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EFFECT OF SEASON IN ROOTING STEM-TIP CUTTINGS OF MEDITERRANEAN SAGES (*Salvia* spp.) NATIVE TO GREECE

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ABSTRACT

Mediterranean sages (*Salvia* spp. family Lamiaceae) are readily propagated by stem cuttings. However, their rooting efficiency may be affected by season because of differences in mother plant physiology and climatic conditions. In the present study, stem-tip cuttings of *Salvia fruticosa, S. officinalis*, *S. pomifera* ssp. *pomifera, S. ringens* and *S. tomentosa,* 8-12 cm long, were collected from greenhouse grown mother plants at the end of November 2020, February, May and August 2021, indicative of four seasons. The aim was to define the most appropriate period for effective rooting of cuttings for each species that could enhance their potential use in floriculture industry through the regeneration of selected genotypes. Cuttings were treated with dusting powder for soft wood cuttings Rhizopon (0.5% w/w IBA) and were placed for rooting on peat-perlite substrate 1:1 (v/v) in a mist for 2 weeks. Then, they remained on the greenhouse bench in a semi-shaded bench for another 4 weeks. Cuttings of all species rooted more efficiently during the period from autumn to spring, excepting *S. fruticosa*, whose cuttings rooted at the lowest percentage in spring, probably because of insufficient lignification, while they presented high rooting percentage in summer similar to that of autumn and winter. Therefore, propagation of studied *Salvia* spp. by stem-tip cuttings was feasible throughout the year, although rooting percentages were reduced during spring (for *S. fruticosa*) and summer (for all species, excepting *S. fruticosa*). By choosing the appropriate season maximum rooting percentages of cuttings can be achieved.

Keywords: *Salvia fruticosa, Salvia officinalis, Salvia pomifera ssp. pomifera, Salvia ringens, Salvia tomentosa, clonal propagation.*

INTRODUCTION

Mediterranean sages (*Salvia* spp. family Lamiaceae) are ideal for xeriscaping, due to their reduced water and cultivation requirements, as well as their high ornamental value and bee friendliness. *Salvia fruticosa* is up to 1.20 m, with white felted stems, leaves often with 1-2 pairs of small lobes below the main one, flowers with high colour variability, pink, lilac, or sometimes white, in March-June. The

leaves are used for flavoring and for an herbal tea (Blamey and Grey-Wilson, 1988). *Salvia officinalis* is a strongly aromatic, rather grayish shrub up to 60 cm, with branches spreading to erect, becoming woody below, leaves oblong to elliptical, rough greenish above but white felted beneath, margin finely toothed, flowers violet, blue, pink or white in May – July (Tutin *et al.*, 1972; Blamey & Grey-Wilson, 1993). It is cultivated worldwide with many varieties as pharmaceutical and ornamental. *Salvia pomifera* ssp. *pomifera* is up to 1.00 m high, with strongly aromatic grey-green oval leaves and pink and violet flowers of intense color, with calyx often reddish-purple (Tutin *et al.*, 1972; Blamey & Grey-Wilson, 1988; Thanos and Doussi, 1995). *Salvia ringens* is up to 0.30 m high (up to 60 with the inflorescences), woody at base, with leaves pinnatisect or pinnate with 3-6 pairs of small lateral segments, appressed-hairy and flowers dark violet-blue or blue, (Tutin *et al.*, 1972). *Salvia tomentosa* is up to 0.80 m high, similar to *S. officinalis*, but has leaves with a rounded or heart-shaped base and flowers usually light violet or pink with reddish-brown calyces (Blamey & Grey-Wilson, 1993).

The asexual propagation by stem cuttings is a simple and easily applied method of plant propagation, which is preferred in case of medicinal and aromatic herbs rather than propagation by seeds (Nicola *et al.*, 2005). Mediterranean *Salvia* species are readily propagated by stem cuttings, as shown by several reports on rooting cuttings of *S. officinalis* (Nicola *et al.*, 2003; Nicola *et al.*, 2005; Kaçar *et al.*, 2009; Paradiković *et al*., 2013; Gudeva *et al*., 2017) and *S. fruticosa* (Sağlam *et al.*, 2014). Besides, rooting of spring cuttings of all *Salvia* species of the present work, collected from native plants, has already been studied testing various treatments for rooting induction and obtaining the mother plants for this study (Martini *et al.*, 2020). However, their rooting efficiency may be affected by season because of differences in mother plants physiology and climatic conditions. So, experimentation for each specific plant is necessary in order to determine the appropriate rooting hormone treatment, since it is well established that exogenous application of auxin accelerates the rates of rooting, increases final rooting percentage and the number of produced roots in leafy cuttings (De Klerk *et al.*, 1999).

The aim of this study was to define for each *Salvia* species the most appropriate period for effective rooting of cuttings collected from greenhouse grown mother plants, which could enhance their potential use in floriculture industry through the regeneration of selected genotypes.

MATERIALS AND METHODS

Stem-tip cuttings of *Salvia fruticosa, S. officinalis, S. pomifera* ssp. *pomifera, S. ringens* and *S. tomentosa*, 8-12 cm long, were collected from mother plants maintained in a greenhouse at the Agricultural University of Athens (37°58’53.94” N, 23°42’25.01” E), at the end of November 2020, February, May and August 2021, indicative of four seasons. After each collection of cuttings, mother plants were fertilized monthly with 2 g/L water soluble fertilizer (20-20-20

plus, HUMOFERT, Metamorfosi, Greece). In each pot, 100 ml of fertilizer was applied. Almost three months later, the following collection was done from the same mother plants. Cuttings were treated with dusting powder for soft wood cuttings Rhizopon (0.5% w/w IBA), which was one of the most effective treatments for all species in a previous study with spring cuttings (Martini *et al.*, 2020). Then, they were placed for rooting on peat-perlite substrate 1:1 (v/v) in a mist for 2 weeks, followed by transfer on the greenhouse bench in a semi-shaded location for another 4 weeks.

At the end of the experiment, rooting percentage (%) of cuttings was recorded. Cutting quality was also evaluated per species considering seasonally cutting final growth and foliage healthiness. The completely randomized design and three repetitions of ten cutting per treatment were used, the significance of the results was tested by one- or two-way analysis of variance (ANOVA) and treatment means were compared by Student's *t* test at $p \leq 0.05$.

RESULTS AND DISCUSSION

The two-way ANOVA revealed significant interaction of the two main factors of the experiment (*Salvia* species and season of cuttings collection), so rooting percentages were analysed by one-way ANOVA per *Salvia* species. Season of cutting collection had a significant effect on the rooting percentage of all species, excepting *S. pomifera* ssp. *pomifera* (Figure 1).

Cuttings of *S. fruticosa* rooted at higher percentage (>80%) during the summer to winter period compared to spring (Figure 1a), probably because spring cuttings, produced after the winter collection, were not sufficiently lignified and elongated, as shown in Figure 2a. In summer and autumn, not only high rooting percentages were recorded but also quality of rooted cuttings was more satisfactory (Figure 1a, Figure 2a).

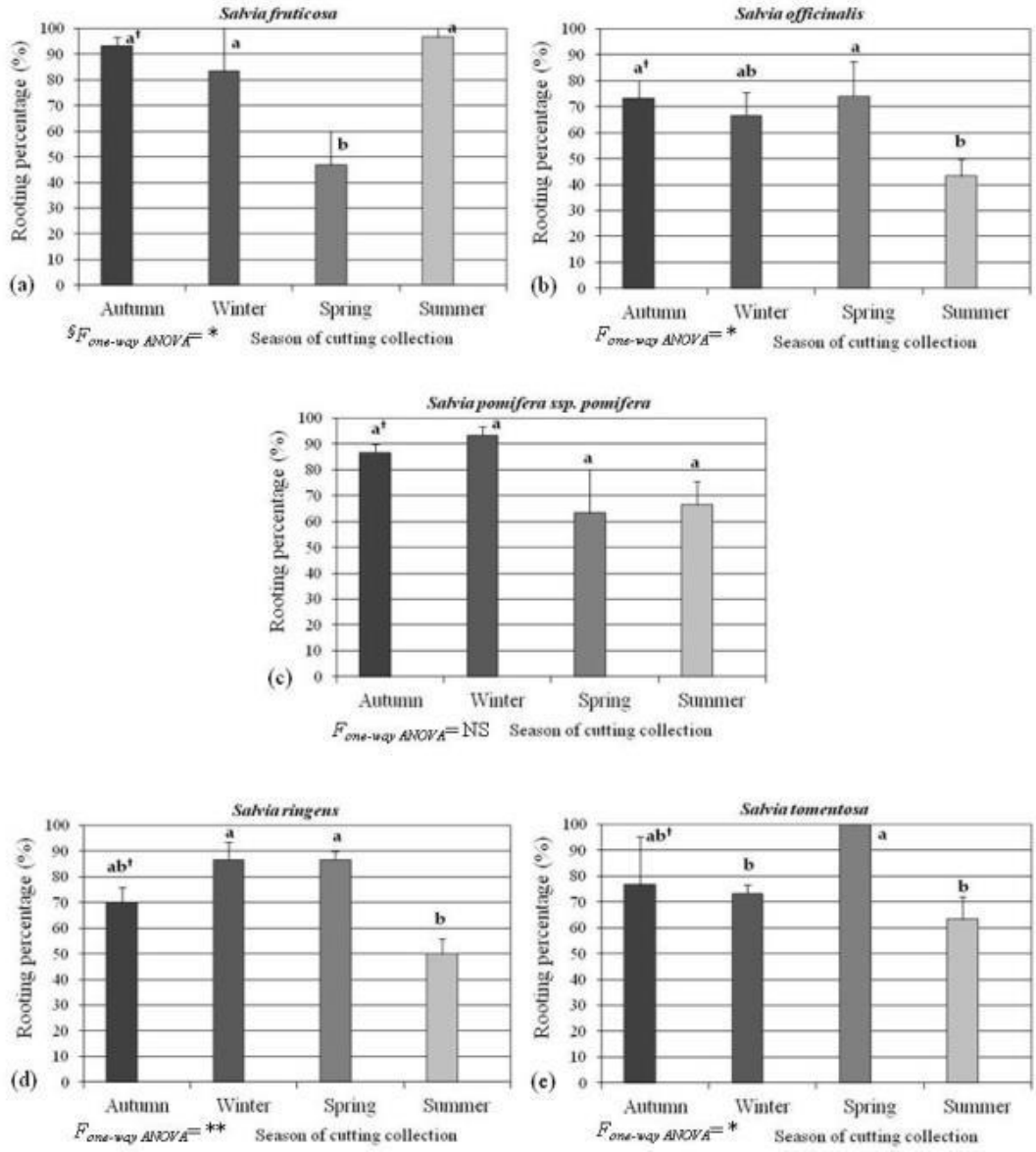

Figure 1. Effect of season in rooting percentage (%) of stem-tip cuttings of Mediterranean sages, i.e., *Salvia fruticosa* (a), *S. officinalis* (b), *S. pomifera* ssp. *pomifera* (c), *S. ringens* (d) and *S. tomentosa* (e), collected from greenhouse mother plants during November 2020 to August 2021 and treated with dusting powder Rhizopon (0.5% w/w IBA).

† Mean values per species (n = 3 replications of 9-10 cuttings each) followed by the same lowercase letter did not differ significantly at $p \leq 0.05$ using Student's t-test.

§ NS or * or **, non-significant at $p \leq 0.05$ or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

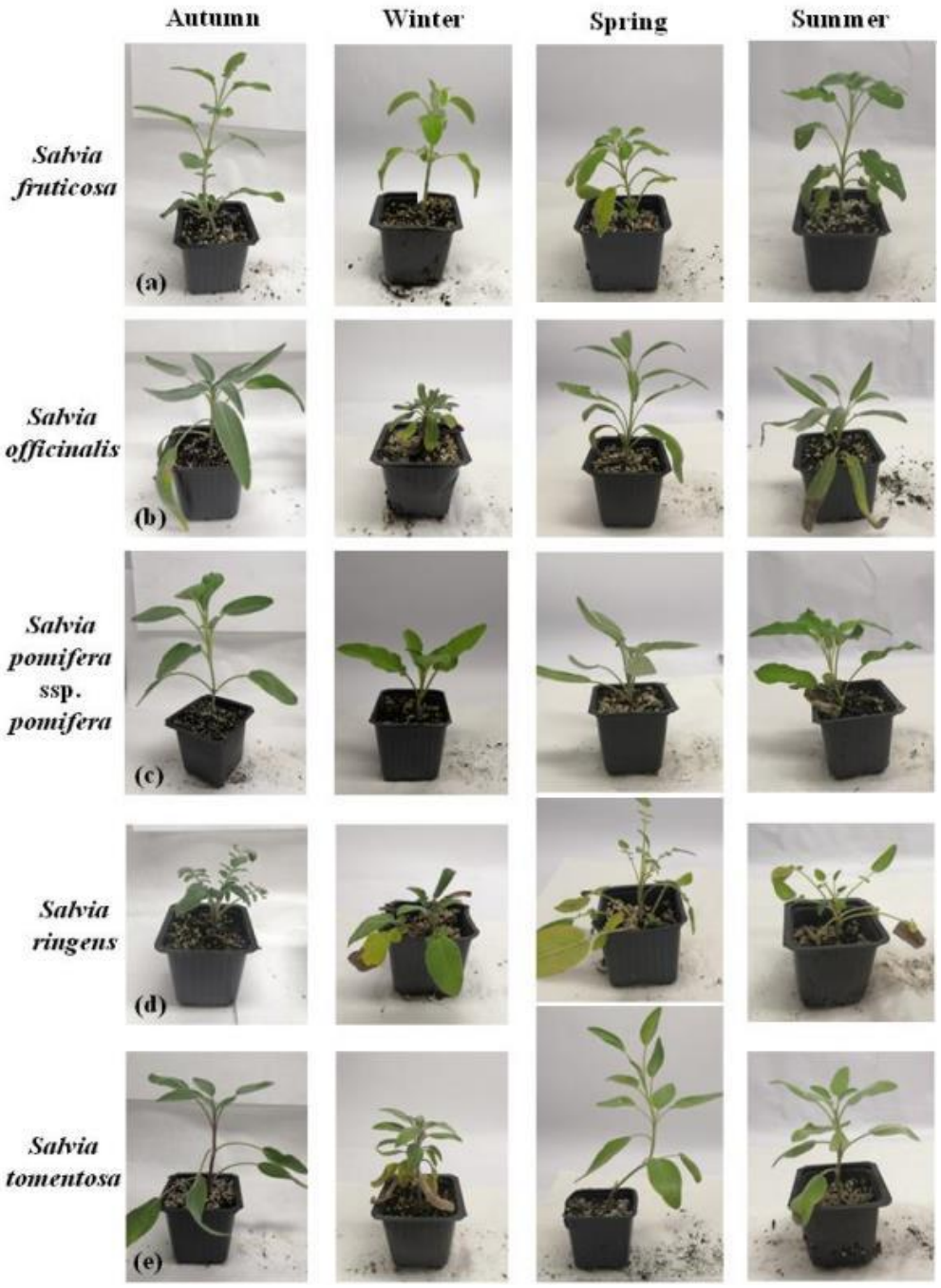

Figure 2. Rooted cuttings of the species *Salvia fruticosa* (a), *S. officinalis* (b), *S. pomifera* ssp. *pomifera* (c), *S. ringens* (d) and *S. tomentosa* (e), collected from greenhouse grown mother plants in marked season, six weeks after their treatment

with dusting powder Rhizopon (0.5% w/w IBA) and their placement for rooting on peat-perlite substrate 1:1 (v/v).

In *S. officinalis,* higher rooting percentages (about 70%) were recorded in autumn to spring period compared to summer (Figure 1b), in verification of previous reports, in which higher than 70% rooting percentages were achieved either using Rhizopon (Paradiković *et al.*, 2013) or after immersion in 1000 mg L^{-1} IBA for 5 sec (Kaçar *et al.*, 2009). Rooting percentages were increased compared to our preliminary study (Martini *et al.*, 2020), in which spring cuttings collected from native mother plants were used and those of *S. officinalis* rooted at the lowest percentages (35%) of all species, probably because of insufficient lignification and the presence of blooming. Quality of rooted cuttings was better in autumn and spring (Figure 2b).

There were no statistically significant differences between the seasons in rooting percentages of *S. pomifera* ssp. *pomifera* cuttings (63-93%), although higher percentages were observed in autumn to winter period (Figure 1c) and quality of rooted cuttings was better in autumn (Figure 2c). Spring cuttings were less lignified and elongated, as in the case of *S. fruticosa* (Figure 2a and c).

Cuttings of *S. ringens* rooted more sufficiently (87%) during winter to spring period compared to summer (Figure 1d), while quality of rooted cuttings, excepting autumn cuttings, seemed to be poorer than those of the other species (Figure 2). However, rooted cuttings of all studied species grew satisfactorily after transplantation in plastic pots with various substrates of peat-perlite (1:1, 2:1 or 3:1, v/v) and monthly fertilization with 2 g L^{-1} water soluble fertilizer 20-20-20 (Tassoula *et al.*, 2021).

Cuttings of *S. tomentosa* rooted at the highest percentage (100%) in spring, followed by autumn (Figure 1e). Quality of rooted cuttings was also optimum in spring, while it was satisfactory in autumn and summer too (Figure 2 e).

In previous studies on *S. officinalis* and *S. fruticosa*, hormones enhanced rooting of cuttings (Nicola *et al.*, 2003) and had a positive effect on root system and plant development (Nicola *et al.*, 2005; Paradiković *et al.*, 2013; Sağlam *et al.*, 2014). Besides, spring cuttings of all the *Salvia* species investigated in the present work rooted more efficiently after treatment with dusting powder Rhizopon or immersion in a 2000 or 3000 mg L^{-1} IBA solution compared to immersion in a solution of 500 or 1000 mg L^{-1} IBA or the control (Martini *et al.*, 2020).

CONCLUSIONS

Propagation of studied *Salvia* spp. by stem-tip cuttings was feasible throughout the year, although rooting percentages were reduced during spring (for *S. fruticosa*) and summer (for all species, excepting *S. fruticosa*). Quality of rooted cuttings in terms of cutting final growth and foliage healthiness was better in autumn for all species, while other seasons were also satisfactory, depending on the species. By choosing the appropriate season for cutting collection maximum rooting percentages and better quality of cuttings can be achieved.

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