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# Self-compatibility and floral morphology of almond cultivars

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**Abstract.** Self-compatibility is an important almond trait aimed in new cultivars of most breeding programs. Nevertheless, different levels of self-fertility occur in almond self-compatible cultivars. Some hypotheses have been postulated about this phenomenon, and it seems that different aspects could be involved. One of them is the position of the stigmata in relation to the anthers in the flowers. In this work the morphology of almond flowers has been studied in 27 almond self-compatible genotypes (12 cultivars and 15 advanced selections from IRTA's almond breeding program). Data have been collected in 100 flowers/genotypes measuring the pistil and higher stamen length. According to these results, flowers were classified as "hypostigmate" (stigmata below the anthers) or "epistigmate" (stigma above the anthers). On the other hand, self-fertility percentages were studied in these self-compatible genotypes for several years, by counting the number of flowers present in bagged branches and the final fruit set obtained. No correlation was found between floral morphology and levels of self-fertility. Other aspects involved in the levels of almond self-fertility, apart from the morphology of the flower, are yet to be evaluated.

**Keywords.** Almond – Self-fertility – Epistigmatic flowers – Hypostigmatic flowers.

***Auto-compatibilité et morphologie florale des cultivars d'amandier***

***Résumé.*** *L'auto-compatibilité est un caractère important chez l'amandier, qui est ciblé chez les nouveaux cultivars pour la plupart des programmes d'amélioration. Cependant, différents niveaux d'auto-fertilité existent chez les cultivars auto-compatibles. Certaines hypothèses ont été émises concernant ce phénomène, et il semble que différents aspects puissent être impliqués. L'un d'eux est la position du stigmate par rapport aux anthères chez les fleurs. Dans ce travail, la morphologie des fleurs d'amandier a été étudiée chez 27 génotypes auto-compatibles (12 cultivars et 15 sélections avancées du programme d'amélioration de l'amandier de l'IRTA). Les données ont été collectées sur 100 fleurs/génotypes en mesurant la longueur du pistil et de la partie supérieure de l'étamine. Selon les résultats, les fleurs ont été classées comme "hypostigmatique" (stigmate en dessous des anthères) ou "épistigmatique" (stigmate au-dessus des anthères). Par ailleurs, les pourcentages d'auto-fertilité ont été étudiés chez ces génotypes auto-compatibles sur plusieurs années, en comptant le nombre de fleurs présentes dans les branches ensachées et la mise à fruit finale obtenue. Aucune corrélation n'a été trouvée entre la morphologie florale et les niveaux d'auto-fertilité. D'autres aspects intervenant sur les niveaux d'auto-fertilité de l'amandier, outre la morphologie de la fleur, restent encore à évaluer.*

***Mots-clés.*** *Amandier – Auto-fertilité – Fleurs épistigmatiques – Fleurs hypostigmatiques.*

## I – Introduction

Self-compatibility is defined as the capacity of the pollen to set the female flower of the same cultivar. In almond, several works showed that floral architecture could play an important role in the different levels of self-fertility expressed by different cultivars. According to Vasilakakis and Porlingis (1984), Socias i Company and Felipe (1992 and 1993) and Bernard and Socias i Company (1994 and 1995), flowers with stigma length at the same level or below the anthers (peristigmatic or hy-

postigmatic flowers), should be considered as a feature easing self-pollination in almond self-fertile cultivars. However, studies carried out with Apulian self-compatible almond cultivars showed that the position stigma/anthers has not any influence in almond fruit-set (Godini *et al*., 1992; De Palma and Godini, 1994; De Palma, 1996).

Given the difference results of the cited studies, further work involving a wider range of self-compatible almond cultivars is necessary. The aim of this work was to study the possible correlation between flower morphology and self-fertility in some self-compatible genotypes.

## II – Materials and methods

Twenty-seven self-compatible almond genotypes (12 cultivars and 15 advanced selections) were used in this work. Cultivars used are from different Spanish almond breeding programs: IRTA, Catalonia ('Constantí', 'Francolí', 'Marinada' and 'Vairo'); CITA, Aragón ('Belona', 'Guara', 'Mardía' and 'Soleta'); CEBAS-CSIC, Murcia ('Antoñeta' and 'Penta'), and other cultivars like 'Lauranne' (France) and 'Tuono' (Italy). The 15 advanced selections are from the IRTA's breeding program. Material is growing at IRTA's almond plots, in Mas de Bover (Tarragona) and Les Borges Blanques (Lleida).

One hundred flowers per almond genotype were randomly collected around the tree in the field in "F" state (Felipe, 1977) and they were taken to the laboratory. Pistil and longer stamen length, from pistil base, were measured. Distances between both flower parts were calculated for each genotype. Flowers presenting positive values were classified as epistigmatic flowers (pistil above anthers); flowers with negative values were classified as hypostigmatic flowers (pistil below anthers) and flowers with values around (± 0,5 mm) were classified as peristigmatic (pistil and anthers at the same level). Data were recorded for two years (2011 and 2012). Other aspects of floral morphology as pistil shape (straight or curved in the upper part) were also recorded.

Records of self-fertility levels of the same almond genotypes, in almond IRTA's collection, were collected from different years. Around 100 flowers from 2-5 branches were counted in each tree. Before anthesis, these branches were bagged to prevent cross pollination. Fruit set in each branch was scored two months later (Vargas *et al*., 1997).

Correlation between floral morphology and self-fertility levels was studied (Pearson's correlation coefficient).

## III – Results and discussion

Data of flower morphology (distance between pistil and the largest stamen) of the 27 almond genotypes studied are shown in Table 1. All types of floral morphology have been found in these self-compatible almonds, with predominance of epistigmatic and peri- epistigmatic flowers (stigma above or at the same level of the anthers) (63% of material studied), a floral architecture not favourable for autogamy according to Socias i Company (1995). De Palma and Godini (1994) presented similar results in the study of 15 Apulian self-compatible almond cultivars, suggesting that the reciprocal stigma/anthers position within the same flower should be considered as a morphological trait of almond cultivars, susceptible to variations, not necessary related to biological behaviour. Socias *et al*. (2004) found in some self-compatible almond selections that the stigma was above the level of the upper anthers, but the upper position of the pistil was coiled and may allow stigma-anther contact.

Referring to specific cultivars studied, the stigma/anthers reciprocal position of our data (Table 1) agree with those defined by 'Guara' (Felipe and Socias i Company, 1987) and with 'Tuono' (synonym of 'Truoito') (Godini *et al*., 1992), and disagree with Vasilakis and Porlingis (1984) for this last cultivar. These authors presented data of stigma/anthers position of -2,3 mm (hypostigmatic flower) for 'Truoito' cv.

**Table 1. Distance between pistil and longer stamen length (mm) (2011 and 2012), and levels of self-fertility observed in the field (different years)**

| Almond genotypes studied | Distance pistil-longer stamen length (mm) (standard deviation) | Flower classification ♠ | Self-fertility (%) (years of study) ♦ (cvs. in Les Borges Blanques) • (cvs. in Mas de Bover) |
|---|---|---|---|
| Cultivars | | | |
| 'Antoñeta' | 0.84 (±0.14) | epistigmatic | ♦ 15.65 (2011-2012-2014) |
| 'Belona' | 2.10* (±0.1) | epistigmatic | ♦ 25.47(2011-2012-2014) |
| 'Constantí' | 0.45* (±0.08) | peri-epistigmatic | • 26.37* |
| 'Francolí' | 0.96* (±0.13) | epistigmatic | • 28.89* |
| 'Guara' | -0.01* (±0.11) | peri-hypostigmatic | ♦ 33.6 (2011-2012-2014) |
| 'Lauranne' | 2.15 (±0.09) | epistigmatic | ♦ 36.87 (2011-2012-2014) |
| 'Mardía' | 2.22 (±0.15) | epistigmatic | ♦ 5.4 (2012-2014) |
| 'Marinada' | -1.09* (±0.18) | hypostigmatic | • 25.30* |
| 'Penta' | 1.44 (±0.23) | epistigmatic | ♦ 17.95 (2012-2014) |
| 'Soleta' | -0.28* (±0.08) | peri-hypostigmatic | ♦ 19.03 (2012-2014) |
| 'Tuono' | 0.18 (±0.12) | peri-epistigmatic | ♦ 8.7 (2011-2012-2014) |
| 'Vairo' | -0.21* (±0.12) | peri-hypostigmatic | • 19.98* |
| Advanced Selections | | | |
| 12-350 | -1.55 (±0.1) | hypostigmatic | • 7.2 (2008-2013) |
| 13-531 | 2.13 (±0.16) | epistigmatic | • 19.1 (2008-2013) |
| 23-160 | 1.75 (±0.16) | epistigmatic | • 17.7 (2008-2013) |
| 23-173 | 0.59 (±0.12) | epistigmatic | • 29.52* |
| 24-53 | -0.44 (±0.15) | peri-hypostigmatic | • 11.4 (2009-2013) |
| 26-258 | 0.04 (±0.12) | peri-epistigmatic | • 2.8 (2009-2013) |
| 26-408 | 0.79 (±0.13) | epistigmatic | • 7.9 (2008-2013) |
| 27-103 | 1.29 (±0.16) | epistigmatic | • 34.1 (2009-2013) |
| 28-105 | -0.90 (±0.10) | hypostigmatic | • 31 (2009-2013) |
| 28-117 | 1.63 (±0.16) | epistigmatic | • 40.3 (2008-2013) |
| 29-59 | 0.60 (±0.12) | epistigmatic | • 9.3 (2009-2013) |
| 29-143 | -1.07 (±0.08) | hypostigmatic | • 13.5 (2010-2013) |
| 29-147 | -1.39 (±0.08) | hypostigmatic | • 5.9 (2010-2013) |
| 29-148 | -1.50 (±0.11) | hypostigmatic | • 22.06* |
| 30-297 | 1.09 (±0.12) | epistigmatic | • 25.33* |

*Two years data (2011-2012), ♠ epistigmatic: flowers with a positive distance pistil-anthers, hypostigmatic: flowers with a negative (-) distance pistil-anthers, peristigmatic: flowers with pistil-anthers at the same level (± 0,5 mm); *more than 8 years of observation.

In our work no relationship was found between the position of stigma in relation to the anthers and fruit set data (r = 0,27) for the 27 autocompatible genotypes studied (Fig. 1). Our results agree with those reported by Godini *et al*. (1992) and De Palma (1996), and disagree with those observed by Vasilakakis and Porlingis (1984) and Socias i Company and Felipe (1992 and 1993).

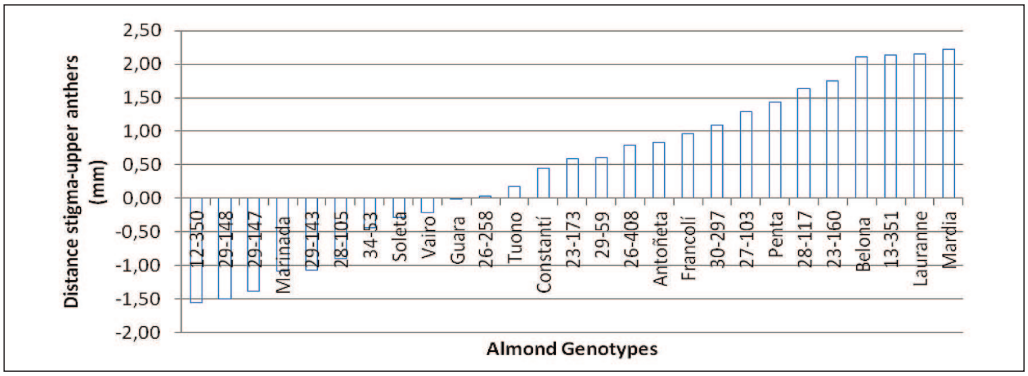


**Fig. 1. Distance between stigma and the upper anthers (mm) of different almond genotypes.**

## IV – Conclusions

No relationship has been found between floral morphology and fruit set in twenty-seven self-compatible almond genotypes. So, the capability of these cultivars to set fruits after flower bagging was independent of the relative position between the stigma and the anthers within the same flower.

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