NUT SIZE AND BLOOMING TIME IN ALMOND

INTRODUCTION

The objective of plant breeding is the release of new cultivars able to satisfy the agronomical and commercial requirements present in the production and consumption of any crop. In the case of almond, the main objectives of nearly all plant breeding programmes (Socias i Company *et al*., 2012) has been self-compatibility and late blooming, which has been attained with many of the new releases from different programmes. For late blooming, the knowledge of the genetics of blooming time (Socias i Company *et al*., 1999), as well as of the chilling and heat requirements (Alonso *et al*., 2005), has facilitated the design of the crosses in the breeding programmes to delay blooming time and obtain new later-blooming selections.

Other objectives, such as nut quality, were introduced later in the breeding programmes. This is difficult to define and involves both physical and chemical traits (Socias i Company *et al*., 2008). One of the physical traits to be considered in the evaluation of nut quality is kernel size, since large kernels often fetch a higher price on the market, even if small sizes are preferred for some specialty products, such as chocolate bars, chocolates and sugared almonds. Due to the different commercial preferences, one of the objectives of some breeding programmes is the release of cultivars that produce very large kernels (Holland *et al*., 2006). However, when considering the objectives of late bloom and nut quality, aspects other than kernel size have been considered, mainly kernel percentage, double kernel percentage and the general appearances of the kernel (Vargas and Romero, 1988). Furthermore, when considering the possibility of obtaining new late-blooming cultivars with large kernel size, some doubts have been expressed about whether it would be possible to advance in the achievement of both objectives at the same time. In fact, when 'Felisia' (Socias i Company and Felipe, 1999) was released, it was the latest blooming cultivar at that time but its kernel size was small. Similarly, the cultivars 'Penta' and 'Tardona', both of very late blooming time, are distinguished by their small kernel size (Dicenta *et al*., 2008).

Probably all these cultivars had been selected early in order to have late-blooming cultivars to cover the demands of the growers. However, experience in selecting among the offspring of the breeding programmes seems to indicate that there is no correlation between blooming time and nut size. Even though in the hypothetical case that this correlation existed in the first families of the almond breeding programmes, it is not found in the present-day crosses. This situation may resemble that of the possible correlation between late bloom and low productivity (Grasselly and Olivier, 1985), a linkage broken in further crosses, giving rise to late-blooming selections with a high bloom density and, consequently, a high productive potential (Kodad and Socias i Company, 2008).

Therefore, nut size of a series of almond cultivars and selections grown in the same experimental plot was measured in order to determine whether there may be any correlation between nut size and blooming time in these genotypes.

Table 1. Nut and kernel traits of several almond cultivars and selections: weight (g) and dimensions (mm): length (L), width (A) and thickness (E), and shelling percentage.

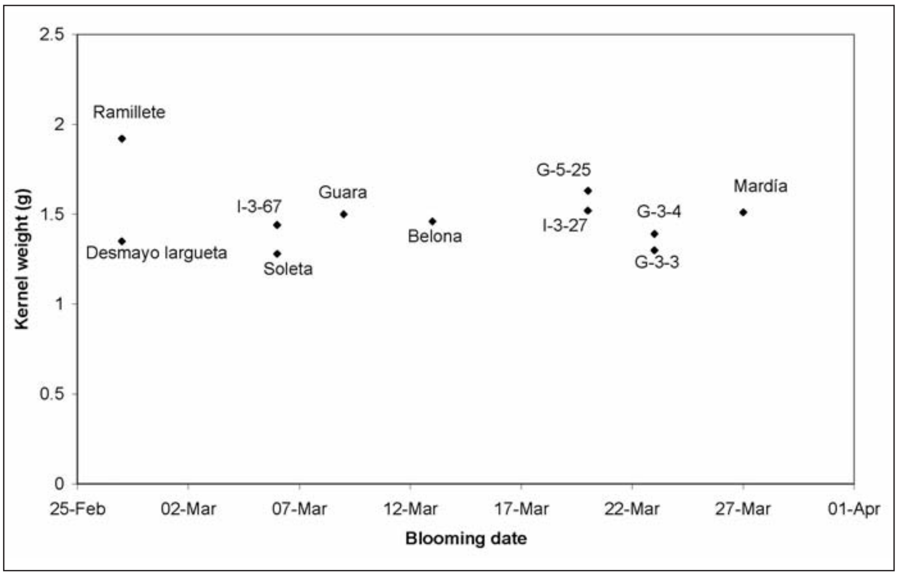
	Nut				Kernel				Shelling percentage
Cultivar	Weight	L	W	T	Weight	L	W	T	
'Belona'	4.40	30.1	25.7	16.0	1.46	24.7	17.2	7.3	33.1
'Guara'	3.50	31.7	23.5	17.2	1.50	25.1	14.8	8.1	42.7
'Soleta'	3.80	34.3	21.5	14.2	1.28	26.7	13.4	7.5	33.6
'Mardía'	5.71	35.5	26.3	17.9	1.51	25.9	16.5	7.8	26.0
I-3-67	4.21	32.8	22.8	17.2	1.44	25.9	14.8	7.9	34.2
I-3-27	5.03	32.6	25.9	17.3	1.52	24.7	17.1	7.9	30.2
G-3-4	5.50	34.8	27.0	16.6	1.39	25.5	17.4	6.6	25.3
G-3-3	4.48	31.8	24.0	16.5	1.30	25.2	15.9	7.8	29.1
G-5-25	5.35	37.0	26.1	16.2	1.63	27.5	16.4	7.4	30.5
'Desmayo Largueta'	4.90	35.6	23.6	14.4	1.35	27.4	14.3	7.4	27.6
'Ramillete'	7.47	41.9	29.5	19.4	1.92	29.5	17.6	7.4	25.7

MATERIALS AND METHODS

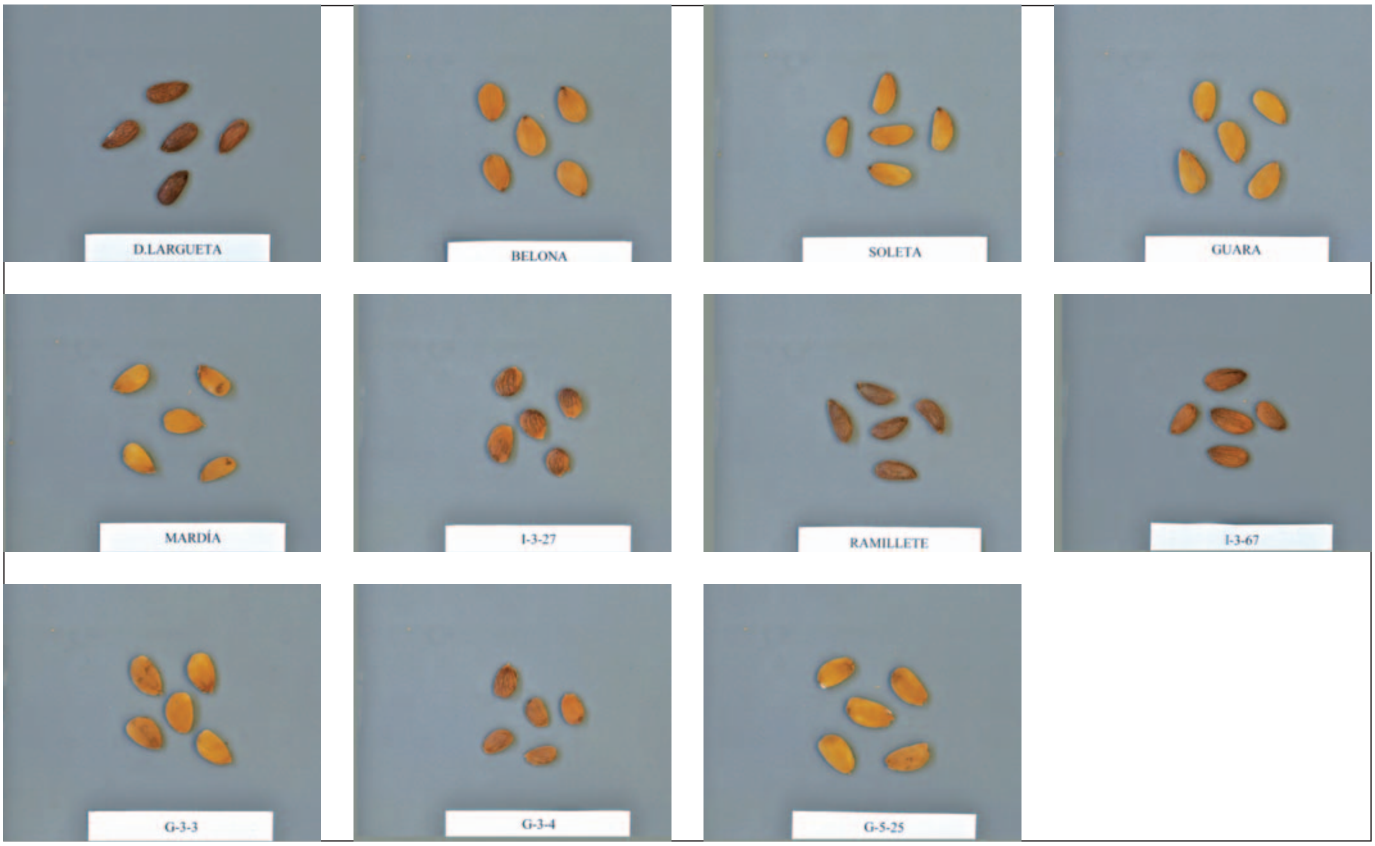
The nuts studied were collected in the experimental almond plot of the Afrucas orchard in Mas de la Punta (Caspe, Zaragoza, Spain). This plot includes several late-blooming cultivars and selections, as well as 'Desmayo Largueta' and 'Ramillete' as early-blooming control cultivars. The plot was established in 2005 on the hybrid peach × almond rootstock GF 677, at a planting distance of 7 × 6 m and drip irrigated. Thus, the crop of 2013 could be considered a plot in full production.

In 2013, the date of full bloom was recorded for each cultivar and selection. A sample of approximately 200 nuts was randomly collected at ripening time from each genotype and taken to the laboratory for evaluation. This was carried out with a

Figure 1. Kernel weight of several almond cultivars and selections as related to the date of full bloom in 2013.



Almond cultivars and selections nuts.



Almond cultivars and selections kernels.

small random sample, measuring the weight, the length, the width and the thickness of both nut and kernel individually, once the nuts had been cracked to obtain the kernels. Therefore the shelling percentage could be calculated and presence of double kernels in each sample could be determined.

RESULTS AND DISCUSSION

Table 1 includes the mean values of the parameters measured for the nut and the kernel of each of the cultivars studied, as well as the shelling percentage. The percentage of double kernels was not included because only 'Guara' showed this kind of kernel. These values agree with the descriptions of these cultivars (Felipe, 2000; Felipe and Socias i Company, 1987; Socias i Company and Felipe, 2007; Socias i Company *et al.*, 2008b) and with the previous observations in the *Unidad de Fruticultura* at CITA, within the levels of variability in the observations in different years.

When the full bloom data of each cultivar and selection were plotted against kernel weight (Fig. 1) the distribution of the dots was almost horizontal. This result concludes that the date of bloom has no effect on kernel size. Evidently, the late-blooming genotypes included in this study were selected in a breeding programme and kernel size has been an evaluation criterion during the selection process, but this same criterion was certainly applied when the traditional cultivars, such as 'Desmayo Largueta' and 'Ramillete' were noticed by our ancestors and clonally propagated because of their good characteristics, kernel size being surely one of the traits taken into account.

If a large number of cultivars was included in this study, as well as the complete offspring of some crosses of the breeding programmes, a different distribution of kernel size and blooming time could be obtained, other than that shown in Fig. 1. However, the objective of any breeding programme is the release of new cultivars possessing extraordinary characteristics distinguishing them from average cultivars. As already mentioned, late blooming has been a main objective of many almond breeding programmes and the results of the present study confirm the possibility of obtaining extremely late-blooming selections, such as 'Mardía', with an average kernel size. Furthermore, these results sustain the possibility of following this research path of obtaining new selections joining the two interesting traits of late bloom and large kernel size.

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KERNEL QUALITY OF LOCAL SPANISH ALMOND CULTIVARS: PROVENANCE VARIABILITY AND END USES

INTRODUCTION

Almond (*Prunus amygdalus* Batsch) is the most popular nut tree crop worldwide in terms of commercial production (faostat.fao.org/site). Spain is the second world producer, with an average production of 223,431 tons of in- shell nuts (Socias i Company *et al.*, 2011). Traditional almond culture utilized open-pollinated seedlings (Socias i Company *et al.*, 2012) which, together with self-incompatibility, produced a very high heterozygosity in this species (Kester *et al.*, 1990; Socias i Company and Felipe, 1992). This large variability has provided a useful genetic pool for almond evolution, allowing in each growing region for the selection of almond cultivars well adapted to this area (Grasselly and Crossa-Raynaud, 1980; Socias i Company *et al.*, 2012). In Spain, almonds are produced under different climatic conditions: from inland regions characterized by high frost risks at blooming time or soon after (Ebro Valley, Castilla-La Mancha), to coastal regions with mild winters and hot and dry summers (Andalusia, Murcia), and the Balearic and Canary islands with high relative humidity. The high climatic diversity of the different producing regions in Spain forced the local farmers to select genotypes to avoid the harsh environmental conditions that cause decreases in production. In the last 15 years more than 18 million almond plants were produced by the Spanish nurseries, and more than 60% of these plants came fromwere of cultivars released by breeding programmes (Socias i Company *et al.*, 2011). However, the traditional Spanish cultivars, with 24.57% of the plants, still represent nearly a quarter of this total.

The Spanish market only distinguishes two cultivars, 'Marcona' and 'Desmayo Largueta', whilst the rest of cultivars are grouped under the undefined name of "comunas" (Socias i Company *et al.*, 2012). Almond kernels are consumed raw, roasted, blanched, unblanched, served alone or mixed with other foods. Almond kernels are also used fresh or can be processed into many different confectioneries (Socias i Company *et al.*, 2008). The kernels of the "comunas" almonds are used in different confectioneries with unspecified requirements, being mainly processed for production of marzipan and in some types of nougat. However, the modern almond industry demands commercial cultivars characterized by kernels with well differentiated and high quality attributes , since the best end-use for each