Project Number: 90-M3

1990-91 Comprehensive Project Report to Almond Board of California

Project Title: Almond Variety Development

Project Leaders: T.M. Gradziel & D.E. Kester
Location: University of California at Davis

Objectives - Long Range:

I. Develop pollenizers for current varieties, particularly Nonpareil.

II. Develop replacement varieties for Nonpareil and other market types that are self-fertile and with a range of bloom time and maturity.

Objectives - 1990-1991:

A) Consolidate present almond information to facilitate identification and prioritization of almond variety requirements.

B) Develop procedures for increasing the number and efficiency of controlled almond crosses during the short flowering periods.

C) Increase the number of new seedlings resulting from controlled crosses by an additional 50%, to 3000 per year using selected parents with low bud-failure (BF) potential.

D) Characterize the minimum pollination requirements for seed set in almond, and test currently unclassified varieties against the newly identified 4th (Monterey?) incompatibility group.

E) Test newly developed techniques for effectiveness for the direct genetic transformation of established almond varieties, particularly Nonpareil.

Progress Report- January, 1990 - January 1991:

A) An extensive collection of promising almond selections have been established at Winters, CA and has begun to produce a crop during summer, 1990. Harvest dates as well as cropping potential estimates eachave been recorded from these items (Tables 1, 2, 3). Cropping potential is determined based on estimates of nuts per tree and canopy size (estimated from trunk circumference)UMME. Improvements in the understanding of tree bearing habit (1) should lead to improved estimates of cropping potential as well. A diversity of almond types have been observed in these blocks with several items possessing good kernel and shell characteristics and self-compatibility. Kernel samples were collected from selected items and are now being analyzed. Crosses will be made to the most promising items this spring, 1991.

A review of the genetic resources available to almond improvement programs is being published (2). A review of modern almond breeding methods is now being prepared. Journal articles are being written concerning results from work on the 'Jeffries' sport of 'Nonpareil', as well as its use in simulating forced self-pollination in 'Nonpareil', and on the identification and characterization of the 4th cross-incompatibility group.

B&C) Approximately 2,000 seedlings resulting from 1989 crosses were transplanted to evaluation plots at Davis and Winters this spring. Survival was very good (>95%) and plants have made very good growth in 1990. Weather conditions in February, 1990 were favorable for controlled crosses at Davis, Wolfskill, and Delta College plots. Approximately 11,000 crosses were made between parents selected for horticultural quality, self-compatibility and low bud-failure potential, and for genetic/breeding studies (including test crosses to identify source-clones possessing low potential for transmitting bud failure to progeny). A summary of crosses made and seed harvested and planted is provided in Table 4. Approximately 1500 of these seed have now been germinated, grown to seedlings in the greenhouse, hardened-off in lathehouses, and planted to the field (final planting date was 10th of November). [Cross and seedling data is summarized in Table 5.]

The heavy freezes of December 21 & 22 have caused some damage to field planted seedlings with the majority appearing to have survived. Final survival will not be known until growth resumes this spring, however. The final 2,000 seed are now being planted in greenhouses for spring transplanting to the field. Since the expected total of 3,800 seedlings is well above our goal of 3,000 seedlings for 1990, even moderate losses from field freeze damage would leave the program in good condition.

Geminating the seed early so that hardened seedlings go through an winter dormant period is thought to accelerate nut production. In addition it allows an efficient cycling of material through our small greenhouse, while the movement of older seedlings to the outside (lathehouse, etc.) suppresses foliar and insect problems which would otherwise get out of hand in the warm glasshouse. In the future, we plan to move older seedlings to a rebuilt screenhouse for hardening and protection from rodents, rabbits, etc., and develop a radiant heating capability to protect against freezes as well as increase heat and so success of crosses made later in the spring on container planted trees in the same facility.

Pollen germination studies made in the spring of 1990, suggested that pollen densities on the stigma surface may affect germination success. Previous (1989) data has demonstrated no significant effect of pollen tube numbers in the upper style on final fertilization success. An accurate understanding of the pollination biology of almond is needed to optimize fertilization and so seed set in new pollenizer varieties and in self-compatible introductions. Such understanding should also allow for an improved crossing efficiency in the breeding program as present crosses are normally successful only about 25% of the time. Further studies on pollen response in both compatible and incompatible combinations are planned for spring, 1991.

D) Pollination tests were made in attempts to identify members of the 4th and final cross-incompatibility group resulting from 'Nonpareil' X 'Mission' crosses. A "standard" for this group would facilitate the cross-compatibility grouping of new and presently ungrouped cultivars (many of which are believed to be progeny from 'Nonpareil' X 'Mission' crosses). Last season's data indicated that the cultivar 'Monterey' may belong to this 4th group, and initial data from this season strongly supports that conclusion. If verified this spring, 1991, other cultivars in this group could be identified by crossing tests with 'Monterey' directly, rather than the multitude of separate test crosses now performed.

Samples have been collected and analyzed in studies on pollen growth characteristics of the 'Jeffries' cultivar. 'Jeffries' is a sport of 'Nonpareil' possessing a partially dysfunctional self-incompatibility mechanism. Examination of the compatibility reaction (pollen tube growth or arrest) following self-pollinations and crosses to 'Nonpareil' and other cultivars may lead to a better understanding of the self-incompatibility response in 'Nonpareil' and ultimately to methods to develop self-compatible 'Nonpareil' types. Standard tissue preparation & staining protocols have produced poor results with almond and new staining procedures are being evaluated.

The partial failure of the self-incompatibility mechanism in 'Jeffries' has been utilized to simulate forced selfing in 'Nonpareil' to test for loss of kernel quality and weight (and so crop yield). Seed weights as well as growth of subsequent selfed seedlings suggest no economically significant differences between selfed and outcrossed kernel characteristics (described in more detail in the 1989-90 Comprehensive Report and verified in summer,1990), and no significant inbreeding depression in subsequent inbred seedling growth (Jeffries x (x), and Jeffries x Nonpareil) vs. outcrossed controls (Nonpareil x 1-69 and Nonpareil x LeGrand - Table 6). These findings support the economic feasibility of a self-fertile 'Nonpareil' type almond.

E) Presently there are several efforts nationally and internationally aimed at the transformation of Prunus cells or tissue followed by regeneration of whole plants from such transformed tissue. These programs have focused on attempts to transform cells or tissue from seed embryos (none yet successfully) since this is the only tissue which has allowed plantlet regeneration to date. The transformation and regeneration of such Prunus tissue would be a significant technological achievement, but since it would apply only to seedling tissue it would have little application for the transformation of established cultivars (which is the greatest potential advantage of this biotechnology). Our program has focused on attempts to transform the meristematic tissue of established cultivars directly. In addition to allowing the transformation of established cultivars such as Nonpareil, this approach would eliminate any callus stage in the regeneration process where high rates of usually deleterious genetic changes are known to occur. This spring, 1990 we have successfully inserted functional genes into meristem cells of Dr. Davis peach and Nonpareil almond using a high velocity particle injection technique (3)(Fig. 1). The gene inserted was transiently expresses at very low levels. We were unable to regenerate new shoots from transformed meristems since the dissection of the growing point to obtain exposed meristems caused excessive trauma to the tissue. We are now experimenting with different meristem dissection and culture strategies in order to achieve dependable shoot regeneration from treated meristems. Recent progress with these techniques have convinced us to increase our efforts in this area from approximately 5% of total project time in 1990 to 10% in 1991. The genetic transformation work is jointly funded by the California Cling Peach Advisory Board and the Almond Board of California.

Citations

1. Kester, D.E. and T. Gradziel. 1990. Growth habit trait nomenclature in almond and peach genotypes - Abstract. 87th Ann. Mting. ASHS. Tucson.

2. Kester, D.E., T. Gradziel and Ch. Grasselly. Almonds. In J.N. Moore and J.R. Ballington (eds.) Genetic Resources of Temperate Fruits and Nuts. (in publication).

3. Gradziel, T.M. 1990. Gene transfer to intact plant meristem cells by high velocity particle bombardment. Abstract. XXIII International Horticultural Congress, Firenze.

Table 1.

WEO F10D 1990 Harvest 9/1 Harvest Date = earliest estimate; Some are nondehiscent

(F10D90H.WK1)

Row	Tree	Sdlg. No.	Item	Number of Nuts/ branch	equiv. branch	nuts/ tree	Suture in mm.	Opening on 8/7 Harvest date
1	1		MILOW X F5, 3-39	2	4	8	HARVEST	8/7
2	1		MILOW X F5, 3-39	0	1			
1	2	8021- 89	F5, 4- 6 X SOLANO	0				
2	2	8021- 89	F5, 4- 6 X SOLANO	0	1	0	START	
1	3	7906- 31	SB20, 1- 5 X 5A-20	11	4	44	10	8/10
2	3	7906- 31	SB20, 1- 5 X 5A-20	31	3	93		8/15
1	4	7914- 26	SB20, 1-19 X 5A-20	39	3	117	10	8/10
2	4	7914- 26	SB20, 1-19 X 5A-20	4	4	16	START	8/15
1	5	8021- 77	F5, 4- 6 X SOLANO	14	3	42	1	8/15
2	5	8021- 77	F5, 4- 6 X SOLANO	19	6	114	START	8/15
1	6	7906- 26	SB20, 1- 5 X 5A-20	115	3	345	HARVEST	8/7
2	6	7906- 26	SB20, 1- 5 X 5A-20	42	4	168	HARVEST	8/7
1	7	7906- 1	SB20, 1- 5 X 5A-20	46	3	138		8/20
2	7	7906- 1	SB20, 1- 5 X 5A-20	32	3	96	0	8/23
1	8	7934- 54	SB7, 2- 1E X F5, 3-52	36	3	108	HARVEST	8/7
2	8	7934- 54	SB7, 2- 1E X F5, 3-52	7	1	7	HARVEST	8/7
1	9		SB 2,6A-11 (parent)	9	3	27	0	8/20
2	9		SB 2,6A-11 (parent)	4	1	4	0	8/20
1	10		SONORA (parent)	36	6	216	5	8/15
2	10		SONORA (parent)	1	1	1	START	
1	11	7924- 5	MILOW X F5, 3-39	42	5	210	4	8/15
2	11	7924- 5	MILOW X F5, 3-39	3	1	8	START	
1	12	6003- 2	SB 8,1-50W	4	4	16	10	8/10
2	12	6003- 2	SB 8,1-50W	0	1			
1	13	8023- 18	F5, 4-10 X MILOW OR SOLANO	14	4	56	3	8/12
2	13	8023- 18	F5, 4-10 X MILOW OR SOLANO	10	5	50	START	8/12
1	14	6006-12	SB 8,2- 4W	61	3	183	0	8/15
2	14	6006-12	SB 8,2- 4W	33	4	132	0	8/15
1	15	6002-38	SB 8,1-45W	9	3	27	10	8/10
2	15	6002-38	SB 8,1-45W	28	1	28	HARVEST	8/7
1	16	8024- 24	F5, 4-10 X SOLANO	25	4	100	5	8/10
2	16	8024- 24	F5, 4-10 X SOLANO	32	3	96	HARVEST	8/7
1	17	8024- 21	F5, 4-10 X SOLANO	1	1	1	0	
2	17	8024- 21	F5, 4-10 X SOLANO	10	1	10	HARVEST	8/7
1	18	8007- 24	NONPAREIL X F5, 4- 4	24	2	48	HARVEST	8/7
2	18	8007- 24	NONPAREIL X F5, 4- 4	30	1	30	START	8/10
1	19	7309- 7	TITAN X SB16,8-60 (parent)	72	2	144	8	8/9
2	19	7309- 7	TITAN X SB16,8-60 (parent)	26	6	156	HARVEST	8/9
1	20		NONPAREIL (parent)	45	2	90	8	8/9
2	20		NONPAREIL (parent)	0	1			
1	21	7920- 22	SB20, 1-28 X 5A-20	53	2	106		8/8
2	21	7920- 22	SB20, 1-28 X 5A-20	MISSING				
1	22	8011- 24	NONPAREIL X F5, 4-43	2	1	2	HARVEST	8/7
2	22	8011- 24	NONPAREIL X F5, 4-43	17	1	17	HARVEST	8/7
1	23	8009- 2	NONPAREIL X F5, 4- 6	3	1	3		8/8
2	23	8009- 2	NONPAREIL X F5, 4- 6	0	1			
1	24		CP 5-58 X F5, 4-10	88	2	176	HARVEST	8/7
2	24		CP 5-58 X F5, 4-10	42	1	42	HARVEST	8/7
1	25	7918- 16	SB20, 1-23 X 5A-20	86	2	172	6	8/10
2	25	7918- 16	SB20, 1-23 X 5A-20	29	4	116	HARVEST	8/7
1	26	8007- 15	NONPAREIL X F5, 4- 4	116	2	232		8/9
2	26	8007- 15	NONPAREIL X F5, 4- 4	12	6	72	HARVEST	8/7

(F10D90H.WK1)

Row	Tree	Sdlg. No.	Item	Number of Nuts/ branch	equiv. branch	nuts/ tree	Suture in mm.	Opening on 8/7 Harvest date
3	1	7906- 33	SB20, 1- 5 X 5A-20	80	3	240	10	8/8
4	1	7906- 33	SB20, 1- 5 X 5A-20	110	2	220	HARVEST	8/7
3	2	8021- 24	F5, 4- 6 X SOLANO	0				
4	2	8021- 24	F5, 4- 6 X SOLANO	0				
3	3	7920- 45	SB20, 1-28 X 5A-20	57	2	114	4	8/10
4	3	7920- 45	SB20, 1-28 X 5A-20	103	3	309	3	8/12
3	4	7915- 88	SB20, 1-21 X SB20, 1-29	14	2	28	HARVEST	8/7
4	4	7915- 88	SB20, 1-21 X SB20, 1-29	0				
3	5	7920- 24	SB20, 1-28 X 5A-20	28	1	28	4	8/9
4	5	7920- 24	SB20, 1-28 X 5A-20	7	1	7	5	8/9
3	6	8024- 12	F5, 4-10 X SOLANO	57	2	114	5	8/10
4	6	8024- 12	F5, 4-10 X SOLANO	51	3	153	10	8/10
3	7	7923- 55	MILOW X F5, 3-60	31	2	62	8	8/10
4	7	7923- 55	MILOW X F5, 3-60	3	3	9	HARVEST	8/7
3	8	7920- 20	SB20, 1-28 X 5A-20	32	3	96	8	8/15
4	8	7920- 20	SB20, 1-28 X 5A-20	27	2	54	6	8/15
3	9	7934- 55	SB7, 2- 1E X F5, 3-52	118	2	236	5	8/17
4	9	7934- 55	SB7, 2- 1E X F5, 3-52	90	2	180	4	8/17
3	10	7927- 56	CP 5-58 X SB20, 1-29	38	3	114	0	8/22
4	10	7927- 56	CP 5-58 X SB20, 1-29	3	4	12	0	8/22
3	11		(F8S, 53-60)	63	2	126	0	8/24
4	11		(F8S, 53-60)	44	3	132	0	8/24
3	12	7932- 87	SB7, 2- 1E X SB20, 1-29	OUT				
4	12	7932- 87	SB7, 2- 1E X SB20, 1-29	OUT				
3	13	7927- 54	CP 5-58 X SB20, 1-29	93	2	186	2	8/24
4	13	7927- 54	CP 5-58 X SB20, 1-29	43	3	129	0	8/22
3	14	8016- 24	CP 5-58 X F5, 4-10	87	4	348	0	8/17
4	14	8016- 24	CP 5-58 X F5, 4-10	13	4	52	3	8/17
3	15	8011- 20	NONPAREIL X F5, 4-43	170	3	510	0	9/1
4	15	8011- 20	NONPAREIL X F5, 4-43	29	3	87	0	9/1
3	16	8006- 10	NONPAREIL X F5, 3- 2	25	2	50	HARVEST	8/7
4	16	8006- 10	NONPAREIL X F5, 3- 2	28	2	56	HARVEST	8/7
3	17	8016- 34	CP 5-58 X F5, 4-10	35	2	70	6	8/8
4	17	8016- 34	CP 5-58 X F5, 4-10	6	6	36	HARVEST	8/7
3	18	7906- 13	SB20, 1- 5 X 5A-20	16	2	32	1	8/15
4	18	7906- 13	SB20, 1- 5 X 5A-20	49	3	147	0	8/15
3	19	7906- 53	SB20, 1- 5 X 5A-20	8	2	16	8	8/10
4	19	7906- 53	SB20, 1- 5 X 5A-20	4	4	16	HARVEST	8/7
3	20	7927- 53	CP 5-58 X SB20, 1-29	24	1	24	0	8/24
4	20	7927- 53	CP 5-58 X SB20, 1-29	3	4	12	0	8/23
3	21	8016- 20	CP 5-58 X F5, 4-10	49	3	147	0	8/24
4	21	8016- 20	CP 5-58 X F5, 4-10	10	3	30	0	8/22
3	22	8024- 19	F5, 4-10 X SOLANO	123	1	123	HARVEST	8/7
4	22	8024- 19	F5, 4-10 X SOLANO	75	4	300	HARVEST	8/7
3	23	8013- 6	PADRE X F5, 4- 4	31	5	155	6	8/12
4	23	8013- 6	PADRE X F5, 4- 4	51	2	102	8	8/12
3	24	7310-46	TITAN X SB16,12-64 (parent)	31	4	124	0	8/20
4	24	7310-46	TITAN X SB16,12-64 (parent)	120	4	480	0	8/20
3	25	8010- 22	NONPAREIL X F5, 4-11	125	1	125	HARVEST	8/7
4	25	8010- 22	NONPAREIL X F5, 4-11	70	4	280	HARVEST	8/7
3	26	8021- 19	F5, 4- 6 X SOLANO	54	3	162	2	8/15
4	26	8021- 19	F5, 4- 6 X SOLANO	140	3	420	0	8/17

(F10D90H.WK1)

Row	Tree	Sdlg. No.	Item	Number of Nuts/ branch	equiv. branch	nuts/ tree	Suture in mm.	Opening on 8/7 Harvest date
5	1		USDA 75-3	14	2	28		8/12
6	1		USDA 75-3	3	1	3	0	
5	2		F85= F8S, 51-32	20	4	80	0	9/1
6	2		F85= F8S, 51-32	28	4	112	0	9/1
5	3		PADRE (parent)	9	4	36	0	8/24
6	3		PADRE (parent)	75	3	225	0	8/24
5	4		USDA CP,5-33 X OP	5	1	5	0	9/1
6	4		USDA CP,5-33 X OP	2	1	2	0	9/1
5	5		USDA 20.5-13	4	1	4	HARVEST	8/7
6	5		USDA 20.5-13	1	1	1	HARVEST	8/7
5	6	7347-16	SB16,12-64 X OP	38	2	76	HARVEST	8/7
6	6	7347-16	SB16,12-64 X OP	25	3	75	HARVEST	8/7
5	7	7347- 5	SB16,12-64 X OP	12	2	24	0	8/20
6	7	7347- 5	SB16,12-64 X OP	26	3	78	0	8/20
5	8		MISSION (parent)	11	2	22	0	9/2
6	8		MISSION (parent)	62	4	248	0	9/1
5	9	7347-15	SB16,12-64 X OP	0				
6	9	7347-15	SB16,12-64 X OP	2	1	2	HARVEST	8/7
5	10		(F8S, 51-36)	58	3	174	0	9/1
6	10		(F8S. 51-36)	25	5	125	0	9/1
5	11		USDA 19.5-12	35	1	35	HARVEST	8/7
6	11		USDA 19.5-12	3	6	18	HARVEST	8/7
5	12	7340- 5	SB16,9-62 X OP	11	1	11	0	8/10
6	12	7340- 5	SB16.9-62 X OP	15	1	15	HARVEST	8/7
5	13	6021-18	SB 8,3-100W	25	2	50	0	8/15
6	13	6021-18	SB 8,3-100W	35	1	35	0	8/15
5	14		USDA 92-59	14	4	56	3	8/17
6	14		USDA 92-59	23	6	138	START	8/20
5	15		USDA 25-26 X SELF	94	4	376	0	8/26
6	15		USDA 25-26 X SELF	53	4	212	0	8/28
5	16		(F8S, 51-20)	26	5	130	0	9/1
6	16		(F8S, 51-20)	10	5	50	0	9/1
5	17		(F8S. 51-27)	30	4	120		9/1
6	17		(F8S, 51-27)	22	5	110	0	9/1
5	18	7326- 1	SB16,2-44XSB6,56-88(parent)	76	1	76	HARVEST	8/7
6	18	7326- 1	SB16,2-44XSB6,56-88(parent)	18	5	90	HARVEST	8/7
5	19	7326- 8	SB16,2-44XSB6,56-88(parent)	32	5	160	HARVEST	8/7
6	19	7326- 8	SB16,2-44XSB6,56-88(parent)	34	6	204	HARVEST	8/7
5	20		PADRE X P54P455	29	1	29	0	
6	20		PADRE X P54P455	11	7	77	0	8/28
5	21		PADRE X P54P455	93	3	279	0	9/1
6	21		PADRE X P54P455	23	8	184	0	9/1
5	22		F5, 4- 6 X SOLANO	53	4	212	3	8/22
6	22		F5, 4- 6 X SOLANO	18	5	90	0	8/22
5	23		SB20, 1-21 X 5A-20	34	5	170	0	8/20
6	23		SB20, 1-21 X 5A-20	48	10	480	0	8/21
5	24		SB20, 1- 5 X 5A-20	53	5	265	0	8/21
6	24		SB20, 1- 5 X 5A-20	9	10	90	0	8/21
5	25	8013- 19	CP 5-58 X F5, 4- 4	154	4	616	7	8/24
6	25	8013- 19	CP 5-58 X F5, 4- 4	100	3	300	START	8/26
5	26	8007- 16	NONPAREIL X F5, 4- 4	74	4	296	HARVEST	8/7
6	26	8007- 16	NONPAREIL X F5, 4- 4	18	6	108	HARVEST	8/7

(F10D90H.WK1)

Row	Tree	Sdlg. No.	Item	Number of Nuts/ branch	Number of equiv. branch	Number of nuts/ tree	Suture Opening on 8/7 in mm.	Harvest date
7	1		PL PATH,1-15	16	3	48	START	8/15
8	1		PL PATH,1-15	4	3	12	6	
7	2		USDA 18-130	0	1			
8	2		USDA 18-130	8	2	16	HARVEST	8/7
7	3		USDA 10A-14 X SELF	15	1	15	HARVEST	8/7
8	3		USDA 10A-14 X SELF	17	2	34	HARVEST	8/7
7	4	7339- 2	SB16,9-59 X SB16,9-60	20	3	60	HARVEST	8/7
8	4	7339- 2	SB16,9-59 X SB16,9-60	40	3	120	HARVEST	8/7
7	5		THOMPSON(PARENT)	60	4	240	0	8/22
8	5		THOMPSON(PARENT)	50	4	200	0	8/22
7	6		(F8S, 51-12)	28	7	196	0	9/1
8	6		O'Henry	PEACH				
7	7		USDA 20.5-18	23	6	138	0	8/20
8	7		USDA 20.5-18	6	4	24	0	8/20
7	8	6021-39	SB 8,4- 3E	6	9	54	START	8/17
8	8	6021-39	SB 8.4- 3E	3	3	9	0	8/17
7	9		USDA 14-37	0	1			
8	9		USDA 14-37	0				
7	10	7326- 4	SB16.2-44XSB6.56-88(parent)	52	5	260	START	8/9
8	10	7326- 4	SB16,2-44XSB6,56-88(parent)	107	3	321	HARVEST	8/9
7	11		USDA 18.5-8	33	3	99	0	9/5
8	11		USDA 18.5-8	11	2	22	0	9/1
7	12		USDA 19.5-9	3	1	3	0	
8	12		USDA 19.5-9	2	2	4	0	8/17
7	13		(F8S, 51-14)	PEACH		0		
8	13		(F8S, 51-14)	79	3	237	0	9/1
7	14		40A-17	0	1			
8	14		40A-17	0				
7	15		USDA 19.5-8	6	5	30	HARVEST	8/7
8	15		USDA 19.5-8	4	2	8	HARVEST	8/7
7	16		USDA 20.5-13	10	6	60	START	8/12
8	16		USDA 20.5-13	5	3	15	HARVEST	8/7
7	17	7326- 3	SB16,2-44XSB6,56-88(parent)	8	4	32	HARVEST	8/7
8	17	7326- 3	SB16,2-44XSB6,56-88(parent)	17	4	68	HARVEST	8/7
7	18	6855- 1	SB16, 9- 9	29	4	116	START	8/10
8	18	6855- 1	SB16, 9- 9	24	4	96	HARVEST	8/7
7	19		PADRE X P54P455	9	5	45	0	9/1
8	19		PADRE X P54P455	20	4	80	0	9/1
7	20		PADRE X P54P455	18	8	144	0	9/1
8	20		PADRE X P54P455	83	4	332	0	9/1
7	21	7326- 2	SB16,2-44XSB6,56-88(parent)	25	3	75	HARVEST	8/7
8	21	7326- 2	SB16,2-44XSB6,56-88(parent)	83	3	249	HARVEST	8/7
7	22		PADRE X P54P455	26	9	234	0	9/1
8	22		PADRE X P54P455	57	3	171	0	9/1
7	23		PADRE X P54P455	20	1	20	0	9/1
8	23		PADRE X P54P455	22	3	66	0	9/1
7	24		SB20,1-28 X 5A-20	60	4	240	0	8/24
8	24		SB20,1-28 X 5A-20	94	4	376	5	8/20
7	25	8011- 29	NONPAREIL X F5, 4-42	41	8	328	HARVEST	8/7
8	25	8011- 29	NONPAREIL X F5, 4-42	0				
7	26	8012- 39	CP 5-58 X F5, 3- 2	120	6	720	START	8/22
8	26	8012- 39	CP 5-58 X F5, 3- 2	57	5	285	3	8/20

(F10D90H.WK1)

Row	Tree	Sdlg. No.	Item	Number of Nuts/ branch	equiv. branch	nuts/ tree	Suture in mm.	Opening on 8/7 Harvest date
9	1		PL PATH,1- 5	9	3	27	0	8/17
9	2		PL PATH,1- 5	3	3	9	0	8/17
9	3		PL PATH,2-15	7	2	14	START	8/17
9	4		PL PATH,2-15	11	4	44	0	8/17
9	5		PL PATH,2-28	61	2	122	HARVEST	8/7
9	6		PL PATH,2-28	50	3	150	HARVEST	8/7
9	7		PR HORTULANA	0				
9	8		PR HORTULANA	0				
9	9	6828-1C	SB16,14-16 PA 6828-1C	35	2	70	START	8/28
9	10	6828-1C	SB16,14-16 PA 6828-1C	20	2	40	0	8/20
9	11		PL PATH,2-15	6	1	6	3	8/17
9	12		PL PATH,2-15	79	1	79	3	8/17
9	13	6827-2A	SB16,14-13 PA 6827-2A	3	1	3	0	
9	14	6827-2A	SB16,14-13 PA 6827-2A	0				
9	15		PR HORTULANA					
9	16		PR HORTULANA					

Table 2.

August 25.1990

File = F588Pr   Almond Variety Collection   WEO Field 5   Planted: Rows 1-5 Febr.8.1988: Row 6,7

Row-tree 1-1 at the NW corner: Nemaguard rootstock for both almonds and peaches

Peaches : All virus-free items; Planted: 2/13/90

Location BkRowTree	Item	Maturity 1990 Date	#Frts/Tr	Location BkRowTree	Item	Maturity 1990 Date	#Frts/Tr
F5,1-1	Jordanolo		0	F5.2-1	Jordanolo		0
F5.1-2	Tarragona		0	F5.2-2	Tarragona	Gone	
F5.1-3	Marcona	Gone		F5.2-3	Marcona	8/17	3
F5.1-4	NePlusUltra	Gone		F5.2-4	NePlusUltra	8/5	17
F5,1-5	Bigelow	8/26	27	F5.2-5	Bigelow		0
F5.1-6	Almendro de la pie		0	F5.2-6	Almendro de la pie	9/5	2
F5.1-7	Peerless	8/15	25	F5.2-7	Peerless		0
F5.1-8	Harriott		0	F5.2-8	Harriott	9/4	3
F5.1-9	IXL	8/7	10	F5.2-9	IXL	8/7	18
F5,1-10	GoldenState		0	F5.2-10	GoldenState	Gone	
F5.1-11	Sonora		0	F5.2-11	Sonora	Gone	
F5.1-12	SB2.6A-11		0	F5.2-12	SB2.6A-11		0
F5,1-13	Trusito	8/10	11	F5.2-13	Trusito	8/12	10
F5,1-14	SydneySpecial	8/15	4	F5.2-14	SydneySpecial	8/17	19
F5,1-15	LaPrima		0	F5.2-15	LaPrima		0
F5,1-16	Kapareil		0	F5.2-16	Kapareil		0
F5,1-17	LaMarie		0	F5.2-17	LaMarie		0
F5.1-18	SmithIXL		0	F5.2-18	SmithIXL	8/15	15
F5.3-1	Mission		29	F5.4-1	Mission	8/31	24
F5.3-2	Arbuckle		0	F5.4-2	Arbuckle		0
F5.3-3	CP.5-46		0	F5.4-3	CP.5-46		0
F5.3-4	Langeudoc	Gone		F5.4-4	Langeudoc		0
F5.3-5	TardyNonpareil		2	F5.4-5	TardyNonpareil		0
F5.3-6	Walton	8/25	35	F5.4-6	Walton		0
F5.3-7	Padre	8/25	32	F5.4-7	Padre		0
F5.3-8	SansFaute	8/20	27	F5.4-8	SansFaute	8/15	9
F5.3-9	Davey		0	F5.4-9	Davey		0
F5.3-10	Milow		0	F5.4-10	Milow	Gone	
F5.3-11	Eureka	8/18	5	F5.4-11	Eureka		0
F5.3-12	Nonpareil		0	F5.4-12	Nonpareil	Dead	
F5.3-13	Vesta	8/7	5	F5.4-13	Vesta	8/17	1
F5.3-14	SB3.7A-17		0	F5.4-14	SB3.7A-17		0
F5.3-15	LongIXL	Gone		F5.4-15	LongIXL	Gone	
F5.3-16	Lewelling	8/15	90	F5.4-16	Lewelling	8/15	32
F5.3-17	SB1.4A-12	8/15	17	F5.4-17	SB1.4A-12	8/13	13
F5.3-18	Kutsch	8/17	3	F5.4-18	Kutsch		0
F5,5-1	Pioneer	8/31	120	F5.6-1	Loadel		
F5.5-2	Pioneer	8/31	105	F5.6-2	Loadel		
F5.5-3	Thompson	8/10	25	F5.6-3	Carson		
F5.5-4	Thompson	8/10	13	F5.6-4	Carson		
F5.5-5	WestSteyn	Gone		F5.6-5	Klamt		
F5.5-6	WestSteyn		0	F5.6-6	Klamt		
F5.5-7	Standard	Gone		F5.6-7	19.2-72		
F5,5-8	Standard	Gone		F5.6-8	19.2-72		
F5,5-9	SB7,1-87W	Dead?		F5,6-9	Andross		
F5.5-10	SB7.1-87W		0	F5.6-10	Andross		
F5.5-11	Carmel		0	F5.6-11	Ross		
F5.5-12	Carmel	Gone	0	F5.6-12	Ross		
F5.5-13	Monterey	Gone		F5,6-13	DrDavis		
F5.5-14	Monterey	Gone		F5.6-14	DrDavis		
F5.5-15	Price		0	F5,6-15	CarolynG		
F5.5-16	Price	Gone		F5.6-16	CarolynG		
F5,5-17	Butte		0	F5.6-17	Halford		
F5,5-18	Butte		0	F5,6-18	Halford		
F5,7-15	Starn						
F5,7-16	Starn						
F5,7-17	Wiser						
F5,7-18	Wiser						

Table 3.

Crop estimates 1990; August 31,1990

Almond Selection and Breeding Block # 1 WEO Field 7 Planted: Febr.1988

Trunk circumference = circumference of scion at the first smooth place approx. 0.5 to f foot above union in Cm.

File = F7_88Pr Rows East to West, Trees North to South

Location BkRowTree	I T E M	Maturity Date	199 #Frts/Tr	Trunk Circumf.
F7,1-1	SB3,54-39E		1	23.2
F7,1-2	SB13,28-21	9/10 ?	12	21.6
F7,1-3	Mission-3-6-1	9/5		130.0
F7,1-4	SB13,28-21		1	25.0
F7,1-5	SB3,54-42E		0	22.3
F7,1-6	SB6,53-24-7		0	23.8
F7,2-1	SB3,54-39E	8/15	7	22.1
F7,2-2	MissionShawBFG	9/5		63.6
F7,2-3	SB4,1-100W		0	18.8
F7,2-5	SB3,54-42E		1	21.5
F7,3-1	SB3,55-13W		2	18.9
F7,3-2	MissionShawBFG	8/31		54.5
F7,3-3	SB4,1-100W		0	15.6
F7,3-4	Ferradeul	8/25		53.0
F7,3-6	Jordanolo,BF		Gone	
F7,4-1	SB3,55-13W	8/22	20	18.6
F7,4-2	SB7,1-87W	8/20	1	19.3
F7,4-3	SB4,2-43W	8/10	58	22.9
F7,4-4	Ferradeul	8/31		54.8
F7,5-1	SB16,4-12	8/28		151.5
F7,5-2	SB7,1-87W		0	15.3
F7,5-3	SB4,2-43W	8/20	51	18.8
F7,5-4	Ferragnes	8/31		66.4
F7,5-5	SB6,53-24-7		0	23.6
F7,6-1	SB16,4-12	9/5		108.6
F7,6-2	Nonpareil-3-8-2	8/7		146.8
F7,6-3	Mission-3-6-1	8/31		124.2
F7,6-4	Ferradeul	8/31		51.8
F7,6-5	SB4,1-102W		2	22.4
F7,6-6	Harpareil	8/20		190.0
F7,7-1	Nonpareil-125	8/5		87.9
F7,7-2	SB3,54-15W		1	17.2
F7,7-3	SB3,54-15W		0	21.7
F7,7-4	Ferragnes	8/25		58.8
F7,7-5	SB13,25-75	8/7	95	18.0
F7,7-6	Nonpareil,BF	8/7		91.9
F7,8-1	SB16,4-55	8/5		142.5
F7,8-2	Unknown	8/27		34.0
F7,8-3	40A-17			51.1
F7,8-4	SB4,2-19E	8/15	75	21.2
F7,8-5	SB13,25-75	8/7	97	19.2
F7,8-6	Nonpareil,IR-2	8/7		69.1
F7,9-1	SB6,56-88	8/20	9	16.5
F7,9-2	SB6,56-98	8/10	8	24.2
F7,9-3	40A-17			42.4
F7,9-5	SB13,36-52	8/7	4	18.7
F7,9-6	SB13,45-7	Rootst	0	13.8
F7,10-1	SB6,56-88	8/20	10	24.2
F7,10-2	SB6,56-98	8/15	3	21.9
F7,10-3	SB4,2-19E	8/20	8	22.0
F7,10-5	SB13,36-52		0	22.9
F7,10-6	SB13,45-7		0	9.4
F7,10-7	SB13,37-9		0	13.7
F7,11-1	SB6,56-89	8/10	7	28.4
F7,11-2	SB6,56-89	8/10	93	29.5
F7,11-3	F8S,59-1		0	25.2
F7,11-4	SB7,2-82W		0	8.1
F7,11-5	SB13,45-8	8/10	47	23.3
F7,11-6	SB13,36-51		0	15.3
F7,12-1	SB6,56-89	8/7	3	26.3
F7,12-2	SB6,56-89	8/7	3	23.5
F7,12-3	F8S,59-1		0	17.2
F7,12-4	SB7,2-82W	8/7	3	22.6
F7,12-5	SB13,45-8	8/20	2	25.0
F7,12-6	SB13,36-51		0	23.2
F7,12-7	SB13,37-9		0	18.4

Table 4.

SUMMARY OF ALMOND CROSSES MADE IN THE SRPING OF 1990

November 30. 1990

Type of Crosses	Crosses Total	Crosses Saved	Seeds Total	Seeds Saved	Planted	Field Planted
Bud-failure	60	49	1674	1315	1208	1091
Delta crosses	53	53	1570	1570		
P x A selves	13	13	609	609		
Other crosses	6	6	326	326	326	
Total	132	121	4179	3820	1534	1091

Table 5.

FILE =90_BF Davis,Delta

Code No	Parentage Seed	Pollen	Crack Date	Plant Date	Kernel	# SdlgS Planted	Kernel/Sdlg Planted,%	Notes
A90.2	Nonpareil,BF	Carmel 114-2	7/2	8/17	9	9	100	
A90.3	Nonpareil,BF	Carmel, BF(F)	7/2	8/17	36	30	83	
A90.4	Nonpareil.BF	Sonora(2)(18)	7/2	8/17	17	11	65	
A90.5	Nonpareil.BF	Jordanolo 24-1(F)	7/2	8/17	38	31	82	
A90.6	Nonpareil.BF	Carmel 1-9	7/2	8/17	8	9	113	
A90.7	Nonpareil.BF	Carmel BF	7/2	8/17	14	11	79	
A90.8	Nonpareil.BF	Price. Fowler	7/2	8/17	21	19	90	
A90.10	Nonpareil.BF	Price 5.6	7/2	8/17	24	4	17	
A90.13	Nonpareil.BF	Sonora	7/2	8/17	52	39	75	
A90.14	Nonpareil.BF	Carmel,Wells 1-4	7/2	8/17	3	2	67	
A90.15	Nonpareil.BF	Fritz.VR 15-9	7/2	8/17	25	17	68	
A90.16	Nonpareil.BF	Carmel N 13-2	7/2	8/17	33	24	73	
A90.18	Nonpareil.BF	Padre	7/11	8/29	51	50	98	
A90.19	Nonpareil,BF	Carmel. BF(6)	7/11	8/29	76	70	92	
A90.20	Nonpareil.BF	XSonora(E)33	7/11	8/29	53	50	94	
A90.21	Nonpareil.BF	Carmel 1-7W	7/12	8/29	36	34	94	
A90.22	Nonpareil.BF	Butte. F 1-15	7/12	8/29	43	41	95	
A90.23	Nonpareil.BF	Monterey 55-4	7/12	8/29	18	19	106	
A90.24	Nonpareil.BF	Carmel. Niches(4)	7/12	8/29	11	10	91	
A90.25	Nonpareil.BF	Monterey(4)	7/12	8/29	58	50	86	
A90.26	Nonpareil.BF	Merced(4)	7/12	8/29	44	24	55	
A90.27	Nonpareil.BF	Jordanolo.(24)(1)	7/13	8/31	25	9	36	
A90.28	Nonpareil.BF	1-69 (2)	7/13	8/31	31	27	87	
A90.29	Nonpareil.BF	Jordanolo. (2)	7/13	8/31	31	30	97	
A90.30	Nonpareil.BF	1-69 (1)	7/13	8/31	35	32	91	
A90.31	Nonpareil.BF	Carmel.BF(3)	7/13	8/31	38	37	97	
A90.32	Nonpareil.BF	Carmel.BF(2)	7/13	8/31	27	27	100	
A90.33	Nonpareil.BF	Jordanolo.(G)	7/13	8/31	16	16	100	
A90.34	Nonpareil.BF	Merced(3)	7/13	8/31	23	24	104	
A90.35	Nonpareil,BF	Carmel. Wells 1-42	7/13	8/31	16	15	94	
A90.37	Nonpareil.BF	Jordanolo(4)	7/13	8/31	23	20	87	
A90.40	Nonpareil.BF	Carmel 1-9(3)	7/13	9/11	17	17	100	
A90.41	Nonpareil.BF	Butte F 1-9	7/18	9/11	31	32	103	
A90.42	Nonpareil.BF	Price.Fowler(3)	7/18	9/11	18	18	100	
A90.45	Nonpareil.BF	Fritz.Var.17-8(1)	7/18	9/11	19	19	100	
A90.46	Nonpareil,BF	Merced(3) Cont.	7/18	9/11	5	4	80	
A90.47	Nonpareil,BF	Butte. 1-9(3)	7/18	9/11	2	2	100	
A90.48	Nonpareil.BF	Monterey 55-2(3)	7/18	9/11	28	28	100	
A90.49	Nonpareil.BF	Sonora(3)	7/18	9/11	43	43	100	
A90.50	Nonpareil,BF	Fritz, Wells(1)	7/18	9/11	50	44	88	
A90.52	Nonpareil.BF	Monterey(9) 55-1	7/18	9/11	14	14	100	
A90.53	Nonpareil,BF	Butte 2-4	7/18	9/11	24	24	100	
A90.54	Nonpareil,BF	Mission(3)	7/18	9/11	27	27	100	
A90.55	Nonpareil,BF	Merced(3)	7/18	9/11	22	20	91	
A90.56	Tuono#1	Self	7/30	9/24	30			
A90.57	Nonpareil	F10C.12-28	7/30	9/24	96			
A90.58	Mission	F10C,12-28	7/30	9/24	14			
A90.59	Mission	F10C,9-22	7/30	9/24	12			
A90.60	F10C,20-51	Self	7/30	9/24	75			
A90.61	Nonpareil	F10C.9-22	7/30	9/24	99			
A90.62	Nonpareil,BF	Carmel	8/14	10/15	14			Grayson(1)(8),114-3
A90.63	WoodsColony	Butte	10/9		4			Delta plot,81

FILE =90_BF Davis,Delta

Code No	Parentage Seed	Pollen	Crack Date	Plant Date	Kernel	# SdlgS Planted	Kernel/Sdlg Planted,%	Notes
A90.64	Nonpareil	Ferradual	10/16		26			Delta plot,Mc.R34T9
A90.65	Fritz	Padre	10/16		13			Delta plot
A90.66	Nonpareil	F7,12-6	10/16		31			Delta plot
A90.67	WoodsColony	Nonpareil	10/16		8			Delta plot
A90.68	Nonpareil	F10D,3,4-19	10/16		51			Delta plot,R34T8
A90.69	WoodsColony	Fritz	10/16		7			Delta plot
A90.70	WoodsColony	Fritz	10/16		8			Delta plot
A90.71	Padre	Monterey	10/16		21			Delta plot
A90.72	Fritz	Monterey	10/16		25			Delta plot
A90.73	Monterey	Padre	10/16		12			Delta plot
A90.74	Nonpareil	F10D,1,2-9	10/16		40			Delta plot,No #
A90.75	Nonpareil	F10D,3,4-19	10/16		51			Delta plot,R34T9
A90.76	WoodsColony	Monterey	10/16		6			Delta plot
A90.77	WoodsColony	Butte	10/16		6			Delta plot
A90.78	WoodsColony	Sonora	10/16		85			Delta plot
A90.79	WoodsColony	Fritz	10/16		6			Delta plot
A90.80	Padre	Fritz	10/16		19			Delta plot
A90.81	Monterey	Padre	10/16		7			Delta plot
A90.82	WoodsColony	Carmel	10/16		27			Delta plot
A90.83	Carmel	Butte	10/16		34			Delta plot
A90.84	WoodsColony	Carmel	10/16		22			Delta plot
A90.85	WoodsColony	Nonpareil	10/16		13			Delta plot
A90.86	WoodsColony	Monterey	10/16		19			Delta plot
A90.87	WoodsColony	Carmel	10/16		20			Delta plot
A90.88	Monterey	Sonora	10/16		46			Delta plot
A90.89	Nonpareil	F10D,3-23	10/16		26			Delta plot,Mc.R34T4
A90.90	Nonpareil	F10D,1,2-9	10/16		19			Delta plot,R34T10
A90.91	Fritz	Sonora	10/16		60			Delta plot
A90.92	Nonpareil	F7,12-5	10/16		31			Delta plot,R34T7
A90.93	Nonpareil	Ferradual	10/16		32			Delta plot,Mc.R34T4
A90.94	WoodsColony	Price	10/16		17			Delta plot
A90.95	NonpareilIR	Ferragues	10/16		20			Delta plot,R42T7
A90.96	NonpareilIR	Ferragues	10/16		31			Delta plot,R42T6
A90.97	Nonpareil	F7,12-4	10/16		46			Delta plot,R34T6
A90.98	Carmel	Fritz	10/16		18			Delta plot
A90.99	Fritz	Monterey	10/16		17			Delta plot
A90.100	Monterey	Nonpareil	10/16		17			Delta plot
A90.101	Monterey	Nonpareil	10/16		14			Delta plot
A90.102	Monterey	Fritz	10/16		17			Delta plot
A90.103	Monterey	Fritz	10/16		18			Delta plot
A90.104	Fritz	Padre	10/16		11			Delta plot
A90.105	Padre	Fritz	10/16		11			Delta plot
A90.106	WoodsColony	Butte	10/16		6			Delta plot
A90.107	Fritz	Sonora	10/16		33			Delta plot
A90.108	Monterey	Fritz	10/16		27			Delta plot
A90.109	Monterey	Mission	10/16		46			Delta plot
A90.110	Monterey	Nonpareil	10/16		61			Delta plot
A90.111	Fritz	Carmel	10/16		70			Delta plot
A90.112	Monterey	Sonora	10/16		93			Delta plot
A90.113	Nonpareil,IR	Ferragues	10/16		39			Delta plot,R42T6
A90.114	Monterey	Mission	10/16		116			Delta plot,R42T2
A90.115	Nonpareil,IR	Ferragues	10/16		62			Delta plot

FILE =90_BF Davis,Delta

Code No	Parentage Seed	Pollen	Crack Date	Plant Date	Kernel	# SdlgS Planted	Kernel/Sdlg Planted,%	Notes
A90.116	Nonpareil,BF	Padre	10/30		24			Bud failure cross
A90.117	Nonpareil,BF	1-69	10/30		27			Bud failure cross
A90.118	Nonpareil,BF	Carmel,Manteca,2-13	10/30		15			Bud failure cross
A90.119	Nonpareil,BF	Carmel,13-13	10/30		27			Bud failure cross
A90.120	F10D,7-22	Self	10/20		96			PA selves
A90.121	F10D,8-23	Self	10/20		71			PA selves
A90.122	F10D,5-21	Self	10/20		49			PA selves
A90.123	F10D,5-17	Self	10/20		28			PA selves
A90.124	F10D,5-20	Self	10/20		15			PA selves
A90.125	F10D,5-21	Self	10/20		14			PA selves
A90.126	F10D,7-19	Self	10/20		25			PA selves
A90.127	F10D,5-19	Self	10/20		44			PA selves
A90.128	F10D,5-16	Self	10/20		49			PA selves
A90.129	F10D,7-20	Self	10/20		211			PA selves
A90.130	F10D,3-14	Self	10/20		4			PA selves
A90.131	F10D,4-14	Self	10/20		1			PA selves
A90.132	F10D,3-23	Self	10/20		2			PA selves
		Total Seeds			3847			

Table 6.

Analysis of Variance of Seedling Height Data (Inch)

	D.F.	S.Sqres	M.S.	F-test
Total	208	30277.3		
Crosses	4	7261.9	1815.5	16.1
Seedlings	204	23015.4	112.8	

Analysis of Variance of Trunk Diameter Data (Millim

	D.F.	S.Sqres	M.S.	F-test
Total	193	3966.7		
Crosses	4	502.6	125.6	6.9
Seedling	189	3464.2	18.3	

Seedling height

Source of Means	Mean	X-33.0	X-35.4	X-36.1	X-45.5
Nonpareil x 1-69	49.1	16.1 * 6.6	13.7 * 6.2	12.9 * 5.6	3.5 NS 4.7
Nonpareil x LeGrand	45.5	12.5 * 6.2	10.1 * 5.6	9.4 * 4.7	
Jeffries x Control	36.1	3.1 NS 5.6	0.7 NS 4.7		
Jeffries x (X)	35.4	2.4 NS 4.7			
Jeffries x Nonpareil	33.0				

Trunk Diameter

Source of Means	Mean	X-18.8	X-19.3	X-19.7	X-22.3
Nonpareil x 1-69	23.3	4.5 * 2.7	4.0 * 2.6	3.6 * 2.4	1.0 NS 2.0
Nonpareil x LeGrand	22.3	3.5 * 2.6	3.0 * 2.4	2.6 * 2.0	
Jeffries x Control	19.7	0.9 NS 2.4	0.4 NS 2.0		
Jeffries x (X)	19.3	0.5 NS 2.0			
Jeffries x Nonpareil	18.8				

Fig. 1.

1281 GENE TRANSFER TO INTACT PLANT MERISTEM CELLS BY HIGH-VELOCITY PARTICLE BOMBARDMENT

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INTRODUCTION - The application of genetic engineering techniques to the improvement of many horticultural crops is limited by the lack of effective procedures for: (a) foreign gene insertion into target cells and/or (b) plant regeneration from treated protoplasts or cells. In addition, transformation/ plant regeneration methods are often limited to embryogenic or otherwise juvenile tissue, deterring the application of these new technologies to established tree cultivars. A simple device for the high-velocity transfer of foreign genes directly into meristematic plant tissue shows promise for circumventing these barriers.

METHOD - The device tested uses a high-velocity spring piston driven airgun rifle action to accelerate a metal faced felt projectile against an inclined stopping plate (Fig. 1). Approximately 0.01ml aqueous solution of plasmid DNA precipitated onto 0.6 micron tungsten micro-particles is placed on the metal facing of the projectile. At impact these particles are propelled through the stopping plate aperture into target cells while the projectile is deflected out the vacuum/exhaust port. The barrel and stopping plate sections are evacuated to a vacuum of 650mm Hg, while a piece of metal foil at the breech prevents the evacuation of the piston cylinder before shooting. The apical region of almond (*Prunus dulcis*) shoots was exposed by the excision of leaf primordia, and the meristem region was bombarded. Transfer was evaluated by visual analysis of particle dispersion observed in longitudinal sections of the meristem regions, and by the expression of a B-glucuronidase (GUS) reporter gene in a 5-bromo-4-chloro-3-indoyl-B-D-glucuronic acid substrate.

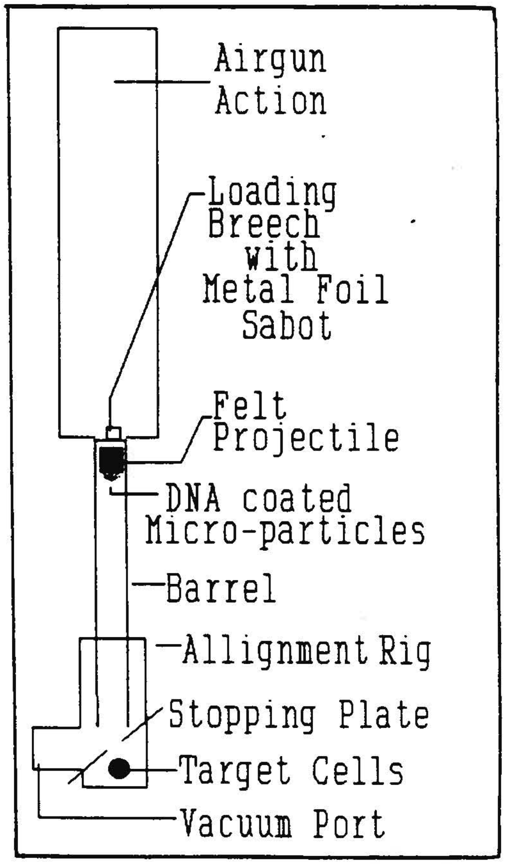

Figure 1. Schematic of particle bombardment apparatus

RESULTS - Plasmid DNA coated tungsten particles were observed dispersed mainly throughout the first two tunica layers of bombarded meristems, though tungsten particles in interior tissues (corpus) were also observed. Transient expression of the GUS reporter gene was detected in less than 0.001% of cells predicted to contain particles. Little damage was apparent with bombarded tissue though further apical growth was arrested in both bombarded and non-bombarded controls, presumably as a result of trauma from leaf primordia excision. No stable expression of the GUS gene was detected.

CONCLUSIONS - High-velocity particle bombardment is an effective approach for transferring foreign material into intact and living plant tissue. Improved tissue handling and DNA packaging techniques need to be developed to fully exploit this as a genetic transformation strategy with this tissue. More efficient plasmid constructs/promoters may also be necessary.

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