Medicinal and Aromatic Plant Science and Biotechnology ©2011 Global Science Books

Comparison of Soil and Perlite (with Nutrient Solution Supply) Growing Media for Cultivation of Lemon Verbena (*Lippia citriodora* var. 'Verbena')

Sasan Aliniaeifard[1*] • AbdolHossin Rezaei-Nejad[2] • Maryam Seifi-Kalhor[3] • Ahmad Shahlaei[4] • Amin Aliniaeifard[5]

[1] Horticultural Supply Chains, P. O. Box 630, 6700 AP Wageningen University, Wageningen, The Netherlands
[2] Department of Horticultural Sciences, Faculty of Agriculture, Lorestan University, P. O. Box 465, Khorramabad, Iran
[3] Laboratory of Molecular Biology, P. O. Box 633, 6700 AP Wageningen University, Wageningen, The Netherlands
[4] Young Researchers Club of Islamic Azad University, Dezfoul Branch, Dezful Islamic Azad University, Dezful, Iran
[5] Rural Cooperation Organization of Lorestan Province, Taavon Street, Khorramabad, Iran

Corresponding author: * **Sasan.aliniaeifard@wur.nl**

ABSTRACT

Protected cultivation is recently shifting from traditional culture systems in soil to soilless culture systems based on growing media. The objectives of this change are to obtain higher qualitative and quantitative standards, to standardize cultural techniques and to reduce both production costs and environmental impacts. Utilizing substrate-based agriculture is a logical alternative to the current soil-based production approach. Therefore, an experiment was designed to evaluate the potential growth (vegetative and physiological characteristics) of lemon verbena (*Lippia citriodora* var. 'Verbena') in two production systems (soil and perlite media). The experiment was performed based on a completely randomized block design with four replications. Results obtained from present experiment showed that: plants were grown in perlite medium had better vegetative and physiological characteristics such as: shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, total fresh weight, total dry weight, leaf number, shoot length and fresh weight of shoot: root ratio in perlite growing medium when compared to plants were grown in soil medium. Whereas, dry weight of shoot: root ratio was not affected by media. Regarding results of the present experiment, it can be concluded that better growth of lemon verbena can be obtained by use of perlite growing medium with nutrient solution supply.

Keywords: cultivation medium, medical plants,, vegetative growth

INTRODUCTION

Lemon verbena (*Lippia citriodora* var. 'Verbena') is a perennial medicinal plant, native to South America (Parodi and Dimitri 1980). It shares an important place on the international herbal market due to the sensory and medicinal properties of accumulated essential oil of its leaves (Bonzani *et al*. 1997; Lawrence 1998). The sensory attributes determine its use as a primary ingredient for infusions and nonalcoholic beverages as well as an aromatic ingredient for the flavor and fragrance industries. The pharmaceutical industry uses lemon verbena for its carminative, antispasmodic, and sedative properties (Pascual *et al*. 2001). The increasing interest in this species has largely contributed to expanding lemon verbena crops in Argentina, Chile, Paraguay, Europe, Africa and Mediterranean regions (Carnat *et al*. 1999).

The interest in plant products has increased considerably all over the world because many herbal medicines are free from side effects (Groenewegen *et al*. 1992; Lipp 1996). The growth and biosynthesis of secondary metabolites in medicinal and aromatic plants are strongly influenced by environmental factors. Also essential oil yield has been shown to be affected by nutrients (Stutte 2006). Adjustment of nutrient solution concentration is useful to growers for modifying water and nutrient availability to the crop and hence the vegetative and reproductive vigour of the plant, which in turns influences the yield and growth of the plants (Cornish 1992; Kang and Van Iersel 2004). Furthermore, environment is likely to influence the production (Bouwmeester *et al*. 1995; Gil *et al*. 2002) as well as the quality (Mihaliak *et al*. 1989; Hay and Waterman 1993; Santos-Gomes *et al*. 2005) of essential oils. Production is also frequently increased by biotic and abiotic stresses (Coleman *et al*. 1991; Herms and Mattson 1992).

Since most medicinal plants are consumed raw, proper management of crop production is needed to achieve high quality plants. On the other hand, consumer demand for greater quality control and standardization of medicinal plants products has proven to be a difficult and expensive challenge. It is inevitable to find the alternative methods of cultivations for reducing potential contamination risks and improving the consistency of the raw material (Tabatabaie *et al*. 2007). For this reason, the advantages offered by soilless culture for growing medicinal plants suggest that these cultivation systems could be a powerful tool for the medicinal products industry (Dorais *et al*. 2001; Hayden 2006). Moreover, soilless culture is considered one of the main components of sustainable protected horticulture. In fact, consumption of water and fertilizers and the environmental pollution that are generally associated to over-irrigation can be reduced by use of soilless media (Pardossi *et al*. 2006; Massa *et al*. 2010). Soilless growing systems offer many advantages. They not only contribute to improve crop yield and quality but also conserve energy and water and reduce the application of crop protection products. In addition soilless system reduces the risk of crop damage from soil-borne pathogens through separation from infested soil (Paranjpe *et al*. 2008; Martinez *et al*. 2010). In many types of soilless systems, which use a variety of different substrates, perlite has proved to be an efficient growing medium in the European market. It is a substrate made from volcanic rock and

Received: 3 September, 2010. Accepted: 24 November, 2010.

Original Research Paper

Table 1 Chemical properties of nutrient solution.

Nutrient solution	Attribute
Nitrogen (mM)	15
Phosphorus (mM)	1
Potassium (mM)	6
Calcium (mM)	4
Magnesium (mM)	2
Sulfur (mM)	2
Iron (Fe-EDTA) (µM)	50
Manganese (µM)	9
Zinc (µM)	0.8
Copper (µM)	0.3
Boron (µM)	45
Molybdenum (µM)	0.11
pH	6.5-6.8
EC (ds m^{-1})	2.6-2.8

often used as a soil additive to increase aeration and draining of the soil. It is also relatively inexpensive. Perlite is a well-established substrate, which has many advantages: it is a natural material, inorganic and therefore physically stable, it does not decompose and is chemically inert with neutral pH, it is sterile and free from pests, pathogens and weed seeds, and is also clean, odourless, lightweight and easy to handle. Its advantages have been proven in several experiments (Marsic and Jakse 2010). Among the many factors responsible for higher yield in soilless culture, adequate nutrient supply is considered one of the most effective tools (Munsi 1992). On the other hand, optimum nutrient concentrations for aromatic plants should be determined.

Lemon verbena has been produced extensively for the medicinal and food products industry; however, there is little information available about effect of medium and nutrient solution with respect to biomass and oil production (Tabatabaie and Nazari 2007). Nowadays, the target in lemon verbena modern crop production has focused on the improvement of leaves biomass and essential oil yields, to meet the pattern that industry demands. It is therefore important to characterize and assess the media with high production and quality for lemon verbena. The aim of conducting this research was to assess the effects of perlite growing medium with nutrient solution supply and soil culture medium on some physiological and growth characteristics of lemon verbena under greenhouse condition.

MATERIALS AND METHODS

Plant material and growth conditions

The lemon verbena shoot tip cuttings supplied by Shahid Beheshti University were transplanted to the greenhouse of the Lorestan University. The cuttings (7.5-10 cm long) were propagated under mist conditions. The original propagation medium was perlite and sand (1:1). After transferring plant materials to the greenhouse, lemon verbena cuttings removed from the original medium then transplanted to the pots (5 L) containing two media: one of them with sandy loam farm soil for soil culture and another with perlite and sand (75: 25, v/v) for soilless culture. Sand was used as stabilizer of cutting in the pots. For better drainage, the bottoms of pots were notched and placed in saucers. Modified Hoagland's solution (Hoagland and Arnon 1950) were used for irrigation of plants. Chemical properties of nutrient solution are given in **Table 1**. The pots were kept in the greenhouse at 70-80% relative humidity and 30 ± 3 and 20 ± 3°C in the day and at night, respectively. EC (Electrical conductivity) and pH regularly controlled by EC-meter and pH-meter. The pH kept in the range of 6.5 to 6.8 and EC kept between 2.6-2.8 ds m^{-1}. In soil culture, plants irrigated with nutrient solution for five days thereafter water were used for daily irrigation of plants. On the other hand, nutrient solution was used for daily irrigation of soilless-cultured plants.

Data collection

The glasshouse experiment lasted for two months. At the end of the second month, plants removed from the substrate, after removing leaves from plants, leaves were counted then root removed from the plants and shoot length (SL) was measured. After weighing plant parts, they were dried at 80°C in an air forced oven for 48 h and dry weight of plant parts was recorded.

Statistical analysis

The experiment was conducted based on a completely randomized block design and each treatment was replicates four times. Data was analyzed by analysis of variance (ANOVA) using SPSS ver. 12 software. Differences between treatments were tested by Student's t-test ($P \leq 0.05$) and differences between means were compared using the least significant difference (LSD) test.

RESULTS

Vegetative growth and physiological characteristics of lemon verbena were considerably improved by using of perlite for cultivation of this plant. Total fresh (TFW) and dry weight (TDW) of lemon verbena significantly affected by media. As depicted in **Fig. 1** plants which cultured in perlite respectively had 27 and 35% more TFW and TDW when compared to its values in soil-cultured plants. There was 23% increase in shoot FW of perlite-cultured plants in comparison with the plants were grown in soil media (**Fig. 2**). Also plants cultured in the perlite had 39% more shoot DW than its value in soil-cultured plants (**Fig. 2**).

Root FW and DW were significantly affected by perlite medium. As shown in **Fig. 3,** use of perlite for cultivation of lemon verbena caused 19 and 42% increase in the FW and DW of root when compared to its values in soil-cultured plants.

SL was affected by use of perlite for cultivation of lemon verbena. The plants which cultured in the perlite were 21% longer than soil-cultured plants (**Fig. 4**). Moreover, leaf number was influenced by utilization of perlite as

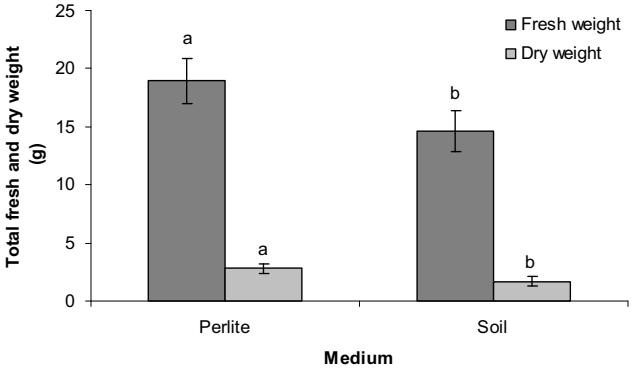

Fig. 1 Effects of media culture on total fresh and dry weight of lemon verbena.

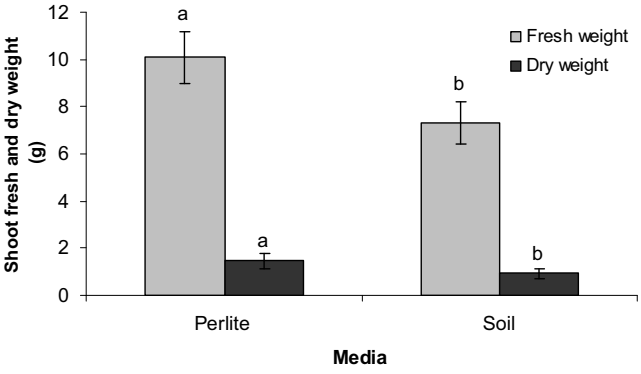

Fig. 2 Effects of media culture on shoot fresh and dry weight of lemon verbena.

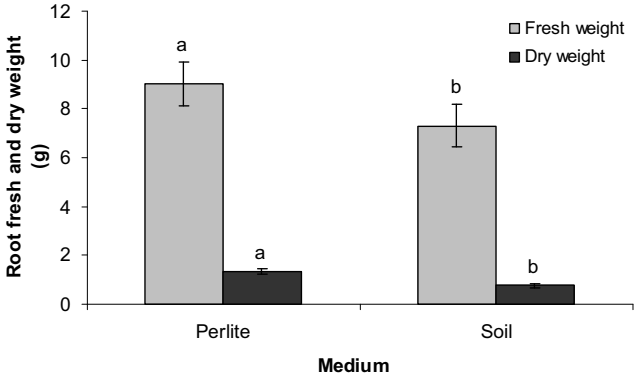

Fig. 3 Effects of media culture on root fresh and dry weight of lemon verbena.

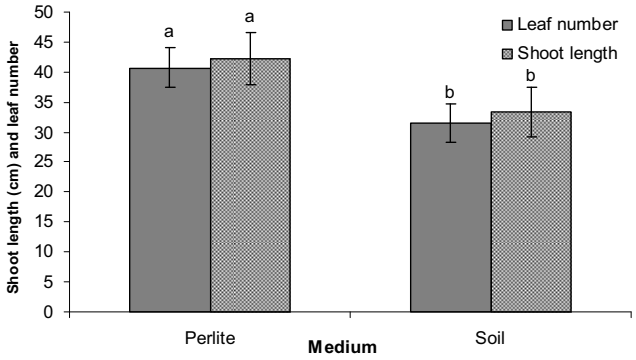

Fig. 4 Effects of media culture on shoot length and leaf number of lemon verbena.

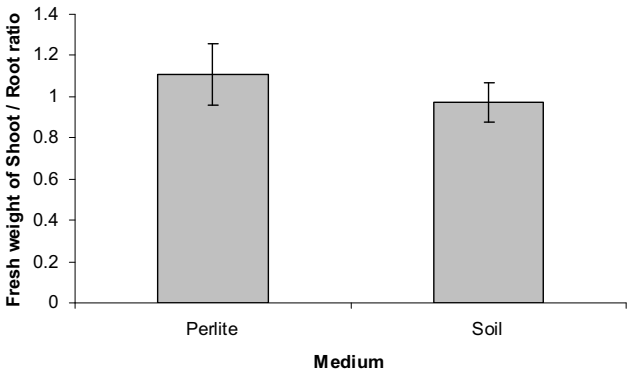

Fig. 5 Effects of media culture on fresh weight of shoot/root ratio of lemon verbena.

cultivation medium. The number of leaves in soil-cultured plants was three-quarters of its number in plants which grown in the perlite (**Fig. 4**).

Finally, FW of the shoot/root ratio influenced by using perlite as cultivation medium. As depicted in **Fig. 5** plants grown in the perlite had 12% more FW of the shoot/ root ratio than its values in soil-cultured plants.

DISCUSSION

In this study, significant increase in vegetative growth and considerable improvement of physiological characteristics were observed by use of perlite with nutrient solution supply as cultivation medium. Various forms of soilless culture systems with or without an inert substrate such as perlite have been described by Schwarz (1995). In all systems it is vital to maintain the highest possible aeration, nutrient solution availability and adjusting the concentration of nutrient at all times. Our results showed that perlite culture medium might be an appropriate system for the growing of lemon verbena, which is in agreement with the finding of Tabatabaie *et al*. (2007) and Dorais *et al*. (2001) who studied *Achillea millefolium*, *Artemisia vulgaris*, *Inula helenium*, *Stellaria media*, *Taraxacum officinalis* and *Valeriana officinalis* in different soilless culture media. Higher planting densities, adjustment of nutrient concentration and multiple harvests may increase yield in soilless cultivation in the greenhouse over those of field production in soil medium. Cultivation of medicinal plants under a controlled environment is an excellent opportunity to study the influence of main environmental factors on yield of these plants. Such studies can provide information about raising species yield as well as improvement of content and composition of bioactive substances (Fonseca *et al*. 2006). The lower FW and DW of lemon verbena and valerian grown in the soil system relative to plants grown in the soilless production system have been also reported by Tabatabaie *et al*. (2007) and Tabatabaei (2008). Liquid fertilization is able to provide nutrition at appropriate levels for both root and shoot growth (Aliniaeifard and Tabatabaei 2010), but the root: shoot ratio may decrease with high fertilizer concentrations (Catanzaro *et al*. 1998). In lily production, greenhouse soilless system have many advantages over soil production, including providing the ideal physical structure for moisture retention and aeration, avoidance of soil-borne pests and diseases, and superior control over plant nutrition. However, selection of the right media type and composition is vital to success in lily (Aliniaeifard and Tabatabaei 2010). Improved physical properties of the growing media are known to play an important role in plant growth (Fonteno 1996). In soil production system, the availability of the nutrients and media physical properties are controllable; hence, both FW and DW production increases are expected in perlite growing media. In the present study, plants grown in the soil were shorter than plants grown in the perlite medium, which is in accordance with the finding of Boyle *et al*. (1991) and Marsic and Jakse (2010). Also in the rosemary, plants grown in the soil-based medium were significantly shorter than plants grown in the soilless mix. In addition, shoot FW and DW tended to be lower among plants grown in the soil-based growing medium relative to plants grown in the soilless mix (Boyle *et al*. 1991). There are several studies on possibilities of using perlite as a substrate and it has been reported that the average yield of fruit-bearing crops (bell pepper and melon) cultivated in perlite achieved 2-3 times higher yield than plants grown in the soil (Gul *et al*. 2007). It has been also reported that growers in the Mediterranean region prefer perlite to other substrates because it is easily available from local suppliers, it is cheap and can be used for at least three, instead of two years, which is the common maximum durability of most other substrates (Marsic and Jakse 2010). A loose, fine aggregate medium, such as perlite or sand, in a system with an open top, provide proper drainage so that the roots of plants have direct contact with fertilizer solution (Hayden 2006). Marsic and Jakse (2010) reported that cucumber growth significantly improved in perlite and there was 30% increase in average marketable yield of cucumber grown in the perlite medium. They assumed that better performance of perlite can be related to higher water holding capacity, which is of particular importance for high nutrient and water demand plants (Marsic and Jakse 2010).

CONCLUSIONS

The present study showed the substantial differences in the vegetative and physiological response of lemon verbena to soil and perlite growing media. The results obtained from this study led to the conclusion that for high economic yields, particularly of biomass, which is a basic raw material for medicinal use, perlite growing medium (with nutrient solution supply) is more beneficial for cultivation of lemon verbena in greenhouse condition than soil growing medium.

ACKNOWLEDGEMENTS

The authors are very grateful to Lorestan beranch of Jahad-e-Daneshgahi for financial support and student of plant production technology of Lorestan University for their kind helps.

REFERENCES

Aliniaeifard S, Tabatabaei SJ (2010) Use of chlorophyll meter for nitrogen management and recommendation of optimum nitrogen concentration in soilless culture of lily. *Floriculture and Ornamental Biotechnology* **4 (Special Issue 1)**, 63-67

Bonzani NE, Filippa EM, Barboza GE (1997) Particularidades epidermicas de algunas especies de Verbenaceae. *Anales del Instituto Ciencias del Mary Limnologia, Universidad, Nacional Autonoma de Mexico, Serie Botanica* **68**, 47-56

Bouwmeester HJ, Davies JAR, Smid HG, Welten RSA (1995) Physiological limitations to carvone yield in caraway (*Carum carvi*). *Industrial Crops and Products* **4**, 39-51

Boyle TH, Craker LE, Simon JE (1991) Growing medium and fertilization regime influence growth and essential oil content of rosemary. *HortScience* **26**, 33-34

Carnat A, Carnat AP, Fraisse D, Lamaison JL (1999) The aromatic and polyphenolic composition of lemon verbena tea. *Fitoterapia* **70**, 44-49

Catanzaro CJ, Williams KA, Sauve RJ (1998) Slow release versus water soluble fertilization affects nutrient leaching and growth of potted chrysanthemum. *Journal of Plant Nutrition* **21**, 1025-1036

Coleman JS, Jones CG, Douglas WT, Raupp MJ (1991) A phytocentric perspective of phytochemical induction by herbivores. In: Douglas WT, Raupp MJ (Eds) *Phytochemical Induction by Herbivores*, Wiley, New York, pp 3-45

Cornish PS (1992) Use of high electrical conductivity of nutrient solution to improve the quality of salad tomatoes grown in hydroponic culture. *Australian Journal of Experimental Agriculture* **32**, 513-520

Dorais M, Papadopulos AP, luo X, Leonhart S, Gosselin A, Pedneault K, Angers P, Gaudrean L (2001) Soilless greenhouse production of medicinal plants in northeastern Canada. *Acta Horticulturae* **554**, 186-189

Fonseca JM, Rushing JW, Rajapakse NC, Thomas RL, Riley MB (2006) Potential implications of medicinal plant production in controlled environments: The case of feverfew (*Tanacetum parthenium*). *HortScience* **41**, 531-535

Fonteno WC (1996) *Growing Media: Types and Physical/Chemical Properties. Water, Media and Nutrition for Greenhouse Crops*, Ball Publishing Inc., Batavia, pp 93-122

Gil A, de la Fuente EB, Lenardis AE, López Pereira M, Suárez SA, Bandoni A, van Baren C, di Leo Lira P, Ghersa CM (2002) Coriander essential oil composition from two genotypes grown in different environmental conditions. *Journal of Agriculture and Food Chemistry* **50**, 2870-2877

Groenewegen WA, Knight DW, Heptinstall S (1992) Progress in the medicinal chemistry of the herb feverfew. *Progress in Medicinal Chemistry* **29**, 217-238

Gul A, Kidoglu F, Anac D (2007) Effect of nutrient sources on cucumber production in different substrates. *Scientia Horticulturae* **113**, 216-220

Hay RKM, Waterman PG (1993) *Physiology in Volatile Oil Crops: Their Biology, Biochemistry and Production*, Longman Scientific and Technical Essex, pp 23-46

Hayden AL (2006) Aeroponic and hydroponic systems for medicinal herb, rhizome, and root crops. *HortScience* **41**, 536-538

Herms DA, Mattson WJ (1992) The dilemma of plants: To grow or defend. *Quarterly Review of Biology* **67**, 284-335

Hoagland DR, Arnon DS (1950) The water culture method for growing plants without soil. *California Agricultural Experiment Station Circular* **374**, 1-2

Kang JG, Van Iersel MW (2004) Nutrient solution concentration affects shoot: Root ratio, leaf area ratio, and growth of subirrigated salvia (*Salvia spleendens*). *HortScience* **39**, 49-54

Lawrence BM (1998) Lemon verbena oil. *Perfume and Flavorist* **23**, 59-60

Lipp FJ (1996) The efficacy, history, and politics of medicinal plants. *Alternative Therapies in Health and Medicine* **2**, 36-41

Marsic NK, Jakse M (2010) Growth and yield of grafted cucumber (*Cucumis sativus* L.) on different soilless substrates. *Journal of Food, Agriculture and Environment* **8**, 654-658

Martínez F, Castillo S, Carmona E, Avilés M (2010) Dissemination of *Phytophthora cactorum*, cause of crown rot in strawberry, in open and closed soilless growing systems and the potential for control using slow sand filtration. *Scientia Horticulturae* **125**, 756-760

Massa D, Incrocci L, Maggini R, Carmassi G, Campiotti CA, Pardossi A (2010) Strategies to decrease water drainage and nitrate emission from soilless cultures of greenhouse tomato. *Agricultural Water Management* **97**, 971-980

Mihaliak CA, Couvet D, Lincoln DE (1989) Genetic and environmental contributions to variation in leaf mono- and sesquiterpenes of *Heterotheca subaxillaris*. *Biochemical Systematics and Ecology* **17**, 529-533

Munsi PS (1992) Nitrogen and phosphorus nutrition response in Japanese mint cultivation. *Acta Horticulturae* **306**, 436-443

Paranjpe AV, Cantliffe DJ, Stoffella PJ, Lamb EM, Powell CA (2008) Relationship of plant density to fruit yield of 'Sweet Charlie' strawberry grown in a pine bark soilless medium in a high-roof passively ventilated greenhouse. *Scientia Horticulturae* **115**, 117-123

Pardossi A, Malorgio F, Incrocci L, Carmassi G, Maggini R, Massa D, Tognoni F (2006) Simplified models for the water relations of soilless cultures: What they do or suggest for sustainable water use in intensive horticulture. *Acta Horticulturae* **718**, 425-434

Parodi LR, Dimitri MJ (1980) *Enciclopedia Argentinade Agricultura y Jardineria*, Editorial Acme, Buenos Aires, pp 922

Pascual ME, Slowing K, Carretero E, Sánchez Mata D, Villar A (2001) *Lippia*: Traditional uses, chemistry and pharmacology: A review. *Journal of Ethnopharmacology* **76**, 201-214

Santos-Gomes PC, Fernández-Ferreira M, Vicente AMS (2005) Composition of the essential oil from flowers and leaves of vervain (*Aloysia triphylla*) Britton grown in Portugal. *Journal of Essential Oil Research* **17**, 73-78

Schwarz M (1995) *Soilless Culture Management*, Springer, Berlin, pp 1-20

Stutte GW (2006) Process and product: Recirculating hydroponics and bioactive compounds in a controlled environment. *HortScience* **41**, 526-530

Tabatabaei SJ (2008) Effects of cultivation systems on the growth, and essential oil content and composition of valerian. *Journal of Herbs, Spices and Medicinal Plants* **14**, 54-67

Tabatabaie SJ, Azarmi F, Dadpour MR, Nazemiyeh H, Nazari J (2007) Evaluation of valerian and lemon verbena production using different soilless and soil cultivations under glasshouse. *Acta Horticulturae* **747**, 465-470

Tabatabaie SJ, Nazari J (2007) Influence of nutrient concentrations and NaCl salinity on the growth, photosynthesis, and essential oil content of peppermint and lemon verbena. *Turkish Journal of Agriculture and Forestry* **31**, 245-253