**Short Communication**

Soilless cultivation of some medicinal and aromatic herb plants under the conditions of Arabian Gulf region

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Abstract: Production of medicinal/aromatic (MA) herb plants to meet the ever increasing demand for these plants is a major challenge facing countries in arid and semi-arid regions which are characterized by limited water and land resources. Recently, soilless cultivation of medicinal plants has gained a great attention in both protected environment and outdoor conditions, due to many advantages like potential for higher yields and quality, cleaner products, year round production, with minimized use of water in comparison to conventional soil-based cultivation. The objectives of this study were to introduce five highly valued MA crops (sage, German chamomile, Jordanian chamomile, thyme and mint) into Arabian Gulf region. As the region is characterized by harsh environment, fragile ecosystems and limited water resources and arable lands, and these crops are native to Mediterranean climates and are not being grown in Gulf region, therefore, these crops were cultivated using re-circulating soilless system, and their growth was evaluated and yield was compared to soil-based yields. Results of this research showed that all studied crops were well adapted to the soilless system and outyielded the soil cultivated by 199, 264, 313, 220, 247, and 243% of herbal biomass for sage, German and Jordanian chamomiles, thyme and mint, respectively with much less water use (up to 70% save). Flower yields of soilless grown German and Jordanian chamomile outyielded the soil cultivated by 199 and 334% respectively. Results suggest that introduction of these crops into Gulf region was successful especially with using soilless technology with high water saving as well as a variety of other important herbaceous medicinal plants.

Key words: Chamomile, Sage, Thyme, Mint, Bahrain, Hydroponics.

استزراع بعض النباتات الطبية والعطرية بدون تربة تحت ظروف منطقة الخليج العربي

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المقصود: إن إنتاج واستخدام النباتات الطبية والعطرية في الدول ذات المناخ الصحراوي وشبه الصحراوي مثل دول منطقة الخليج العربي، تواجه تحديات كبيرة من أجل تلبية الطلب المتزايد على هذه النباتات وذلك بسبب تحولات المصادر المائية والأراضي الزراعية. لذا فاستزراع النباتات الطبيعية دون تربة في السنوات الأخيرة اعتمدت كثربياً في كثير من الدول سواء تحت الطفو المتغير أو خارجها وذلك للنزاعات التي تقدم بها هذه الفتوحات مثل الري الكمي وطول العام، وتوجه الزراعي والتنوع النباتي والöße النباتات إلا أن ذلك تحتاج إلى المواد والمزادات المشروعة في النباتية. تهدف هذه الدراسة إلى ابدال وتحقيق زراعة عدد من النباتات الطبية والعطرية (الباليونجي، الزعتر، والتوت) غير المترورة في المنطقة تحت ظروف الزراعة بدون تربة باستخدام نظام ثلاثي وممارسة ذلك مع إنتاج نباتات الصنفية الزراعية التي تحقق الزراعة بدون نزاعات مماثلة مع نظم الزراعة بنسكر تربة وتقوف في إنتاج النباتات الطبية على ذلك المزروع تحت نظام الزراعة التقليدية في النباتية بحوالي 264، 220، 247 و 234٪، 313 و 243٪. هذه النتائج تظهر استعداد الزراعة بدون تربة بالكامل للزراعة باستعداد للزراعة الطبيعية. وفقاً لذلك الفيزيولوجيا الزراعية والبيولوجيا الزراعية، يمكن استخدام هذه النباتات الزراعة دون تربة في إنتاج النباتات الطبية في منطقة الخليج العربي بشكل كبير، وأنها تمكن استخدام هذه الفتوحات في زراعة النباتات الطبية الأخرى الهامة في منطقة الخليج العربي.

الكفاءات المقاولة: الزعتر، الباليونج، التومات، الزراعة المائية، مركز السلطان قابوس للزراعة، البحرين.
Introduction

Plants have been the source of food, fragrances, dyes, and medicine from time immemorial. The majority of the medicinal/ aromatic (MA) herb plants have many medicinal, nutritional, and industrial uses. The industrial uses of MA plants are many, which include the traditional medicines, herbal teas, and health foods such as phytopharmaceuticals and industrially produced pharmaceuticals.

During the last decade, the demand for MA plants has increased in the Gulf region for medicinal purposes, savoring foods, pungent, or otherwise desirable substances. As the region is characterized by harsh environment, fragile ecosystems and limited water resources and arable lands, many MA plants which are not indigenous to the region (e.g., sage, chamomile, and thyme) cannot be cultivated under the natural environmental conditions of the region. Therefore, these plants are imported from outside and mostly in the dry form. However, drug quality and consequently earnings are significantly influenced by the drying regime (Muller and Heindl, 2006). Many of the MA plant species were reported to have added values when they are used fresh (Yineger and Yewhalaw, 2007). In this study, five highly valued MA plant species were evaluated: German chamomile (Matricaria chamomilla), Jordanian chamomile (Matricaria aurea), thyme (Thymus vulgaris), sage (Salvia officialis), and mint (Mentha Piperita). Chamomile’s primary uses are as a sedative, anxiolytic, and antispasmodic, and as a treatment for mild skin irritation and inflammation (Salamon, 1992). Sage is well known as a common medicinal and aromatic plant widely used in food, perfumery, and herbal products. Essential oil of sage is applied in the treatment of a large range of diseases such as those of the nervous system, heart and blood circulation, and respiratory system (Cuvelier et al., 1994). Thyme has many uses as gastrointestinal ailments, bronchial problems, laryngitis, diarrhea, and lack of appetite. It has also antiseptic properties, and can be used as a mouthwash, skin cleanser, anti-fungal agent for athlete's foot and as an anti-parasitic for lice, scabies, and crabs (Zarchi and Babaei, 2006). Traditionally, peppermint essential oil has been used to treat indigestion, headaches, colic, gingivitis, irritable bowel syndrome, spasms and rheumatism. This volatile and potent essential oil has very diverse uses because of its many properties (McKay and Blumberg, 2006). It relaxes muscles; has antiviral and bactericidal qualities; increases stomach acidity (to aid digestion); is an analgesic and counterirritant; and is a carminative (eases intestinal cramping).

Cultivation of MA plants and their sustainability in countries located in arid and semi-arid regions (e.g. Gulf region) is facing a major challenge of limited water and land resources. Water resources are scarce, mainly non-renewable, overexploited fossilized ground water, low in quantity and quality as saline water intrusions takes place in many parts of the region as well as water tables drop due to excessive extraction. Soils are poorly structured, sandy, low water holding capacity, and low mineral and organic matter content. Therefore, looking for methods of cultivation that enhance the production and improve the quality of the raw material of these plants and considering the efficient use water resources became a major issue. Recently, soilless cultivation of medicinal plants has gained a great attention in both protected environment and outdoor conditions. This technology offer many advantages, namely minimized use of water and nutrients due to recycling capability, crop uniformity and high productivity, clean produce and free from soil contaminants, improved phytochemical consistency and
accelerated cultivation cycles due to increased rate of growth and maturation (Dorais et al., 2001; Santish, 2003; Tran et al., 2005; Hyden, 2006; Al-Karaki, 2008). Soilless cultivation is a method that permits a good control of plant growth and development, and is currently in practice all over the world. The development of closed growing systems offers excellent prospects in terms of maximizing water use (Al-Karaki et al., 2008).

The objectives of this study were to introduce five highly valued MA crops (sage, German chamomile, Jordanian chamomile, thyme and mint) into Arabian Gulf region. As the region is characterized by harsh environment, fragile ecosystems and limited water resources and arable lands, and these crops are native to Mediterranean climates and are not being grown in Gulf region, therefore, these crops were cultivated using re-circulating soilless system, and their growth was evaluated and yield was compared to soil-based yields of previous literature.

Materials and Methods

A group of experiments were conducted at the experimental farm of Sultan Qaboos Center for Advanced and Soilless Agriculture, Arabian Gulf University (Bahrain) during the season 2007/2008. Five medicinal/aromatic (MA) herb species were included in these experiments which are: sage (*Salvia officialis*), German (*Matricaria chamomilla*) and Jordanian (*Matricaria aurea*) chamomiles, thyme (*Thymus vulgaris*) and mint (*Mentha Piperita*). These experiments were conducted under PE covered greenhouse with evaporative cooling system under re-circulated soilless systems using concrete troughs.

Sage seedlings (4-leaf stage produced from seeds in polystyrene trays), thyme and mint transplants (~12cm height) were planted and seeds of German and Jordanian chamomiles were planted at appropriate rates into concrete troughs (14m L× 0.6m W × 0.25m D) filled with tuff zeolite (Ø 3-8mm) brought from Jordan as growth medium. The planting densities were 4,12 and 20 seedlings per m² for sage, thyme and mint, respectively, and 0.1 g seeds m² for both German and Jordanian chamomiles. All plant materials were brought from Jordan. The nutrient solution (irrigation water and nutrients) was delivered from solution tanks to the plants via drip irrigation system twice a day. The nutrient levels in solution (in mg/L) were N:210, P:230, Ca:160, Mg:48, S:64, Fe:1.5, Mn:0.5, B:0.4, Zn:0.05, Cu:0.05, Mo:0.2. The nutrient solution was renewed every 2 weeks. The base of troughs were lined with plastic sheets and elevated at 1.5% to collect and channel nutrient solution to solution tanks for reuse. The experiments were laid out in RCBD replicated three times. German and Jordanian chamomiles were harvested approximately three months after planting when plants were fully bloomed with a second harvest for German chamomile to remove the remainder of the crop. Herbage biomass of sage and thyme crops was harvested twice and thrice for mint during the season which extended for about 5 months for these crops. Measurements of growth characteristics for these plant species were: plant height, branches number, fresh and dry herbage yields. Flower fresh and dry yields were determined for German and Jordanian chamomiles.

Results and Discussion

The plants of different species tested in this study were well adapted to soilless cultivation conditions and showed vigorous growth and development (Figures 1 and 2). Biometric and yield data for tested plants are presented in Table 1. The average plant height of three-month-old soilless Jordanian and German chamomile reached 25 and 91
cm, respectively. The average total of the fresh herbal biomass (leaves, stem, and flower) of Jordanian and German chamomile was 906 and 3015 g/m², with flower mass of 66 and 534 g/m² which accounted to 7 and 18% of total biomass, respectively (Table 1). Aerial herbal mass (leaves and stem) of sage, thyme, and mint were 2280, 1283 and 3208 g/m², respectively. However, total air-dry mass of sage and thyme reached 1377, 451g/m² respectively (Table 1). These results are comparable to those obtained by Stapleton and Hochmuth (2001) using vertical hydroponic system for thyme and sage. Plant height of sage, thyme and mint reached about 76, 35 and 36 cm after about 150 days of planting. Branches number was highest in sage (41/plant) and lowest in Jordanian chamomile (6.2/plant).

Table 1. Biometric and yield data of some medicinal plants grown under soilless conditions.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Fresh herbal yield</th>
<th>Dry herbal yield</th>
<th>Plant height</th>
<th>Branches number</th>
<th>Fresh flower yield</th>
<th>Dry flower yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/m²</td>
<td>g/m²</td>
<td>cm</td>
<td>/ plant</td>
<td>g/m²</td>
<td>g/m²</td>
</tr>
<tr>
<td>Sage</td>
<td>2280±279</td>
<td>1377±179</td>
<td>76±4</td>
<td>41±5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>German chamomile</td>
<td>3015±151</td>
<td>854±73</td>
<td>91±4</td>
<td>30±2</td>
<td>534±20</td>
<td>117±7</td>
</tr>
<tr>
<td>Jordanian chamomile</td>
<td>906±78</td>
<td>370±40</td>
<td>25±5</td>
<td>6.2±1</td>
<td>66±5</td>
<td>37±3</td>
</tr>
<tr>
<td>Thyme</td>
<td>1283±94</td>
<td>451±31</td>
<td>35±4</td>
<td>21±3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mint</td>
<td>3208±595</td>
<td>-</td>
<td>36±5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

§ Data not taken.

Figure 1. Soilless plants of (a) Sage (*Salvia officialis*) just before harvest, (b) German chamomile (*Matricaria chamomilla*) at full bloom, (c) Jordanian chamomile (*Matricaria aurea*) at full bloom and (d) mint (*Mentha Piperita*) just before harvest.
Table 2. Herbal fresh yield comparisons (Soilless vs. published field data).

<table>
<thead>
<tr>
<th></th>
<th>Sage</th>
<th>German chamomile</th>
<th>Jordanian chamomile</th>
<th>Thyme</th>
<th>Mint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported average</td>
<td>863 g m⁻²</td>
<td>962 g m⁻²</td>
<td>411 g m⁻²</td>
<td>518 g m⁻²</td>
<td>1320 g m⁻²</td>
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<tr>
<td>Herbal yield – field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>plants</td>
<td>2289 g m⁻²</td>
<td>3015 g m⁻²</td>
<td>906 g m⁻²</td>
<td>1283 g m⁻²</td>
<td>3208 g m⁻²</td>
</tr>
<tr>
<td>Soilless vs. field</td>
<td>264 %</td>
<td>313%</td>
<td>220%</td>
<td>247%</td>
<td>243%</td>
</tr>
<tr>
<td>grown yields</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Reported average</td>
<td>-</td>
<td>270 g m⁻²</td>
<td>54 g m⁻²</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>flower yield – field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plants</td>
<td>-</td>
<td>536 g m⁻²</td>
<td>181 g m⁻²</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soilless vs. field</td>
<td>-</td>
<td>199%</td>
<td>334%</td>
<td>-</td>
<td>-</td>
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<tr>
<td>flower yields</td>
<td></td>
<td></td>
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*a Sari and Oguz (2002); *bWhitten (2000); *cOzguven and Tansi (1998); *dAl-Karaki, 2009 (unpublished data); § No data available.

Figure 2. Flowers of soilless (a) German (*Matricaria chamomilla*) and (b) Jordanian (*Matricaria aurea*) chamomiles just after harvest, and (c) Soilless plants of thyme (*Thymus vulgaris*).
Soilless culture of all tested species is feasible and according to results obtained, it is efficient and prospective especially with the great save in water which reached up to 70% of that used in soil-based cultivation (data not reported). Soilless culture systems may increase crop yield substantially over soil based systems and likely use 50% or less water to achieve the same yield in soil cultivation (Al-Karaki, 2009; Burrage, 1998; Papadopoulos, 1991). Flower yield of German and Jordanian chamomiles in soilless cultivation out-yielded those cultivated under conventional soil based cultivation by 199 and 334%, respectively (Table 2).

After 3-5 months, fresh herbal biomass of sage, German and Jordanian chamomiles, thyme and mint under soilless cultivation out-yielded the soil cultivated by 264, 313, 220, 215, and 243%, respectively (Table 2). The results of soilless sage cultivation in this study were higher than those obtained with soilless grown sage by Manukan et al., (2004). However, Dorais et al. (2001) reported that the medicinal plants *Achillea millefolium*, *Taraxacum officinaleis*, and *Valeriana officinalis*, grown hydroponically produced higher shoot dry weights by 22.9, 13.7 and 15.2 times, respectively, than field-grown plants. Moreover, Tabatabaie et al. (2007) indicated that the medicinal plant lemon verbena (*Lippia citriodora*) cultivated under soilless culture system produced significantly higher leaves fresh weight than that cultivated under soil system.

**Conclusion**

The results of study suggest that soilless cultivation is capable of superior yields compared to conventional field production and should serve as a model for cultivation of other MA plants under soilless conditions.

**Acknowledgments**

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**References**


