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SUMMARY – A process of early selection has been applied within the almond cultivar breeding programme conducted at IRTA Mas Bové. Progenies are raised in the nursery at high density spacing (about 3-4 x 0.3 m), without further transplanting, and seedlings presenting undesirable characters are quickly removed from the field. Several traits, such as leafing date, vigour, growth habit and branching, can be observed during the second year. Some other characters like blooming date, early cropping, nut traits, self-fertility and disease sensibility can also be assessed when the seedlings are young. The process over the past ten years is reviewed (18,171 seedlings from 313 crosses were managed). The average percentage of conserved seedlings at the end of the second year was 44%, in the third year it was reduced to 12%, in the fourth year to 5% and only to 0.5% in the fifth year.

Key words: *Prunus amygdalus*, almond, breeding, early selection, cultivars.

RESUME – *"Sélection précoce dans le programme d'amélioration génétique de l'amandier à l'IRTA de Mas Bové". A l'IRTA de Mas Bové, tout un processus de sélection précoce est conduit dans le programme d'amélioration génétique de l'amandier. Les familles sont semées dans la pépinière avec une haute densité (environ 3-4 x 0,3 m), sans postérieure transplantation, et les descendants présentant des caractères indésirables sont éliminés à un stade très précoce. Quelques aspects comme la date de feuillaison, vigueur, architecture de l'arbre, peuvent être observés durant la deuxième année. D'autres caractères comme date de floraison, fructification précoce, caractéristiques du fruit, autofertilité et sensibilité aux maladies peuvent être aussi étudiés au jeune âge des plantes. Le processus durant les derniers dix ans est examiné (18 171 descendants dérivant de 313 croisements ont été aménagés). Le taux moyen de descendants conservés à la fin de la deuxième année est de 44%, 12% à la troisième année, 5% à la quatrième année et seulement 0,5% à la cinquième année.*

Mots-clés : Prunus amygdalus, *amandier, amélioration, sélection précoce, variétés.*

Introduction

Scion breeding programmes in fruit trees, are slow and require important resources. Generally, to release a new outstanding variety, which is the aim of all programmes, it is necessary to make many crosses and to study a large number of seedlings. A new variety should have a number of excellent features. If a seedling shows several outstanding characteristics, but fails in one which is considered essential, it will be discarded in the selection process. In almond, there are some characteristics that define the interest of a cultivar, but its importance varies according to the aims and priorities of the breeding programmes (Grasselly and Crossa-Raynaud, 1980; Kester and Gradziel, 1996; Socias i Company *et al.*, 1998).

At the start of a breeding programme, usually a reduced number of crosses are made and the characteristics of the seedlings are studied in detail, to asses the prospects of improvement and the interest of parents and crosses. Usually, at this stage the number of seedlings managed is not large, as its study would require considerable resources. In further stages of the programme it may be advisable to increase the number of seedlings and make early selection. Early elimination of inferior phenotypes saves resources and makes it possible to manage many trees, increasing thus the chances of obtaining new cultivars. In almond several important agronomic and commercial characters can be detected at an early stage, which enables fast removal of undesirable genotypes (Kester *et al.*, 1977; Vargas and Romero, 1984; Vargas *et al.*, 1997; 1998).

In the almond breeding programme conducted at IRTA Mas Bové since 1975, the characteristics of several thousands of seedlings were studied in evaluation plots (Vargas *et al.*, 1984). With the information obtained a process of early selection is currently being carried out. In this work, the process followed during ten years is reviewed.

Materials and methods

Progenies included in this work derived from crosses made between 1991 and 2000 (Table 1): 18,171 seedlings from 313 crosses (235 different ones) using 85 genitors.

Table 1. Material and years of analysis

Crossing years	Number of crosses	Number of seedlings	Number of years analysed†
1991-1997	120	9333	5
1991-1998	158	10,941	4
1991-1999	229	14,543	3
1991-2000	313	18,171	2.5

†Crosses from 1998: 1999, 2000, 2001 and 2002. Crosses from 1999: 2000, 2001 and 2002. Crosses from 2000: 2001, 2002 and spring 2003.

Cross combinations of parents were made aiming to achieve:

(i) Late flowering (reduced frost risk). In all the crosses, at least one of the parents was late blooming, similar or later than 'Cristomorto' (Vargas and Romero, 2001).

(ii) Self-fertility (self-compatibility and self-fruitfulness). In all crosses, at least one genitor was self-compatible.

(iii) High production capacity.

(iv) High vigour.

(v) Easy tree training and pruning.

(vi) Tolerance to hard conditions (drought, diseases, pest, etc.).

(vii) Nut quality (hard shell, absence of double kernels and good kernel appearance).

Seeds were sown at a distance of 3-4 m x 0.3 m (about 8000-10,000 seeds/ha) and seedlings were raised in the nursery at this high density spacing, without further transplanting. In the selection process, seedlings presenting undesirable characters are removed from the field. Main steps of the process are shown in Table 2.

Some traits can be observed when the seedlings are very young (during the second year), easing the removal of undesirable seedlings. These useful traits for very early selection are the following:

(i) Leafing date. The known correlation between leafing and flowering date (Kester *et al.*, 1977; Vargas and Romero, 1984) allows very early selection for this important character.

(ii) Vigour. Weak trees can be eliminated.

(iii) Growth habit and branching. Very useful features for removing undesirable seedlings.

Table 2. Main steps in the process of early selection

Year	Season	Activity / observation
0	Winter	Making crosses
0	Fall - winter	Sowing of the seeds
1	All year	Seedling growing in the nursery
2	Winter	Leafing date
2	Fall - winter	Vigour, growth habit and branching
3†	Winter - spring	Blooming date, early cropping
3†	Fall - winter	Nut characteristics, tree appearance
4	Winter - spring	Self-fertility, blooming date, production
4	Summer - winter	Nut characteristics, tree appearance
5	Winter - spring	Self-fertility, blooming date, production
5	Summer - winter	Nut characteristics, tree appearance, sensitivity to drought and diseases

†With good orchard and seedlings management.

Some other characters can also be assessed when the seedlings are in the third-fourth year:

(i) Blooming date. If selection is first made by leafing date, number of seedlings removed by early blooming is reduced.

(ii) Early cropping.

(iii) Nut features. After fruiting, observation of several important traits (hardness of the shell, double kernels, kernel appearance and flavour) is carried out.

Later, in the forth-fifth year, other important characters like self-fertility, production capacity and sensitivity to drought and diseases (mainly to *Fusicoccum amygdali* Del.) are observed, but only in a reduced number of trees, as earlier referred characters would have contributed to large elimination of inferior seedlings.

Results and discussion

The percentage of retained seedlings at the end of different years and seasons is shown in Table 3. The average percentage of conserved seedlings at the end of the second year was of 44.43%, in the third year it was reduced to 12.34%, in the fourth year to 4.89% and only to 0.55% in the fifth year.

Table 3. Percentage of retained seedlings at the end of different years and seasons

Crossing years	NC†	NS††	Year 2		Year 3		Year 4		Year 5	
			Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
1991-1997	120	9333							3.38	0.55
1991-1998	158	10,941					9.18	4.89		
1991-1999	229	14,543				12.34				
1991-2000	313	18,171	66.23	44.43	18.78					

†NC: Number of crosses.
††NS: Starting number of seedlings.

The leafing date was a very useful trait in the process of selection, mainly when one of the two parents used in the cross was early-medium blooming (Table 4). Vigour and tree appearance were also very useful features for discarding undesirable seedlings at early stage.

Table 4. Selection by leafing date. Influence of parents blooming date

Blooming time of the parents	NC†	NS††	% Retained seedlings
2 Late parents	147	9498	63.60
1 Late parent and 1 early - medium parent	51	3534	34.04
Total	198	13,032	55.59

†NC: Number of crosses.
††NS: Starting number of seedlings.

Undoubtedly, the flowering time of the genitors influence considerably in the selection process (Table 5).

Table 5. Influence of parent blooming date in the selection rate. Percentage of retained seedlings at the end of different years

Blooming time of the parents	NC†	NS††	Year 2	Year 3	Year 4	Year 5
2 Late parents	262	14,637	51.06	15.44	6.38	0.72
1 Late parent and 1 early – medium parent	51	3534	16.98	2.69	0.94	0.08
Total	313	18,171	44.43	12.34	4.89	0.55

†NC: Number of crosses.
††NS: Starting number of seedlings.

With good management of the orchard and seedlings (slight pruning) it is possible to assess the flowering time, early cropping capacity and some nut characters in the third year. These traits influence largely in the selection process.

Some important features, like nut characteristics and self-fertility, which are time consuming, should only be observed in a relatively small number of retained seedlings. Nut traits were recorded only in the 11.19% of the seedlings. Self-fertility was tested in 7.39% of the trees only.

Conclusions

The results of the process of early selection in the almond cultivar breeding programme conducted at IRTA Mas Bové showed that the percentage of seedlings that could be quickly discarded and removed from the field was very high. The use of early selection techniques has reduced the amount of land and labour needed for seedling assessment and has shortened the time from germination to selection of new genotypes. The process improves the efficiency and economy of the scion breeding programme.

Leafing date, vigour, growth habit and branching, can be observed in the second year, easing the fast removal of undesirable seedlings. The leafing date is a very useful trait in the process of selection, mainly when one of the parents used in the cross is early-medium blooming. Some other characters like blooming date, early cropping, production, nut characteristics, self-fertility and some disease sensibility can be also assessed when the seedlings are in the third-fifth years. With good management it is possible to assess the flowering time, early cropping capacity and some nut characters in the third year. Some important features, like self-fertility and nut traits, which are time consuming, should only be determined in a small percentage of retained seedlings.

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