			567	247	173	204	157	089	023	111	032	060	023	117	185	140
20. Rayon																				578	081	198	139	119	028	190	063	063	028	176	135	250
21. SanPedro																					663	190	157	052	025	066	020	036	025	069	078	073
22. Shermans Early																						554	128	081	024	100	028	050	024	112	109	114
23. Shermans Red																							539	245	050	259	042	075	050	414	101	125
24. Sundowner																								774	117	261	133	297	117	422	074	108
25. Sungold																									500	069	070	164	250	071	051	039
26. Sunhome																										780	061	088	069	434	090	174
27. Sunland																											500	146	070	057	034	062
28. Sunlite																												500	164	094	074	067
29. Sunrich																													500	071	051	039
30. Sunred																														750	074	149
31. Sunripe																															711	221
32. Tropic Sweet																																551
Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

raises the inbreeding coefficients for case II in the UF cultivars since several resulted from repeated open pollinators (Table 1).

Many cultivars released by the UF were either intended for home owners or are no longer suitable under current fruit market standards. In addition, many of the UF clones named in other countries do not meet minimum U.S. market standards in fruit qualities such as size, color, firmness, shape, or resistance to cracking. Only 'Floridagold,' 'FlordaGrande,' 'Flordaking,' 'Flordaprince,' 'Sunland,' and 'TropicSweet' are currently recommended for commercial production. These elite cultivars have average inbreeding coefficients of .072 and 2.06 for case I and case II respectively. These values are lower than the average inbreeding coefficients for the 30 selected eastern US freestone cultivars and comparable to the inbreeding of all eastern US freestone peaches (0.39 case I; .286 case II) (8). This indicates that while inbreeding has been necessary for the development of commerical fruit quality, high levels of inbreeding are not necessary to incorporate the low chill, short FDP characteristics into high fruit quality genotypes. It may alternatively be stated that although unique, unrelated germplasm has been incorporated into these cultivars, a certain level of inbreeding, i.e., a level comparable with that of eastern US freestone peach germplasm in general, seemed to be necessary to obtain commercial fruit quality.

There was no correlation between the year of cultivar release and inbreeding, as has been found in highbush blueberries (3). The absence of such a correlation indicates that unrelated germplasm is being continually brought into the program and used in cultivar development.

Coefficients of coancestry analyses (Tables 2 and 3) indicate that except for a relatively few specific combinations, the inbreeding potential of the UF germplasm is low and represents a rich source of low chill requiring, short FDP peach and nectarine germplasm. Recent influxes of new germplasm into the breeding program include low chill genotypes from Venezuela, Peru, southern Brazil, Mexico, the Canary Islands, and Australia. These accessions possess characters such as evergreen foliage, peento (flat) fruit shape, nematode resistance, and non-melting flesh. These genotypes are now 1 to 3 generations in combination with low chill, short FDP germplasm. With current emphasis on fruit quality, potential cultivars are expected to be selected within 5 years. The incorporation of these characters has proceeded at a rapid pace because their inheritance is relatively simple and most are readily selected. This implies that the development of peach cultivars with additional unique characters controlled by 1 or few genes such as dwarf and compact growth habits (1, 6), white flesh (1), and "stony hard" flesh (9), can proceed rapidly, provided that the new character(s) can be readily selected and provided that crosses with high fruit quality genotypes are included in the breeding program. The development of new germplasm and cultivars having characters unique for commercial production would be useful not only for low chill areas but for the temperate zone as well.

Literature Cited

1. Bailey, J. S. and A. P. French. 1949. The inheritance of certain fruit and foliage characters in the peach. Mass. Ag. Expt. Sta. Bull. 452, Univ. Mass., Amherst. 31 p.
2. Fogle, H. W. 1977. Self-pollination and its implication in peach improvement. Fruit Var. J. 31:74-75.
3. Hancock, J. F. and J. H. Siefker. 1982 Levels of inbreeding in highbush blueberry cultivars. HortScience 17:363-366.
4. Hesse, C. O. 1975. Peaches. p. 285-355. *In:* J. Janick and J. N. Moore (eds). Advances in Fruit Breeding. Purdue Univ. Press, West Lafayett, Ind.

5. Lesley, J. W. 1957. A genetic study of inbreeding and of crossing inbred lines in peaches. Proc. Amer. Soc. Hort. Sci. 70:93-103.
6. Mehlenbacher, S. A. and R. Scorza. 1986. Inheritance of growth habit in progenies of 'Com-Pact Redhaven' peach. HortScience 21:124-126.
7. Mowery, B. and W. B. Sherman. 1984. Breeding early ripening low-chilling peaches in Florida. Fruit Var. J. 38:6-8.
8. Scorza, R., S. A. Mehlenbacher, and G. W. Lightner. 1985. Inbreeding and coancestry of freestone peach cultivars of the eastern United States and implications for peach germplasm improvement. J. Amer. Soc. Hort. Sci. 110:547-552.
9. Yoshida, M. 1976. Genetical studies of the fruit quality of peach varieties. III Texture and keeping quality. (In Japanese). Bull. Fruit Tree Res. Sta. A3:1-16.

Fruit Varieties Journal 42(3)85-87 1988

Performance of Selected Peach Rootstocks in Ohio[1]

DAVID C. FERREE AND JOHN C. SCHMID[2]

Abstract

'Veteran' on 12 clones of *P. besseyi* was compared to 'Veteran' on Siberian C over a 10-year period with no particular advantage of any of the clones. Own-rooted 'Redhaven' was compared to 'Redhaven' on 8 other rootstocks. Trees in this trial experienced severe tree loss due to winter injury between the second and third year of growth. Trees on GF655-2 and Damas 1869 survived better than on the other rootstocks. Trees on Damas 1869 root-suckered badly.

Introduction

Peach production in the Midwest has declined markedly in recent years primarily due to the loss of crops resulting from fluctuating cold winter temperatures. The winter conditions have also caused significant tree loss due to winter injury and the subsequent increase of peach canker in the injured tissue. Tree losses in commercial orchards often occur first in imperfectly drained areas of the field.

Considerable grower interest exists in identifying a rootstock more tolerant of imperfectly drained soil that will survive more adverse weather conditions. Another interest is in the production of a smaller more efficient tree to facilitate more intensive orchards that will produce significant crops earlier in the life of the orchard. The two trials reported here evaluated selected rootstocks based on these criteria.

Materials and Methods

In 1977, Dr. James Cummins of the New York Agricultural Experiment Stateion at Geneva, donated 'Veteran' peach trees on 12 clones of *Prunus besseyi*. They were selected as promising trees from a New York orchard. Since there were variable numbers of trees of each clone, the trees were planted in a completely randomized design with trees of 'Veteran' on Siberian C as a control. The trees were planted 9' x 18' at the Jackson Branch of the Ohio Agricultural Research and Development Center.

In 1984, the NC-140 peach rootstock trial, 'Redhaven' peach was established at Wooster, Ohio. The trees were spaced 4.5 m x 6.0 m and trained as open center trees. The rootstock treatments were arranged as a randomized complete block with 10 single tree replicates with a guard row surrounding the planting. Trunk circumferences

[1]Salaries and research support provided by state and federal funds appropriated to the Ohio State University. Journal Article No. 235 87.
[2]Professor and Agricultural Technician, Department of Horticulture, The Ohio State University/ OARDC, Wooster, OH 44691. Appreciation is extended to Paul Brown of Jackson and John Elliott of Wooster for care of the trees.