BOTANICAL INVESTIGATIONS ON *Asparagus officinalis* L. (ASPARAGACEAE)

By

SALLY FARAG DESOUKY MOHAMED
B.Sc. Agric. Sci. (Biotechniology), Fac. Agric., Cairo Univ., 2009

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

MASTER OF SCIENCE

In

Agricultural Sciences
(Agricultural Botany)

Department of Agricultural Botany
Faculty of Agriculture
Cairo University
EGYPT

2016

APPROVAL SHEET

BOTANICAL INVESTIGATIONS ON *Asparagus officinalis* L. (ASPARAGACEAE)

M.Sc. Thesis
In
Agric. Sci. (Agricultural Botany)

By

SALLY FARAG DESOUKY MOHAMED

B.Sc. Agric. Sci. (Biotechniology), Fac. Agric., Cairo Univ., 2009

APPROVAL COMMITTEE

Dr.ARAFA AHMED ARAFA ……

Professor of Agricultural Botany, Fac. Agric., Mansoura University.

Dr.HASSAN RAMADAN HASSAN……..

Professor of Agricultural Botany, Fac. Agric., Cairo University.

Dr. RAMADAN KORANY HUSSEIN HARB…….

Professor of Agricultural Botany, Fac. Agric., Cairo University.

Dr.OSAMA SOLIMAN MAHMOUD EL-OBISY……

Professor of Agricultural Botany, Fac. Agric., Cairo University.

Date: 11 / 1 /2016

SUPERVISION SHEET

BOTANICAL INVESTIGATIONS ON *Asparagus officinalis* L. (ASPARAGACEAE)

M.Sc. Thesis

In

Agric. Sci. (Agricultural Botany)

By

SALLY FARAG DESOUKY MOHAMED

B.Sc. Agric. Sci. (Biotechniology), Fac. Agric., Cairo Univ., 2009

SUPERVISION COMMITTEE

Dr. RAMADAN KORANY HUSSEIN HARB.

Professor of Agricultural Botany, Fac. Agric., Cairo University

Dr .OSAMA SOLIMAN MAHMOUD EL-KOBISY

Professor of Agricultural Botany, Fac. Agric., Cairo University

Name of Candidate: Sally Farag Desouky **Degree:** M.Sc.

Title of Thesis: BOTANICAL INVESTIGATIONS ON *Asparagus officinalis* L. (ASPARAGACEAE)

Supervisors: Dr. Ramadan Korany Hussein Harb

Dr. Osama Soliman Mahmoud El-Kobis

Department: Agricultural Botany Branch: Agricultural Botany

Approval: 11 /1/ 2016

ABSTRACT

Although Asparagus (*Asparagus officinalis* L.) is chiefly known as a vegetable herb, little information about the botanical characteristics of such plant are available. Therefore, it is aimed in this study to bring to light more information about the morphological, anatomical and some important chemical contents of vegetative and reproductive organs of the plant, throughout the consecutive stages of its entire life span under the local conditions.

Seeds of aspagous (cv. Mary Washington 500 W) were sown 2nd Feb. 2012. The field experiment was carried out at the Experimental and Research Station of Fac. of Agric., Cairo Univ., Giza, Egypt during the three successive growing seasons 2012, 2013 and 2014. Four plants were designated in each of the three replicates to follow up the vegetative characters at weekly intervals, including; the seed and germination, plant height (cm), internodes number of the aerial stem, lateral branches number, aerial stem diameter (mm). Also, fresh and dry weights of vegetative organs / plant (g) were determined. In addition, the spear (Marketable yield) characters at 15th April intervals were investigated; spears number, scale – like leaf number, spear diameter (mm). As well as , fresh and dry weights of spear/plant (g), the cumulative; total numbers, total fresh and dry weights of spears/plant of whole growth season were recorded. Moreover, the flowering behavior was followed up by recording the cumulative number of flower bunds developing opened flowers and flower buds in blooming at 15th May intervals.

Ultra structural features of the seed coat, cladode epidermal cells and the epidermis of both adaxial and abaxial surfaces of sale-like leaf were investigated using scanning electron microscope. The crown (rhizome and adventitious roots) characters were investigated.

Anatomical studies were carried out for various organs of Asparagus plant including adventitious root, apex of the aerial stem , visible internode below shoot apex, median portion of the aerial stem , rhizome, median portion of spear, scale - like leaf, the cladode, the ovary and the fruit. The major chemical metabolites contents of spear were determined .

Key words: Asparagus, *Asparagus officinalis* L. morphology, anatomy, plant chemical analysis, scanning electron microscope.

ACKNOWLEDGEMENT

Firstly, my unlimited thanks to "Allah"

The authoress owes a deep dept of gratitude and appreciation to ***Dr. Ramadan K. Hussein Harb****, Emeritus Professor of Agricultural Botany, and* ***Dr. Osama Soliman El-Kobisy*** *,Professor of Agricultural Botany, Faculty of Agriculture, Cairo University, for their supervision of this study. They have been kind enough to provide critical advice, and guidance throughout this investigation.*

CONTENTS

	Page
INTRODUCTION.....	**1**
REVIEW OF LITERATURE.....	**5**
1. Family Liliaceae ……..	**5**
a.General aspects ……..…….....	**5**
b.Vegetative characters	**7**
c.Reproductivecharacters.....	**8**
d.Distribution and habitate……	**11**
e.Economic important of the family ……	**12**
2. **Family Asparagaceae** …….	**14**
a.Vegetative characters……..…..…….	**14**
b.Reproductive characters ……...……	**16**
c.Testa morphotypes found in the Asparagaceae ……..……..	**18**
3.*Asparagus Genus*	**20**
a. Vegetative characters	**20**
b. Reproductive characters.....	**21**
c. Anatomical characters ……	**22**
4. *Asparagus officinalis* L …….	**29**
a.Taxonomy and distribution …….....	**29**
b.Vegetative characters……..	**34**
c. Reproductive characters…….	**36**
d. Anatomical characters ……..	**38**
e. Some aspects on chemical contents of *Asparagus officinalis* L.	**40**
MATERIALS AND METHODS……..	**47**
RESULTS AND DISCUSSION.....	**61**
1. Morphological investigations ……..……..	**61**
a.Vegetative growth …….	**62**
1.The seed and seedling…….……..	**63**
2. The propagation	**66**
3.The root system(the crown) ……..……	**88**
4. The shoot system ……..	**88**
b. The spear (Marketable yield) characters ……..	**88**
1. Number of spears …….. ..	**93**
2. Number of scale – like leaf ……. …..	**93**
3. Diameter of the spear ……. …	**98**

4. Fresh weight of the spears..... **101**
5. Dry weight of the spears …… **101**
6. Total marketable yield /year **102**
c. Economic considerations ……..…… . **104**
2. Scanning Eletron Microscopy Investigations…….…… **106**
3.The root system(the crown) characters …….. **106**
4. Anatomical investigations…… **109**
a. The adventitious root …….. **109**
b. The main stem …… . **111**
1.The shoot apex…….. **111**
2. Visible internode below the shoot apex…… . .. **114**
3. The aerial stem (median portion)……. **116**
c. Subterranean stem (the rhizome)……..……. **118**
d.Median portion of spear ……..…….. **118**
e. The scae-l like leaf…… . **121**
f.The cladodes …… ……..... **123**
g.Structure of the flower……..….. **125**
h. Structure of the fruit …….. **125**
5. Chemical investigations…….…… **126**
a. The major metabolites contents…… **126**
b.Total chlorophyll , sugars and thiamin …….. ..…… .. . **130**
c. The organic acid contents …….…….. **143**
SUMMARY ……... ……..
REFERENCES ……...
ARABIC SUMMARY

LIST OF TABLES

No	Title	Page
1.	Systematic hierarchy of *Asparagus officinalis* L. according to well known systems of plant taxonomy……..	32
2.	The periodic growth and statistical parameters of plant height (cm) of *Asparagus officinalis* L.in two seasons…….. ……..	70
3.	The periodic growth and statistical parameters of the aerial stem internodes number of *Asparagus officinalis* L. in two seasons……	73
4.	The periodic growth and statistical parameters of the lateral branches number of *Asparagus officinalis* L. in two seasons	75
5.	The periodic growth and statistical parameters of the aerial stem diameter (mm) of *Asparagus officinalis* L.in two seasons …….....	78
6.	The statistical parameters of fresh weight of vegetative growth (g) of *Asparagus officinalis* L. in two seasons …….……..……..	81
7.	The statistical parameters of dry weight of vegetative growth (g) of *Asparagus officinalis* L. in two seasons …….……	83
8.	Cumulative number of flowers of *Asparagus officinalis* L. per plant (8-weeks intervals) at flower bud and opened flower stages at the 2 nd season ……..….....	86
9.	The statistical parameters of spears number of *Asparagus officinalis* L.(marketable yield) in two seasons ……..……	89
10.	The statistical parameters of scale –like leaf numbers(on the spear) of *Asparagus officinalis* L.(marketable yield) in two seasons ……	91

11. The statistical parameters of spear diameter (mm) of *Asparagus officinalis* L.in two seasons …… 94
12. The statistical parameters of spears Fresh weight (g) of *Asparagus officinalis* L. in twoseasons ……. 96
13. The statistical parameters of spears Dry weight (g) of *Asparagus officinalis* L. in twoseasons …… 99
14. Cumulative number , fresh and dry weights of total spears/ plant (total marketable yield) in two seasons ……..…… 101
15. Counts and measurements of the crown at end of the 2 nd season (2014)……. 106
16. Percentage of total carbohydrate , crude protein, fat, crude fiber and ash of *Asparagus officinalis* L.spear at the onset of flowering time, mean of 2 samples……..……. 125
17. Chlorophyll, sugars and thiamin (vit.B1)contents of *Asparagus officinalis* L . spear at the onset of flowering time, means of 2 samples…….. 126
18. The organic acid contents of *Asparagus officinalis* L. at onset of flowering time of the corresponding chromatogram peaks ……... 127

LIST OF FIGURES

No	Title	Page
1.	Photographs of *A. officinalis* L.showing the seeds and seedlings …….……	62
2.	A photograph showing the underground crown of *Asparagus officinalis* L. …….	64
3.	photographs of *Asparagus officinalis* L.showing the spears and the vegetative growth ……	65
4.	A photograph of *Asparagus officinalis* L. showing the vegetative growth at 20 weeks – old……..……..	67
5.	Photographs of *Asparagus officinalis* L. showing the flowers and fruits…….……	68
6.	Graph of regression of plant height (cm)on plant age of *Asparagus officinalis* L.in the 1 st season ……..……	71
7.	Graph of regression of the aerial stem internodes number on plant age of *Asparagus officinalis* L. in the 1st season……	74
8.	Graph of regression of branches number on plant age of *Asparagus officinalis* L.in the 1 st season ……..	76
9.	Graph of regression of aerial stem diameter (mm) on plant age of *Asparagus officinalis* L.in the 1 st season ……..	79
10.	Graph of regression of fresh weight of vegetative organ (g) on plant age of *Asparagus officinalis* L.in the 1 st season ……	82
11.	Graph of regression of dry weight of vegetative organ (g) on plant age of *Asparagus officinalis* L.in the 1 st season …….....	84

12. Graph of regression of number of buds and opened flowers/ plant on plant age of *Asparagus officinalis* L.in the 2nd season …… 87
13. Graph of regression of spears number on plant age of *Asparagus officinalis* L.in the 1st season…… 90
14. Graph of regression of scale –like leaf numbers on plant age of *Asparagus officinalis* L.in the 1st season……. 92
15. Graph of regression of spear diameter (mm) on plant age of *Asparagus officinalis* L.in the 1st season……. 95
16. Graph of regression of spears fresh weight (g) on plant age of *Asparagus officinalis* L.in the 1st season…… 97
17. Graph of regression of spears dry weight (g) on plant age of *Asparagus officinalis* L.in the 1st season…… 100
18. Scanning Electron Microscopy of seed epidermal cells of *Asparagus officinalis* L……. 103
19. Scanning Electron Microscopy of cladode epidermal cells of *Asparagus officinalis* L……. 103
20. Scanning Electron Microscopy on scale –like leaf of *Asparagus officinalis* L …… 105
21. Transverse section through the store adventitious root of *Asparagus officinalis* L**.** (40X)…… 108
22. Longitudinal section through the shoot apex of *Asparagus officinalis* L**.**a(40x),b(80x)……. 110
23. Microphotographs showing transverse sections through the aerial stem (visible internode below shoot apex) *Asparagus officinalis* L.a (40x), b(100x)…….. 112
24. Microphotograph showing transverse section through the main stem (median portion) of *Asparagus officinalis* L.(40x)…… 113

25. Microphotographs showing transverse sections through the rhizome (the underground stem) of *Asparagus officinalis* L. a(200x),b(40x),c(80x)…….. 115
26. Microphotograph showing transverse section through the spear (median portion) of *Asparagus officinalis* L. (40x) …… 117
27. Microphotographs showing transverse sections through the scale–like leaf of *Asparagus officinalis* L. a(40x),b(60x)…… 119
28. Microphotograph showing transverse section through the cladode of *Asparagus officinalis*L.(40x)…… 120
29. Microphotograph showing longitudinal section through the male flower of *Asparagus officinalis* L. (40x)…… 122
30. Microphotograph showing transverse section through the ovary of female flower of *Asparagus officinalis* L.(80x)…… 122
31. Microphotograph showing transverse section through the fruit of *Asparagus officinalis* L.(80x)…….. 124
32. High performance liquid chromatogram of organic acids of *Asparagus officinalis* L. spear …….. 128

INTRODUCTION

Asparagus is a large genus with over 160 different species of herbaceous perennials crop of high economic value with a chromosome number of 2n=20. They are grown throughout the world but they originated mainly from Asia, Africa and Europe (Prophen *et al*., 2008). The most economically important asparagus (*Asparagus officinalis* L.), which is a highly prized dioeciously vegetable crop (Stajner *et al*., 2002). Male plants show higher yields and vigor than those of female individuals. Tender and unexpanded shoots, commonly called spears, are the edible organs of garden asparagus and a planting can produce spears for up to 15 years (Rubatzky and Yamaguchi, 1997). Other species used mainly as ornamental or medicinal plants.

Asparagus (*Asparagus officinalis* L.) is one of the promising nontraditional horticultural crops in Egypt. However, it's considered one of the most important vegetable crops in some Asian, African, European and American countries whose markets demand a big quantity from fresh green, purple and white spears. Asparagus is one of the most nutritionally well balanced vegetables in existence, which is high in folic acid, thiamin, vitamin B6 and a good source of potassium. It represents sources of rutin, a drug which strengthens capillary wall, also, an excellent source of folacin, vitamin B, which helps in the duplication of cells for growth and repair of the body and in blood cell reproduction in the bone marrow. It contains glutathione which is one of the most potent anticarcinogens and antioxidants found within the body, thereby preventing damage to DNA and other

macromolecules. Asparagus had the highest glutathione content of the several foods. Asparagus has no fat, no cholestrol and low in sodium.

The acreage planted with the recommended asparagus cultivar in 1997was about 200 feddans which produced about 60 tons of spears but the acreage planted reduced presently to become about 70 feddans. One of the most important factors affects spear yield and quality is the cultivated cultivar. In the last ten years, several asparagus cultivars were imported and cultivated in several places in Egypt (Hassan, 2001).

The genus *Asparagus* was included in the"Species Plantarum "of Linnaeus, (1753) with 12 species listed. Roemer and Schultes, (1829) chose to treat *Asparagus* as a genus within the family of **Liliaceae**, which subdivided into three separate genera: *Myrsiphyllum* Willd., *Asparagus* L. with unisexual flowers and *Asparagopsis* Kunth with bisexual flowers, linear to filiform cladodes and flowers arranged in fascicles or racemes.

In the most recent monograph on the genus, Baker (1875) recognized only one genus *Asparagus*, but sub divided it into three sub genera: *Asparagus* Baker, *Asparagopsis* Kunth and *Myrsiphyllum* Willd.

This treatment of the genus was followed by all subsequent taxonomists until Dahlgren and Clifford (1982), after Huber (1969, 1977), revived the idea of three separate genera. At the same time they transferred *Asparagus* from Liliaceae to Asparagaceae, in which it included the three genera: *Asparagus*, *Asparagopsis* and *Myrsiphyllum*.

Therefore, modern taxonomists have placed the genus *Asparagus* in family Asparagaceae of Order Asparagales rather than in Liliaceae, then, the family Asparagaceae contains two other genera, *Asparagopsis* and *Myrsiphyllum*, and about 370 species, most of them are cultivated as ornamental or medicinal plants (Ali and Khan, 2009).

Concerning the family Asparagaceae, Malcomber and Demissaw, (1993) determined that the characters used to separate the three genera were inconsistent and so pointed out that these genera should at best be treated as subgenera of the *Asparagus*. Then, the family Asparagaceae was proposed with only one genus *Asparagus*, and subdivided into two subgenera: *Asparagus* and *Myrsiphyllum.* Subsequently, Fellingham and Meyer (1995), who investigated southern African *Asparagus* species, did not accept the existence of subgenera. They determined that the family is recognized by having scale– like, cladodes (leaf –like stems) and axillary flowers or axillary inflorescences. Perennial herbs or subshrubs with short rhizomes . Aerial stem: generally much branched. *Cladodes:* axillary, solitary or fascicled, green, flattened, triquetrous, subterete or filiform. L*eaves*: reduced to scales, scarious, often with a spine at the base. *Flower*s: bisexual or unisexual, solitary or in clusters or racemes. *Perianth*: in two series of three segments each. S*tamens*: six; filaments usually adnate to perianth segments; anthers usually dorsifixed. *Ovary*: trilocular. *Fruit:* a berry.

Although *Aspargus officinalis* L. is chiefly known as a vegetable herb as mentioned above, little information about the botanical