Evaluation of self-compatible offsprings of almond hybrids "Ferragnes" x "Falsa barese", "Ferragnes" x "Genco" and "Ferragnes" x "Tuono"

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SUMMARY - 'Ferragnès', the well-known French and self-incompatible cultivar, was artificially pollinated in 1988 with 'Falsa barese', 'Genco' and 'Tuono', of Apulian origin and self-compatible. From 1,206 seeds were obtained 881 seedlings (average germination = 73.1%), as follows: 310 'Ferragnès' x 'Falsa barese', 293 'Ferragnès' x 'Genco' and 278 'Ferragnès' x 'Tuono'. At the end of the 1991, 10.8% of the 881 seedlings were discarded for the stunted growth; 55.5% of the remaining 786 seedlings were discarded at the end of 1992 because they were not yet into production; 7.9% of the residue 297 seedlings were discarded in 1995 for the incidence of doubles above 5%. Between 1993 and 1995, studies on flowering phenology, biological behaviour and production characteristics of the remaining 227 seedlings were carried out: all the tested individuals were late blooming and about 60% were self-compatible. At present, 11 offsprings appear to be of particular interest in terms of productivity and kernel characteristics, thereby deserving further observations; 3 of them belong to 'Ferragnès' x 'Falsa barese', 4 to 'Ferragnès' x 'Genco' and 4 to 'Ferragnès' x 'Tuono'.

Key words: Almond, 'Ferragnès', breeding, self-compatibility.

RESUME - *"Evaluation des descendants autofertiles des croisements d'amandier 'Ferragnès' x 'Falsa barese', 'Ferragnès' x 'Genco', 'Ferragnès' x 'Tuono'". Le cultivar 'Ferragnès', français et autoincompatible, a été pollinisé artificiellement en 1988 avec 'Falsa barese', 'Genco' et 'Tuono', des cultivars des Pouilles autocompatibles. A partir de 1 206 graines, 881 semis ont été obtenus au total (germination moyenne = 73,1%), répartis comme suit : 310 pour 'Ferragnès' x 'Falsa barese', 293 pour 'Ferragnès' x 'Genco' et 278 pour 'Ferragnès' x 'Tuono'. Des semis obtenus, à la fin de la quatrième année de vie (1992), 10,8% ont été écartés à cause de leur développement chétif, 55,5% parce qu'ils n'étaient pas entrés en production et 7,9% vu qu'ils avaient produit plus de 5% de graines doubles. Sur les 227 semis restants, des études ont été menées entre 1993 et 1995 concernant la phénologie de la floraison, le comportement biologique et les caractéristiques de la production. Tous les descendants se sont avérés être à floraison tardive ; environ 60% de ceux-ci se sont révélés autocompatibles. En décembre 1995, 11 descendants se sont montrés particulièrement intéressants en raison de leur productivité et des caractéristiques de leur production. Par conséquent, ils méritent d'être soumis à des observations supplémentaires. Il a été mis en évidence que de ceux-ci, 3 appartiennent à la lignée 'Ferragnès' x 'Falsa barese', 4 à la lignée 'Ferragnès' x 'Genco' et 4 à la lignée 'Ferragnès' x 'Tuono'.*

Mots-clés : *Amandier, 'Ferragnès', amélioration, autocompatibilité.*

Introduction

'Ferragnès' is undoubtedly the most interesting result of the European almond cultivar breeding programmes of the past thirty years. 'Ferragnès' was obtained in France in 1960 by crossing the local 'Aï' with the Apulian 'Cristomorto' (Grasselly and Crossa Raynaud, 1980). The positive traits of 'Ferragnès' are its late blooming, satisfactory shelling percentage, absence of doubles and good kernel features. On the other hand, the negative characteristics are its tree weeping habit, and especially self-incompatibility. As for the latter characteristic, studies carried out over the last twenty years have shown the inferior productivity of self-incompatible cultivars, including 'Ferragnès', with respect to self-compatible ones (Godini *et al.*, 1992). 'Ferragnès' may be excused by the fact that it is the result of breeding programmes which began before self-compatibility was discovered in the Apulian (Southern Italy) almond germplasm (Jaouani, 1973; Godini, 1975; Grasselly and Olivier, 1976).

The mechanisms and the easy transmission of the self-compatible character by hybridization are widely known (Socias i Company and Felipe, 1977; Grasselly and Crossa Raynaud, 1980; Dicenta and García, 1993). At the end of the 70's, French and Spanish researchers started to cross 'Ferragnès' with 'Tuono' an Apulian self-compatible cultivar. Despite its known defects (Grasselly *et al.*, 1992), to which we can add intermediate blooming time, alternate bearing, tendency to production of sticktight fruits during dry years, susceptibility to *Monosteira* and to 'Mosaic' virus (ApMV, PDV, PNRV) 'Tuono' was the only cultivar used. This is to be explained by the fact that 'Tuono' was the best among the few Apulian self-compatible cultivars known at that time and present in the French and Spanish collections. These programmes produced new self-compatible cultivars such as the French 'Lauranne' and 'Steliette' (Grasselly *et al.*, 1992), and the Spanish 'Ayles', 'Guara' and 'Moncayo' (Felipe and Socias i Company, 1987).

Recently 'Genco', another Apulian cultivar, has been used as male parent in Spain and its offspring are already undergoing preliminary evaluations (Dicenta and García, 1993).

In 1988, we started a programme aimed at using some of the Apulian self-compatible almonds in our collection in order to introduce the self-compatibility not only in 'Ferragnès' but also in some important Spanish ('Marcona') and Californian ('Texas') almonds. In addition to 'Tuono' we used 'Falsa barese', 'Genco' and a bitter-kernel cultivar 'Padula di Ruvo'. The latter three cultivars were chosen with the goal of obtaining offsprings which would be not only self-compatible but also late blooming, early coming into production, upright and broad in habit, with good shelling percentage, absence of doubles, acceptable kernel features in terms of shape and taste, and without defects particular to 'Tuono' and sometimes to its offspring. The present paper deals with the first results of our crosses of 'Ferragnès' with 'Falsa barese', 'Genco' and 'Tuono'.

Material and methods

The study has been carried out in Valenzano, near Bari (Southern Italy) using seeds coming from another research subject and obtained from artificial cross-pollinations executed in 1988 (Godini *et al.*, 1991). With each male parent, about 1,000 flowers of 'Ferragnès' were pollinated.

At ripening, fruits from each hybrid combination were separately gathered, hulled, dried, stratified at 4ºC for 3 months, and sown in seed beds in December 1988. In December 1989, the seedlings obtained were transplanted in the open field and spaced 1.5 x 1.0 m.

In the following two years (1990 and 1991), the seedlings showing an evident stunted growth with respect to the average population, were discarded. At the end of 1992, four years after their emergence, seedlings which had neither produced nor formed flower buds were also discarded.

Between 1993 and 1995 a third selection was made and those seedlings which had produced fruits with a percentage of double kernels above 5% were eliminated. In 1994 and 1995 observations on the flowering time were made (on three flowering twigs per seedling) and self-compatibility tests were performed (bagging of flowering twigs during blooming). At the end of 1995, as a result of a fourth selection, self-incompatible seedlings were excluded from any further observation.

In conclusion, within the framework of the several individuals belonging to the three parental groups, only offspring showing the following features were selected: (i) coming into production within the fourth year from germination; (ii) late blooming time (50% of open flowers in the first half of March); (iii) overall production of kernel between the fourth and seventh year: ≥200 g; (iv) kernel weight: ≥1.1 g; (v) shelling percentage: ≥30%; (vi) double kernels: ≤5% and (vii) self-compatibility (≥5% set by selfing in paper bags).

Results and discussion

Table 1 reports the data concerning the various steps of the research activity carried out between 1988 and 1995. A high number of seedlings (294 on average) were obtained by hybridization from a

considerable number of seeds (402 on average) corresponding to a fairly good germination (73.1%) which did not differ according to the intervarietal combination.

Differences among parental groups came out when seedlings had to be discarded for the reasons reported in Table 1, offspring with stunted growth were reported particularly in the parental group 'Ferragnès' x 'Tuono'. Our data confirm the results of other authors who have noticed similar stunted growth in self-fertilized 'Tuono' offsprings and have attributed it to the effect of inbreeding (Grasselly and Olivier, 1988).

Table 1. Criteria adopted and descending results to select self-compatible offsprings of hybrids 'Ferragnès' x 'Falsa barese', 'Ferragnès' x 'Genco' and 'Ferragnès' x 'Tuono'

		Ferragnès x Falsa barese	Ferragnès x Genco	Ferragnès x Tuono
Seed sown, Dec. 1988	(n)	423	407	376
Seedling, Dec. 1989	(n)	310	293	278
Germination	(%)	73.3	72.0	73.9
Causes of seedlings discard between 1989 and 1995				
(i) Stunted growth (1990-91)	(n)	18 out of 310	15 out of 293	62 out of 278
	(%)	5.8	5.1	22.3
(ii) Delayed coming into production	(n)	203 out of 292	158 out of 278	128 out of 216
	(%)	69.5	56.8	59.2
(iii) Doubles ≥5% (1993-95)	(n)	15 out of 89	16 out of 120	39 out of 88
	(%)	16.8	13.3	44.3
(iv) Self-incompatible (1994-95)	(n)	20 out of 74	51 out of 104	20 out of 49
	(%)	27.0	49.0	40.8
Passed seedlings				
Dec. 1995	(n)	54 out of 310	53 out of 293	29 out of 278
	(%)	17.4	17.4	10.4

The duration of a seedling juvenile stage is a biological parameter of utmost importance for the characterization of its potential fruitfulness (Kester *et al.*, 1992). The behaviour of the three parental groups did not show substantial differences as far as this parameter is concerned. However, the duration of the juvenile stage proved to be the main cause of exclusion of the seedlings from further observations since it concerned 62.2% of the individuals on the average.

It is known that the production of medium to high percentage of double kernels is among the defects of 'Tuono' (Grasselly *et al.*, 1992); really this negative trait appeared within the offspring population having 'Tuono' as male parent in as much as 50% of the seedlings which had already passed the first two steps of selection (Table 2). In 'Falsa barese' and 'Genco' offsprings, the percentage of discarded individuals because of a production of doubles exceeding the established limit was much lower.

Moreover, 36.6% of the offspring of the three groups which had passed the first three exclusion criteria, were discarded for their self-incompatibility. It is not possible to make any evaluation of the transmission of the self-compatibility character in the offspring because of the exclusions we made previously. As stated before, the modes of the character transmission have been studied thoroughly and are well known. It is worth pointing out that, as far as the evaluated material is concerned, the incidence of self-compatible offspring lowered from a 2:3 average ratio in the hybrid 'Ferragnès' x 'Falsa barese' to a 3:5 average ratio in the hybrid 'Ferragnès' x 'Tuono' and to a 1:2 average ratio in the hybrid 'Ferragnès' x 'Genco'.

After all, the seedlings which passed the four different selective steps were a sharp minority of the initial number, ranging from a minimum of 10.4% ('Ferragnès' x 'Tuono') to a maximum of 17.4% ('Ferragnès' x 'Falsa barese' and 'Ferragnès' x 'Genco').

Table 2. Essential traits of the parents (5) and of the most promising self-compatible offsprings of 'Ferragnès'

Parent and hybrid	First crop (year)	Cumulated 1992-95 kernel yield (g)	Double kernel (%)	Shelling (%)	Kernel weight (g)	Blooming time
Parent						
Ferragnès	3rd-4th		0-2	37.0	1.7	Late
Falsa barese	3rd-4th		0-3	37.0	1.4	Late
Genco	3rd-4th		0-4	34.0	1.4	Late
Tuono	3rd		10-20	39.0	1.4	Medium
Hybrid						
'Ferragnès' x 'Falsa barese'						
H-10	4th	340	0.0	30.0	1.1	Late
K-41	4th	246	0.0	30.0	1.2	Late
N-30	4th	231	0.0	31.8	1.1	Late
'Ferragnès' x 'Genco'						
P-44	4th	252	0.0	32.2	1.5	Late
S-13	4th	273	0.0	36.4	1.2	Late
S-17	4th	398	1.3	33.0	1.2	Late
T-5	4th	363	0.0	37.6	1.2	Late
'Ferragnès' x 'Tuono'						
C-8	4th	302	2.0	40.6	1.3	Late
D-4	4th	401	0.0	32.0	1.5	Late
F-13	4th	325	0.0	30.6	1.2	Late
G-14	4th	267	0.0	40.8	1.3	Late

Conclusions

The selective criteria we chose were strict as were their application. This was imposed by the need to successfully master the numerous population of the 881 seedlings. The continuation of the evaluation of these seedlings in the programme which will follow will compliment these figures. On the basis of the hybrids obtained in 1988, the eleven seedlings reported in Table 2 are the most promising since they show the traits we established as they are indicated on the side. Our future task is therefore the further evaluation of the above offsprings along with the study of the particular characteristics of the kernel.

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