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Recent advances in breeding for autogamy in almond

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SUMMARY – Three new almond cultivars have been released from the almond breeding programme of the SIA-DGA of Zaragoza. They are distinguished by their autogamy, which allows their cultivation in solid plantings of a single cultivar. All of them produce high quality fruits with single kernels. They also show different blooming times and, consequently, they can be recommended for different growing regions. Their kernel characteristics will also offer different commercial possibilities.

Key words: Almond, autogamy, breeding, cultivar, *Prunus amygdalus* Batsch.

RESUME – *"Progrès récents en amélioration pour l'autogamie chez l'amandier". Trois nouvelles variétés d'amandier ont été obtenues dans le cadre du programme d'amélioration génétique de l'amandier du SIA-DGA de Saragosse. Les trois se distinguent par leur autogamie, ce qui permet de les cultiver dans des vergers homogènes d'une seule variété. Les trois produisent des fruits de bonne qualité avec des graines sans doubles. Elles ont aussi différentes époques de floraison et, par conséquent, sont à recommander pour différentes régions de culture. Les caractéristiques des graines offrent aussi différentes possibilités commerciales.*

Mots-clés : *Amandier, autogamie, amélioration, variétés,* Prunus amygdalus *Batsch.*

Introduction

Since the beginning of almond (*Prunus amygdalus* Batsch) research in 1966 at Zaragoza it was evident that the most important problem in the Spanish almond production was its very low productivity, as it did not even reach 125 kg/ha, what was often not enough to cover the fixed costs of almond growing (Felipe, 1984). This low productivity was mainly due to two causes: the incidence of spring frosts and a deficient pollination. The incidence of frosts at bloom is important in all inland growing regions of Spain, but also intermittently in the coastal regions. Consequently, late blooming became a trait of the most importance for almond cultivars as this has been the first fruit species to bloom. One of the first steps then undertaken was the establishment of a collection to include the most important cultivars of almond grown throughout the world, but mainly the late-blooming cultivars from different foreign countries (France, Italy and the then Soviet Union) as most of the Spanish cultivars resulted early or only middle blooming. Late blooming cultivars offer two evident advantages. Firstly they can bloom when the risk of late frosts is low or even minimal, thus escaping from the loss caused by low temperatures. Secondly, they bloom when temperatures are higher and thus more favourable for the processes of pollination and fertilization.

At the same time it was shown that a deficient pollination was a problem found in most almond orchards. This was mainly due to the fact that many of them were planted with the two main Spanish cultivars, 'Marcona' and 'Desmayo Largueta', which do not coincide in bloom sufficiently to allow a good pollination between them. Besides, the presence of pollinating insects was very low as it only relied on the presence of wild bees and beehives were not introduced at bloom into the orchards. The weather conditions during the early bloom of almond are often inadequate for bee flight, decreasing the efficiency of the low population of pollinating insects. For all these reasons from the very beginning self-compatibility was considered as a primary objective of the almond breeding programme to avoid the requirement of two simultaneously blooming cultivars, the presence of pollinating insects and the occurrence of favourable weather conditions, because self-compatible cultivars can be pollinated by the pollen of the same flower without the requirements of any foreign intervention.

The low productivity of many Spanish almond orchards was aggravated by the presence of a very large number of local cultivars, often of low quality and coming from the empirical selection done by the

growers along several centuries. Only a few cultivars, as those mentioned, 'Marcona' and 'Desmayo Largueta', are really of good quality, although early blooming.

To solve these problems an almond breeding programme was started in 1974 (Felipe and Socias i Company, 1985). At the same time, the study of the pollination requirements of the late blooming cultivars introduced in the collection (Herrero *et al*., 1977) allowed to identify the self-compatibility of some of them (Herrero and Felipe, 1975). The first step in this selection and breeding work allowed the release of three new cultivars, 'Guara', 'Aylés' and 'Moncayo' (Felipe and Socias i Company, 1987), but the breeding programme was followed because none of these three cultivars fulfilled all the requirements looked for in a cultivar, taking also into account that these requirements may change depending on the growing region (Socias i Company *et al*., 1998).

Now three new cultivars from our breeding programme are described, characterized by their different blooming times (Fig. 1) and kernel type but with two common traits: the three are autogamous, thus not requiring any foreign intervention for their proper pollination and consequently for the production of a commercial crop, and besides their kernels show no doubles.

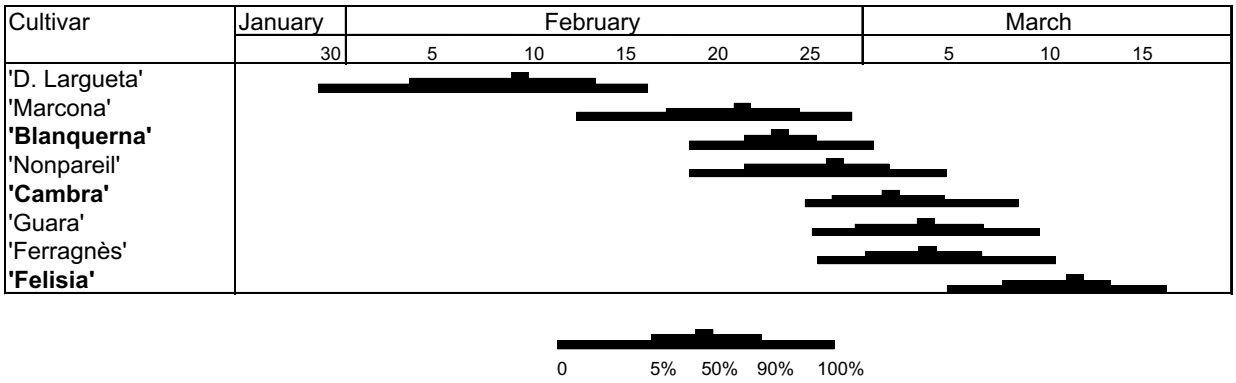

Fig. 1. Blooming time of the new cultivars as compared to other widely grown ones (average 1994-1998). Percentages refer to the amount of opened flowers.

Origin of the new cultivars

The three new cultivars come from artificial or natural pollinations, following the traditional steps in a fruit breeding programme (Socias i Company and Felipe, 1987). The fruits were stratified and the seedlings were planted in a bed previously to their transfer to the field, where they were studied to proceed to their screening according to the selection process. The first characters to be considered were self-compatibility, blooming time, morphological traits of the plant and the fruit, kernel quality... Once the best seedlings were selected, they were grafted and planted in a study plot in order to deeply characterize the most important traits, as the effectiveness of self-pollination (Ben Njima and Socias i Company, 1995a,b), the morphological and biochemical characteristics of the plants (Bernad and Socias i Company, 1994), the flower and blooming characteristics (Bernad and Socias i Company, 1995) and the branching habit and bloom density (Bernad and Socias i Company, 1998).

'Blanquerna' comes from 'Genco' self-pollinated. 'Genco' is probably the self-compatible cultivar from the Italian region of Puglia of higher quality, but it has not been widely used in the almond breeding programmes because of its blooming time, a little earlier than 'Tuono', which otherwise has been repeatedly utilized as a parent. The blooming time of 'Blanquerna' is middle and, consequently, is only recommended for planting in regions with low frost risk. Its ripening time is very early, which allows harvest when temperatures are high for a quick drying process and thus an early marketing. Its name comes from the philosophical novel "Blanquerna", a book written by Ramon Llull (1232/33-1315/16), probably the most universal man born in Majorca, the home island of one of the obtentors (RSiC).

'Cambra' comes from the cross 'Tuono' x 'Ferragnès', having inherited many good traits from 'Ferragnès', but also with a good level of autogamy. Its name is a homage to Mariano Cambra Ruiz de Velasco (1916-1985), a remarkable fruit researcher, interested in all fruit species and a pioneer in the study of almond pollination (Cambra, 1954).

'Felisia' comes from the cross 'Titan' x 'Tuono'. 'Titan' is a Californian cultivar which has transmitted an allele for late blooming (Socias i Company *et al*., 1999), making 'Felisia' the latest blooming cultivar so far released. Its name is a homage to one of the obtentors (AJF) and the institution where the work has been developed, Servicio de Investigación Agroalimentaria (SIA).

Description

As already mentioned, the main trait of these new cultivars is their autogamy, which avoids all the problems of cross-pollination and allows the planting of single cultivar orchards, with all the benefits for orchard management related to this type of plantings. Another important trait is the absence of double kernels, considered at present a positive trait for fruit quality, although some photoelectric devices may screen single and double kernels for their separate processing. The blooming time of the three cultivars is different and consequently they can be recommended for different growing regions (Fig. 1). Although blooming time of 'Felisia' is very late, it can only be recommended where the near commercial channels can absorb the production of kernels of small size (Fig. 2).

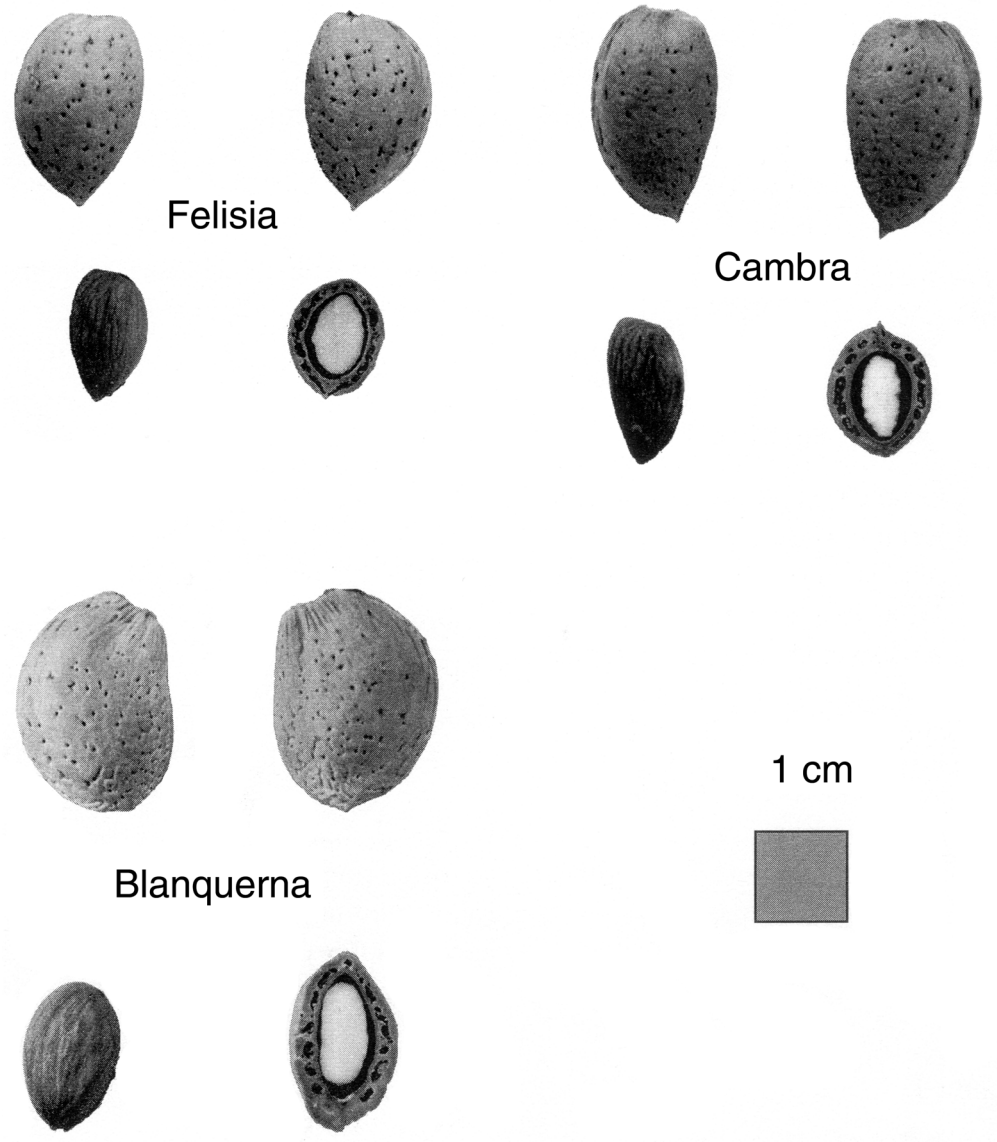

Fig. 2. Fruits of the three new cultivars.

Table 1 includes the main traits of the new cultivars.

Table 1. Main traits of the new cultivars

Trait	'Blanquerna'	'Cambra'	'Felisia'
Origin	'Genco' OP	'Tuono' x 'Ferragnès'	'Titan' x 'Tuono'
Clone	434	398	427
Selection number	E-5-7	A-10-8	D-3-5
INSPV register	97/187	97/186	97/188
Tree habit	Open	Lightly open, but erect	Slightly open
Vigour	Medium to low	Medium	Medium
Blooming time	Early, two days after 'Marcona' and a week before 'Guara'	Late, with 'Guara' or slightly before	Very late, about a week after 'Guara'
Flower colour	White	White	White
Flower size	Medium to large	Medium	Small
Flower localization	Spurs and mixed shoots	Spurs and mixed shoots	Mixed shoots
Flower density	High	High	Intermediate to high
Pollination	Autogamous. It may pollinate 'Marcona'	Autogamous. Possible pollination with coincident cultivars	Autogamous. It may pollinate extremely late cultivars
Shell	Hard without layers	Hard, sometimes with layers	Hard, sometimes with layers
Kernel shape	Elliptic, no doubles	Amigdaloid, no doubles	Elliptic, no doubles
Kernel percentage	30	27	35
Kernel size	1.1 g	1 g	0.85 g
Stigma position	Among the anthers	Among the anthers	Among the anthers
Observations	For regions with low risks of spring frosts. Very productive, exhausting must be avoided. Very early ripening time	Less frost resistant than 'Guara'. Very productive. Early ripening time	The latest blooming cultivar. Very productive, without alternance. Small kernel for special commercial uses
Pruning	Easy	Easy	Easy

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