

**STUDIES ON PRODUCTION OF *LIMONIUM*
SINUATUM FLOWERS USING SOILLESS
CULTURE TECHNIQUE**

By

WARDA ABD EL-SAMEA ALY ALY

B. Sc. Agric. Sc. (Horticulture), Ain Shams University, 2001

M.Sc. Agric. Sc. (Ornamental Plants), Ain Shams University, 2005

**A thesis submitted in partial fulfillment
of
the requirements for the degree of**

DOCTOR OF PHILOSOPHY

in

**Agricultural Sciences
(Ornamental Plants)**

**Department of Horticulture
Faculty of Agriculture
Ain Shams University**

2012

دراسات على إنتاج أزهار الليمونيم باستخدام تقنية الزراعة بدون تربة

رسالة مقدمة من

وردة عبد السميع على

بكالوريوس علوم زراعية (بساتين) ، جامعة عين شمس ، 2001

ماجستير علوم زراعية (زينة) ، جامعة عين شمس ، 2005

للحصول على
درجة دكتور فلسفة في العلوم الزراعية
(زينة)

قسم البساتين
كلية الزراعة
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(زينة)

وقد تمت مناقشة الرسالة والموافقة عليها

اللجنة:

..... د. إمام محمد صابر نوفل
أستاذ الزينة المتفرغ ، كلية الزراعة ، جامعة كفر الشيخ

..... د. عوض محمد قنديل
أستاذ الزينة المتفرغ ، كلية الزراعة ، جامعة عين شمس

..... د. أسامة أحمد البحيرى
أستاذ الخضر ، كلية الزراعة ، جامعة عين شمس

..... د. سهير السيد محمد حسن
أستاذ الزينة المتفرغ ، كلية الزراعة ، جامعة عين شمس

تاريخ المناقشة : 11 / 10 / 2012

رسالة دكتوراه

اسم الطالبة : وردة عبد السميع على على
عنوان الرسالة : دراسات على إنتاج أزهار الليمونيم باستخدام تقنية
الزراعة بدون تربة
اسم الدرجة : دكتور فلسفة في العلوم الزراعية (زينة)

لجنة الإشراف

- د. سهير السيد محمد حسن
أستاذ الزينة المتفرغ ، قسم البساتين ، كلية الزراعة ، جامعة عين شمس
(المشرف الرئيسي)
د. أسامة أحمد البحيري
أستاذ الخضر ، قسم البساتين ، كلية الزراعة ، جامعة عين شمس
د. فيصل محمد عبد العليم سعداوى
رئيس بحوث متفرغ ، قسم بحوث نباتات الزينة وتنسيق الحدائق ، معهد بحوث البساتين ،
مركز البحوث الزراعية

تاريخ التسجيل 11 / 9 / 2006

الدراسات العليا

أجيزت الرسالة
2012 / 10 / 11

ختم الإجازة
2012 / /

موافقة مجلس الجامعة
2012 / /

موافقة مجلس الكلية
2012 / /

Approval Sheet

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This thesis for Ph.D. degree has been approved by:

Dr. Emam Mohamed Saber Nofal
Prof. Emeritus of Ornamental Plants, Faculty of Agriculture,
Khafr El Sheikh University

Dr. Awaad Mohamed Kandeel
Prof. Emeritus of Ornamental Plants, Faculty of Agriculture,
Ain Shams University

Dr. Usama Ahmed El-Behairy
Prof. of Vegetable Crops, Faculty of Agriculture, Ain Shams
University

Dr. Sohair El-Sayed Mohamed Hassan
Prof. Emeritus of Ornamental Plants, Faculty of Agriculture,
Ain Shams University

Date of Examination: 11 / 10 / 2012

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By

WARDA ABD EL-SAMEA ALY ALY

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Under the supervision of:

Dr. Sohair El-Sayed Mohamed Hassan

Prof. Emeritus of Ornamental Plants, Department of Horticulture,
Faculty of Agriculture, Ain Shams University (Principal
Supervisor)

Dr. Usama Ahmed El-Behairy

Prof. of Vegetable Crops, Department of Horticulture, Faculty of
Agriculture, Ain Shams University

Dr. Faisal Mohamed Abdel-Aleam Saadawy

Head of Research Emeritus, Ornamental Plants and Landscape
Design Research Department, Horticulture Research Institute,
Agricultural Research Center

1. INTRODUCTION

Limonium (*Limonium sinuatum* (L.) Mill.), Statice, Sea-lavender, Caspia, Misty, Seafoam, German Statice and English Statice belong to the Family Plumbaginaceae. The genus *Limonium* consists of up to 150 species. Plants of *Limonium* along with those of *Armeria* were once included in the genus *Statice*, and are still often known by that name in gardens.

Limonium is considered one of the most important annual plants for flower beds and cut-flowers in fresh and dry floral arrangements (Everett, 1981; Huxley *et al.*, 1992 and InterNet Sites 1-6, 2011). The relative suitability of Egypt climate offers the possibility of growing cut-flower limonium in the open field and under protected cultivation.

Traditionally, most grown flower crops have been cultivated in beds utilizing the natural soil. Soil texture, structure, fertility and drainage must all be carefully assessed during site selection, especially when growing inside greenhouses. Moreover, for mono culture production, i.e. cultivation of the same flower crop year after year in the greenhouse soil, problems associated with the soil will gradually develop. Soil borne diseases will increase in severity with the number of crops produced in the soil.

To keep the demand for cut-flower crops such as chrysanthemum lively, different agricultural practices are tried to improve production, yield and quality. One of these practices is soilless culture.

Soilless culture is an agricultural technique to produce plants without culturing in soil. It includes several cultivation systems. These systems have been developed rapidly in recent years. Soilless culture systems possesses numerous advantages compared to traditional cultivation using soil as a substrate. The most important advantages of soilless culture systems include higher potential yield,

better product quality, easier sterilization, economy of water usage in irrigation, reduction in labour requirement and higher cultivation intensity **Baudoin *et al.* (1990)**. Above all, they provide independence from soil conditions and freedom from soil-borne diseases (**Olympios, 1999; Burrage, 1992; Abak & Celikel, 1994 and Buwalda *et al.* 1994**).

Soilless cultured cut-flower plants are produced in many different types of soilless systems, most of which are media-based, eg. using perlite, vermiculite and sand in recirculating or non-recirculating systems.

The aim of this study is to define the most suitable substrate culture methods in closed system for the production of cut-flower *Limonium sinuatum* cv. Statice mixed colors under greenhouse conditions. To achieve this aim, soilless culture treatments undertaken in this study included,

- 1) Two levels of the nutrient solution EC (2 and 3 mmohs/cm).
- 2) Five types of growing media mixtures (in equal amounts by volume), i.e. (sand alone, sand + peatmoss, sand + peatmoss + perlite, sand + peatmoss + vermiculite, and sand + peatmoss + peanut husk).
- 3) Two levels of planting density (44.4 and 25 plants/m²).

2. REVIEW OF LITERATURE

Production in soilless culture is much more efficient than cultivation in soil. Therefore, many countries all over the world are greatly interested in extending this growing technique. Lately, in Egypt an interest in this method has risen sharply for vegetable crops production, while cut-flower crops have been tried on a smaller scale. Further development is still required to define the most suitable soilless culture systems for the production of different cut-flower species.

Maršić and Jakše (2010) stated that in greenhouse, soilless culture is the most intensive and effective form of cultivation, which offers significant advantages, such as enabling the successful cultivation of vegetables on unproductive degraded soil. However, **Levai and Farkas (2011)** started a chain of research with cut flower in hydroponics, and expanded this thematic research to pot flowers. They found that the cut flowers stem yield in hydroponics is about the same that in traditional soil mix and chemo culture. However, flower quality was better, due to the more balanced nutrients supply, especially for the vase-endurance. Quality attributes were also better in pot plants. In both crops, timing was more effective than in traditional technologies.

The methods of growing plants without soil fall into two general categories;

a) Liquid culture (true hydroponics) where the nutrient solution is either recirculated after re-aeration and adjustment of the pH and nutrient levels, e.g. NFT and deep re-circulating water culture, or the nutrient solution is not recirculated (static solution), e.g. deep water culture and floating hydroponic systems, and

b) Substrate (aggregate) culture, where the nutrient solution is supplied to plants via irrigation system through the media, and excess

solution is allowed to run to waste (open system), or the solution is recirculated (closed system) (**Baudoin *et al.* (1990) and Olympios, 1999**).

2.1. Substrate culture system

Substrate culture is the cultivation of crops in other media except soil. There are two types of substrates: 1) Inert substrates, such as perlite, rockwool, pumice, sand and vermiculite and 2) Organic substrates as peatmoss, sawdust and wood park. The nutrient solution is supplied to plants via irrigation system through the media and excess solution is allowed to run to waste (open system) or the solution is recirculated (closed system). For environmental consideration, most of the countries start to shift to the closed system instead of the open one, where the drained nutrient solution is reused (**Resh, 1989; Baudoin *et al.* (1990) and Olympios, 1999**).

The growing media such as sand, peat moss, peat-sand, agricultural wastes or composts are used to raise plants through improving aeration and supporting them adequately. However, **Jackson *et al.* (1984)** found that replacing the composts with more open structured inorganic media such as perlite, rockwool or capogro (inert and sterile product made from the fibrization of molten basalt and other minerals) almost completely eliminated the symptoms of poor aeration observed in compost.

In substrate culture, all the nutrients are supplied to the plants with water during irrigation. The media here also not only provides support to plants but also is a mean of oxygenation/aeration of the roots. Indeed, aggregate systems are now the most widespread forms of soilless culture (**Olympios, 1999**).

Two of the most extensively used EC of the nutrient solution; five substrate materials in addition to two planting densities were utilized in this study.

2.1.1. EC of the nutrient solution

EC of the nutrient solution has a great influence on growth and development of the plant. **Halder and Burrage (2005)** conducted an experiment in a glasshouse on rice plants grown using NFT technique to find out the effect of nutrient solution EC. Two levels of nutrient solution EC (2.0 and 3.0 mS cm⁻¹) were used. They noticed that EC 3.0-plants performed better than EC 2.0-plants. **Gent (2006)** noticed that electrical conductivity (EC) affects tissue composition of lettuce (*Lactuca sativa*) grown in hydroponic system. **YoungYeol and JungEek (2007)** declared that management of electrical conductivity is very important for crop growth in hydroponics, as optimum conditions of the EC could improve the growth and yield of hydroponically-grown plants.

2.1.2. Growing substrates

One of the most obvious decisions, hydroponic farmers have to make, is which medium they should use. Different media are appropriate for different growing techniques.

2.1.2.1. Sand

Sand consists of small rock grains, from about 0.05 to about 2.0 mm in diameter. Formed as the result of weathering of various rocks, its mineral composition depending upon the type of rock. Quartz sand is generally used for propagation purposes, consisting chiefly of a silica complex. The type used in plastering is the grade ordinarily the most satisfactory for rooting cuttings. Sand is the heaviest of all rooting media used, a cubic meter of dry sand weighing about 1.67 ton. Sand contains virtually no nutrients and has no buffering capacity. It is used mostly in combination with organic materials (**Hartmann and Kester, 1975**).

2.1.2.2. Sphagnum peat moss (Peat Moss)

Commercial sphagnum moss is the dehydrated young residue or living portions of acid-bog plants in the genus *Sphagnum*, such as *S.*

papillosum, *S. capillaceum*, and *S. painstre*. It is relatively light in weight, and has a very high water-holding capacity, being able to absorb 10 to 20 times its weight of water. The stem and leaf tissues of sphagnum moss consist largely of groups of water-holding cells. This material is generally shredded, either by hand or mechanically, before it is used as a propagating medium. It contains such small amounts of minerals that plants (grown in it for any length of time) require added nutrients. Sphagnum moss has a pH of about 3.5 (**Hartmann and Kester, 1975**).

2.1.2.3. Perlite

This gray-white siliceous material is of volcanic origin, mined from lava flows. The crude ore is crushed and screened, then heated in furnaces to about 760°C, at which temperature the small amount of moisture in the particles changes to steam, expanding the particles to small, sponge-like kernels which are very light, weighing only 80 to 125 kg/m³. The high processing temperature gives a sterile product. A particle size of 1.5-3.5 mm in diameter is usually used in horticultural applications. Perlite will hold three to four times its weight of water. It is essentially neutral with a pH of 6.0 to 8.0 but with no buffering capacity; unlike vermiculite, it has no cation exchange capacity and contains no mineral nutrients. It is most useful in increasing aeration in a mixture (**Hartmann and Kester, 1975**).

2.1.2.4. Vermiculite

This is a micaceous mineral which expands markedly when heated. Extensive deposits in the United States are found in Montana and in North Carolina. Chemically, it is a hydrated magnesium-aluminum-iron silicate. When expanded, it is very light in weight (100-170 kg/m³), neutral in reaction, with good buffering properties, and insoluble in water; it is able to absorb large quantities of water, 720-950 liters/m³ of vermiculite. Vermiculite has a relatively high cation exchange capacity and thus can hold nutrients in reserve and

later releases them. It contains enough magnesium and potassium to supply most plants. In the crude vermiculite ore, the particles consist of a great many very thin, separate layers, with microscopic quantities of water trapped between them. When run through furnaces at temperatures near 1093.3°C, the water turns to steam, popping the layers apart, forming small porous sponge-like kernels. Heating to this temperature gives complete sterilization. Horticultural vermiculite is graded to four sizes: No. 1 has particles from 5 to 8 mm in diameter; No. 2, the regular horticultural grade, from 2 to 3 mm; No. 3, from 1 to 2 mm; and No. 4, which is most useful as a seed-germinating medium, from 0.75 to 1 mm. Expanded vermiculite should not be pressed or compacted when wet, as this will destroy its desirable porous structure (**Hartmann and Kester, 1975**).

2.1.2.5. Peanut husk

Agricultural wastes, such as straws of many crops and peanut hulls represent a big problem for our society. It is necessary to get rid of these wastes by means of a scientific and economic method. A good approach to solve this problem is turning these wastes to media suitable for growing a lot of plants. Through this technique we can make use of these wastes and save a big sum of money needed for importing expensive substrates from abroad. Locally available and sustainable substrates and amendments play an increasingly important role in what growers choose for soilless substrates, as the cost of basic materials increases. The major concern for many growers is the continuity of supply, the uniformity and longevity of the substrate in the container to grow quality plant material.

Peanuts, or "groundnuts" as they are known in some parts of the world, are the edible seeds of a legume (*Arachis hypogaea*, Fam. Fabaceae). World peanut production totals approximately 29 million metric tons per year, with the U.S. being the world's third largest producer, after China and India, (**InterNet Site 7, 2011**)

Worldwide peanut production in 2010

Country			Country		
		Million metric tons			Million metric tons
1	China	13,420,000	11	Vietnam	400,000
2	India	7,700,000	12	Sudan	370,000
3	United States	1,880,000	13	Congo, Dem	360,000
4	Nigeria	1,510,000	14	Burkina Faso	320,000
5	Indonesia	1,130,000	15	Guinea	250,000
6	Burma	710,000	16	Brazil	220,000
7	Chad	450,000	17	Egypt	190,000
8	Senegal	450,000	18	Mali	160,000
9	Ghana	440,000	19	Mexico	90,000
10	Argentina	420,000			
Total		30,470,000			

(InterNet Site 7, 2011)

Peanut husk, peanut hull, peanut skin or peanut shell, are all the same definitions, referring to the pericarp or fruit wall that enclosed the seeds or peanuts. **Ingram *et al.* (2003)** reported that peanut shells have the potential to be used as an alternative to peat moss to increase aeration and decrease weight up to 25% by volume, although it decomposes relatively quickly and should not be used for crop cycles longer than 12 weeks.

Using the right substrate is a good indication for successful soilless culture project. Peat moss is considered to be the most important substrate in this concern. However, it is a non-renewable resource as mentioned by some authors. **Mugnai *et al.* (2007)** reported that peat is extensively used in nurseries as a primary component in commercial soilless potting media. The increased use of peat as an organic amendment with superior water holding capacity is

challenged by economic and environmental pressures. To stay competitive and satisfy environmental concerns, potential alternatives to peat need to be investigated. **Kazaz *et al.* (2010)** stated that initial investment cost of soilless culture is expensive; however, locally available substrates may reduce production cost in the long term.

2.1.2.6. Horticulture crops in substrate cultures

Nowadays, soilless culture is so widely used for greenhouse crop production, especially for many vegetable and ornamental crops (**Resh, 1989 and Larson, 1980**). A great deal of ornamental plants, cut-flower crops and/or pot plants are produced all over the world by soilless culture, largely by substrate culture under greenhouse controlled conditions (**Armstrong, 2004 and Wijchman, 2004**).

Choosing the right substrate plays a very important role in the success of the soilless culture technique. **Quintero *et al.* (2009)** found that the production and quality of rose stems grown on soilless substrates were affected by the substrate type. **Samadi (2009)** stated that the selection of a growing medium is one of the most important decisions in the culture of hydroponic crops. **Radhouani *et al.* (2011)** remarked that the selection of suitable media is the key that ensures the success of soilless culture, seeing that the adoption of not standardized one, limits the correct nutrient solution management and the development of plant. The substrate selection must consider technical and economical implications.

The criteria on which a certain substrate is chosen were investigated. **Salvador and Balas (2006)** noticed that no general conclusions could be drawn regarding the recommendations for physical characteristics of substrates to suit all plant species, as each species showed specific needs. For this reason they studied three