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F.J. Vargas, M.A. Romero, I. Batlle and J. Clavé
Institut de Recerca i Tecnologia Agroalimentàries (IRTA),
Departament d'Arboricultura Mediterrània, Centre de Mas Bové,
Apartat 415, E-43280 Reus, Spain

SUMMARY - In the almond breeding programme conducted at IRTA, some traits of 3,912 seedlings derived from 94 controlled crosses made in the period 1975-1991, using 55 parents, were studied in evaluation plots. During the third-fourth year after planting, records were taken in relation to flowering (date and intensity), vigour, general appearance of the tree (observations of growth habit, branching, production, vigour, disease susceptibility, etc.) and nut characteristics (shelling percentage, double kernels, kernel appearance and taste). The prospects to carry out early screening were explored, considering three levels of selection (low, medium and high) for the studied characters. For any of these levels, the percentage of trees to be discarded, which were under the minimum requirements for one or several of the characters considered, resulted very high. Currently, early selection in segregating generations is conducted at Mas Bové. Large progenies are raised eliminating trees already in the nursery, without transplanting to evaluation plots. The known correlation between leafing and flowering date allows to select for this important character the first year after sowing. Other important traits, like vigour, growth habit and branching, can also be detected in the nursery, making easy the removal of seedlings showing undesirable features. The process followed is described and results are presented.

Key words: Almond, *Prunus amygdalus*, breeding, selection, cultivars.

RESUME - *"Sélection précoce chez des descendances d'amandier". Au Centre de Mas Bové, Reus (Espagne), les caractéristiques de 3 912 semis d'amandier, provenant de 94 croisements contrôlés utilisant 55 géniteurs et réalisés dans la période de 1975 à 1991, ont été étudiées. Pendant la troisième et la quatrième année après plantation, des notations portant sur la date et l'intensité de floraison, la vigueur, l'aspect général de l'arbre (observations du port, de la ramification, de la vigueur, de la production, de la sensibilité aux maladies, etc.) et sur les caractères du fruit (rendement au cassage, pourcentage d'amandons doubles, aspect et saveur, de l'amandon) ont été réalisées. On a étudié la possibilité de réaliser une sélection précoce des arbres en utilisant trois niveaux d'exigence (bas, moyen et élevé) pour les caractères étudiés. Le pourcentage d'arbres éliminés, dû à un niveau de notation bas pour un ou plusieurs caractères, a été très élevé. Actuellement, une méthodologie de sélection très précoce est en train d'être développée à Mas Bové. On utilise des descendances nombreuses, et l'élimination des arbres est réalisée dès le stade de la pépinière, sans que la transplantation et l'évaluation des plants en parcelles ne soient nécessaires. La corrélation existant entre les dates de débourrement et de floraison permet de sélectionner, pour ce dernier caractère, dès l'année qui suit le semis en pépinière. D'autres caractéristiques importantes (vigueur, port, ramification, etc.) peuvent être aussi détectées précocement en pépinière. Dans ce travail, la méthodologie suivie est décrite et les résultats obtenus sont présentés.*

Mots-clés : *Amandier,* Prunus amygdalus, *amélioration génétique, sélection, variétés.*

Introduction

Breeding programmes in fruit and nut trees through controlled crosses are slow and require important human and material resources. Generally, to release a new outstanding variety is necessary to make many crosses and to study the characteristics of a large number of segregating F_1 generations. For a new variety to be considered outstanding should have a large range of good attributes. If a phenotype presents several excellent characteristics but fails in one which is considered essential it will not pass the selection.

During the first development stages of a breeding programme, frequently many crosses are made and the characteristics of the F_1 progenies are studied in detail, to asses the possibilities of crop improvement and to know the interest of parents and crosses. Offspring size is not often very large, as its detailed study would require considerable resources. In this period, very valuable information

can be detected in relation to outstanding observable characters in young seedlings. After, and based on this information, it may be advisable to increase the number of seedlings managed and make early selection. Early elimination of phenotypes showing undesirables attributes saves resources and makes possible to manage larger families, increasing therefore the probabilities to raise interesting genotypes.

In almond, there are many characteristics that define the interest of a cultivar. Its importance varies according to the aims and priorities of breeding programmes (Grasselly and Crossa-Raynaud, 1980; Kester and Gradziel, 1996). Several important agronomic and commercial characters can be detected at early stage, which enables fast removal of undesirable genotypes (Kester *et al.*, 1977; Vargas and Romero, 1984; Vargas and Romero, 1988; Vargas *et al.*, 1995).

In 1975, an almond scion breeding programme, by controlled crosses, was started at IRTA-Mas Bové. The characteristics of several thousands of seedlings were studied in evaluation plots (Vargas *et al.*, 1984; Vargas and Romero, 1990). In this paper, the prospects of early selection for some characters like flowering, vigour, tree appearance and nut traits are reviewed.

Currently, early selection is conducted at Mas Bové. Large progenies are raised every year and seedlings eliminated already in the nursery, without transplanting to evaluation plots. The process followed is described and results are presented.

Materials and methods

Assessment of progenies

Seeds from 94 controlled crosses made during the period 1975-1991, using 55 parents, were sown in the nursery. After one year of growing, a total number of 3,912 seedlings were planted in evaluation plots. Planting spaces were about 4 m x 1.5 m. During the third-fourth year after planting, records were taken in relation to flowering (date and intensity), vigour, general appearance of the tree (observations of growth habit, branching, production, vigour, disease susceptibility, etc.) and nut characteristics (shelling percentage, double kernels, kernel appearance and taste). Cross combinations of outstanding parents were made aiming to: late blooming, productivity, vigour, limited branching, medium-upright tree growth habit, nut with hard or semihard shell, absence of double kernels, good kernel appearance and sweet flavour.

The features, records, number and mean of the seedling analysed are presented in Table 1. Some observations in relation to these characteristics are mentioned below:

(i) *Blooming date (full bloom).* To prevent the influence of climate in the blooming date, the number of days after 'Cavaliera', which is the cultivar considered as reference by GREMPA due to its early blooming, were recorded. Late blooming is a main aim in the programme. In all the crosses, at least one of the parents was late blooming (similar or later than 'Cristomorto').

(ii) *Flowering intensity (score 0-9).* This character is related to early bearing and productivity and it is not influenced by possible bad whether conditions in spring (frost damages).

(iii) *Tree vigour (score 1-9).* Records were taken by 2-3 people.

(iv) *Tree appearance (score 1-9).* With this observation the seedling, as a whole, is evaluated (growth habit, branching, production, vigour, disease susceptibility, etc.). It is a very useful observation to estimate the possible interest of a seedling. Records were taken by 2-3 people.

(v) *Shelling percentage (percentage of kernel).* This character is related to shell hardness. In Mediterranean countries the hard shell is a desirable feature.

(vi) *Double kernels (percentage of double kernels).* Very important feature.

(vii) *Kernel appearance (score 1-9).* Records were taken by 3 people.

(viii) *Flavour (sweet or bitter).* In the crosses, only sweet cultivars were used as parents.

Table 1. Features, records, number and mean of the seedlings analysed

Features	Records	No. of seedlings	Mean of the seedlings
Blooming date	Full bloom†	3510	24.72
Flowering intensity	Score (0-9)	3868	3.97
Tree vigour	Score (1-9)	3242	5.89
Tree appearance	Score (1-9)	3239	4.20
Shelling percentage	% kernel	2843	33.45
Double kernels	% double kernels	2842	13.71
Kernel appearance	Score (1-9)	2848	4.99
Flavour	Sweet or bitter	2906	
Total		3912	

†Number of days after 'Cavaliera'

For each character, according to its interest, seedlings were grouped in 3 categories (Table 2), undesirable (low interest), acceptable (middle interest) and desirable (high interest).

Table 2. Criteria of seedling classification for the features analysed

Features	Mean	Undesirable seedlings	Acceptable seedlings	Desirable seedlings
Blooming date		<'Cristomorto'	'Crist.'-'Fgnes.'	≥'Ferragnes'
Flowering intensity	3.97	<3	3-5	>5
Tree vigour	5.89	<5	5-6.9	>6.9
Tree appearance	4.20	<4	4-5.5	>5.5
Shelling percentage	33.45	<23 or >45	23-28 or 36-45	28-36
Double kernels	13.71	>15	5-15	<5
Kernel appearance	4.99	<4.5	4.5-5.9	>5.9
Flavour		Bitter	Sweet	Sweet

In addition, three levels of selection (low, middle and high) for the features analysed were established (Table 3) to estimate the percentage of seedlings rejected according to the different criteria required.

Table 3. Selection levels of the seedlings for the features analysed

Features	Mean	Low level	Middle level	High level
Blooming date		<'Cristomorto'	<'Ferragnes'	<'Fgnes.' + 5 days
Flowering intensity	3.97	<3	<4	<5
Tree vigour	5.89	<5	<6	<7
Tree appearance	4.20	<4	<4.5	<5.5
Shelling percentage	33.45	<23 or >45	<26 or >39	<28 or >36
Double kernels	13.71	>15	>10	>5
Kernel appearance	4.99	<4.5	<5.5	<6.5
Flavour		Bitter	Bitter	Bitter

Early selection in the nursery

In this case, large progenies are raised eliminating seedlings already in the nursery, without transplanting to evaluation plots. In the selection process, seedlings presenting undesirable characters are removed from the plot.

Seeds are sown at a distance of about 0.30 m apart, with a space between rows of 4 m (about 8,000 seeds/ha). As several important characters of almond cultivars can be detected at an early stage (Vargas *et al.*, 1995), it is possible to manage a large number of seedlings on a very small surface. Among useful characteristics for early selection, there are the following:

(i) *Tree vigour.* By the end of the first growing season in nursery, very weak trees can be eliminated.

(ii) *Leafing date.* The known correlation between leafing and flowering date allows selection for this important character the first year after sowing (Kester *et al.*, 1977; Vargas and Romero, 1984).

(iii) *Tree appearance (growth habit, branching, vigour, early bearing, etc.).* Useful for removing undesirable seedlings.

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

(v) *Nut traits.* After fruiting, observation of several important traits (hardness of the shell, double kernels, kernel appearance and flavour) can be carried out.

Later, other important characteristics are studied, as for instance self-compatibility and self-fruitfulness, disease susceptibility, etc., but only in a small number of seedlings.

A scheme of the process followed in the early selection of seedlings from crosses made in 1990 (2,191 seedlings), 1993 (1,401 seedlings) and 1994 (2,309 seedlings) is shown in Table 4. The main selection criteria used were: leafing date, vigour, bearing habit, branching, early bearing and nut traits.

Table 4. Early selection in the nursery. Main traits used (3 examples)

Crossing year	Sowing year	No. of crosses	No. of seedlings	Start of selection		Main traits used†
				Date	Traits used	
1991	1992	18	2191	1993 February	Leafing date Vigour	Leafing date Vigour Growth habit Branching Blooming date Production Nut traits
1993	1994	21	1401	1995 February	Leafing date Vigour	Leafing date Vigour Growth habit Branching Blooming date
1994	1995	27	2329	1995 October	Vigour	Leafing date Vigour

†Until March 1996

Results and discussion

Assessment of progenies

Seedling classification for the features assessed is presented in Table 5. The high percentage of undesirable seedlings regarding blooming date (55.5), tree appearance (32.1), double kernels (31.8)

and kernel appearance (31.7) could be standed out, although in all the crosses made at least one of the parents had the desirable attribute for these selected traits.

Table 5. Seedling classification (%) for the features analysed, according to the criteria established on Table 2

Features	Undesirable seedlings	Acceptable seedlings	Desirable seedlings
Blooming date	55.5	22.5	22.0
Flowering intensity	19.0	65.7	15.3
Tree vigour	17.3	59.1	23.6
Tree appearance	32.1	59.4	8.5
Shelling percentage	11.8	38.1	50.1
Double kernels	31.8	16.2	52.0
Kernel appearance	31.7	39.4	28.9
Flavour	2.5		97.5

The percentage of seedlings discarded according to the three selection levels considered is shown in Table 6. The results are in agreement with the seedling classification mentioned above as expected. For any of these values, the percentage of trees to be discarded, being under the minimum requirements for one or several of the characters considered, resulted high. For some features, this percentage was also high. Blooming date, tree appearance, double kernels and kernel appearance, which are important attributes, influence largely in the selection process.

Table 6. Percentage of seedlings discarded according to the selection levels established in Table 3

Features	Low level	Middle level	High level
Blooming date	55.50	77.98	92.14
Flowering intensity	19.03	37.90	59.98
Tree vigour	17.30	42.41	76.43
Tree appearance	32.14	70.86	88.23
Shelling percentage	11.81	29.79	51.18
Double kernels	31.84	39.13	47.85
Kernel appearance	31.71	57.79	85.53
Flavour	2.48	2.48	2.48
Total	87.81	98.06	99.72

Early selection in the nursery

Table 7 data are gathered in relation to early selection in the nursery. The percentage of removed seedlings, when these were two years old or under, was very high.

Table 7. Early selection in the nursery. Removed trees (%) in 3 examples (Table 4)

Example	Sowing year	No. of seedlings	Start of selection	Removed trees† (%)
1	1991	2191	1993 February	91
2	1993	1401	1995 February	92
3	1994	2329	1995 October	55

†Until March 1996

In progenies from crosses with one early blooming parent, the observation of the leafing date (related to blooming date) at the starting of the second year allows the removal of a very important number of seedlings. Undesirable features concerning vigour, tree appearance and nut traits (soft shell, double kernels, and bad kernel appearance) can also be detected in the nursery.

Conclusions

The assessment of segregating F_1 almond progenies, during the third-fourth year after planting in evaluation plots, regarding flowering (date and intensity), vigour, general appearance of the tree (observations of growth habit, branching, production, vigour, disease susceptibility, etc.) and nut characteristics (shelling percentage, double kernels, kernel appearance and taste), considering three possible levels of selection (low, medium and high), showed that the amount of seedlings that could be discarded (not reaching the minimum requirements for one or several of the characters considered) was very high.

In relation to early selection in the nursery, without transplanting to evaluation plots, the known correlation between leafing and flowering date allows selection for this important character in the first year after germination. Other important traits, like vigour, growth habit and branching, can also be detected in seedling nurseries, easing the removal of phenotypes with undesirable features. The use of early selection techniques has shortened the time from germination to selection of new genotypes, and has decreased the amount of land and labour needed for seedling assessment. Preselection techniques in seedling nurseries will improve the efficiency and economy of most almond breeding programmes.

References

Grasselly, Ch. and Crossa-Raynaud, P. (1980). *L'Amandier.* G.P. Maisonneuve and Larose, Paris, p. 446.

Kester, D.E. and Gradziel, M. (1996). *Almonds. Fruit Breeding.* Volume III: Nuts, Janick, J. and Moore, J.N. (eds). J. Wiley and Son, Inc., New York, pp. 1-97.

Kester, D.E., Raddi, P. and Asay, R. (1977). Correlations of chilling requirements for germination, blooming and leafing, within and among seedling population of almond. *J. Amer. Soc. Hort. Sci.*, 120(2): 145-148.

Vargas, F.J. and Romero, M.A. (1984). Considérations autour de la sélection précoce dans des programmes d'amélioration de variétés d'amandier. In: V GREMPA Meeting, Sfax, Tunisia, 1983, *Options Méditerranéennes*, IAMZ 8(2): 143-145.

Vargas, F.J. and Romero, M.A. (1988). Comparación entre descendencias intervarietales de almendro en relación con la época de floración y la calidad del fruto. In: *VII GREMPA-AGRIMED Meeting,* Reus, Spain, 1987, Rapport EUR, 11557: 59-72.

Vargas, F.J. and Romero, M.A. (1990). Mejora de variedades de almendro en Cataluña. In: *Actas del III Congreso de la Sociedad Española de Ciencia Hortícolas (SECH)*, Puerto de la Cruz, Tenerife, Spain, 1988, Galán, V., Rodríguez, M.C., Hernández, P.M. and Díaz, M. (eds). SECH, Córdoba, 1: 139-144.

Vargas, F.J., Romero, M.A. and Batlle, I. (1995). Selección precoz en la mejora del almendro. In: *VI Congreso de la Sociedad Española de Ciencia Hortícolas (SECH), Resúmenes,* Barcelona, Spain, SECH, p. 100.

Vargas, F.J., Romero, M.A., Rovira, M. and Girona, J. (1984). Amélioration de l'amandier par croisements des variétés. Résultats préliminaires à Tarragone (Espagne). In: VI GREMPA Meeting, Sfax, Tunisia, 1984, *Options Méditerranéennes*, IAMZ 84(2): 101-122.