Trialling of pistachio rootstocks in nursery

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SUMMARY – A two year trial was made on the behaviour of pistachio seedling rootstocks in nursery. Seeds derived from 14 clones of different *Pistacia* species from different origin were used. These seed source clones were planted at IRTA Mas Bové in small isolated groups, according to their origin, to prevent, as much as possible, hybridizations, which are common in this genus. As seed sources, the following open pollinated rootstocks were used: 3 *P. atlantica* (1 from Syria and 2 from USA), 1 *P. palaestina* (Syria), 1 *P. terebinthus* (Spain), 2 *P. vera* cultivars ('Larnaka' and 'Mateur') and 7 interspecific hybrids (although they were introduced at Mas Bové as true species, they are hybrids): 3 introduced as *P. integerrima* (USA), 3 introduced as *P. palaestina* (1 from USA and 2 from Greece) and 1 introduced as *P. atlantica* (USA). Seedlings obtained were not budded. At the end of the second growing season in nursery, records were taken on: trunk diameter and height, number of feathers, weight of the whole seedling, weight of the root system and number of roots. Important and significant differences were obtained for all the parameters studied. *P. integerrima* hybrids (USA), *P. atlantica* (Syria) and *P. palaestina* hybrids (Greece) showed interesting characteristics. This trial has allowed the wide potencial of pistachio seedling rootstock selection to be observed. For the commercial production in nursery, it is important to select fast-growing rootstocks to allow early budding and transplantation, with a branched root system which allows them to withstand the transplantation crisis.

Key words: *Pistacia* spp., *P. atlantica*, *P. integerrima*, *P. palaestina*, *P. terebinthus*, *P. vera*, pistachio, rootstocks, vigour, selection.

RESUME – *"Essais en pépinière de porte-greffes de pistachier". Dans le centre de Mas Bové a été réalisé un essai de comportement des porte-greffes du pistachier en pépinière durant deux années. Les semences utilisées proviennent de 14 clones de différentes espèces du genre* Pistacia*, d'origine diverse. Ces clones sont plantés à Mas Bové, suivant leurs origines, en petits groupes isolés pour éviter au possible les hybridations qui sont très fréquentes dans ce genre. Comme source de semences, on a utilisé les suivants porte-greffes pollinisés librement : 3* P. atlantica *(1 de Syrie et 2 de EUA), 1* P. palaestina *(Syrie), 1* P. terebinthus *(Espagne), 2* P. vera *(cultivars 'Larnaka' et 'Mateur') et 7 hybrides interspécifiques (quoiqu'ils étaient introduits à Mas Bové comme espèces, ils sont en réalité hybrides) : 3 introduits comme* P. integerrima *(EUA), 3 comme* P. palaestina *(1 de EUA et 2 de la Grèce) et 1 comme* P. atlantica *(EUA). Les arbres obtenus n'ont pas été greffés. À la fin de la deuxième année en pépinière, on a pris les mesures de : diamètre du tronc, hauteur de l'arbre, nombre des rameaux partant du tronc, poids entier de l'arbre, poids du système radiculaire et nombre des racines. Pour tous les paramètres étudiés, on a obtenu des différences significatives et importantes.* P. integerrima *(hybrides, EUA),* P. atlantica *(Syrie) et* P. palaestina *(hybrides, Grèce) ont montré des caractéristiques intéressantes. L'essai a permis d'observer le grand potentiel existant à la sélection des porte-greffes francs du pistachier. Pour la production commerciale en pépinière, il est important de sélectionner des porte-greffes ayant une croissance rapide, qui permet un greffage et une transplantation précoces, dotés d'un système radiculaire bien ramifié qui leur permet de supporter le stress de la transplantation.*

Mots-clés : Pistacia *spp.,* P. atlantica*,* P. integerrima*,* P. palaestina*,* P. terebinthus*,* P. vera*, pistachier, porte-greffes, vigueur, sélection.*

Introduction

Six species of the genus *Pistacia* are available as rootstocks of the cultivated pistachio (*Pistacia vera* L.): *Pistacia terebinthus* L., *Pistacia palaestina* Boiss, *Pistacia atlantica* Desf., *Pistacia integerrima* Stewart (*Pistacia chinensis* Bge.) and *Pistacia khinjuk* Stocks, in addition to *Pistacia vera* L. The species *P. atlantica*, *P. terebinthus*, *P. palaestina*, *P. khinjuk* and *P. vera* are widely difused, and are used as rootstocks, in the Mediterranean area and Western Asia. Wild forests of *P. integerrima* are located in Central Asia. Hybridation is common between *Pistacia* species, therefore hybrids are often found, very usefull as rootstocks, in the wild *Pistacia* populations (Zohary, 1952; Maggs, 1973; Kaska, 1990; Zohary, 1996; Kaska *et al*., 1998).

The interest of pistachio rootstocks is mainly related to their capacity of adaptation to environmental conditions in which the crop is developed. Simplicity of management in nursery is another important feature. Considering the hybridation easiness in the *Pistacia* genus, for rootstock choice not only the species is important, but also the source. At present, the knowledge on the possibilities of the different rootstocks is very scarse. There are important differences between them. For instance, *P. terebinthus* and *P. atlantica* are well adapted to very poor soils, *P. integerrima* and some hybrids have strong vigour and good tolerance to *Verticillium,* etc. The hybrids have a special interest for their vigourness (Kaska *et al*., 1996; Khaldy and Kouja, 1996; Monastra *et al*., 1997).

P. vera, with reduced vigour, is the most used rootstock in the world. Most orchards in Iran, Turkey, Syria and Tunisia are planted using this rootstock (Kaska *et al*., 1996; Sheibani, 1996). *P. terebinthus*, with low vigour and shrubby habit but very hardy, is the most common in Italy and some areas of Turkey (Kaska *et al*., 1996; Mazzola *et al*., 1996). *P. atlantica*, more vigorous than *P. terebinthus* and also very hardy, has been widely used in USA, Spain and other Mediterranean countries (Crane and Maranto, 1988; Batlle *et al*., 1996; Vargas *et al*., 1999). *P. palaestina* is very close to *P. terebinthus* (Zohary, 1996). In Greece, a vigorous type, called 'Tsikoudia', which probably has a hybrid origen between *P. palaestina* and *P. terebinthus*, is spread (Rouskas, 1996). *P. khinjuk* is used in Turkey (Kaska *et al*., 1996). The utilization of *P. integerrima* has been started in rather recent dates in the USA (Ferguson *et al*., 1995).

Commercial pistachio nursery production needs to rise fast growing rootstocks to allow early budding and transplanting to orchard. In addition, vigour is a desirable character in pistachio rootstocks, due to its effect on the time needed by the scion to form a large canopy (related with yield capacity) and on the adaptation of the tree to adverse growing conditions in which usually the crop is placed. The achievement of a good rooting system is a very important characteristic for transplanting to the orchard.

At IRTA Mas Bové, a two years long trial was made on the behaviour of pistachio seedling rootstocks in nursery, using seeds derived from 14 seed source trees of different *Pistacia* species, hybrids and origins. During the first year, important growth differences were already observed (Vargas *et al*., 1998). In this paper, records of several seedling traits, after two years of nursery growing are presented.

Materials and methods

At Mas Bové seeds of several *Pistacia* species from different countries were introduced in different years. Several of them had really hybrid origin, which could be observed later (Rovira *et al*., 1995). Seedlings derived from those seeds were planted at Mas Bové, according to their origins, in small isolated groups to prevent, as much as possible, hybridizations, very common in this *Pistacia* genus.

As seed sources, in this trial, the following open pollinated rootstocks were used (Table 1): 3 *P. atlantica* (PA) (1 from Syria and 2 from USA), 1 *P. palaestina* (PP) (Syria), 1 *P. terebinthus* (PT) (Spain), 2 *P. vera* (cultivars 'Larnaka' and 'Mateur') and 7 interspecific hybrids (introduced at Mas Bové as true to type species) – 3 introduced from USA as *P. integerrima* (PAI), 2 introduced from Greece (PTS, 'Tsikoudia') and 1 from USA (PPH) as *P. palaestina* and 1 introduced from USA as *P. atlantica* (PAH). All the source trees used had different origins, with the exceptions of the clons PAI-0-260, PAI-0-265 and PAI-0-278, derived from seeds introduced as *P. integerrima* (presumably, hybrids between *P. atlantica* and *P. integerrima*), that had the same origin.

Seeds were sowed in trays in January 1996. Seedlings grew in the greenhouse and then they were transplanted to nursery in early May. The planting spaces were 4 0.25 m. Rootstocks were randomly distributed in 6 plots by rootstock, including 14 seedlings by plot. The seedlings were not budded. At the end of the second growing season in nursery, records on a total number of 990 seedlings were taken on: trunk diameter, trunk height, trunk branching (number of feathers), weight of the whole seedling, weight of the root system and number of roots.

Results and discussion

Regarding trunk diameter, which is essential to allow early budding, significant and very important differences between rootstocks were observed (Table 2). PAI-0-265, PAI-0-278 and PA-0-I21 stood out while PT-0-220, 'Mateur' and 'Larnaka' showed a reduced vigour. In relation to trunk height (Table 3),

results were quite similar to the last, and once again the important height of the seedlings PAI-0-265, PAI-0-278 and PA-0-I21 stood out and the shortness of PP-0-114, PT-0-220 and 'Larnaka'. As expected, a highly significant correlation was found between trunk diameter and trunk height records of the seedlings (r = 0.84) (Table 4). Also, the comparison of records obtained when the seedlings were 1 and 2 years old gave a significant correlation (r = 0.74 for diameter and r = 0.70 for height).

Table 1. *Pistacia* species used as seed source

Rootstocks	Clon or cultivar	Origin	Remarks
P. atlantica	PA-0-48	USA	
P. atlantica	PA-0-121	Syria	
P. atlantica	PA-0-175	USA	
P. atlantica (h)†	PAH-0-143	USA	Hybrid
P. integerrima (h)†	PAI-0-260	USA	Hybrid (probably with *P. atlantica*)
P. integerrima (h)†	PAI-0-265	USA	Hybrid (probably with *P. atlantica*)
P. integerrima (h)†	PAI-0-278	USA	Hybrid (probably with *P. atlantica*)
P. palaestina	PP-0-114	Syria	
P. palaestina (h)†	PTS-0-24	Greece	'Tsikoudia' (close to *P. palaestina*)
P. palaestina (h)†	PTS-0-110	Greece	'Tsikoudia' (close to *P. palaestina*)
P. palaestina (h)†	PPH-0-130	USA	Hybrid
P. terebinthus	PT-0-220	Spain	
P. vera	'Larnaka'	Cyprus	
P. vera	'Mateur'	Tunisia	

†(h) were intoduced at Mas Bové as species (*P. atlantica*, *P. integerrima* or *P. palaestina*), but they are hybrids, according to their tree morphology and isoenzymatic banding patterns.

Table 2. Trunk diameter (ground level). Mean of the seedlings (mm)

Rootstocks	Clon or cultivar	Mean
P. integerrima (h)	PAI-0-265	19.1 a
P. integerrima (h)	PAI-0-278	17.6 ab
P. atlantica	PA-0-121	17.4 ab
P. palaestina (h)	PTS-0-24	16.9 b
P. integerrima (h)	PAI-0-260	16.7 bc
P. palaestina (h)	PTS-0-110	16.6 bc
P. atlantica	PA-0-48	14.9 c
P. palaestina	PP-0-114	13.0 d
P. atlantica (h)	PAH-0-143	12.4 de
P. palaestina (h)	PPH-0-130	12.3 de
P. atlantica	PA-0-175	10.9 ef
P. terebinthus	PT-0-220	10.1 fg
P. vera	'Mateur'	9.6 fg
P. vera	'Larnaka'	8.7 g
Total		14.0

Trunk branching records are presented on Table 5. Significant differences were also recorded. To enable grafting, it is desirable that the number of shoots is as reduced as possible. Seedlings from PA-0-121 and PA-0-48 had an important branching while in the seedlings from 'Mateur', 'Larnaka', 'PP-0-114 and PT-0-220 the number of feathers was very reduced. Considering together the height and the branching of the trunk (Tables 3 and 5), it is clear that PA-0-121, PA-0-48 and PA-0-175 have a relatively high number of trunk shoots.

Table 3. Trunk height. Mean of the seedlings (cm)

Rootstocks	Clon or cultivar	Mean
P. integerrima (h)	PAI-0-265	134.7 a
P. integerrima (h)	PAI-0-278	109.5 b
P. atlantica	PA-0-121	108.4 b
P. integerrima (h)	PAI-0-260	106.5 bc
P. atlantica	PA-0-48	95.4 bc
P. palaestina (h)	PTS-0-24	94.8 bc
P. palaestina (h)	PTS-0-110	92.6 cd
P. atlantica (h)	PAH-0-143	79.6 de
P. palaestina (h)	PPH-0-130	78.4 de
P. atlantica	PA-0-175	69.2 ef
P. vera	'Mateur'	68.2 ef
P. palaestina	PP-0-114	59.4 f
P. terebinthus	PT-0-220	57.6 f
P. vera	'Larnaka'	57.0 f
Total		86.2

Table 4. Correlations. Trunk diameter and trunk height

Features	N	r	S.L.
Diameter-height	990	0.84	0.0001
Diameter (1-2 years old)	993	0.74	0.0001
Height (1-2 years old)	990	0.70	0.0001

Table 5. Trunk branching. Mean of the seedlings (number of feathers)

Rootstocks	Clon or cultivar	Mean
P. atlantica	PA-0-121	13.1 a
P. atlantica	PA-0-48	10.9 ab
P. integerrima (h)	PAI-0-278	10.2 b
P. integerrima (h)	PAI-0-265	10.1 b
P. atlantica	PA-0-175	10.0 b
P. palaestina (h)	PTS-0-110	9.9 b
P. integerrima (h)	PAI-0-260	9.4 b
P. palaestina (h)	PTS-0-24	8.7 b
P. atlantica (h)	PAH-0-143	8.3 b
P. palaestina (h)	PPH-0-130	8.0 b
P. vera	'Mateur'	4.9 c
P. vera	'Larnaka'	2.9 cd
P. palaestina	PP-0-114	1.8 d
P. terebinthus	PT-0-220	1.6 d
Total		7.83

Regarding weight of the whole tree (Table 6) and weight of the root system (Table 7) the results are very similar. PAI-0-265, PAI-0-278, PA-0-121, PAI-0260, PTS-0-24 and PTS-0-110 were outstanding and PAH-0-143, 'Mateur', PA-0-175, 'Larnaka', PPH-0-130 and PT-0-220 had a reduced weight. Obviously, these results are according to the results obtained referring to trunk diameter and trunk height.

Table 6. Weight of the whole tree. Mean of the seedlings (kg)

Rootstocks	Clon or cultivar	Mean
P. integerrima (h)	PAI-0-265	6.97 a
P. integerrima (h)	PAI-0-278	5.64 b
P. atlantica	PA-0-121	5.22 bc
P. integerrima (h)	PAI-0-260	4.99 bcd
P. palaestina (h)	PTS-0-24	4.98 bcd
P. palaestina (h)	PTS-0-110	4.09 cde
P. atlantica	PA-0-48	3.73 de
P. palaestina	PP-0-114	3.32 e
P. atlantica (h)	PAH-0-143	2.06 f
P. vera	'Mateur'	1.32 f
P. atlantica	PA-0-175	1.31 f
P. palaestina (h)	PPH-0-130	1.13 f
P. terebinthus	PT-0-220	0.98 f
P. vera	'Larnaka'	0.85 f
Total		3.30

Table 7. Weight of the root system. Mean of the seedlings (kg)

Rootstocks	Clon or cultivar	Mean
P. integerrima (h)	PAI-0-265	3.12 a
P. integerrima (h)	PAI-0-278	2.68 ab
P. palaestina (h)	PTS-0-24	2.53 b
P. atlantica	PA-0-121	2.4 bc
P. integerrima (h)	PAI-0-260	2.38 bc
P. palaestina (h)	PTS-0-110	2.21 bc
P. palaestina	PP-0-114	2.18 bc
P. atlantica	PA-0-48	1.78 c
P. atlantica (h)	PAH-0-143	1.03 d
P. vera	'Mateur'	0.79 d
P. atlantica	PA-0-175	0.65 d
P. vera	'Larnaka'	0.56 d
P. palaestina (h)	PPH-0-130	0.54 d
P. terebinthus	PT-0-220	0.52 d
Total		1.66

In relation with the number of roots (Table 8), PP-0-114, PAI-0-278, PA-0-121,PTS-0-110 and PAI-0-265 showed promise.

Considering observations made, PAI-0-265, PAI-0-278, PA-0-121, PAI-0260, PTS-0-24 and PTS-0-110 seem to be promising. On the contrary, PAH-0-143, PA-0-175, PPH-0-130, PT-0-220, 'Mateur' and 'Larnaka' showed low interest.

Conclusions

This trial shows the wide potential of pistachio rootstock seedling selection. Significant differences were obtained for all the parameters studied. *P. integerrima* hybrids (probably with *P. atlantica*, from USA), *P. atlantica* (from Syria) and *P. palaestina* hybrids ('Tsikoudia', from Greece) showed interesting features. On the contrary, seedlings from *P. terebinthus* and *P. vera* had low interest. For the commercial production

in nursery, it is important to select fast growing rootstocks to allow early budding and transplantation, with a branched radicular system which allows to stand the transplantation crisis.

Table 8. Number of roots (with diameter > 5 mm). Mean of the seedlings

Rootstocks	Clon or cultivar	Mean
P. palaestina	PP-0-114	6.8 a
P. integerrima (h)	PAI-0-278	6.7 a
P. atlantica	PA-0-121	6.1 a
P. palaestina (h)	PTS-0-110	6.1 a
P. integerrima (h)	PAI-0-265	6.0 ab
P. integerrima (h)	PAI-0-260	5.7 abc
P. atlantica	PA-0-48	5.6 abc
P. terebinthus	PT-0-220	4.9 bcd
P. palaestina (h)	PTS-0-24	4.8 bcd
P. palaestina (h)	PPH-0-130	4.6 cd
P. atlantica	PA-0-175	4.5 cd
P. vera	'Mateur'	4.5 cd
P. atlantica (h)	PAH-0-143	4.5 cd
P. vera	'Larnaka'	3.9 d
Total		5.3

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