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Rooting of 'Ayvalik' olive cuttings in different media

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Abstract

The 'Ayvalik' olive cultivar, the most grown for high quality olive oil in Turkey, is generally regarded as showing very good rooting ability. However, cuttings sometimes show moderate or even poor rooting performances, a problem likely related to the use of inappropriate rooting media. The aim of this work was to determine the most successful media among those traditionally used and to identify promising alternatives. October cuttings were planted in 25 different media in two consecutive years under mist propagation conditions. Substrates such as peat, perlite, bark, pumice, sand, polystyrene beads, phenolic foam, rockwool and vermiculite were used pure or in mixtures. In the first year the highest rooting percentage (100%) and visual rating scores (5) were obtained with phenolformaldehyde foam. Perlite-vermiculite (1:1 v/v) was associated with a 95% rooting percentage in both years. The highest mean number of roots (10.8), root length (47 mm), root dry (382 mg) and fresh weights (48.3 mg), and number of secondary roots (13) were recorded in the same medium in the second year. Rockwool, peat-polystyrene (2:1 v/v) and sand-perlite (1:2 v/v) also led to more than 90% of cuttings taking root, while pure sand, peat and peat-sand mixtures gave very low (5-28%) rooting percentages. Perlite-vermiculite 1:1 (v/v) and pre-sized rockwool cubes may be appropriate alternatives to traditional sand-perlite mixtures for rooting 'Ayvalik' olive cuttings.

Additional key words: *Olea europaea*, perlite, propagation, root, substrate.

Resumen

Enraizamiento de esquejes de olivo 'Ayvalik' en varios medios

El olivo 'Ayvalık' se considera que es el cultivar más extendido en Turquía como productor de aceite de mayor calidad y con una buena capacidad de enraizamiento. Sin embargo, sus esquejes muestran un enraizamiento moderado o pobre, debido probablemente a que se utilizan medios poco adecuados. El objetivo de este trabajo fue determinar los medios con mejor comportamiento entre los tradicionales y seleccionar los alternativos más prometedores. Para ello se analizaron en *mist* esquejes de octubre en 25 diferentes medios durante dos años consecutivos. Se utilizaron sustratos como turba, perlita, corcho, piedra pómez, arena, bolas de poliestireno, espuma fenólica, lana de roca y vermiculita, tanto solos como combinados. En el primer año, el mayor porcentaje de enraizamiento (100%) y puntuación en escala visual (5) se obtuvo con espuma de fenolformaldehído. La mezcla de perlita-vermiculita (1:1 v/v) dió un 95% de enraizamiento durante dos años consecutivos. En el segundo año, el mayor número medio de raíces (10,8), longitud (47 mm), peso de raíz seca (382 mg), peso fresco (48,3 mg) y número de raíces secundarias (13) se obtuvo con este mismo medio. Según el año, la lana de roca, turba-poliestireno (2:1 v/v) y arena-perlita (1:2 v/v) produjeron también más del 90% de enraizamiento, mientras que arena o turba solas y mezclas turba-arena dieron lugar a muy poco enraizamiento (5-28%). Se concluye que tanto la mezcla de perlita-vermiculita (1:1 v/v) como los cubos pre-embalados de lana de roca pueden ser los mejores medios alternativos a las mezclas tradicionales de arena-perlita para un buen enraizamiento de esquejes de olivo 'Ayvalik'.

Palabras clave adicionales: *Olea europaea*, perlita, propagación, raíz, sustrato.

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Abbreviations used: IBA (indole butyric acid), OGRI (Olive Growing Research Institute), VR (visual rating).

Introduction

Olive (*Olea europaea* L.) can be propagated in several ways, although mist propagation of leafy cuttings is currently the method most widely employed (Hartmann *et al*., 2002; Fabbri *et al*., 2004). Unfortunately, economically important cultivars that show intermediate or even poor rooting capacities are to be found in most olive producing countries (Fabbri *et al*., 2004). Clonal variation, the type of cutting material, the concentration of hormone (indole butyric acid) applied, and the physical properties of the rooting medium can all influence rooting, especially in more difficult-to-root cultivars (Loreti and Hartmann, 1964; Fernandes Serrano *et al*., 2002; Hosseini *et al*., 2004; Gerrakakis and Özkaya, 2005).

Rooting media should be considered an integral part of the propagation system (Loach, 1988); percentage rooting and the quality of the roots produced are directly influenced by the medium. The appropriateness of the medium depends on the species, the cutting type, the season, the propagation system used, and the cost and availability of the medium components (Macdonald, 1986; Hartmann *et al*., 2002). Good water management is also crucial for success.

Perlite is by far the most used rooting substrate in olive producing countries. Mixtures such as perlite plus peat, coconut fiber or vermiculite have also given good results (Fabbri *et al.*, 2004). Mixtures of perlite and vermiculite have traditionally been used in Californian nurseries (Sutter, 2005). Despite its apparent disadvantages, coarse sand has recently become more popular in Turkey for economic reasons.

'Ayvalik', also known as 'Ada Zeytini', 'Edremit Yağlık', 'Midilli' or 'Şakran' (Barranco *et al*., 2000), is the foremost cultivar grown for high quality olive oil in Turkey. Despite its being recently classified as a cultivar showing good rooting ability (Fabbri *et al*., 2004), the rooting of Ayvalik cuttings is generally intermediate or sometimes poor (Battaglini *et al.*, 1975; Karakır, 1985; Luma *et al.*, 1991; Ayanoğlu *et al.*, 2000; Gerrakakis and Özkaya, 2005). Poor rooting might be a consequence of the rooting media used.

Certain organic and mineral components, such as pine bark, pumice, polystyrene beads and rockwool, which are fairly cheap and obtainable in Turkey and probably in other olive-producing countries, might be used as alternatives to traditionally used rooting substrates. Synthetic rooting blocks (e.g., made of phenol-formaldehyde foam or rockwool) are also used in the nurseries of some countries (Hartmann *et al*., 2002). The demand for synthetic blocks in olive propagation is likely to increase.

The aims of the present work were: 1) to determine the most successful combinations of media among those traditionally used in Ayvalik olive cutting propagation under mist conditions, and (2) to determine the effects of rooting media that might be used as alternatives.

Material and methods

Leafy, semi-hardwood olive cuttings were collected on 15 October 2003 and 2004 from selected stock plants growing at the Olive Growing Research Institute Bornova, İzmir, Turkey (OGRI). All were taken from vigorous 1 year-old shoots about 6-7 mm in diameter and 20 cm in length. Sub-terminal cuttings with 3-4 pairs of leaves were used. These were soaked in a fungicide solution before dipping for 5 s in 3 g L^{-1} indole butyric acid (IBA) dissolved in 50% isopropanol. All cuttings were then placed in 40 x 20 x 11 cm root flats filled with 25 different media either on their own or as mixtures (2:1, 1:1 and 1:2 v/v). Table 1 shows the media used and their characteristics.

The rooting flats were placed in a low polyethylene tunnel equipped with mist nozzles. Mist cycles were controlled by an electronic leaf between 08:00 and 18:00 h. Basal heat was adjusted to 25±2ºC. Shading cloth was suspended over the tunnel and natural sunlight reduced to approximately 80%. Changes in daily ambient temperature and relative humidity were recorded.

The design of the experiments was a completely randomized block with three replicates of 20 cuttings per treatment. Cuttings were examined eight weeks after planting to determine the percentage that had rooted, the primary root number and root length, the fresh and dry weights of the roots, the secondary root number, and a visual rating (VR) score on a 0-5 scale (0: dead; 1: alive, no callus or roots; 2: little callus; 3: medium amount of callus; 4: heavily callused, and 5: rooted).

Data were analysed by ANOVA. Duncan's Multiple Range Test was then used to identify differences between the treatments (significance was set at $P<0.05$). Mean values were given in histograms. The non-parametric VR scores were not statistically examined. All calculations were performed using SPSS software.

Table 1. Features of media components used

Media components	Features
1. Sand	Coarse
2. Perlite	Horticultural grade (Etiper Co.-Turkey)
3. Pumice	3-5 mm (Soylu Madencilik Ltd.-Turkey)
4. Rockwool	3.5 x 4.5 x 10 cm cubes (Agroban s.r.o-Slovakia)
5. Phenol formaldehyde foam	3.5 x4.5 x 10 cm cubes in standard density (Naturel-Turkey)
6. Peat	Medium grade Lithuanian white peat **(**Klasmann-Deilmann GmbH-Germany)
7. Bark	Milled and composted red pine (*Pinus brutia* Ten.) bark (Ministry of Environment and Forestry, Dalaman, Turkey), passed through a 1 cm mesh sieve
8. Polystyrene	Beads, 3-8 mm (Altındağ Ltd.-Turkey)
9. Vermiculite	Horticultural grade no. 1 (Projar-Mexico)

Results

In 2003 the mean weekly temperature and relative humidity ranged between 13.5 and 24.7ºC and 85.8 and 91.7% respectively. In 2004 these figures were 14.5-24.5ºC and 80.3-88.5% respectively.

Significant differences were seen between years for some rooting variables; the rooting percentage, root fresh and dry weights were all significantly higher in the first than in the second year, while the secondary root number was significantly lower in 2003 than in 2004 (data not shown).

The effects of the different media on the rooting characteristics of the cuttings were significant. The highest rooting percentage and VR scores were obtained for rockwool, although perlite-vermiculite 1:1 gave the highest number of primary and secondary roots, the longest roots, and the highest root fresh and dry weights. Rooting was dramatically decreased when pure sand, pure peat or their mixtures were used (data not shown).

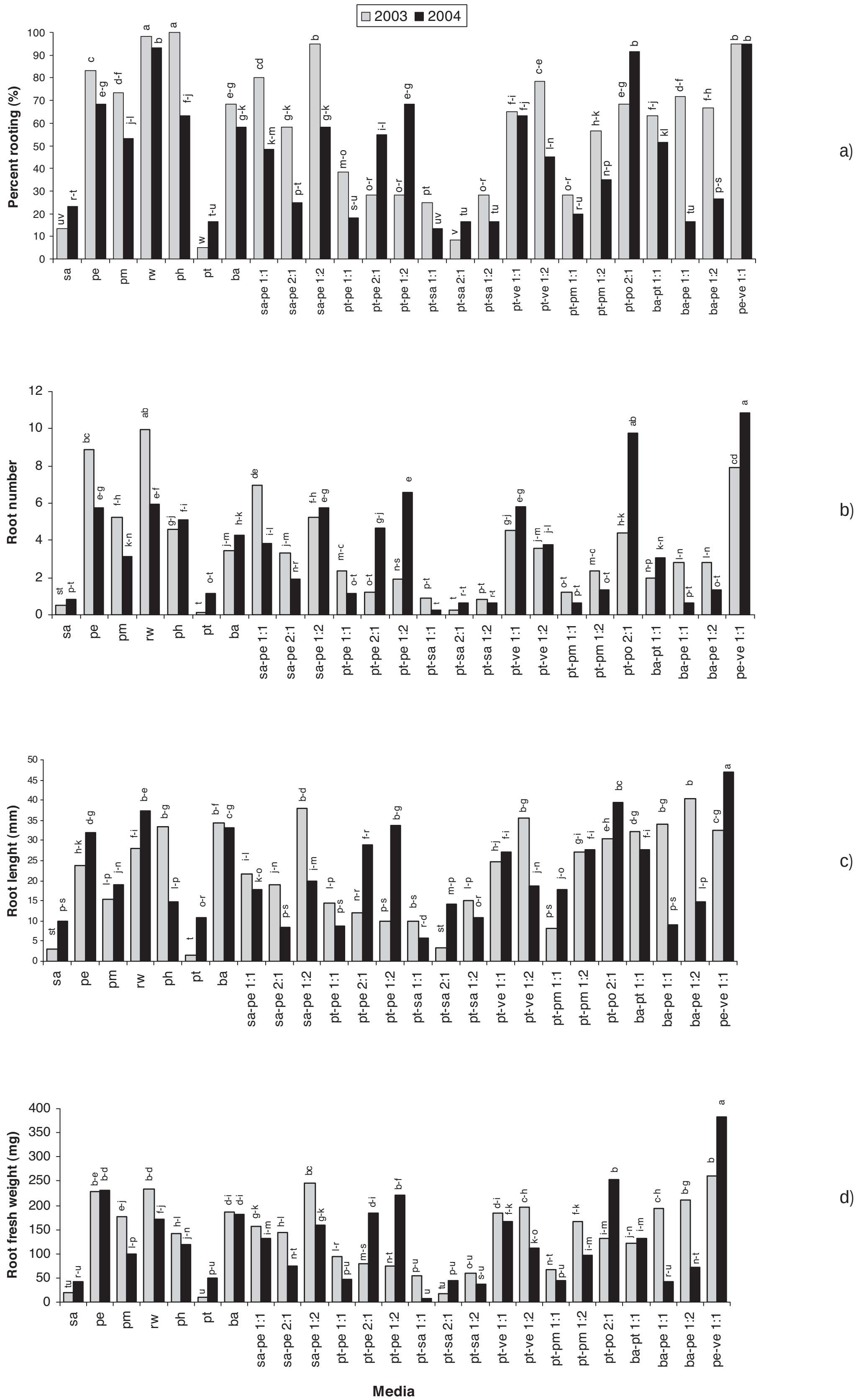
The interaction *cutting year* x *medium* had a significant effect on the rooting variables studied ($P<0.01$). The highest percentage of rooted cuttings was observed in phenol formaldehyde foam (100%), rockwool (98.3%), perlite-vermiculite (95%) and sand-perlite 1:2 (95%) in the first year (Fig. 1a). Rooting was remarkably reduced in the second year in most of the media tested, with the perlite-vermiculite mixture giving the most rooted cuttings (95%) followed by rockwool (93.3%). However, in some media, such as peat-polystyrene 2:1, the cuttings showed a significantly greater level of rooting in the second year than in the first. Pure peat and peat-sand 2:1 gave low rooting percentages in both years.

The cuttings grown in rockwool produced the greatest number of roots (9.9) in the first year, but root production was markedly reduced in this medium in the second year (Fig. 1b). The cuttings also produced many roots (8.9) in pure perlite in the first year. Perlite-vermiculite and peat-polystyrene gave the largest number of roots (10.8 and 9.7 respectively) in the second year. Root production was very scarce in pure sand, pure peat, and their mixtures in both years.

Bark-perlite 1:2 gave the longest roots (40.4 mm) followed by sand-perlite 1:2 in the first year, but both media were unsuccessful in terms of root elongation in the second year (Fig. 1c). The longest roots were obtained for perlite-vermiculite (47.6 mm) in the second year. Peat-polystyrene and rockwool also produced long roots in the second year. Pure bark also gave relatively constant results in terms of root elongation in both years (34.4 and 33 mm respectively). Root elongation was very poor when cuttings grown in pure sand, pure peat and their mixtures.

Cuttings grown in perlite-vermiculite had the highest root fresh weights in both years (261.5 and 382 mg respectively) (Fig. 1d). A high root fresh weight (254.4 mg) was also seen in the second year with the peat-polystyrene mixture. Root fresh weights were also high for cuttings in rockwool and sand-perlite 1:2 (more than 230 mg) in the first year; low dry weights were recorded in sand, peat and peat-sand mixtures in both years.

In the first year, sand-perlite 1:2 gave the highest root dry weight (31.8 mg), followed by rockwool (30.3 mg) (Fig. 1e). In the second year, the highest root dry weight (48.3 mg) was also obtained in perlite-vermiculite, followed by peat-polystyrene (30.7 mg). Sand, peat and peat-sand mixtures gave the lowest values, as observed for root fresh weights.


2003
2004
Percent rooting (%)
a)
Root number
b)
Root lenght (mm)
c)
Root fresh weight (mg)
d)
sa
pe
pm
rw
ph
pt
ba
sa-pe 1:1
sa-pe 2:1
sa-pe 1:2
pt-pe 1:1
pt-pe 2:1
pt-pe 1:2
pt-sa 1:1
pt-sa 2:1
pt-sa 1:2
pt-ve 1:1
pt-ve 1:2
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Media

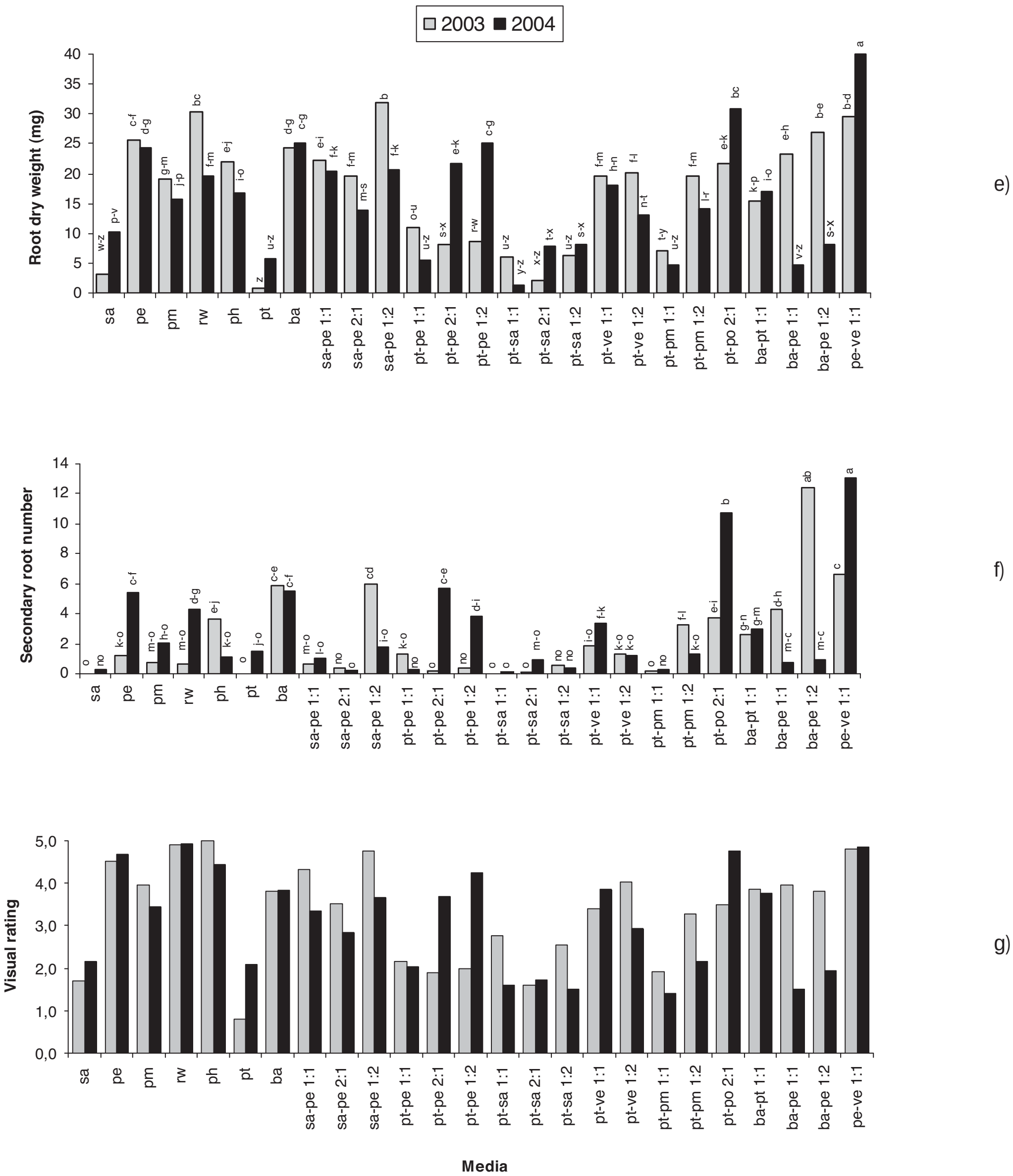

Figure 1. The effects of different media on the a) rooting percentage, b) root number, c) root length, d) root fresh weight e) root dry weight, f) secondary root number, and g) visual rating of olive cuttings in 2003 and 2004. SA: sand, PE: perlite, PM: pumice, RW: rockwool, PH: phenol formaldehyde foam, PT: peat, BA: bark, PO: polystyrene, VE: vermiculite. [a-z]Means followed by different letters are significantly different according to Duncan's Multiple Range Test ($P<0.05$).

In the first year, the cuttings produced the most lateral roots in the bark-perlite 1:2 mixture (12.4) (Fig. 1f). In the second year, the formation of secondary roots was more stimulated in perlite-vermiculite. Indeed, the largest number of lateral roots (13) was obtained with this combination. Peat-polystyrene also led to good lateral root production in the second year. The cuttings generally produced a few lateral roots in most of the media tested in the first year. Despite its moderate effects on most rooting variables, the pure bark increased the number of lateral roots obtained in both years.

The highest VR score (5) in the first year was obtained with the phenol formaldehyde foam, followed by rockwool (4.9) and perlite-vermiculite (4.8) (Fig. 1g). In the second year, the rockwool provided the highest VR score (4.9). Cuttings rooted in perlite-vermiculite, peat-polystyrene and pure perlite had also very high

VR scores. Sand, peat and their various combinations were associated with low scores in both years.

Discussion

In this work, the percentage of rooted cuttings varied between 5-100% depending on the year and the medium tested. Three year experiments on the rooting ability of 83 Turkish olive cultivars showed significant differences between years in terms of root production (Canözer and Özahçı, 1992). However, Luma *et al*. (1991), who examined the growth of Ayvalik olive cuttings in volcanic scoria, reported no significant differences in rooting in the two years of their work. Further, the rooting percentages ranged between 41-56%, and 6-7 roots were obtained. Year differences in the rooting ability of olive cuttings have been ascribed to the alternate-bearing trend shown by mature stock plants; they might therefore be related to the endogenous carbohydrate status (Özkaya and Çelik, 1999). In this study, cuttings were collected from non-bearing stock plants, thus the differences might be linked to other factors. Further, the internal ambient conditions might have been indirectly affected by yearly variations in external atmospheric factors (radiation levels, temperatures, relative humidity, wind speeds, etc.), as suggested by Loach (1988); as a consequence the air/water balance of some media may have changed to favour or disfavour rooting.

Of the 25 different media tested in the present work, the perlite-vermiculite mix showed very high rooting variable values, particularly in the second year (Fig. 1b, c, d, e, f). This agrees with the results obtained for 'Ascolano' and 'Sevillano' olive cuttings (Loreti and Hartmann, 1964). In fact, perlite-vermiculite 2:1 or 3:1 is the most used propagation medium in Californian olive nurseries (Sutter, 2005). Vermiculite has also been recorded to positively affect the rooting of Iranian cultivars when used as a medium component for cuttings grown under fog conditions (Hosseini *et al*., 2004).

Rockwool gave very high rooting percentages and VR scores in both years but inconsistent results were obtained with respect to other rooting variables in the second year (Fig. 1b, c, d, e, f). Despite the relatively small degree of root regeneration obtained in phenolic foam, the highest rooting percentage (100%) and VR scores (5) recorded were for this substrate in the first year (Fig. 1a, g). The very high VR scores achieved with both solid media reflects the strong viability of these cuttings, probably a consequence of the good fungal control achieved and of resistance to contamination.

Pure sand markedly reduced root formation as well as the quality of the roots actually obtained (Fig. 1a, b, c). Root production is negatively affected when cuttings of other woody species are grown in sand (Loreti and Hartmann, 1964; Loach, 1985; Torres, 1986). Gerrakakis and Özkaya (2005) reported the rooting and survival rates of Ayvalik olive cuttings to be significantly reduced in pure sand, depending on the year, when propagated in non-mist conditions in shaded polyethylene tunnels. However, some species of *Prunus*, *Hydrangea* and *Ilex* showed good rooting in sand (Macdonald, 1986). The poor rooting in olive cuttings in this medium may be linked to the rapid loss of water from this medium. In fact, in the present work, sand-perlite mixtures led to significantly improved rooting compared to sand alone. Indeed, sand-perlite 1:2 gave the highest root dry weights (Fig 1e), as well as very high rooting percentages, root lengths and root fresh weights in the first year (Fig. 1a, c, d). This might be explained by the good water holding capacity and porosity of perlite.

Better results were achieved when media with good aeration and a reduced water retention capacity were used. For instance, root regeneration was strongly suppressed in pure peat, but the values for all rooting variables were significantly increased by mixing this with polystyrene and vermiculite in both years (Fig. 1a, b, c, d, e and f). The negative effects of peat are likely related to its high water retaining capacity. In fact, the relatively high moisture levels of peat in the autumn and winter months, caused by low solar radiation levels, has been suggested to negatively affect the rooting of cuttings (Loach, 1988). Pokorny and Austin (1982) reported that the volumetric percentages of air-filled and water-filled pore spaces were 9.6 and 85.6% in Canadian peat moss but 21.7 and 66.1% in a peat-perlite 1:1 mixture, in which cuttings of *Vaccinium ashei* cultivars showed significantly better rooting.

The effects of pure bark on the rooting of the cuttings were fairly constant in both years. Despite the relatively poor root production obtained, positive effects were seen in terms of root elongation and secondary rooting (Fig. 1c and f). Mixing bark with peat and perlite, however, gave rise to different results depending on the year. The longest roots and the most lateral roots were obtained in the bark-perlite 1:2 mixture in the first year. Bark (<7 mm particle size) has been recommended for cutting propagation of many species, particularly under mist conditions in which good aeration and drainage are necessary (Macdonald, 1986). In this work, the shredded bark was only passed through a 1 cm mesh sieve. Commercial Loblolly pine (*Pinus taeda* L.) bark (95% of particles <4.7 mm) and bark-perlite 1:1 have been reported to significantly improve the rooting of *Vaccinium* spp. cuttings compared to peat and peat-perlite blends (Pokorny and Austin, 1982). Bark-perlite mixtures were also reported to provide the greatest root quality in difficult-to-root *Camellia chinensis* cuttings among 20 different media combinations tested (Torres, 1986). If the particle size distribution were properly adjusted, pine bark might be a choice medium or at least a good media component for rooting olive cuttings.

In conclusion, the present results show that perlite-vermiculite 1:1 might be the best medium for ensuring a high rooting percentage and good root production in Ayvalik olive cuttings probably in relatively alternate ambient conditions. Further work is required to determine the best perlite/vermiculite proportions. The use of rockwool cubes was associated with very high rooting percentages and healthy roots. Regardless of economic and environmental considerations, pre-sized rockwool cubes might be a good solid medium alternative. Despite the relatively low root regeneration and significant yearly differences in most of the rooting variables when phenolformaldehyde foam was used, the most rooted and viable cuttings were obtained in this medium. Given its availability, ease of use and suitability for the direct insertion of cuttings, phenolic foam may also be a good option. This work also records the positive effects of pure perlite and its mixture with sand, especially in a 2:1 ratio. Polystyrene beads appeared to be the best component for mixing with peat, however, the optimum particle size range of these beads for use in peat-based mixtures needs to be determined. Despite the relatively poor root formation achieved with pure bark, the rooting variables did not show large differences in the different years. Pine bark may therefore be a good alternative for the rooting of olive cuttings if the physical properties of this substrate can be properly adjusted.

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