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Short Communication

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

G.N. Al-Karaki[1,2] and Y. Othman[1]

[1]Sultan Qaboos Center for Developed & Soilless Agriculture, Arabian Gulf University, Bahrain; [2]Faculty of Agriculture, Jordan University of Science & Technology, P.O. Box 3030, Irbid, Jordan

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 semiarid 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 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%m 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

غازي الكركي[1،2]؛ يحيى عثمان[1]

[1]مركز السلطان قابوس للزراعة المتطورة وبدون تربة، جامعة الخليج العربي، البحرين؛ [2]العنوان الحالي: كلية الزراعة، جامعة العلوم والتكنولوجيا الأردنية، اربد، الأردن

الملخص: إن إنتاج واستدامة النباتات الطبية والعطرية في الدول ذات المناخ الجاف وشبه الجاف مثل دول منطقة الخليج العربي تواجه تحديا كبيرا من اجل تلبية الطلب المتزايد على هذه النباتات وذلك بسبب محدودية المصادر المائية والأراضي الزراعية. لقد لقي استزراع النباتات الطبية بدون تربة في السنوات الأخيرة اهتماما كبيرا في كثير من الدول سواءا تحت الظروف المحمية او خارجها وذلك للميزات التي تقدمها هذه التقنية مثل الإنتاج العالي وطوال العام والنوعية العالية ونظافة الناتج بالاضافة إلى التوفير الكبير في المياه وكفاءة استخدامها مقارنة مع الزراعة التقليدية في التربة. تهدف هذه الدراسة إلى ادخال وتقييم زراعة عدد من النباتات الطبية والعطرية (الميرمية، البابونج، الزعتر، والنعناع) غير المستزرعة في المنطقة تحت ظروف الزراعة بدون تربة باستخدام نظام التدوير ومقارنة ذلك مع الإنتاج تحت ظروف الزراعة التقليدية في الحقل. أظهرت النتائج بان جميع النباتات المدروسة كانت متكيفة تماما مع نظام الزراعة بدون تربة وتفوقت في إنتاج المادة العشبية على تلك المزروعة تحت نظام الزراعة التقليدية في التربة بحوالي 264، 313، 220، 247، و 243% لكل من الميرمية، البابونج الالماني، البابونج الاردني، الزعتر، والنعناع ،على التوالي، بالاضافة الى التوفير العالي للمياه. وقد تفوق انتاج الازهار في البابونج الالماني والبابونج الاردني المزروع بالزراعة بدون تربة بحوالي 199 و 334% ، على التوالي، عن ذلك المزروع بالتربة. وهذا يدل على إن استخدام تقنية الزراعة بدون تربة في إنتاج النباتات المدروسة كان ناجحا بشكل كبير، وانه بالامكان استخدام هذه التقنية في زراعة النباتات الطبية الأخرى الهامة في منطقة الخليج العربي .

الكلمات المفتاحية: الزعتر، الميرمية، البابونج، النعناع، 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 semiarid regions (e.g. Gulf region) is facing a major challenge of limited water and land resources. Water resources are scarce, mainly non-renewable, overexploited fossilled 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 m^{-2} for sage, thyme and mint, respectively, and 0.1 g seeds m^{-2} 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:31, K:230, Ca:160, Mg:48, S:64, Fe:1.5, Mn:0.5, B:0.4, Zn:0.05, Cu:0.05, Mo:0.02. 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 re-use. 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 removes 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/m^2, with flower mass of 66 and 534 g/m^2 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/m^2, respectively. However, total air-dry mass of sage and thyme reached 1377, 451g/m^2 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.

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

[§] 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).

	Sage	German chamomile	Jordanian chamomile	Thyme	Mint
Reported average herbal yield – field plants	863 g m^{-2} [a]	962 g m^{-2} [b]	411 g m^{-2} [d]	518 g m^{-2} [c]	1320 g m^{-2} [a]
Herbal yield – soilless systems	2289g m^{-2}	3015 g m^{-2}	906 g m^{-2}	1283 g m^{-2}	3208 g m^{-2}
Soilless vs. field grown yields	264 %	313%	220%	247%	243%
Reported average flower yield – field plants	-	270 g m^{-2} [b]	54 g m^{-2} [d]		
Flower yield – soilless system	-	536 g m^{-2}	181 g m^{-2}	-	-
Soilless vs. field flower yields	-	199%	334%		

[a] Sari and Oguz (2002); [b]Whitten (2000); [c]Özguven and Tansi (1998); [d]Al-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 officinalis,* 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 (*Lipia 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.

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