Interspecific Breeding Germplasm for Rootstock Research & Development

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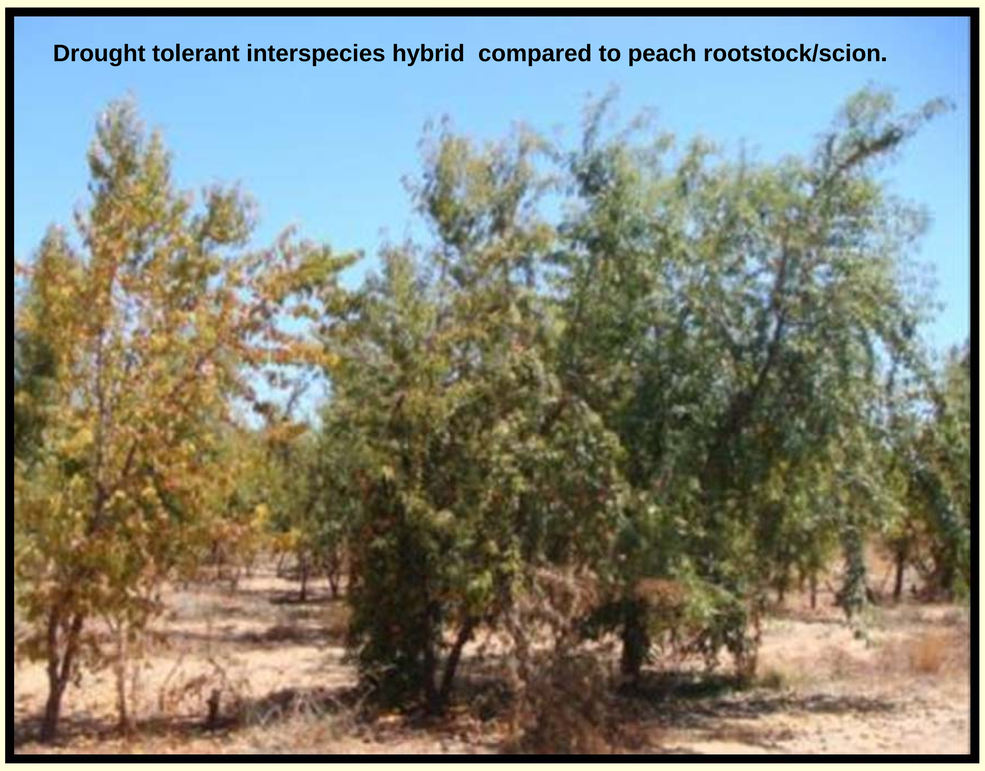
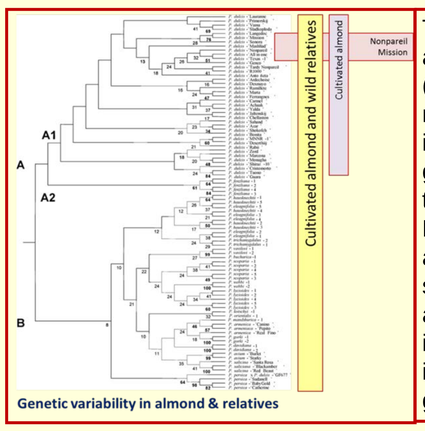
Location: Plant Sciences, University of California/ Davis



Introduction and Approach

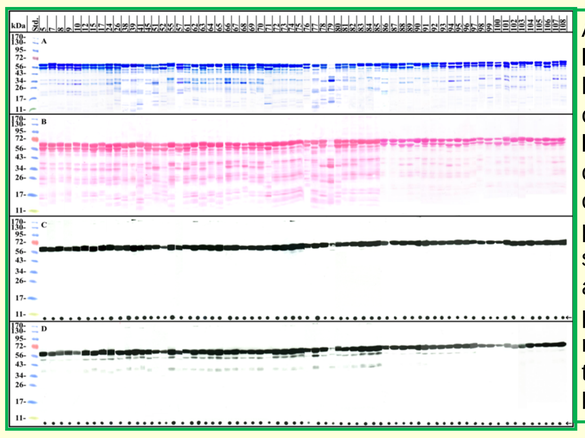
Inter-species crosses, an important source for self-fruitfulness and disease resistance in the UCD Almond Variety Development program, can also contribute to rootstock improvement since many important high-vigor and/or disease resistant rootstocks have interspecies origins. Interspecific UCD hybrids have demonstrated continued productivity under drought stress (see top-right image) and modified scion tree architecture when used as rootstocks (see very bottom-right image). The goal of this project is to collect, preserve and distribute a comprehensive sampling of the diverse germplasm developed by the UCD variety improvement program for use by public and private researchers and breeders working to advance the development of improved rootstocks and interstocks. Further studies of this germplasm will also improve our understanding important disease and drought resistant traits. The identification of appropriate germplasm is being pursued through field and laboratory evaluations and through genomic studies to facilitate an improved understanding of the genetic basis of rootstock performance/potential in collaboration with UCD, UCR, USDA/ARS researchers and private nurseries and breeders.



Genetic variability in almond & relatives

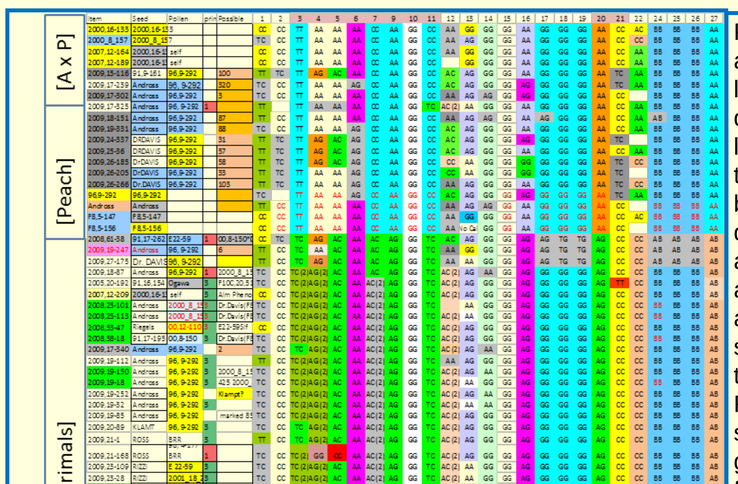
The phylogenetic tree at left shows almond and closely related species (items within the same branch are more closely related). The red bar identifies traditional California germplasm while the violet shows the greater diversity when Mediterranean and Asian varieties are added. The yellow column shows the larger diversity when wild and cultivated (peach) relatives are included. The UCD program has incorporated much of this larger germplasm for variety improvement.

Many of the wild species incorporated into UCD breeding lines have evolved high levels of resistance to stresses in their native habitat (*Prunus scoparia* in the Persian dessert at left). Resistance is expressed in both root as well as shoot development, complicating its direct use as a rootstock. Conversely, native germplasm can be susceptible to non-native threats requiring the appropriate recombination of desired traits from different genetic backgrounds.



A sizable proportion of this larger, diverse germplasm has already been partially characterized. The chart at left shows the results from a chemical analysis of compounds (primarily proteins) involved in seedling growth vigor as well as cross-recognition and possible graft-incompatibility responses. [Numbers refer to the genotypes in the Table below].

A frequent characteristic of interspecies hybrids is a pronounced growth vigor which is often maintained when used as a rootstock with standard varieties as scions. As interspecific hybrids, however, it is difficult to combine desirable traits from multiple sources. Some of our advanced introgression lines demonstrate hybrid vigor (left compared to peach) despite their advanced introgression level (typically 80-90% cultivated genome). These breeding lines (designated as Primals) may thus facilitate the incorporation of desirable traits from multiple genetic backgrounds.



Primals are genetically distinct from almond, peach and almond x peach (AxP) introgression lines as shown at left by 9K SNP mini-array marker patterns for primals demonstrating hybrid vigor (as in image above) but in a largely peach genomic background. (Similar primal-types have also been recovered in mainly almond backgrounds). The molecular data clearly distinguishes primals from standard peach and almonds and also suggests that certain markers (and associated DNA/chromosome segments) may be associated with this trait (markers shown are a smaller selected subset from a larger dataset). We plan to test these associations in the much more comprehensive RosBREED-2 project beginning in 2015. The successful identification of a relatively few number of genetic segments (loci) conferring growth vigor would facilitate the subsequent accumulation (pyramiding)of other disease and stress resistance genes, particularly if effective molecular markers could be identified.

No.	Genotype	Origin	(%) Almond genome	Nut Length (mm)	Kernel Length (mm)	Nut Width (mm)	Kernel Width (mm)	Nut Thickness (mm)	Kernel Thickness (mm)	Nut Mass (g)	Kernel Mass (g)	Soluble protein (g/100 g)	R-ELISA	R-WB	R-DB
99	A7-23	*P. argentea* (bitter seed)	0	19.03	13.38	15.25	9.73	12.05	6.04	1.47	0.37	17.28	0.61	0.64	0.61
107	A7-25	*P. webbii* (bitter seed)	0	28.97	20.39	18.28	11.75	13.66	7.26	2.93	0.82	19.09	0.51	0.75	0.57
102	F10D,2-14	*P. fenzliana* (F2)	0	30.55	22.3	16.48	11.38	11.33	8.43	4.54	1.03	19.21	1.66	0.78	1.1
52	Halford	Peach (*P. persica*) (bitter seed)	0	35.31	17.77	26.12	11.43	19.5	3.89	6.21	0.36	20.65	0.39	0.53	1.01
105	A10-4	*P. bucharica* (bitter seed)	0	19.14	14.33	10.33	6.62	7.35	4.66	0.58	0.21	20.94	0.59	1.01	0.82
87	A7-28	*P. webbii* (bitter seed)	0	25.72	18.43	14.13	9.1	10.2	6.3	1.39	0.49	21.04	0.88	1.11	1.03
101	F10D,2-12	*P. fenzliana* (F2)	0	26.49	20.61	16.11	10.78	11.51	7.04	1.41	0.77	21.38	1.53	1.06	1.44
71	P11-58	*P. mira* (bitter seed)	0	26.55	14.48	17.75	9.86	12.82	4.33	2.48	0.29	23.39	0.53	0.79	0.83
76	A13-1	*P. persica* × *P. davidiana* (bitter seed)	0	21.47	13.77	20.69	11.41	17.83	6.1	3.83	0.46	23.41	0.45	0.5	0.9
51	40A-17	Peach (*P. persica*) (bitter seed)	0	24.25	13.35	16.83	7.18	12.45	3.35	1.81	0.11	23.74	0.51	0.52	1.02
106	A2-11	*P. tanguitica* (bitter seed)	0	16.54	13.36	15.23	10.28	12.4	8.28	1.34	0.49	25.44	0.7	0.94	0.87
88	F5,4-42	*P. webbii* (F2)	0	26.82	18.54	14.98	9.46	10.83	6.7	1.96	0.55	25.8	0.64	1.1	1.06
5	F5,4-10	*P. webbii* × (Nonpareil × *P. persica*) BC1	38	27.5	19.69	18.32	11.94	12.78	7.22	2.69	0.78	22.12	0.53	1.02	0.96
77	Hansen2168	Almond × *P. persica*	50	44.06	27.95	28.46	15.71	18.29	7.34	9.07	1.44	12.35	1.57	0.81	1.31
97	F10D,3-24	*P. webbii* (BC1)	50	25.71	19.33	19.52	13.23	13.29	6.13	2.66	0.71	13.39	1.27	0.95	1.16
79	Nickels	Almond × *P. persica*	50	36.88	23.87	28.7	16.37	20.85	8.75	9.18	1.53	13.79	0.75	0.09	0.85
104	F10D,3-50	*P. fenzliana* (BC1)	50	36.2	27.32	19.3	13.93	13.31	8.75	2.37	1.59	15.37	2.18	0.73	0.91
96	F10D,3-13	*P. webbii* (BC1)	50	25.39	19.4	19.08	12.02	13.66	8.03	1.85	0.83	17.07	0.47	0.57	0.87
100	F10D,3-3	*P. argentea* (BC1)	50	29.57	23.42	18.62	12.41	13.8	7.01	1.88	0.96	17.47	0.26	0.4	0.65
93	F10D,3-2	*P. webbii* (BC1)	50	30.57	19.71	17.83	11.09	13.64	6.99	1.53	0.77	17.84	0.66	0.51	1.09
94	F10D,2-5	*P. webbii* (BC1)	50	28.66	20.83	14.57	9.81	11.31	8.07	1.23	0.76	17.99	0.47	0.75	0.86
89	F10D,3-15	*P. webbii* (F2BC1)	50	33.32	24.03	20.99	12.86	14.64	7.18	4.1	0.96	18.58	0.33	0.91	0.82
41	F10C,12-28	(Nonpareil × *P. persica*) F2	50	35.09	20.24	23.93	13.04	17.99	9.02	4.96	1.08	19.32	1.76	0.71	1.19
92	F10D,1-2	*P. webbii* (BC1)	50	29.97	20.76	19.8	12.21	14.21	7.15	1.59	0.84	20.4	0.68	1.11	1.14
91	F10D,1-4	*P. webbii* (BC1)	50	30.79	23.09	18.07	11.93	13.31	7.57	1.94	0.95	20.5	1.32	0.62	1.1
90	F10D,1-22	*P. webbii* (F2BC1)	50	28.91	21.59	21.35	12.65	15.24	7.72	2.45	0.97	21.05	1.78	1.01	1.11
78	Hansen536	Almond × *P. persica*	50	34.51	23.82	24.61	13.93	18.9	7.46	7.44	1.12	21.06	0.66	1	0.77
95	F10D,3-26	*P. webbii* (BC1)	50	33.55	24.05	20.27	11.4	14.4	7.45	3.23	0.93	21.17	1.06	1.02	0.89
45	F10C,20-51	(Nonpareil × *P. persica*) F2 (bitter seed)	50	35.12	25.14	21.25	12.63	14.98	7.31	2.43	1.1	23.87	0.56	0.7	0.69
57	F5,16-60	(Mission × *P. argentea*) F2	50	32.85	23.77	17.06	11.1	11.9	7.34	1.56	0.87	24.08	0.44	0.57	0.99
84	F10D,3-23	Padre × F5,4-4	69	27.45	20.37	19.82	11.85	13.38	7.71	2.32	0.84	14.48	1.49	0.76	1.11
12	F5,20-42	Padre × F5,4-10	69	26.76	21.42	17.85	12.07	14.03	8.18	1.87	1	16.72	0.65	0.99	0.66
83	F10D,1-26	Nonpareil × F5,4-4	69	30.84	23.05	24.82	14.16	15.84	6.87	3.88	1.11	17.64	1.61	1.27	0.99
17	F8N,7-4	F5,4-10 × Sonora	69	31.96	22.74	16.12	10.66	10.66	6.21	1.17	0.76	19.52	0.65	1.14	0.81
39	B010-22	Nonpareil × F5,4-10	69	37.57	24.6	19.31	12.5	14.1	7.07	1.9	1.05	21.06	2.09	1.43	0.89
55	SB13,25-75	Nonpareil × F5,4-10	69	NA	23.08	NA	12.54	NA	7.76	NA	1.17	22.18	1.78	0.94	1.49
82	F10D,2-18	Nonpareil × F5,4-4 (see No. 4)	69	24.86	19.04	17.53	10.8	13.13	8.47	1.95	0.8	22.4	0.76	0.65	1.2
15	F8N,6-68	F5,4-10 × Solano	69	30.72	21.57	19.93	12.47	14.38	7.19	1.89	0.96	23.47	0.88	1.02	0.91
81	F10D,3-7	Almond × *P. webbii* × *P. persica* (BC2)	84	26.25	20.45	16.6	10.62	12.64	6.74	1.41	0.69	15.35	0.42	0.55	0.77
72	97,1-232	SB13,25-75 × Winters (see No. 55)	85	NA	23.62	NA	13.42	NA	8.16	NA	1.29	20.61	2.06	0.99	0.9
9	F5,13-54	(Mission × *P. fenzliana*) BC1 × Sonora	88	37.19	23.69	19.52	11.92	16.68	8.31	2.94	1.05	16.28	0.7	0.54	0.68
10	F5,10-9	(Mission × *P. fenzliana*) BC1 × Sonora	88	27.28	21.12	18.82	12.24	14.15	7.04	3.08	0.82	18.11	0.61	1.08	0.99
103	F10D,2-3	(Mission × *P. fenzliana*) BC1 × Sonora	88	27.63	21.82	20.09	13.17	16.3	8.92	3.24	1.13	20.71	1.56	0.89	1.15
7	F5,6-13	(Mission × *P. fenzliana*) BC1 × Sonora	88	32.03	22.06	17.25	10.83	10.51	6.71	1.66	0.84	25.6	0.95	0.83	0.84
8	F5,6-1	(Mission × *P. fenzliana*) BC1 × Sonora	88	33.78	23.01	23.68	14.64	16.75	7.38	5.08	1.33	25.88	0.92	1.13	0.94
108	97,3-40	Almond × *P. webbii* × *P. persica* (BC3)	92	NA	33.26	NA	15.14	NA	8.7	NA	2.08	25.31	0.9	0.9	0.87
75	2004,9-1	Nonpareil × 97,1-232	93	34.28	24.96	23.78	13.46	18.07	7.54	3.15	1.24	14.54	1.89	1.1	0.86
74	2004,8-201	Nonpareil × 97,1-232	93	32.14	24.05	21.45	12.97	13.97	8.13	2.06	1.26	15.81	1.67	1.09	1.22
73	2004,8-160	Nonpareil × 97,1-232 (see No. 72)	93	38.45	28.58	22.52	14.18	15.41	8.64	2.96	1.77	19.84	2	1.15	0.85
38	SB13,54-39E	(Nonpareil × *P. persica*) BC3	94	26.19	16.93	15.83	10.23	12.33	8.18	1.05	0.7	21.51	1.96	0.72	1.16
98	97,2-240	*P. webbii* (BC4)	94	NA	23.76	NA	12.61	NA	9.45	NA	1.28	22.22	0.4	0.61	1
80	2005,20-192	(*P. persica*) BC4	94	37.09	20.55	26.46	14.58	19.27	7.37	7.31	0.99	23.91	0.63	0.88	1
85	2000,2-3	Almond × *P. webbii* × *P. persica* (BC4)	96	NA	23.91	NA	11.62	NA	8.97	NA	1.17	19.89	1.93	0.96	0.75
86	2000,8-27	Almond × *P. webbii* × *P. persica* (BC4)	96	NA	24.26	NA	12.13	NA	8.62	NA	1.2	23.92	0.55	0.87	0.9
68	Tuono	Almond variety	100	38.43	26.35	27.67	16.27	18.3	8.22	5.45	1.58	17.14	0.32	0.96	0.8
69	2004,18-20	Almond variety	100	NA	26.34	NA	13.12	NA	8.7	NA	1.54	18.72	0.68	0.85	0.99
61	Mission	Almond variety	100	27.89	20.76	19.79	12.36	15.77	8.87	2.55	1.04	19.17	0.46	0.84	0.93
64	Ferragnes	Almond variety	100	36.35	26.8	23.06	14.18	17.04	8.29	4.09	1.48	19.37	1.56	1.02	1.21
70	95,1-26	Almond variety	100	NA	29.66	NA	14.25	NA	9.47	NA	1.98	20.94	1.1	0.66	0.74
24	Sonora	Almond variety	100	37.02	27.7	18.89	13.08	12.69	7.8	2.25	1.52	22.07	0.74	1.08	1.13
67	Marcona	Almond variety	100	29.38	21.96	25.83	17.26	19.62	8.75	5.55	1.55	22.22	0.88	1.02	1
66	Winters	Almond variety	100	36.41	26.33	19.25	11.87	14.08	8.13	2.09	1.21	22.37	1.05	0.73	1.3
26	Nonpareil	Almond variety	100	NAc	24.74	NA	13.49	NA	7.86	NA	1.31	23.07	1.02	1	1
65	Sweetheart	Almond variety	100	22.47	19.1	18.98	12.51	14.33	8.84	1.54	0.98	25.52	1.73	1.12	1.16

Considerable horticultural data for this wild germplasm as well as breeding lines resulting from their incorporation (introgression) into a cultivated backgrounds is also being developed. The Table at left summarized nut characteristics for several accessions of wild relatives as well as breeding lines involved in their introgression to a cultivated almond background. [The first data column shows the % cultivated almond in each accession, and the table has been sorted by this variable with the more introgressed material towards the bottom]. Note that a wide variation in commercially desirable traits such as kernel mass is apparent even in mainly wild germplasm.

In addition to hybrid vigor and disease/stress resistance, interspecies hybrids/introgression lines may confer novel traits not obvious from parent characteristics. For example, the peach x *P. scoparia* hybrid 2000,3-205 shows a pronounced affect on *Nonpareil* tree architecture when used as a rootstock as compared with Nemaguard (at left). Different architectures will also affect tolerance to environmental stress and some diseases such as Alternaria leaf spot. Data from a collaborative evaluation by UCD, Fowler Nurseries and Paramount Farms. (Image courtesy of C. Fleck).