

1 Flower age and pollenizer could affect fruit set in late-blooming self-
2 compatible almond cultivars under warm climatic conditions

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16 Effective pollination period, Temperature, Fruit set

17

18 **ABSTRACT**

19 The effect of the pollination time and of the pollen origin was studied in three self-compatible
20 and late-blooming almond genotypes in order to evaluate their effect on fruit set and yield.

21 The full self-compatibility of the three genotypes was clearly assessed as fruit sets after self-
22 pollination were similar to those obtained after cross-pollination with pollen from two
23 different genotypes. Sets reached the level of a commercial production, ranging from 34.02 to
24 49.98% when the flowers were pollinated at the best pollination time, two days after
25 emasculation. Pollination at later times significantly decreased fruit set, as well as high
26 temperatures, negatively affecting stigma receptivity and, consequently, pollen germination
27 and fruit set. Thus, early pollination is essential for self-compatible almond cultivars, mainly
28 if these cultivars are grown in regions with warm conditions in late winter and early spring.

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31 **1. Introduction**

32

33 The pollination process in fruit trees involves the release, transport, and deposition of
34 pollen from the anthers onto a stigma. Almond [*Prunus amygdalus* Batsch syn. *P. dulcis*
35 (Mill.) D.A. Webb] cultivars are, with few exceptions, self-incompatible (SI), thus making
36 cross-pollination essential for yielding acceptable crops because the commercial part of the
37 fruit is a seed (Socias i Company, 1990). The development of consensus and specific
38 molecular markers linked to the *S*-alleles (Tamura et al., 2000; Channuntapipat et al., 2003),
39 involved in the recognition and inhibition of the pollen tube growth in pistils harbouring the
40 same *S*-genotype, has allowed the establishment of cross-incompatible groups of the most
41 important almond cultivars grown around the world (Kodad and Socias i Company, 2009a).
42 Although this progress has allowed checking the cross-compatibility between cultivars before
43 planting in commercial orchards, the most important problem for efficient pollination is the
44 synchronisation of flowering time of both cultivars in order to maximize the possibilities of
45 pollen interchange. Flowering time is affected by temperatures before bloom (Alonso and
46 Socias i Company, 2009), and the success of the pollination process is additionally affected
47 by other climatic conditions such as rain, wind or fog during bloom, as they distress the
48 activity of the pollen vectors in the orchard. The release of new autogamous almond cultivars
49 (Socias i Company et al., 2009) has been directed to avoid the problems related to pollination,
50 thus allowing the establishment of orchards with a single cultivar and, as a consequence,
51 facilitating their management and solving the frequent situations of a deficient pollination
52 resulting in low yields (Socias i Company, 1990).

53 However, some self-compatible cultivars have shown setting and production problems
54 (Godini et al., 1994; Socias i Company et al., 2004), raising the question of whether the
55 introduction of adequate insect vectors in the mono-varietal orchards must be maintained to

56 ensure optimum pollination for increasing fruit set (Godini et al., 1994). Several factors
57 conditioning fruit set, and consequently yield, have been identified and studied, such as bud
58 density and factors determining the floriferous capability of a genotype (Bernad and Socias i
59 Company, 1998; Dicenta et al., 2006); the ability for the flower population to be pollinated
60 and fertilized (Socias i Company et al., 2005), which depends on the genetic control of
61 incompatibility (Dicenta et al., 2002); the proportion of flower sterility (Socias i Company,
62 1983); the environmental conditions (Socias i Company et al., 2005); and the inbreeding
63 effect (Alonso and Socias i Company, 2005).

64 Kodad and Socias i Company (2009b) have reported that the effective pollination time
65 could be considered as a determinant factor for fruit set in ‘Guara’, an autogamous cultivar,
66 and pointed out the importance of the early pollination of flowers. The concept of effective
67 pollination period (EPP) was introduced by Williams (1965) to assess floral receptivity in
68 apple, and was defined as the period during which pollination was effective for producing
69 fruit. This period is determined by the longevity of the ovules minus the time-lag between
70 pollination and fertilization, provided that this resulting value does not exceed the length of
71 stigma receptivity. EPP plays a clear role in controlling fruit set and yield of temperate fruit
72 crops (Sanzol and Herrero, 2001). In almond, yield has been shown to be determined by the
73 number of flowers per tree and the EPP (Griggs and Iwakiri, 1964; DeGrandi-Hoffman et al.
74 1989; Vezvaei and Jackson, 1994). Several factors related to pollination-fertilization
75 efficiency, such as stigma receptivity (Ortega et al., 2004), pollen tube kinetics (Alonso and
76 Socias i Company, 2005), ovule longevity (Pimienta and Polito, 1982), temperature (Socias i
77 Company et al., 2005), and chemical treatments (Socias i Company and Gómez Aparisi,
78 2002; Yi et al., 2006), were studied and their importance was underlined in limiting fruit set
79 in almond cultivars.

80 The possible effect of the pollen source on fruit set in self-compatible almond cultivars
81 must be known because in these cultivars fruits are obtained from self-pollination.
82 Consequently, the ability of these cultivars to produce acceptable yields must be assessed in
83 order to recommend them for planting in single-cultivar commercial orchards. Fruit set
84 obtained after hand self- and cross-pollination have been compared (Dicenta et al., 2002;
85 Socias i Company et al., 2005; Ortega et al., 2006; Kodad and Socias i Company, 2008),
86 showing that self-pollination does not negatively affect yield in some genotypes, whereas
87 others showed lower fruit sets when self-pollinated as compared with cross-pollination
88 (Godini et al., 1994; Alonso and Socias i Company, 2005; Socias i Company et al., 2005;
89 Kodad and Socias i Company, 2008).

90 So far, all studies have utilized a single source of foreign pollen in the cross-pollination
91 treatments, or pollen of unknown origin in the case of open pollination. As a consequence, our
92 objective was to assess the influence of stigmatic receptivity and different pollenizers on fruit
93 set in late-blooming self-compatible almond cultivars.

94

95 **2. Materials and methods**

96

97 *2.1. Plant material*

98

99 The experiments were conducted over two consecutive years on three almond genotypes
100 from the almond breeding programme of the Centro de Investigación y Tecnología
101 Agroalimentaria de Aragón (CITA), in Zaragoza, Spain, including two released cultivars,
102 ‘Felisia’ (Socias i Company and Felipe, 1999) and ‘Mardía’ (Socias i Company et al., 2008),
103 and one advanced selection (I-2-12). These genotypes are all late-blooming and self-
104 compatible, sharing the S_f allele responsible of self-compatibility in almond (Felisia: S_8S_f ;

105 Mardia: S_6S_7 ; I-2-12: S_3S_7). The treatments were carried out on three trees of these genotypes
106 grafted in 1998 on the almond \times peach hybrid clonal rootstock ‘Garnem’ (Felipe, 2009) and
107 planted in the orchard in 2000. These plants are maintained according to standard cultural
108 management. Pollenizers included two traditional cultivars, ‘Marcona’ ($S_{11}S_{12}$) and ‘Fournat
109 de Brézenaud’ ($S_{24}S_{25}$), grown in the same location. The CITA experimental station is located
110 in Zaragoza, at latitude 41° 38' 50" N and longitude 0° 53' 07" W, at 220 m over sea level.

111

112 2.2. *Pollen grain germination*

113

114 Pollen was obtained by desiccating anthers for 48 h at room temperature and storing it at
115 4°C in glass vials until pollination. Pollen germination was tested on a solidified culture
116 medium consisting of 0.3 mM sucrose, 0.6 mM calcium nitrate, 1.6 mM boric acid and 0.8%
117 agar in a Petri dish (Hormaza and Herrero, 1996). Petri dishes were incubated at 22°C for 6
118 hours and pollen germination was observed under light microscope. A pollen grain was
119 considered germinated when the length of the pollen tube exceeded its diameter (Ducon,
120 1968). The percentage of pollen grain germination was calculated for each sample.

121

122 2.3. *Effective pollination period*

123

124 EPP was determined according to Williams (1970) on tree homogenous branches selected
125 at random around the canopy of the three trees of each genotype, including the different
126 directions around the canopy and being of the same order of branching, of an approximate
127 length of 1 m and placed at about 1.5 m above ground. Only flower buds at Stage D (Felipe,
128 1977) were left on the branches for emasculation as their evolution indicated that they were at
129 one day before anthesis (Kodad and Socias i Company, 2009b). Emasculated flowers (~ 100

130 flower buds) were hand self-pollinated or cross-pollinated with ‘Marcona’ and ‘Fournat de
131 Brézenaud’ pollen, at 0, 2, 4, 6 or 8 d after emasculation. Intact flowers were left for assessing
132 the anthesis day. Fruit set (i.e., the percentage of pollinated flowers that produced fruit) was
133 recorded in June, approximately three months after bloom.

134

135 *2.4. Stigma receptivity*

136

137 Stigma receptivity was determined on the same three trees. Flowers were emasculated and
138 hand self-pollinated or cross-pollinated with ‘Marcona’ and ‘Fournat de Brézenaud’ pollen at
139 0, 2, 4, 6, or 8 d after emasculation. For each pollination treatment, 10-15 flowers were
140 collected 1 and 4 d after pollination, fixed in 1:1:18 (v/v/v) FAA (formaldehyde-acetic acid-
141 70% ethanol), rinsed several times in water, and autoclaved in a 5% solution (w/v) of Na₂SO₃
142 for 12 min at 1.2 kg cm⁻². Samples were maintained at 2-4°C until examination of pollen
143 germination on the stigmas. The percentage of stigmas with pollen tubes in the upper part of
144 the style were determined using a Leitz Ortholux II (Wetzlar, Germany) microscope with UV
145 illumination via an Osram HBO 200 W/4 mercury lamp after staining with 0.1% (w/v) aniline
146 blue in 0.1M potassium phosphate (Linskens and Esser, 1957). Each stigma was considered
147 receptive when it was able to support pollen hydration, germination, and initial pollen-tube
148 growth into the transmitting tissues of the style (Sanzol et al., 2003). The percentage of pistils
149 with pollen penetrating the stigma 1 d after pollination, out of 25-30 pistils examined, was
150 determined as an index of stigma receptivity.

151

152 *2.5. Statistical analysis*

153

154 All statistical analyses were performed using the SAS 2000 programme (SAS Institute,
155 Cary, NC, USA). Analysis of variance used the PROC GLM procedure to distinguish the
156 effects of pollination time and year. Means were separated by Duncan's multiple range test (P
157 < 0.05).

158

159 *2.6 Meteorological data*

160

161 Climatic parameters during flowering were measured at a station located in an adjacent
162 sprinkler-irrigated grass plot. The daily minimum and maximum temperatures ($^{\circ}\text{C}$), humidity
163 (%), and wind speed (ms^{-1}) during the flowering period and 8 d after emasculation are shown
164 in Fig. 1 and 2 for the two years of the study.

165

166 **3. Results and discussion**

167

168 *3.1 In vitro pollen germination*

169

170 Pollen germination was evaluated for the five almond cultivars included. In 2006, pollen
171 germination of the pollenizers was 82% and 89% for 'Fournat de Brézenaud' and 'Marcona'
172 respectively. For the pollen receivers it was 94%, 92%, and 92% for 'Felisia', 'Mardía', and I-
173 2-12 respectively. In 2007, pollen germination was 90%, 92%, 92%, 90%, and 89% for
174 'Fournat de Bréznau', 'Marcona', 'Felisia', 'Mardía', and I-2-12 respectively. These
175 percentages agree with those already reported in almond (Weinbaum et al., 1984; Hill et al.,
176 1985; Martínez-Gómez et al., 2002). Although the pollen of the early blooming varieties
177 'Fournat de Brézenaud and 'Marcona' had to be stored for 1 to 2 months at 4 $^{\circ}\text{C}$ to be used
178 for pollinating the late blooming genotypes, Martínez-Gómez et al. (2002) reported that this

179 temperature was suitable for almond pollen storage for up to 2 months. The germination
180 percentages obtained were high and considered sufficient to ensure the correct development
181 of pollen tube growth and fertilization (Martínez-Gómez et al., 2002).

182

183 *3.2 Pollination day effect*

184

185 The analysis of variance of the percentage of pistils with germinated pollen and fruit set
186 revealed that the day of pollination and the genotype \times day interaction were significant (Table
187 1 and 2). In the same way, the pollen receiver and the year were significant (Table 1 and 2).
188 The present results showed that the day of pollination, the pollen receiver and the year are
189 important factors determining the stigmatic receptivity and fruit set in almond cultivars, as
190 already pointed out by Ortega et al (2004). In our study, selection I-2-12 showed the highest
191 number of pistils with pollen tubes in the upper part of the style in both years, whereas
192 'Felisia' showed the lowest value in 2006 (Table 3). Not all stigmas were receptive at
193 emasculatation for all genotypes in both years (Table 3), probably due to immature stigmas as
194 reported in almond cultivars (Ortega et al. 2004; Yi et al., 2006). In the same way, fruit set
195 with pollination time at day 0 was lower than that for days 2 and 4 (Fig. 3), as already
196 observed (Ortega et al., 2004; Kodad and Socias i Company; 2009b). The lowest values of
197 fruit set were obtained with pollination times at days 6 and 8, coinciding with the lowest
198 stigma receptivity (Fig. 3). Acceptable fruit sets were obtained following pollination from day
199 0 to day 4 after emasculatation in both years for all cultivars (Fig. 3), coinciding with the
200 duration of EPP in almond, reported to be between 4 and 6 days, depending on the cultivar
201 and the temperature during bloom (Ortega et al., 2004; Kodad and Socias i Company, 2009b).

202 When the statistical analysis was done for each pollination time, the results showed no
203 significant differences between years for the time of 0 and 2 days after emasculatation for

204 stigmatic receptivity and fruit set, whereas for 4, 6 and 8 days the differences were significant
205 (data not shown). Thus, the year effect on stigmatic receptivity and fruit set is related to the
206 time of pollination, which in turn is related to the climatic conditions during bloom, but not to
207 the pollen receiver. In fact, the stigmatic receptivity decreased 4 days after emasculation,
208 independently of the pollen receiver and the pollen donor. This decrease has already been
209 described in almond (Griggs and Iwakiri 1975, Ortega et al., 2004), and we have observed
210 differences in the rate of decrease between years, being more drastic in 2006. However, the
211 reduction of fruit set with pollination time was more drastic in 2007 than in 2006 for ‘Felisia’
212 and ‘Mardía’ than for selection I-2-12 (Fig. 3). The year effect on stigma receptivity could be
213 due to different climatic conditions, mainly temperatures during bloom (Ortega et al., 2004).
214 However, fruit set could also be affected by frost damage during bloom and during the first
215 stages of fruit growth (Felipe, 1988). In the present study no abnormal climatic conditions
216 were observed during fruit growth, which could drastically affect fruit set (data not shown).
217 Relative humidity and wind speed also could affect stigmatic receptivity during bloom. In
218 both years of the study, the average humidity during this period was more than 60% (Fig. 2).
219 The average wind speed, however, was higher in 2007 than in 2006 during the blooming time
220 of ‘Felisia’ and I-2-12 (Fig. 2), although for ‘Mardía’ it was similar in both years of the study.

221 However, not all genotypes behaved similarly in both years. ‘Mardía’ and ‘Felisia’ showed
222 a drastic decrease of stigma receptivity and fruit set during the first year as compared with
223 selection I-2-12 (Table 3). In 2006, emasculation day was March 13 for I-2-12, March 25 for
224 ‘Felisia’, and March 28 for ‘Mardía’ (Fig. 1). At blooming time of I-2-12 temperatures were
225 lower, with maximum temperatures under 20°C, mainly during the first days after
226 emasculation (Fig. 1), whereas for ‘Felisia’ and ‘Mardía’ maximum temperatures were higher,
227 between 21-26°C, probably affecting the stigma receptivity and fruit set of these cultivars. In
228 2007 the maximum temperatures during the blooming period of all genotypes were lower than

229 in 2006, generally under 20°C (Fig. 1). Under these conditions, the stigmas maintained their
230 receptivity and offered a good support for pollen germination and pollen tube penetration into
231 the style, explaining the high stigma receptivity for all genotypes in 2007. Since the decrease
232 of stigmatic receptivity was more drastic in 2006 than in 2007 (Table 3), it appears that the
233 most important factor affecting stigmatic receptivity under the climatic condition of the
234 present experiment is temperature during bloom, not humidity or wind.

235 Selection of very late blooming cultivars has been adopted in order to avoid damage by
236 late spring frosts, characteristic of many inland regions where almond growing has expanded.
237 However, not all genotypes react in the same way to high temperatures. Additionally, it was
238 supposed that later blooming, coinciding probably with higher temperatures, would favour
239 pollen transport, germination and growth, but our results show that late-blooming almond
240 selections require a previous evaluation of adaptability to high temperatures because fruit sets
241 may be negatively affected if flowers are not pollinated efficiently during the first days after
242 anthesis.

243

244 *3.3. Pollen source effect*

245

246 The statistical analysis showed that the pollination treatment was not significant for
247 stigmatic receptivity and fruit set (Table 1 and 2), clearly showing that fruit set in self-
248 compatible almond cultivars depends primarily on the genotype and the climatic conditions of
249 the year, but not on the pollen source. Fruit sets were similar for all cultivars in the two years
250 after both self- and cross-pollination (Fig. 3). As the main objective of the almond breeding
251 programme was the obtaining of self-compatible and late blooming almond cultivars, the
252 present results assess that this objective was reached. Self-pollination gave a similar or better
253 set than cross-pollination, confirming that self-pollen did not negatively affect fruit set and,

254 consequently, yield. The strategy of obtaining self-compatible cultivars to avoid the problems
255 related to pollination and management of orchards with multiple cultivars has been successful
256 (Socias i Company, 1990), as confirmed by other results when pollination was done at day 0
257 or 2 after emasculation (Dicenta et al., 2002; Martínez-García et al., 2011). However, in other
258 cases fruit set after cross-pollination has been higher than after self-pollination (Socias i
259 Company et al., 2004; Martín and Rovira, 2009), stressing the need for a correct evaluation of
260 self-compatibility during the selection process (Socias i Company et al., 2010), as other
261 factors may affect fruit set. These different results are probably not contradictory, but
262 consequence of the effect of inbreeding depression.

263 The most important criterion to evaluate the degree of self-compatibility for any genotype
264 is its ability to produce a high number of fruit when self-pollinated (Socias i Company et al.,
265 2010), a feature mostly depending on the intrinsic characteristics of the genotype (Socias i
266 Company et al., 2005; Kodad and Socias i Company, 2008). ‘Tuono’ has been a self-
267 compatible almond cultivar repeatedly utilized in most breeding programmes as a source of
268 self-compatibility (Socias i Company, 2002), having given rise to many self-compatible
269 cultivars released in the last years. ‘Tuono’ has been reported to show a clear inbreeding
270 effect (Socias i Company, 2002; Martínez-García et al., 2012), and several inbred genotypes
271 have been identified and described in its progeny (Grasselly and Olivier, 1988; Alonso and
272 Socias i Company, 2005). Inbreeding affords the expression of lethal and deleterious genes,
273 which could cause disruption of pollen tube growth and embryo sac development (Alonso and
274 Socias i Company, 2005; Martínez-García et al., 2012), leading to lack of fertilization and low
275 or nil fruit set (Martínez-García et al., 2012). The level of inbreeding expression may depend
276 on the number of altered genes inherited by each genotype (Lynch and Walsh, 1988). Thus,
277 the effect of self-pollination on fruit set will depend on the presence and number of these
278 deleterious alleles in each genotype. As a consequence, the negative effect of self-pollen on

279 fruit set of a given genotype is probably due to the level of inbreeding depression manifested
280 in that genotype. Since no differences were found between self- and cross-pollination in these
281 genotypes, they do not show any kind of depression and could be advised to be planted in
282 single-cultivar orchards.

283

284 **4. Conclusion**

285

286 The present results confirm the effect of the year, the genotype, the time of pollination, and
287 the warm temperatures during flowering on fruit set. The effective pollination period in
288 almond appears to be variable among genotypes, conditioned by high temperature during
289 blooming, ranging generally between 0 and 6 days after emasculation. It appears that self-
290 pollination does not negatively affect fruit set in these late-flowering self-compatible
291 genotypes, and that the most important factor determining fruit set in these genotypes is
292 pollination time. The efficiency of self-pollination during the first few days (4 days) after
293 emasculation appears to be crucial to ensure high fruit set, and consequently yield, in self-
294 compatible almond cultivars, mainly under warm climatic conditions during bloom. The
295 ability of self-pollination or autogamy depends on the reciprocal position of the stigma and
296 the anthers, because the closer they are the greater the possibility of self-pollination. Thus, the
297 selection of autogamous cultivars is crucial in any almond breeding programme, mainly if
298 these cultivars are planted in regions with warm conditions during late winter and early
299 spring.

300

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413 **Table 1**

414 Analysis of variance for the number of pistils with pollen tubes in the upper part of the style
 415 of the three almond genotypes studied.

Source of variation	df	Mean square [†]	<i>F</i> -value	P (>F)
Genotype	2	3084.90 ***	15.79	<.0001
Treatment	2	71.74 ns	0.37	0.6931
Genotype × Treatment	4	92.99 ns	0.48	0.7532
Year	1	6809.45 ***	34.86	<.0001
Genotype × Year	2	35.15 ns	0.18	0.8354
Year × Treatment	1	65.71 ns	0.34	0.5626
Genotype × Year × Treatment	2	12.65 ns	0.06	0.9373
Day of pollination	4	25209.8 ***	129.07	<.0001
Genotype × Day of pollination	8	681.12 **	3.49	0.0009
Year × Day of pollination	4	55.17 ns	0.28	0.8891
Genotype × Year × Day of pollination	8	117.49 ns	0.60	0.7759
Treatment × Day of pollination	8	127.85 ns	0.65	0.7309
Genotype × Treatment × Day of pollination	16	51.24 ns	0.26	0.9983
Year × Treatment × Day of pollination	4	33.77 ns	0.17	0.9521
Genotype × Year × Treatment × Day of pollination	8	29.57 ns	0.15	0.9964
Error	195	195.31		

416 [†]Significance of the mean squares at $P < 0.001(**)$, $P < 0.0001(***)$ or non-significant (ns)
 417 by Student's *t*-test.

418

419 **Table 2**

420 Analysis of variance for fruit set in the three almond genotypes studied.

Source of variation	df	Mean square [†]	<i>F</i> -value	P (>F)
Genotype	2	1004.69 ***	12.63	<.0001
Treatment	2	204.93 ns	2.58	0.0589
Genotype × Treatment	4	49.99 ns	0.63	0.6429
Year	1	7128.98 ***	89.60	<.0001
Genotype × Year	2	778.14 ***	9.78	<.0001
Year × Treatment	2	34.17 ns	0.43	0.6515
Genotype × Year × Treatment	4	53.99 ns	0.68	0.6076
Day of pollination	4	10305.80 ***	129.54	<.0001
Genotype × Day of pollination	8	326.11 **	4.10	0.0002
Year × Day of pollination	4	159.72 ns	2.01	0.0553
Genotype × Year × Day of pollination	8	128.71 ns	1.62	0.1224
Treatment × Day of pollination	8	65.55 ns	0.82	0.5825
Genotype × Treatment × Day of pollination	16	38.34 ns	0.48	0.9535
Year × Treatment × Day of pollination	8	76.16 ns	0.96	0.4710
Genotype × Year × Treatment × Day of pollination	16	65.13 ns	0.82	0.6634
Error	180	79.5		

421 [†]Significance of the mean squares at $P < 0.05$ (*), $P < 0.001$ (**), $P < 0.0001$ (***) or non-
 422 significant (ns) by Student's *t*-test.

423

424

425 **Table 3**

426 Mean values of number of pistils with pollen tubes in the upper part of the style 24 hours after
 427 pollination for the three almond genotypes studied after different pollination treatments and
 428 pollination times.

Genotype	Treatment ^z	Day of pollination after emasculation				
		0	2	4	6	8
<u>2006</u>						
Felisia	⊗	89.41	91.48	59.72	32.76	18.92
	×F	90.74	92.36	62.18	26.19	14.17
	×M	86.67	88.33	49.44	28.69	16.19
Mardía	⊗	88.89	89.63	64.60	30.28	17.41
	×F	91.11	90.00	62.22	38.15	20.74
	×M	90.28	88.89	52.98	39.49	15.74
I-2-12	⊗	92.32	89.03	51.67	37.41	30.26
	×F	90.86	89.63	62.96	44.95	24.66
	×M	91.90	90.32	64.81	44.07	31.11
<u>2007</u>						
Felisia	⊗	94.71	95.12	70.83	55.45	31.72
	×F	90.74	94.21	66.13	53.17	29.17
	×M	91.90	93.89	71.11	52.98	29.84
Mardía	⊗	92.96	92.96	70.79	48.98	34.44
	×F	91.11	92.96	70.00	51.85	30.74
	×M	90.28	91.11	67.98	49.15	30.56
I-2-12	⊗	90.46	89.03	73.33	57.08	37.78
	×F	93.64	92.96	73.70	57.88	35.03

	×M	92.80	95.08	67.78	51.48	34.44
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429 ^z ⊗: self-pollination; ×F; cross-pollination with ‘Fournat de Brézenaud’ pollen; ×M: cross-

430 pollination with ‘Marcona’ pollen.

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433 Figure legends

434

435 **Fig. 1.** Maximum, minimum and mean daily air temperatures during the blooming period in
436 2006 (A) and 2007 (B) at the experimental site.

437

438

439 **Fig. 2.** Average relative humidity and wind speed during the blooming period in 2006 (A) and
440 2007 (B) at the experimental site.

441

442

443 **Fig. 3.** Mean values of fruit set for I-2-12 (A), 'Felisia' (B) and 'Mardia' almond genotypes
444 after different pollination treatment and pollination times during the two years of study.

445

446 ⊗: self-pollination; ×F; cross-pollination with 'Fournat de Brézenaud' pollen; ×M: cross-
447 pollination with 'Marcona' pollen.

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