increased to 28C, seedling width and number of leaves increased (Table 2). The mean number of days to visible bud increased as temperature increased to 31C. These results indicated that higher temperatures resulted in larger transplants. However, the production of larger transplants would be of little value commercially since many of the large transplants did not flower on schedule.

In summary, the results of both experiments support the hypothesis that high temperature exposure of lisianthus seedlings causes development of rosetted and semirosetted plants. The percentage of rosetted plants increased as the duration of exposure to 28C soil increased from 0 to 28 days and as soil temperature increased from 22 to 31C. Cultivars varied in their sensitivity to high temperatures during the seedling stage. The pink

cultivars were the most sensitive in both experiments, with 34% rosetted plants for 'USDA-Pink' at the lowest temperature of 22C. The cultivar GCREC-Blue was selected for heat tolerance from a tissue cultured line of 'Blue Poppy' at the Gulf Coast Research and Education Center. The low tendency to form rosetted plants by 'GCREC-Blue' at high temperature exposure (2% rosetted plants with 31C soil for 28 days) indicates that breeding efforts can reduce the high temperature sensitivity in lisianthus.

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Role of Self-pollination and Reciprocal Stigma/Anthers Position on Fruit Set of Eight Self-compatible Almonds

A. Godini, L. de Palma, and M. Palasciano

Istituto di Coltivazioni Arboree, Università di Bari, 70126 Bari, Italy

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Abstract. A study to ascertain the highest possible fruit set following self-pollination of eight self-compatible cultivars of almond (*Amygdalus communis* L. = *Prunus dulcis* Mill) was carried out in Apulia (southern Italy). Fruits set from daily hand-selling were high, compared to those from unassisted self-pollination. The results support growing most of the self-compatible Apulian almonds in solid blocks, without need for cross-pollination, provided that self-pollination is optimized by insect vectors. The relative capability of the cultivars to set fruits by unassisted self-pollination was independent of the reciprocal stigma/anthers position within the same flower.

About 30 sweet and bitter almond cultivars native to Apulia (southern Italy) have been identified as self-compatible. Their fruit set after natural self-pollination averaged <15% and never >26% (Godini, 1977b; Godini et al., 1990a; Reina et al., 1985). Since 25% to 40% fruit set is considered optimal for almond, depending on the bloom density of the cultivar (Kester and Griggs, 1959a), the fruitfulness of Apulian self-compatible almonds by natural self-pollination is biologically interesting but horticulturally inadequate.

Two studies on the effect of natural and

artificial selfing on the fruit set of single self-compatible almond cultivars have been completed. The first study, undertaken in Greece, demonstrated the capability of the Apulian cv. Truoto (syn. "Tuono") to exceed the optimal fruit set by both artificial and natural selfing of flowers (Vasilakakis and Porlingis, 1984). These successful results have been attributed to the intimate stigma/anther contact within single 'Truoto' flowers, which

facilitates the natural transfer of pollen grains to the stigmatic surface. The second study was conducted in the United States on 'Le Grand', derived from peach-almond interspecific hybridization and possessing a flower morphology similar to that of 'Truoto' (Weinbaum, 1985). 'Le Grand' was incapable of achieving optimal fruit set using either artificial and natural selfing of flowers.

Given the different results of the above studies and the few genotypes concerned, further documentation involving a wider range of self-compatible almond cultivars seemed necessary. Therefore, we conducted a study to determine if self-pollination may allow self-fruitful almond cultivars to bear sufficient crops to be planted in solid blocks i) without provision for cross-pollination (Kester and Asay, 1975) and/or ii) without insect vectors (Weinbaum, 1985). To answer these questions, the capability of eight Apulian self-compatible almond cultivars to reach optimal fruit set after artificial and natural self-pollination was tested in 1990 at Valenzano (Apulia, Italy).

Cross-pollination was prevented by covering single mature trees throughout bloom with insect-proof cheesecloth cages, thus eliminating any possible injury to flowers by branch-bagging (Grasselly and Olivier, 1976). A single tree was chosen for each cultivar. On each tree, 20 flowering branches, each bearing 80 to 120 blossoms, were divided

Table 1. Bloom date and duration, number of hand self-pollinations, and weather conditions throughout the pollination period of Apulian almonds.

Cultivar	Bloom		Hand self-pollination (no.)	Mean daily air temp (°C)	Rainfall (mm)	Avg wind speed (m·s ⁻¹)
	Date	Duration (days)				
Sannicandro	6-21 Feb.	16	14	10.2	8.4	1.3
Scorza verde	6-24 Feb.	19	17	10.4	8.4	1.2
Ferrante	7-24 Feb.	18	16	10.5	8.4	1.3
Filippo Ceo	15-23 Feb.	9	9	12.0	0.0	1.0
Patalina	19 Feb.-1 Mar.	11	11	13.1	0.0	1.2
Tuono	19 Feb.-1 Mar.	11	11	13.1	0.0	1.2
Calò	21-28 Feb.	8	8	13.0	0.0	1.0
Genco	21 Feb.-1 Mar.	9	9	13.5	0.0	1.2

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Table 2. Fruit set of hand and unassisted self-pollinated flowers and spatial position of stigma and anthers of Apulian almonds.

Cultivar	Fruit set following self-pollination		Significance	Distance of stigma from highest anther ($\pm$ mm $\pm$ SE)
	By hand (%)	Unassisted (%)		
Sannicandro	40.8	8.7	**	3.48 $\pm$ 0.33 cd ^a
Scorza verde	44.4	19.1	**	-0.47 $\pm$ 0.35 e
Ferrante	14.3	2.8	NS	-0.19 $\pm$ 0.34 e
Filippo Ceo	46.5	8.5	**	6.61 $\pm$ 0.38 a
Patalina	28.0	2.3	**	2.55 $\pm$ 0.30 d
Tuono	33.5	18.0	*	0.20 $\pm$ 0.30 d
Calò	67.0	18.7	**	5.42 $\pm$ 0.53 b
Genco	62.5	4.8	**	3.88 $\pm$ 0.23 c
Mean	42.1	10.4	**	
CV (%)	25.2	61.3		

^aMean separation by Duncan's multiple range test, $P = 0.01$.

NS, *, **Nonsignificant or significant at $P = 0.05$ or 0.01 , respectively. Significance tested by ANOVA of arcsin-transformed fruit sets, then backtransformed from Arcsin.

into two groups of ≈ 1000 flowers each. The flowers of the first group of 10 branches were artificially selfed daily from the start to the end of bloom by rubbing stigmas with a small bristle brush carrying self pollen. The method used mimics insect vectors' activity and assumes that 100% of counted flowers were effectively self-pollinated at least once during their effective pollination period (Kester and Griggs, 1959a). The pollen for selfing was harvested every 3rd day from the same tree under study. Repeated viability testing with aceto-carmin indicated $\approx 90\%$ live pollen. The flowers of the second group of 10 branches were left to naturally self-pollinate by wind buffeting of branches (unassisted self-pollination).

The distance from stigma to the highest anther was measured on samples of 30 flowers per cultivar to test the role of reciprocal stigma/anthers position on fruit set following unassisted selfing. Measurements were taken 24 h after flowers had opened, when at least one to five anthers were dehiscing, so as to make it possible for the pollen to be naturally transferred to the stigmatic papillae of the same flower.

Weather conditions were recorded. Hand self-pollinations were made late in the morning, except on rainy and/or windy days. The cages were removed after petal fall. The data are reported as final fruit set, calculated in mid-July, 2 months after the end of physiological fruit drop in almond (Kester and Griggs, 1959b).

The bloom period of the eight cultivars lasted from 6 Feb.–1 Mar. (Table 1). The average air temperature throughout bloom was 12°C, ranging from 1 to 27°C. Total rainfall was 8.4 mm, and average wind speed was 1.2 m·s⁻¹. Weather conditions were favorable for pollen germination, pollen tube growth, and fertilization.

Hand self-pollination allowed very high average fruit set (Table 2), which in many cultivars exceeded the levels reported as optimal for almond. Unassisted selfing proved inadequate, and none of the cultivars tested reached 20% fruit set. The higher coefficient of variation indicates that the setting ability of the unassisted selfed flowers was some-

what more erratic than that of hand-selfed ones. Hand-selfing increased the average fruit set by four times compared with unassisted selfing. The increase in fruit set of hand-selfed cultivars ranged from 1.9 times ('Tuono') to 13.0 times ('Genco'). Hand-selfing was ineffective only in 'Ferrante', which behaved like 'Le Grand' (Weinbaum, 1985), thus confirming its partial self-compatibility (Godini et al., 1990b). The distance of stigmas from the highest anther was essentially constant within the same cultivar but varied significantly among cultivars (Table 2). 'Scorza Verde', 'Ferrante', and 'Tuono' exhibited mesostigmatic flowers, whereas 'Sannicandro', 'Filippo Ceo', 'Patalina', 'Calò', and 'Genco' exhibited epistigmatic flowers. Since no correlation was found between stigma/anthers position and fruit set obtained by unassisted selfing, it may be erroneous to attribute a biological significance to the noted morphological characteristics of almond flowers.

Wind buffeting of unbagged flowering branches alone was inadequate to ensure sufficient pollination to support optimum fruit set (Weinbaum, 1985). Therefore, the role of intimate contact of the pollen grains with the stigmatic surface appears to be critical to produce a satisfactory fruit set (Westwood et al., 1966). Because of the high bloom density of Apulian almond ecotypes (Grasselly and Crossa Raynaud, 1980), all cultivars tested, except 'Ferrante', proved sufficiently self-fertile to produce a full crop, but only when self-pollination was artificially optimized. Our results on fruit set induced by unassisted selfing agree with those of Weinbaum (1985) and disagree with those of Vasilakakis and Porlingis (1984). We suggest that Vasilakakis and Porlingis (1984) used a particularly fertile clone of 'Truquito'. In fact, in our past investigations (Godini, 1977b; Godini et al., 1990b; Reina et al., 1985) and in the present study, none of the 30 self-compatible Apulian cultivars, including 'Tuono', approached the unusually high fruit sets after natural selfing shown by 'Truquito' in Greece.

Our data indicate that most of the self-compatible Apulian almonds tested can be grown in solid blocks without the need for

cross-pollination, provided that adequate insect vectors are available to ensure optimum self-pollination. The availability of self-compatible almond cultivars can be interpreted as a step toward overcoming some of the problems of almond orchard management due to self-incompatibility (Tufts, 1919). We point out that Apulian almond growers ignore the relationship between pollinating intensity and fruit set (Kester and Griggs, 1959a) and continue to entrust the pollen transfer to wild insect vectors. Because of the scarcity of the wild vector populations, pollen transfer and fruit sets are generally low. Under such conditions, self-compatible almond cultivars set consistently more heavily (two times and more) than self-incompatible ones (Godini, 1977a). The comparatively higher and more consistent yield is the main reason for the interest in some self-fertile Apulian almond cultivars by growers and scientists in the Mediterranean basin. 'Genco' and 'Tuono' are increasingly planted in commercial orchards and are being used as parents in breeding programs to introduce self-compatibility into the genome of self-incompatible cultivars native to France (Grasselly, 1985), Spain (Felipe and Socias i Company, 1988) and Tunisia (El Gharbi, 1980).

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Defoliation of Strawberry Transplants for Fruit Production in Florida

E.E. Albregts, C.M. Howard, and C.K. Chandler

Agricultural Research and Education Center, University of Florida,
13138 Lewis Gallagher Road, Dover, FL 33527

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Abstract. Florida-developed strawberry (*Fragaria* × *ananassa* Duch.) clones or varieties grown in Florida nurseries and California-developed varieties grown in Canadian nurseries were evaluated in fruiting studies in Florida during four seasons. Transplants were defoliated so that 0%, 35%, 60%, or 87% of the foliage was removed. The Florida clones 'Dover' and selection 79-1126 gave significant linear and/or quadratic early and total marketable yield responses to defoliation treatments for all seasons. The Canadian-grown clones 'Chandler' and 'Selva' gave similar responses during three seasons, but differences were not as great as for the Florida-grown clones. Many significant linear and quadratic responses in seasonal average fruit weight and plant size occurred for Florida-grown plants, but only one occurred with the Canadian-grown plants. Relative plant size at early and midseason decreased with greater defoliation.

Strawberry transplants used in the annual hill cultural system in Florida are produced locally for clones developed in Florida, while clones developed in California are generally produced in nurseries in the northern United States or southern Canada. The reasons for this are 2-fold. California clones grown in northern areas are less susceptible to anthracnose (*Colletotrichum* spp.) (a devastating disease in Florida) in the nursery and fruiting field than the same clones grown in Florida (Howard and Albregts, 1982). In addition, because of plant chilling and the shorter daylengths in the northern nurseries, plants have flower buds in the crown and starch stored in the roots when shipped to Florida (Bringhurst et al., 1960). Florida-developed plants flower 4 to 8 weeks later than the same plants from northern U.S. nurseries. Since Florida-developed plants are mostly resistant to anthracnose, production of transplants is generally done in Florida because of lower costs. Locally produced plants are transplanted with foliage intact, since defoliation of these plants has been found to cause plant mortality and fruiting problems (Albregts and Howard, 1972). Regardless of origin, transplants are usually irrigated with overhead sprinklers during the daytime stress

period until established to reduce foliage loss. Irrigation for establishment could be reduced by as much as 50% and shipping costs would also be less if Canadian-grown plants could be defoliated before shipping or if Florida-grown plants could be partially defoliated before planting. With reduced foliage, foliage diseases and mites (*Tetranychus urticae* Koch) would have a lower probability of being transferred to the fruiting field, which might

lower pesticide usage. However, for economic reasons, fruit production should not be delayed or reduced by defoliation.

The purpose of this study was to determine the effect of various amounts of defoliation on the plant growth and fruiting response of Florida- and Canadian-grown nursery plants.

Studies were conducted at Agricultural Research and Education Center (AREC), Dover, during four winter (October through April) seasons, 1987-88 through 1990-91, using the annual hill cultural system. The soil was a Seffner fine sand (sandy, siliceous, hyperthermic Quartzipsammic Haplumbrepts). Transplants of 'Dover' and breeding line FL-79-1126 were produced at AREC-Dover, and 'Chandler' and 'Selva' transplants were produced in southern Ontario. 'Chandler' and 'Selva' transplants were not produced in Florida because of the problem with anthracnose as noted above. Raised beds were fertilized with 224N-20P-184K (kg-ha⁻¹), fumigated with a 98% methylbromide and 2% chloropicrin mixture at 448 kg-ha⁻¹ of bed area and mulched with black polyethylene. Transplants were set on 27 Oct. 1987, 20 Oct. 1988 and 1989, and 22 Oct. 1990, with two rows per bed and plants spaced 30 cm between and 28 cm within rows. Overhead sprinkler irrigation and labeled pesticides were applied as needed. Defoliation treatments of plants consisted of measuring the height of the foliage and removing

Table 1. Early marketable fruit yields of strawberry (through January) during four seasons as affected by foliage removal and plant source.

Plant source	Foliage removed (%)	Early marketable fruit yield (Mg-ha ⁻¹) ^a			
		1987-88	1988-89	1989-90	1990-91
Florida ^b	87	1.4 b	4.1	1.7	2.9
	60		8.1	5.0	4.1
	35		9.3	5.6	5.7
	0	6.4 a	10.9	5.1	7.7
Significance					
Treatment		**	***	**	***
Linear			***	***	**
Quadratic			*	***	NS
Canada ^b	87	4.6	6.5 b	4.6 b	5.3
	60			4.6 b*	6.3
	0	4.6	10.3 a	6.2 a	8.4
Significance					
Treatment		NS	**	*	***
Linear					***
Quadratic					NS

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^aMegagrams/2.78 = yield/plot in kilograms.

^b1987-88 data are only for Florida-grown FL-79-1126, and 1987-88 and 1988-89 data are only for Canadian-grown 'Chandler'. All other data are averages of two clones.

*Defoliated 87% 2 weeks before plant harvest.

NS,*,**,*Nonsignificant or significant at $P = 0.05$, 0.01 , or 0.001 , respectively, using ANOVA F test (treatment) and regressions.