populations (at least once every 5 years).

2) Focus surveys on cultivars shown to be promising sources of taxol and taxanes.

3) Continue to sample clippings yields annually for plants more than 3 years old.

4) Study the potential for harvesting other plant organs and whole plants for taxol along with clippings. Questions to be answered include: a) What would be the optimum plant age to harvest?; b) At what time of year should harvesting be done?; c) should plants be dried, after which needles only are stored and marketed?; d) how can agronomic practices be adjusted (row spacing, fertilization, irrigation, choice of climate, etc.) to maximize taxol/taxane yields per acre?; e) how does the dedicated "whole-plant-for-taxol" system compare economically to harvesting clippings and cull plants as by-products of traditional production and marketing of ornamental yews?

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The Effect of Orchard Design on Almond Fruit Set

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Additional index words. pollination, *Prunus amygdalus*, *Prunus dulcis*

Summary. Low levels of fruit set were measured in a commercial almond [*Prunus amygdalus* Batsch, syn. *Prunus dulcis* (Mill.) D.A. Webb] orchard during 3 years. Low sets may be attributed mostly to orchard design, as cultivars are distributed in contiguous rows where pollen interchange among different cultivars is not facilitated. An appropriate orchard design and proper bee management are essential for commercial yields in self-incompatible almond cultivars.

Most commercial almond cultivars are self-incompatible (Socias i Company, 1990). Because the seed is the commercial part of the fruit, fertilization must occur to obtain a crop. Efficient cross-pollination by insects, mostly honey bees, is required, and any reduction in the number of cross-pollinated flowers can reduce yield (Kester and Griggs, 1959). Consequently, maximum yield efficiency requires the presence of simultaneously blooming inter-compatible cultivars, the presence of pollinating insects, and favorable weather conditions for both adequate bee activity and pollen tube growth. In addition, the proper proportion and distribution of the cultivar combination is necessary for efficient transport of pollen from one cultivar to another.

Although these facts are widely recognized (Traynor, 1993), some new orchards are established without con-

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sidering these requirements. The problem is aggravated further in intensively managed orchards, where, at bloom, tree rows form floral walls. These walls probably reduce bee transfer between rows and intensify the tendency of bees to visit a single cultivar (Jackson and Clarke, 1992).

A commercial orchard with six contiguous rows of the same cultivar allowed us to test the effect of orchard design on almond fruit set.

Materials and methods

The orchard was planted in Feb. 1987 with 'Ferragnès', 'Ferraduel', and 'Cristomorto' almonds on the clonal peach × almond rootstock 'INRA GF 677'. These three scion cultivars are self-incompatible, simultaneously blooming, and cross-compatible, being good pollinizers of each other (Socias i Company and Felipe, 1977). Cultivar distribution is shown in Fig. 1. Tree distance was 5 × 3 m.

In two different locations in the orchard, identified as sites A and B, 11 trees were selected in contiguous rows in order to form a group limited by 'Cristomorto' trees at both ends and three 'Ferraduel' and six 'Ferragnès' trees between them. Four branches of comparable size (≈1.25 m long) and position (≈1 to 1.5 m on ground) were selected on each tree, and all the flowers on each were counted. After "June drop," the total number of fruits was counted on each branch to assess fruit set. Counts were made during 3 consecutive years (1991, 1992, 1993) on the same trees.

Fig. 1. Cultivar distribution in the orchard: Replication of one row of 'Cristomorto', three rows of 'Ferraduel', and six rows of 'Ferragnès'.

Table 1. Fruit set of the different trees according to their distribution in the orchard.

Cultivar	Set (%)					
	1991		1992		1993	
	Site A	Site B	Site A	Site B	Site A	Site B
Cristomorto	3.05	5.25	14.91	14.77	30.32	12.11
Ferraduel-1	6.39	6.30	9.38	9.04	9.79	18.85
Ferraduel-2	5.02	4.96	8.45	8.76	10.35	13.20
Ferraduel-3	3.14	8.65	5.61	11.84	16.63	19.27
Ferragnès-1	3.95	7.25	12.04	6.34	24.20	16.36
Ferragnès-2	1.84	4.06	5.89	7.53	16.95	12.30
Ferragnès-3	5.56	4.21	7.89	4.68	15.99	13.67
Ferragnès-4	1.75	4.09	5.63	11.16	12.19	14.66
Ferragnès-5	5.60	5.08	6.37	11.18	12.57	15.19
Ferragnès-6	6.75	5.97	12.85	13.43	16.58	13.91
Cristomorto	4.59	3.67	19.03	15.38	32.61	12.54

Results and discussion

Final fruit sets for each tree (Table 1) are considered low. The orchard, relatively young, already produced a crop in 1990, the year before the evaluation of sets was initiated. This precocity could be due to its high density, the application of fertigation, and that the three cultivars are considered highly productive. These sets are lower than those reported as average for commercial almond orchards in California, 30.2 for 'Nonpareil', and 33.4 for 'Texas' in growing conditions that can be considered similar (Kester and Griggs, 1959).

Sets of individual trees do not follow exactly the expected gradation in relation to the proximity of another cultivar. For this reason only, overall sets of cultivars and rows were examined. Similarly, as no yield data were available, overall yield rate was used for

each cultivar (Table 2). These results suggest that the conditions for cross-pollination and fruit set are not favorable, although they could have improved in each of the 3 years. The very low sets and yields in 1991 could be due to both a low presence of beehives at bloom and to unfavorable weather conditions in spring. Some frosts took place in March, followed by a long period of wind in April and May that damaged the canopies. Although fruit set in 'Ferragnès' was significantly higher than in the two other cultivars (Table 2), this increase had no effect in improving yield. All the sets and yields were very low, being mostly attributable to the bad weather conditions.

Weather conditions were much better in 1992 and 1993, and were similar in both years. Sets and yields increased as compared to 1991, especially in 1993. This last increase must be attributed to a higher presence of bees, because an average of four beehives per hectare were distributed in 1993, whereas 1.5 were employed in 1992.

The benefit of bees can be observed in all 3 years by combining sets for different rows according to their proximity to a pollinizer. This effect occurred even in 1991, when the weather conditions were least favorable. Rows 1 and 3 of 'Ferraduel' were combined, because both are between a row of the same cultivar and a row of a pollinizer ('Cristomorto' or 'Ferragnès'). Rows 1 and 6 of 'Ferragnès' were combined, as were rows 2 and 5 (both at one row from a pollinizer), and 3 and 4 (both at two rows from a pollinizer).

Sets of rows 1 and 3 of 'Ferraduel' were significantly higher than those of row 2 in 1991 and 1993, although not in 1992. 'Ferragnès', however, showed

Table 2. *Global fruit set of the different cultivars.*

Cultivar	1991			1992			1993		
	No. flowers	Set (%)	Yield rating	No. flowers	Set (%)	Yield rating	No. flowers	Set (%)	Yield rating
Cristomorto	12,109	4.31 a ^z	0.1 ^y	3,093	16.10 b	3.0	3,820	20.58 b	3.7
Ferraduel	10,252	5.87 b	0.1	9,432	8.68 a	1.5	6,895	13.88 a	3.2
Ferragnés	15,623	4.63 a	0.1	15,667	8.67 a	1.3	10,401	15.11 a	3.0

^zSets for each year followed by different letter are different by LSD test at $P \leq 0.001$.

^yYield rated on a 0 to 5 scale; 5 could represent 2000 kernel yield/ha.

Table 3. *Analysis of fruit set as related to the proximity to a pollinizer.*

Cultivar	Rows	Set (%)		
		1991	1992	1993
Ferraduel	1-3	6.22 a ^z	8.74 a	15.05 a
Ferraduel	2	4.99 b	8.56 a	11.60 b
Ferragnés	1-6	5.93 a	11.03 a	17.08 a
Ferragnés	2-5	4.05 b	7.82 b	14.42 b
Ferragnés	3-4	3.92 b	7.34 b	14.09 b

^zSets for the same cultivar and year followed by different letter are different by LSD test at $P \leq 0.01$.

the same behavior during the 3 years, with sets of rows 1 and 6 being significantly higher than those of the other rows, which did not differ between them. The lack of differences between the sets of rows 2 and 5 vs. 3 and 4 may be due to the absence of a pollinizer row close to any of these rows. Hill (1989) showed that bees fly from one cultivar to another up to 24% of times when the pollinizers are distributed in alternate rows, but the change of cultivar is reduced to 15% if the orchard design is that of 1 row-2 rows of different cultivars. There is a further decrease in bee efficiency if the rows of pollinizers are placed further apart. Hill (1989) described as ideal the orchard design of alternate trees on alternate rows, where bees change cultivar as often of 32% of the time, but this design would not be convenient for orchard management.

Pollen transfer from one cultivar to the other is quite reduced, even with the presence of bees, taking place mostly between tree halves of contiguous rows, without progression through the rest of the orchard (Jackson and Clarke, 1991). This explains the higher sets of 'Cristomorto' as compared to the other cultivars, even with the best sets of 'Ferraduel' and 'Ferragnés' (Tables 2 and 3), because 'Cristomorto' has pollinizers on both sides. Other cultivars have only a pollinizer on one side in the best situation.

These results show that this orchard design is not advisable for efficient cross-pollination and production.

The higher presence of bees in 1993 has shown its positive effect for increasing sets, although they remain low, even for 'Cristomorto'. Sets were especially low at site B because beehives were not distributed evenly, showing that a good orchard design and proper bee management are essential for obtaining a crop in self-incompatible almond cultivars.

Acknowledgements

ALM Group is acknowledged for allowing us to work in its orchard. The help of its manager, J.M. Estela, is appreciated, and also that of P. Castañer and J.M. Ansón for counts. Work conducted under projects INIA 9567 and CICYT AGF92-0294.

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Planting-date Effects on Early maturing Pigeonpea in a Short-season Environment

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Additional index words. *Cajanus cajan*

Summary. Determinate, photoperiod-insensitive genotypes of pigeonpea [*Cajanus cajan* (L.) Millsp.] have production potential for the short growing seasons of the temperate region. A 3-year field study was conducted to determine the effect of three planting dates on the growth and development of pigeonpea in Missouri. Seeds of four genotypes, ICPL 87 Isolation (85k), ICPL 85010, ICPL 85024, and ICPL 8304 were planted 1 May (PD1), 15 May (PD2), and 1 June (PD3). Germination of the earliest-planted seeds was <32%, but increased to an average of 57% for PD3. Earliest-planted seeds generally took the longest time to first flowering and harvest. The initial fresh pod harvest of plants from PD1 and PD2 overlapped. The earliest harvest was produced by ICPL 85024 from PD2 at 91 days (1300 degree-days C) after planting. Over the 3 years, the genotypes in PD1 produced the highest fresh pod weights (205-357 g/plant) and longest pods. Those of PD3 produced the lowest pod weight. The seed number per pod (three to four) and weight of 100 seeds (16-22 g) were generally unaffected by planting dates.

Pigeonpea is a leguminous crop adaptable to tropical and subtropical climates (Saxena, 1981;

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Journal paper A6-101-94 of the Lincoln Univ. Agricultural Experiment Station. Trade names are mentioned with the understanding that no discrimination is intended and no endorsement by the author of Lincoln Univ. is implied. Research supported in part by USDA-CSRS funds allocated to the Univ. Agricultural Experiment Station. 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.