

**EFFECT OF IRRIGATION INTERVALS,
SALINITY AND SOME AMINO ACIDS ON
GROWTH, YIELD, ESSENTIAL OIL
PRODUCTION AND CHEMICAL COMPOSITION
OF ROSEMARY (*Rosmarinus officinalis* L.) PLANT**

BY

GEHAD ABDULRAZZAQ MOHAMMED ANAAM

**B. Sc. Agric. Sci. (Horticulture), Fac. Agri. Sana'a Univ., Yemen, 1993
M. Sci. (Medicinal and Aromatic Plants), Fac. Agric., Sana'a Univ., Yemen, 2006**

THESIS

**Submitted in Partial Fulfillment of the
Requirements for the Degree of**

DOCTOR OF PHILOSOPHY

In

**Agricultural Sciences
(Ornamental Horticulture)**

**Department of Ornamental Horticulture
Faculty of Agriculture
Cairo University
EGYPT**

2019

Format Reviewer

Vice Dean of Graduate Studies

APPROVAL SHEET

EFFECT OF IRRIGATION INTERVALS, SALINITY AND SOME AMINO ACIDS ON GROWTH, YIELD, ESSENTIAL OIL PRODUCTION AND CHEMICAL COMPOSITION OF ROSEMARY(*Rosmarinus officinalis* L.) PLANT

**Ph.D. Thesis
In
Agric. Sci. (Ornamental Horticulture)**

By

GEHAD ABDULRAZZAQ MOHAMMED ANAAM

**B.Sc. Agric. Sci. (Horticulture), Fac. Agri. Sana'a Univ., Yemen, 1993
M. Sci. (Medicinal and Aromatic Plants), Fac. Agric., Sana'a Univ., Yemen, 2006**

Approved Committee:

Dr. SHOUKRY MAHMOUD SELIM.....
Professor of Ornamental Horticulture, Fac. Agric., El-Fayoum University.

Dr. MOHAMED ABDELKHALEK EL-KHATEEB.....
Professor of Ornamental Horticulture, Fac. Agric., Cairo University.

Dr. AHMED SALAMA EL-LEITHY
Professor of Medicinal and Aromatic Plants, Fac. Agric., Cairo University.

Dr. MOHAMED SAYED HANAFY.....
Professor of Medicinal and Aromatic Plants, Fac. Agric., Cairo University.

Date: 2 /4 / 2019

SUPERVISION SHEET

EFFECT OF IRRIGATION INTERVALS, SALINITY AND SOME AMINO ACIDS ON GROWTH, YIELD, ESSENTIAL OIL PRODUCTION AND CHEMICAL COMPOSITION OF ROSEMARY(*Rosmarinus officinalis* L.) PLANT

Ph.D. Thesis
In
Agric. Sci. (Ornamental Horticulture)

By

GEHAD ABDULRAZZAQ MOHAMMED ANAAM

B.Sc. Agric. Sci. (Horticulture), Fac. Agri. Sana'a Univ., Yemen, 1993
M. Sci. (Medicinal and Aromatic Plants), Fac. Agric., Sana'a Univ., Yemen, 2006

SUPERVISION COMMITTEE

Dr. MOHAMED SAYED HANAFY
Professor of Medicinal and Aromatic Plants, Fac. Agric., Cairo University

Dr. AHMED SALAMA EL-LEITHY
Professor of Medicinal and Aromatic Plants, Fac. Agric., Cairo University

Dedication

*I dedicate this work to whom my heartfelt thanks; to my parents and to my wife **Manal** and my children (**Ghaida** and **Alya**) for their patience and help. As well as my brothers and sisters for all the support they lovely offered along the period of my post-graduation.*

Gehad

ACKNOWLEDGEMENTS

I wish to extend my deep appreciation to Dr. MOHAMED SAYED HANAFY, Professor of Medicinal and Aromatic plants, Faculty of Agriculture, Cairo University, for his direct supervision, suggesting the problem, continued assistance and his guidance through the course of study and revision of this manuscript. My indebted thanks are also extended to Dr. AHMED SALAMA EL-LEITHY, professor of Medicinal and Aromatic plants, Faculty of Agriculture, Cairo University, for supervision, helpful assistance and guidance during the progress of this manuscript.

Sincere appreciation is also expressed to Dr., MOHAMED ABDELKHALEK EL-KHATEEB professor of Ornamental Horticulture, Faculty of Agriculture, Cairo University, for his co-operation and guidance. Grateful appreciation is also extended to all staff members of Ornamental Department, Faculty of Agriculture, and Cairo University. Lastly, I have the highly indebted to my parents, wife, Children, friends and colleagues for their patience, encouragement and continuous support during the study period to make this research a success. Also, I feel deeply grateful to my dear country Yemen.

Name of Candidate: Gehad Abdul Razzaq Mohammed Anaam **Degree:** Ph.D.
Title of Thesis: Effect of Irrigation Intervals, Salinity and Some Amino Acids on Growth, Yield, Essential oil Production and Chemical Composition of Rosemary (*Rosmarinus officinalis* L.) Plant
Supervisors: Dr. Mohamed Sayed Hanafy
Dr. Ahmed Salama El-Leithy
Department: Ornamental Horticulture **Approval:** 2/4/2019

Abstract

Two experiments were done, the first one aimed to study the effect of irrigation intervals and Cyto-flow amin⁻⁵⁰ application on growth, oil production and chemical composition of rosemary plant in the field. The second one was done in plastic pots, to study the effect of saline water irrigation and proline treatments on growth, oil production and chemical composition. The experiments were carried out at the Department of Ornam. Hort., Fac. Agric. Cairo Univ., during seasons of (2014/2015) and (2015/2016), uses a factorial design, in split plot.

The first experiment. Aimed to study the effect of different irrigation intervals at (1, 2 and 3 weeks) and Cyto-flow amin⁻⁵⁰ at 0, 1 and 2g/l on growth, yield, oil production and plant constituents of rosemary (*Rosmarinus officinalis* L.) plants. Cyto-flow amin⁻⁵⁰ was monthly sprayed during both seasons.

On 10th October for the first and second seasons, the soil was prepared, by adding calcium super-phosphate (200kg /fed), while potassium sulfate at 150 kg/fed, was added in two equal doses. The experiment contained 9 treatments; each treatment was replicated 3 times in randomly distributed plots. **The data obtained could be summarized as follows:**

1. Effect of irrigation intervals -Irrigating rosemary plants every 7 days significantly increased plant height, in the second cut of the first season, the No. of branches/plant in first cut (both seasons). -Prolonging irrigation intervals to 21 days, gave the highest percentages of β -Pinene, Limonene, 1,8 Cineole, Linalool, Borneol, and Bornyl acetate

2. Effect of cyto-flow amin⁻⁵⁰

- Cyto flow amin⁻⁵⁰ at 2g/l gave the highest% of α -Pinene, Linalool, α -Terpineol, Borneol and Eugenol, treating with 1g/l gave the highest Camphene, β -Pinene and 1, 8 Cineol percentages.

3. Interaction between irrigation intervals and cyto flow amin⁻⁵⁰

-Irrigation every 7 days + Cyto-flow amin at 1g/l, gave the tallest plants, highest No. of branches/plant (first cut/both seasons). -The highest essential oil yield/feddan (liter) was obtained from irrigation every 21 days cyto-flow amin⁻⁵⁰ at 1g/l.

The second experiment.

The aim was to study the effect irrigation salinity at (500, 1000, 1500 and 2000ppm) and proline at 10 and 20 ppm on growth, essential oil production and chemical composition of rosemary herb (in plastic pots 30cm, in sandy clay loam soil). The rooted cutting (15-20 cm length) were planted on 28 October in 2014/2015 and 2015/2016.

The results indicated that:

Effect of saline water irrigation

-In general, increasing salinity rates decreased the quantity of oil (ml/plant). In the first and second seasons, (salinity at 1000 ppm) gave the highest value of oil yield of dry herb (ml/plant) followed by the control. **GLC analysis of the essential oil revealed that** the highest α -pinene% was found in plants received saline water at 2000 ppm combined with proline at 20ppm. The highest camphene % was found with salinity at 1000 ppm.

On plant chemical composition

-The maximum free amino acid content in the first season was recorded with proline at 20 ppm for non-salt stressed plants, in the two cuts.

-Treating plants with proline at 10ppm had a great effect on increasing the N, P and K-contents and proline at 10 or 20 ppm, markedly reduced P-content.

Key words: *Rosmarinus officinalis* L., Irrigation intervals, Cyto flow amin⁻⁵⁰, Essential oil percentage, 1, 8 Cineol, saline water, proline and amino acid.

CONTENTS	Page
INTRODUCTION	1
REVIEW OF LITERATURE	5
1. Effect of irrigation	5
a. On growth and yield	5
b. On essential oil production	12
c. On chemical composition	17
2. Effect of salinity	20
a. On growth and yield	20
b. On essential oil production	29
c. On chemical composition	45
3. Effect of amino acid	41
a. On growth and yield	41
b. On essential oil production	45
c. On chemical composition	50
MATERIALS AND METHODS	53
RESULTS AND DISCUSSION	69
The first experiment : Effect of irrigation intervals, Cyto flow amin⁻⁵⁰ and their interaction on rosemary (<i>Rosmarinus officinalis</i> L.) on growth, yield, oil production and chemical constituents	69
1. On vegetative growth and yield	69
a. Plant height (cm).....	69
b. Number of branches/plant.....	71
c. Fresh leaves: stems ratio	72
d. Herb fresh weight (g)/plant.....	74
e. Herb dry weight (g/plant).....	77
f. Fresh herb yield (ton)/feddan	79
g. Dry herb yield (ton)/feddan	80
2. On essential oil production	82
a. Essential oil percentage (%) in dry herb	82
b. Essential oil yield (ml/plant).....	84
c. Essential oil yield/feddan (liter).....	87
d. GLC analysis of the essential oil.....	88
3. On plant chemical composition	91
Leaf pigments	91
a. Chlorophyll (a) content (mg/gm F.W).....	91

b. Chlorophyll (b) content (mg/gm F.W).....	93
c. Total carotenoids content (mg/gm F.W).....	94
d. Nitrogen (%) in dry herb.....	97
e. Phosphorus (%) in dry herb.....	98
f. Potassium (%) in dry herb.....	99
g. Total carbohydrates % in the dry herb.....	100
h. Total free amino acids.....	103
i. Total phenolic compounds.....	104
The Second experiment: Effect of irrigation with saline water, proline and their interaction on growth, oil yield and chemical composition of <i>Rosmarinus officinalis</i> L. plant	105
1. On vegetative growth and yield	105
a. Plant height (cm).....	105
b. Number of branches per plant.....	110
c. Fresh leaves: stems ratio	112
d. Herb fresh weight per plant (g)	114
e. Herb dry weight per plant (g).....	117
2. On essential oil production	119
a. Essential oil percentage in dry herb.....	119
b. Essential oil yield dry herb (ml/plant).....	125
c. GLC analysis of the essential oil components	130
3. On plant chemical composition	140
Leaf pigments	140
a. Chlorophyll (a) content (mg/gm F.W)	140
b. Chlorophyll (b) content (mg/gm F.W).....	141
c. Total chlorophylls (mg/g F.W).....	143
d. Carotenoids contents (mg/g F.W).....	145
e. Total carbohydrates % in the dry herb.....	146
f. Total free amino acids.....	149
g. Total phenolic compounds.....	151
h. Total free proline (μ mole/g) in the fresh herb.....	153
i. N, P and K contents (%D.W).....	155
(1) Nitrogen content.....	155
(2) Phosphorus (%) in dry herb.....	156
(3) Potassium content (%D.W).....	158
j. Calcium, magnesium, sodium and chlorine (%).....	162
(1) Ca - percentage (Ca%).....	162