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Research Paper

AUTECOLOGY OF *Origanum syriacum* A THREATENED PLANT SPECIES GROWING IN SAINT CATHERINE MOUNTAINS, SOUTH SINAI, EGYPT

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Abstract

The flora of South Sinai has been subjected to threats causing declines in population number and size. The present study focused on the conservation of the endemic medicinal plant species *Origanumsyriacum* subsp. *sinaicum* through studying of different ecological aspects; seed germination behavior against different treatments, seed storage behavior, moisture isotherm and ecological field conditions and distributions. Three hundred and twenty-six species were recorded in St. Catherine Protectorate in recent surveys. Among recorded species, 115 species (35.6%) are considered as medicinal species the specific threats facing conservation and sustainable use of these globally significant medicinal species.. The results showed that seventy seven species belonged to 28 taxonomic families were found in the one hundred and seventy seven stands including thirty species vulnerable, sixteen species are endangered, sixteen species are common, fourteen species are rare, seven species are endemic, and five species are critically endangered.Seed germination experiments were done for the studied species and revealed that the highest germination of *Origanumsyriacum* (23.8%) obtained when seeds were soaked in GA_3 (10 ppm) for 24h before sowing at room temperature, while the lowest percentage was that of hot water treatment. Data of vegetation and environmental variables were subjected to multivariate analyses using TWINSPAN for classification and CCA for ordination. Four main assemblages were recognized as a result of classification:1-*Teucrium polium* 2- *Chiliadenusmontanus*3- *Hypericumsinaicum* 4- *Origanumsyriacum* – *Menthalongifolia*. According to the present study, a sound conservation plant targeting medicinal plants in the study area (South Sinai) should including establishment of botanical garden for conservation *ex situ* and teaching purposes.

INTRODUCTION

*Origanum*is one of over 200 genera in the Labiatae (mint family), the genus includes culinary, fragrant, medicinal and ornamentalplants. *Origanum*is native tothe Mediterranean and Eurasia, and grow in mountainous areas withrocky, calcareous soil. Although Linnaeus first classified *Origanum*as a single genus, over the years, plants in the genus have been ordered under various botanical names including *Amaracus*, *Origanum*and *Majorana*(Ietswaart, 1980 and Talbert, 2004a). According to current estimates there are 44 species, 6 subspecies, 3 varieties (botanical varieties) (Talbert, 2004b) and 18naturallyoccurringhybrids (Kintzios, 2002).Because*Origanum* taxa are so variable and cross easily, there are hundreds of unclassified hybrids growing in gardens where close proximity encourages crossing that isn't likely in the wild (Talbert, 2004b).

The subspecies*Origanum* is endemic to anticlines of the northern Sinai and the lower and upper Sinai massif (Boulos, 2002 and Danin, 1983). Its distribution is correlated with exposure aspect and it reaches its optimal performance at NW aspects (Zaghloul*et al*. 2010a). Leaves have an aromatic odour with slightly bitter, very hot taste, and are used for various flavouring purposes. In folk medicine, dry leaves are used as spice, digestive, condiment and pain relief, and in treatments for stomach disorders, and diabetes. It has been integrated in a Bedouins' mixture of forty different herbs, which are collected during spring and used as a general recipe for improvement of the body health (Omran and Moustafa, 2006).

Dried *Origanum* leaves are used as antitussives, expectorants, sedatives anti-parasitics, anti-rheumatics and gastrointestinal complaints in folk medicine (Baser, 2002; El-Beyrouthy*et al*., 2008; Loizzo*et al.*, 2009). Recently, this plant has drawn more attention due to the antimicrobial, antifungal, insecticidal and antioxidative effects (Kusilic*et al*., 2004; Bakkali*et al.*, 2008; Azizi*et al.*, 2009). Also, the essential oil uses are more and more widespread as alternatives to synthetic chemical products to protect the ecological equilibrium.The leaves of *Origanumsyriacum*, a very popular Arab spice, have been used as an herbal (traditional) medicine, flavour, fragrance and for aromatherapy in the form of bath, massage, steam inhalation, and vaporization(Baytop, 1999;Dudai*et al*., 1999).

There are some studies on the essential oils from *Origanumsyriacum*leaves, **(**Tunc*et al*., 2000 and Baser*et al*., 2003).Thirteen componentsrepresentingalmost 98.21% of the essential oil of *Origanumsyriacum*leafwere characterized. The major components were: g-terpinene (27.79%), Carvacrol (26.97%), *p*-cymene (15.69%) and b -caryophyllene (12.59%). Baser *et al.* (2003) reported that *Origanumsyriacum*var. *bevanii*contained carvacrol (64.1%) and *p*-cymene (12.3%) as major components. On the other hand, it was reported that while essential oil from *Origanumsyriacum*originating from Israel contained thymol (59.87%) and carvacrol (80.17%) as a major component, the essential oil the same plant originating in Egypt only contained carvacrol as the major constituent (76.7%) (Fleisher *et al.*, 1991). It is well known that these sorts of variations are due to geographical origin, harvesting time and growing conditions.A number of threats to medicinal plants have been identified they include: over-cutting for fuel, over-collection, over grazing, tourism activities, feral donkeys, collection for scientific research, aridity and irregularity of rain fall, in addition to climate change and drought cycles.Our objectives of this study is; studying the distributional behavior of theendemic medicinal plants species*O. Syriacum* subsp. *sinaicum* and figuring out the seed characteristics, germination, storagebehavior, moisture content and moistureisotherms and its variation among populations in order to recommend appropriate *ex situ* conservation measurements.

STUDY AREA

Sinai Peninsulacovers an area of 61,000 Km^2. It is triangular in shape and is separated from the mainland of Egypt by the Suez Canal and the Gulf of Suez. It is continuous with the Asiatic continent for a distance of over 200 Km between Rafah on the Mediterranean Sea and Taba at the head of the Gulf of Aqaba.The study was carried out in St. Catherine protectorate in the area located between 34°00'to 33°50'east, and 28°29'to 28°34' north (Figure 1). The area is approximately 25 Km^2 and is characterized by high and rugged mountains that range between 1500 and 2641 m a.s.l. The temperature varies from summer to winter in a great extent with a high temperature of 37°C in July and a low temperature of -2.7°C in January.

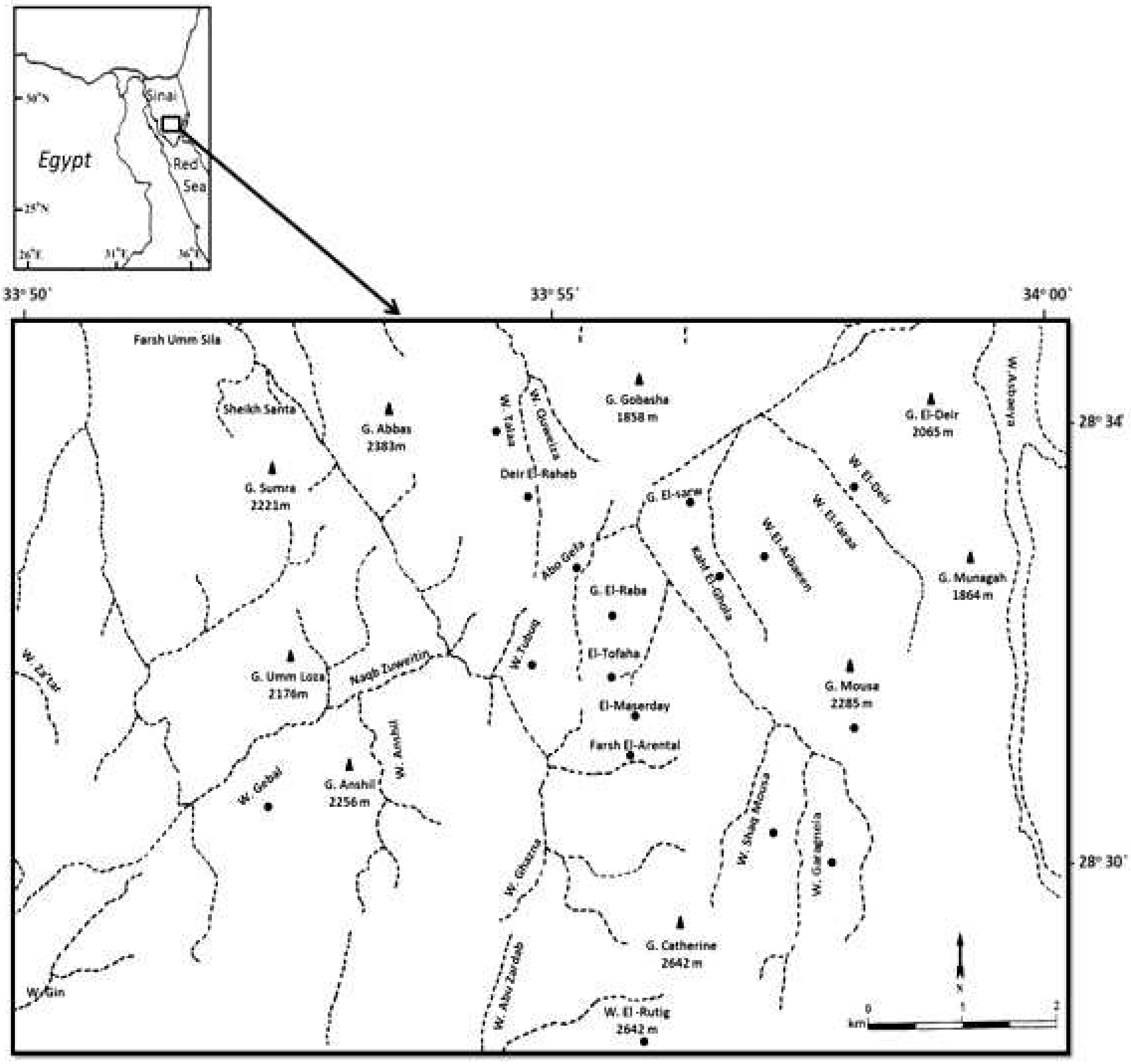

Figure 1: Location map of the study area (Saint Catherine) in the southern part of Sinai. Mountain tops (Gebel = G) are represented by (▲). Dashed lines indicate drainages into wadis (W) or valleys. Sampling sites are represented by (●).

MATERIALS AND METHODS

One hundred seventy-seven stands (5x5m) have been sampled in various major locations in the study area: Gabel El-Sarw (27 stands), Kahf El-Ghola area (33 stands), Abo Gefa (13 stands), El-Tofaha (33 stands), Gabel El-Raba (10 stands), Wadi El-Rutig (6 stands), WadiGebal (11 stands), Gebal Catherine (17 stands), WadiTalaa (2 stands), Farsh El-Arental (10 stands), Gabel Mousa (3 stands), WadiGaragneia (2 stands) and Wadi El-Maserday (10 stands). The number of stands selected in each location depended upon variations in environmental factors such as elevation, slope degree, and nature of soil surface. Presence of the study species was a pre-requisite for choosing locations. Each stands was characterized by a reasonable degree of visual physiographic and physiognomic homogeneity. At each stands, slope and exposure were measured. Canopy cover of each species was measured. Täckholm (1974) was followed for identification of plant species, while updating speciesnomenclature and life forms done following Boulos (2005).

To estimate the seed viability, a quick 24-hour viability test was applied. The isolated seed embryos were soaked in water for 24 hours and then in a diluted (1%) solution of 2, 3, 5-triphenyltetrazolium chloride for 24 hours, according to (Peters, 2000). Preliminary germination experiments were carried out at laboratory conditions to determine the germination behavior for each species. Then untreated seeds were tested for germination at 25°C ±2 in dark incubator and at 25°C ± 2 in light for 12 hours fluctuated with 15°C ± 2 in dark for 12 hours in fluctuating growth chamber. To study the effect of different treatments on the germination behavior of the studied species, pretreated seeds were tested for germination in the same conditions simultaneously with untreated (control). Different pretreatments were used including soaking in hot water (80°C) for 5 and 15 minutes, wet chilling at 5°C for different periods (2 weeks, 4 weeks and 8 weeks), soaking in 0.1 and 1% citric acid for 96 hours,in 10, 50, 100, 200, and 500 ppm gibberellic acid (for 24 hours), and in 1, 2, and 3% Calcium Carbonate ($CaCO_3$) for 30 minutes, then the seeds were washed thoroughly under tap water to remove all the acid residual.In most germination tests, four replicas of 25 seeds were used.

Moisture content was determined by weighing empty crucibles with lids and clearly labels with sample numbers.Three replicates were used for each sample.After adding the seeds, the crucibles were reweighed to estimate the fresh weight of the seeds, using approximately 0.2 gram of seeds in each crucible. Then the crucibles were placed in the oven for 4 hours at 130°C, and then the samples were let to cool in desiccators for 30 minute. Then, the crucibles were reweighed again to estimate the dry weight.Saturated salt solutions were prepared by adding the indicated salt to warm (about 40°C) distilled water with stirring until no more salt dissolves. Additional salt is added to ensure an excess of the saturating salt. The saturated solution is then cooled to ambient temperature and allowed to set for at least 24 hour before use.

After that the prepared saturated salt solutions are placed in labeled glass jar at least 20% of the total volume. Seeds were weighed (approximately 0.2 gm) and packed in tulle fabric and then placed in the jar above thesolutions. The jars then were sealed and allow enough time for seed moisture to equalize with the surrounding air. Seeds will either absorb or lose moisture depending on the gradient in water pressure between the seeds and surrounding air. When the weight of seeds remains unchanged, equilibrium moisture content is attained. Determining the equilibrium seed moisture content at each RH was carried out by oven-drying as described in the previous section. Put seeds in salt for a certain period of time 6 weeks after it germinated in Petri dishes to compare the percentage of germination moisture.

A number of soil samples per each stand were collected as a mixture of 0-25 cm depth for physical and chemical analysis according to Robertson *et al*. (1999). Moisture content, organic matter, Soil pH, EC, TDS and water holding capacity were measured. Particle size analysis was determined by dry sieving for the coarse sand and by pipette method for fine sand, silt, and clay (Richards, 1954). Inorganic carbonate in soil was analyzed using a volumetric calcimeter method (Loeppert and Suarez, 1996).

RESULTS

FLORISTIC COMPOSITION

Saint Catherine area is characterized by high diversity of plant species. Seventy-seven species were recorded in the studied 177 stands. These species belong to 28 taxonomic families. Compositae is the most represented family (15 species), followed by Labiatae (9 species), Caryophyllaceae (8 species), Leguminosae (6 species), Gramineae (5 species), Cruciferae and Scrophulariaceae (4 species for each), Boraginaceae and Zygophyllaceae (3 species for each), Polygonaceae and Resedaceae (2 species for each). Adiantaceae, Asclepiadaceae,Capparaceae, Dipsacaceae, Ephedraceae, Euphorbiaceae, Funariaceae, Geraniaceae, Guttiferae, Juncaceae,Moraceae, Papaveraceae, Plantaginaceae, Polygalaceae, Rosaceae, Rubiaceae and Umbelliferae are represented by only one species(Figure 2).

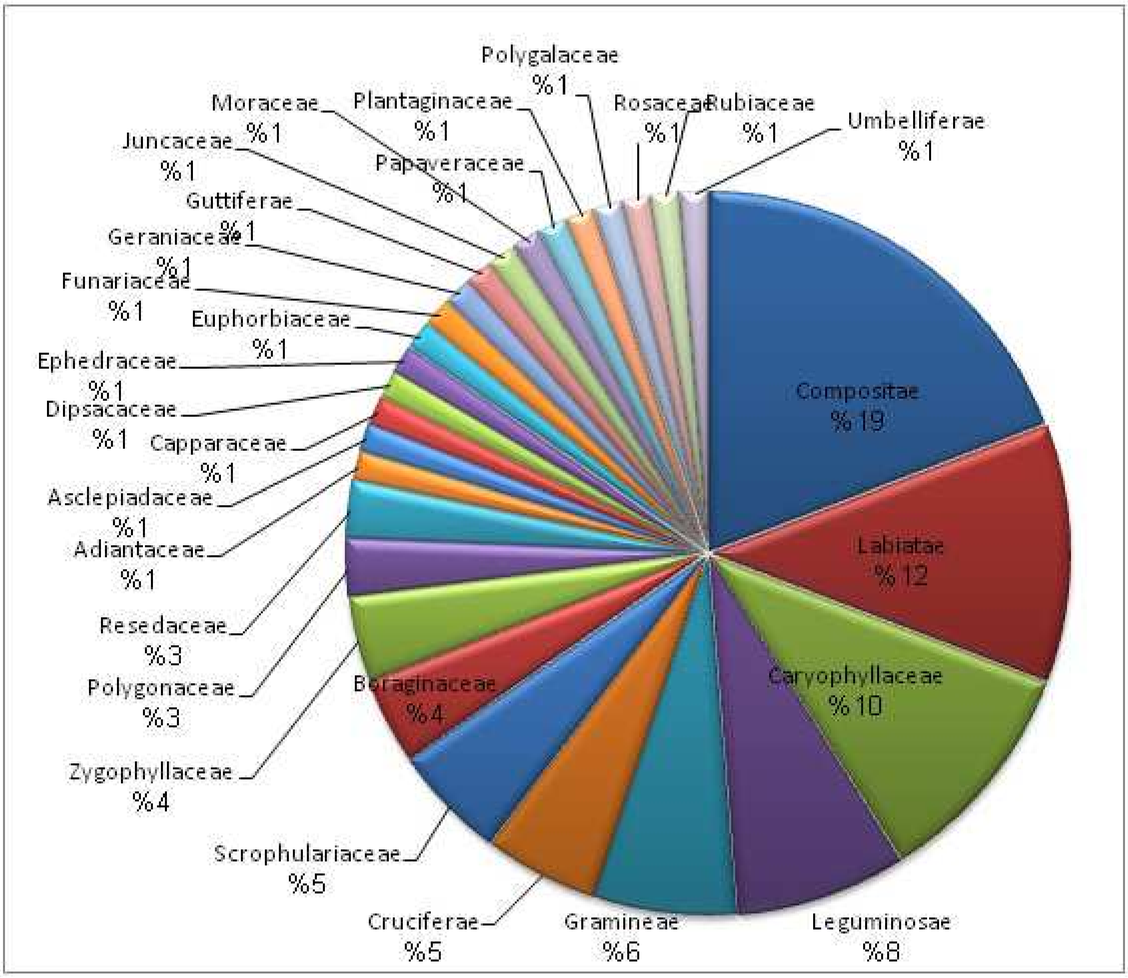

Figure 2: Representation of taxonomic families in collected species list during the study in Saint Catherine area.

The recorded species include 40% Geophytes(31 species), 21% Therophytes(16species), 21% Phanerophytes(16species), 15% Chamaephtyes(12species), and 3% Hemicryptophytes (2 species). Thirty species are vulnerable (34%),sixteen are endangered (18%), sixteen are common (18%),fourteen are rare (16%), sevenre endemic (8%), and five species are critically endangered(6%)

SEED VIABILITY AND GERMINATION

After had been soaked in dilute tetrazolium salt solution for 24 hours, 76% of the *Origanumsyriacum*seedss were revealed to be viable. When testing for germination in bulked seeds (mixed from different populations), the highest germination percentage (23.8%) in*Origanumsyriacum* resulted from soaking seeds in gibberellic acid (10 ppm) for 24 hours before germination in room temperature (Figure 3). Germinating seeds without any pre-treatment either in fluctuating temperature (15/20°C) or in room temperature resulted in very close germination percentages (23.7% and 23.5%, respectively).The lowest germination ratio was obtained after pre-treating seeds with hot water for 15 min. Generally, germination started after four days of sowing.No significant difference was detected by Mann-Whitney statistical test (P=0.5) in the germination rate of the seeds between different temperature.
Considering the variation between treatments, the maximumgermination of 86% (Mean= 20.5, Std. Dev. = 30.39) wasobtainedwhen the seedswere soaked in gibberellic acid(200 ppm) (Table 1).

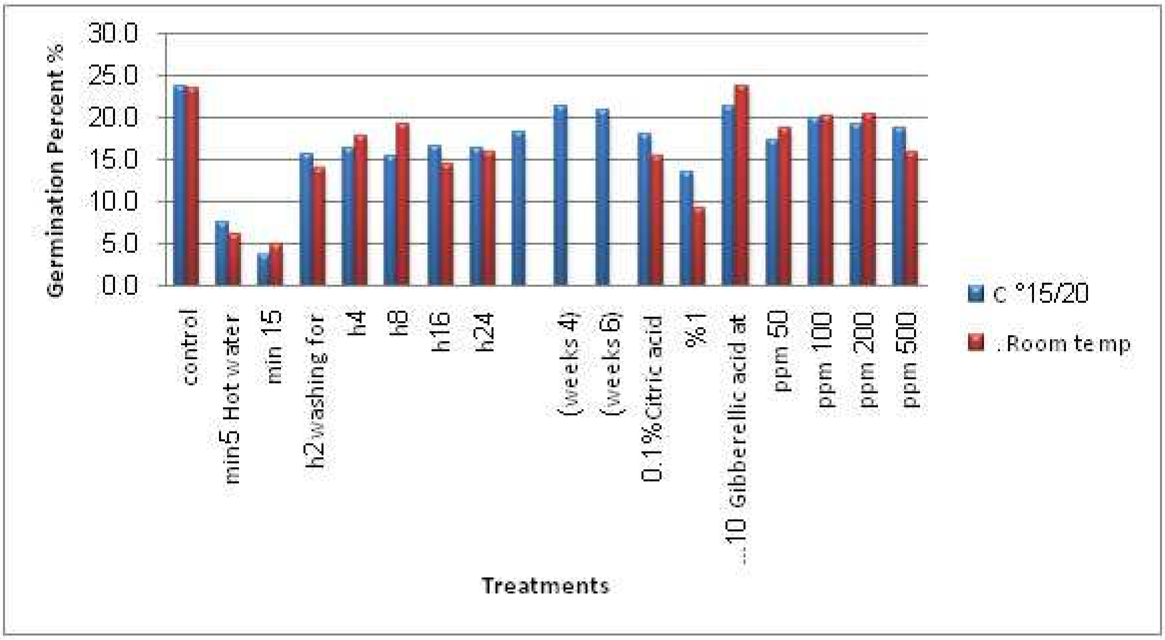

Figure 3: Germination percent of*Origanumsyriacum*with different pretreatments.

Table1: Summary statistics of germination behavior in *Origanumsyraicum* populations

Treatment	**Incubator 15-20° C**				**25° C**				**At Room temp.**			
	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.
Control	**0**	**84**	**23.7**	26.1	0	70	20.9	21.7	0	74	23.5	26.3
Hot water at 80 °C for 5min	0	20	7.5	1.1	-	-	-	-	**0**	32	62	95
Hot water at 80 °C for15min	**0**	**14**	**3.7**	5.2	-	-	-	-	**0**	**18**	4.9	**6.6**
Soaking in citric acid for 96h (0.1%)	**0**	**70**	**18.0**	**23.0**	**0**	**50**	**16.0**	**19.8**	0	50	15.4	17.9
Soaking in citric acid for 96h (1%)	**0**	**50**	**13.5**	**18.1**	**0**	**50**	**8.8**	**15.4**	0	42	9.2	13.8
Washing in tap water for 2h	**0**	**64**	**15.5**	**18.1**	-	-	-	-	0	**54**	14.0	19.0
Washing in tap water for 4h	**0**	**50**	16.3	17.9	-	-	-	-	0	48	17.7	17.4
Washingin tap water for 8h	**0**	**66**	**15.4**	18.0	-	-	-	-	0	**68**	19.2	**21.6**
Washing in tap water for 16h	**0**	**40**	**16.6**	15.6	-	-	-	-	0	48	14.5	**17.5**
Washing in tap water	**0**	**58**	**16.3**	**20.0**	-	-	-	-	0	66	**15.8**	**21.9**

for 24h												
Wet chilling at 5°C for 2weeks	**0**	**66**	**18.3**	**19.8**	-	-	-	-	-	-	-	-
Wet chilling at 5°C for 4weeks	**0**	**60**	**21.4**	**23.7**	-	-	-	-	-	-	-	-
Wet chilling at 5°C for 6weeks	**0**	**74**	**20.9**	**6.3**	-	-	-	-	-	-	-	-
Soaking in GA_3 for 24h at 10ppm	**0**	**80**	**21.2**	**26.4**	-	-	-	-	**0**	**82**	**22.0**	**29.2**
Soaking in GA_3 for 24h at 50ppm	**0**	**72**	**17.2**	**24.3**	-	-	-	-	**0**	**84**	**18.8**	**28.3**
Soaking in GA_3 for 24h at 100ppm	**0**	**72**	**20.0**	**24.2**	-	-	-	-	**0**	**84**	**20.2**	**27.6**
Soaking in GA_3 for 24h at 200ppm	**0**	**80**	**19.2**	**25.1**	-	-	-	-	**0**	**86**	**20.5**	**30.3**
Soaking in GA_3 for 24h at 500 ppm	**0**	**68**	**18.6**	**24.2**	-	-	-	-	**0**	**74**	**15.8**	**23.7**

SEED MOISTURE CONTENT AND MOISTURE ISOTHERM

The moisture content of each sample was determined in a drying oven at 130°C for 4 hours (AOAC, 1990).The results showed that seeds moisture contentfor *Origanumsyriacum*, was 7.5%. Themoisture content of *Origanumsyraicum*, was equilibrated by incubation in six different saturated salt solutions (LiCl, NaCl, Mg Cl, K_2CO_3, Na OH, and KCl) at 25ºC(Figure 4).The targeted moisture degrees were ranging from 7.5 to 85% according to the used salt (Greenspan, 1976).Equilibrium moisture content was reached after 6 weeks in different salts.The highest rate of germination after incubating the seeds with different salts for 6 weeks at 25°C for *Origanumsyraicum* was 40% in K_2CO_3 (Figure 4). As evidenced by the Pearson correlation coefficient, thelinear correlation between germination and the moisture content in the seeds of *Origanumsyriacum*(P = 0.5) was non-significant.

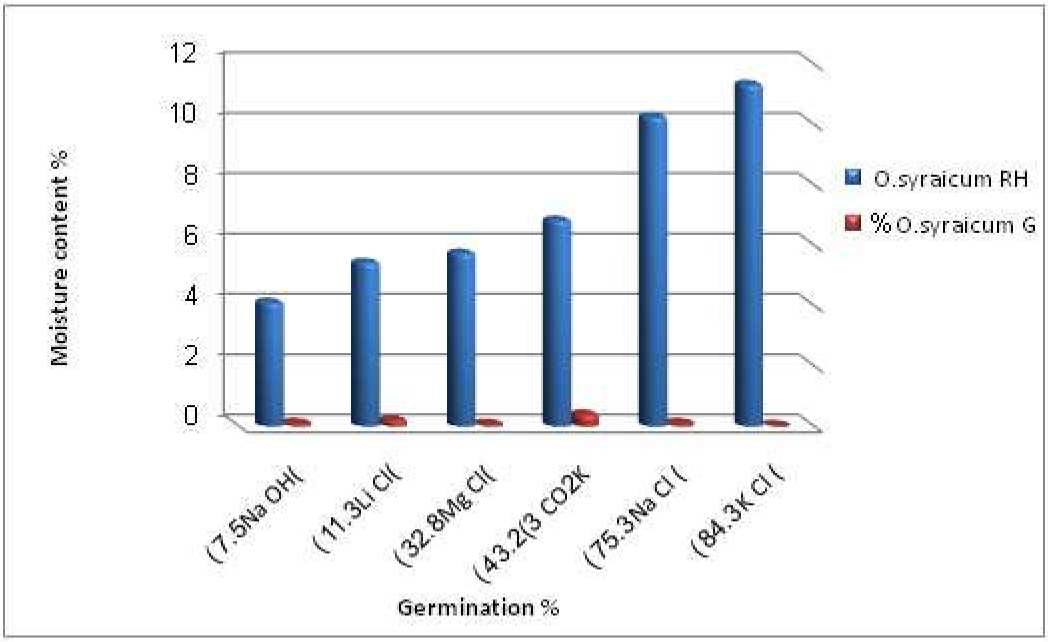

Figure 4: Seed moisture content and germination after incubation with different salts for 6 weeks in *Origanumsyraicum*.

QUANTITATIVE VEGETATION ANALYSIS

Preliminary inspection of data

The study included twenty-two physical and chemical environmental factors as well as habitat features. These factors can be classified into three main groups. The first groupencompasseshabitat features which include landform type, exposure degree, elevation (m a.s.l.) and slope degree. The second group is thephysical characteristics of the soil and includes nature of soil surface, soil texture, soil moisture content, and organic matter content. The parameters of this group are represented as percentages of weight except nature of soil surface which is represented as a percentage of area. The third group which is the chemical characteristics of soil includes six parameters; acidity (pH), electric conductivity (EC), calcium, magnesium, bicarbonate and chloride, which arerepresented as a percentages.

Classification of stands

The TWINSPAN classification of one-hundred seventy-seven stands and seventy-seven species resulted in four main vegetation groups(Figure 5). These groups are separated at the second level of classification where the main dominantspecies are*Teucriumpolium, Chiliadenusmontanus, Hypericumsinaicum*and*Origanumsyriacum-Menthalongifolia.*

The four vegetationgroupswerenamed according to the dominant species based on their presence percentages in each group:

Assemblage I: ***Teucriumpolium***
Assemblage II: ***Chiliadenusmontanus***
Assemblage III: ***Hypericumsinaicum***
Assemblage IV: ***Origanumsyriacum-Menthalongifolia***

Ranges and means of environmental variables of stands supporting each groupweretabulated in table 2 which reveals a general idea about the magnitude of variation in the environmental factors among the four assemblages.The four assemblages can be described as follows:

Assemblage I: *Teucriumpolium*

Assemblage I is dominated by *Teucriumpolium* (98.9%) withaverage abundance 1.43. The most importantassociatedspecies include *Chiliadenusmontanus*(89.0%)with average abundance1.09*,* *Artemisiaherba-album*(83.9%) with average abundance1.43,*Matthiolaarabica*(76.0%) with average abundance1.43,*Stachysaegyptiaca*(67.5%) with average abundance1.05, and*Galiumsinaicum*

(61.2%) with average abundance1.01. This assemblage is found on ridges with fissures, steep slope, gorge and terraces habitats of G.El-Sarw, Kahf El-Ghola, W.El-Tofaha, Abo Gefa, W.El-Rutig, W.Gebel and G.El-Rabah(Photo 1).

This assemblage is characterized by average altitude of 1746m.a.s.l. with exposure degrees ranging from15°to 340°(North) and the average slope degree is 21.75° with high organic matter content (18.53%), gravel percentage (48.98%), pH (8.16%) and cobbles (11.73). Mostsites where this assemblage was recorded have a high boulders (54.42%) covering the surface area, while the other parameters such as coarse sand, medium sand, fine sand, silt and clay, EC, Ca, Mg, HCO_3, Cl, are moderate in theirrange.

Assemblage II:*Chiliadenusmontanus*

This assemblage is dominated by *Chiliadenusmontanus* (100%) with average abundance 2.22. The associating species include *Teucriumpolium* (98.4%) with average abundance 1.28, *Stachysaegyptiaca* (48.5%) with average abundance 1.06, *Plantagosinaica* (47.5%) with average abundance 1, *Origanumsyriacum* (45.2%) with average abundance 1.28, and*Tanacetumsinaicum* (34.5%) with average abundance1.05.

This assemblage is high terraces with fissures and ridges with fissures steep slope with fissures. It is found in all sites except W. Garagneia(Photo 1). In this group the altitude is 1813 m. with exposure degree ranging from 20° to 340°(North, North-Western, South-Eastern) and the slope degree is 45.18°.This assemblage is characterized by low organic matter mean percent (3.13%) while the other parameters landform, slope degree, exposure degree, elevation, gravel, coarse sand, medium sand, fine sand, silt and clay, pH, electrical conductivity, moisture content, calcium, magnesium, bicarbonate, chloride, and nature of soil surface are moderate in its range.

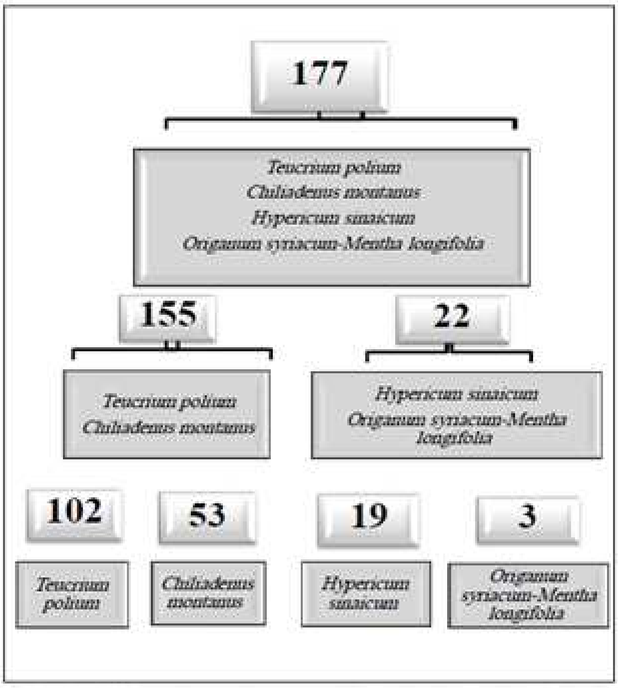

Figure5: The TWINSPAN four main vegetation groups resulted fromtheclassification of 177 stands based on the cover of77 plant species.

Photos 1: The plant species of the vegetation assemblages of the TWINSPAN; (A)*Teucriumpolium* (I) at wadi El-Tofaha, (B) *Chiliadenusmontanus* (II)at wadi El-Rutig,(C) *Hypericumsinaicum* (III)at Al-Maserdayand (D) *Origanumsyriacum-Menthalongifolia*(IV)at wadiGaragneia.

Assemblage III:*Hypericumsinaicum*

Assemblage III is dominated by*Hypericumsinaicum* (91.7%) with average abundance 1.05. The associating species include *Menthalongifolia* (81.5%)with average abundance 1.34,*Teucriumpolium* (77.4%)with average abundance1,*Alkannaorientalis* (57.1%)with average abundance1,*Juncusacutus*(57.1%)with average abundance 1,*Ficus pseudo-sycomorus*(56.5%)withaverage abundance1.2,*Stachysaegyptiaca*(50.6%) with average abundance 1,*Plantagosinaica*(50%)with average abundance 1, and *Verbascumsinaiticum*(47.6%) with average abundance 1.12.

This assemblage is found in gorges at springs and steep slopes with fissuresof W.El-Tala'a, W. Gebel, G.Catherine, Al-Maserday, W. El-Tofaha and G.Mousa(photos 1). This assemblage is characterized by average altitude of 1762 m. with exposure degree ranging from20^{o} to 340^{o} (North, North-Western, South-Eastern)and the slope degree is (30.23^{o}).Most sites where this assemblage was recorded have a high percentage of boulders (68.09%) covering the surface area and the soil has a high medium sand percentage(39.00%), while the other parameters are moderate in its range.

Assemblage IV:*Origanumsyriacum - Menthalongifolia-Hypericumsinaicum*

This assemblage is co-dominated by *Origanumsyriacum*-*Menthalongifolia*-*Hypericumsinaicum*(100%) with average abundance 2.33, 1and 1 respectively. The associating species include*Galiumsinaicum*(33.3%)with average abundance3, *Phlomisaurea* (33.3%) with average abundance 2,and *Verbascumsinaiticum*, *Adiantumcapillus-veneris*and*Poasinaica*(33.3%) with average abundance1.

This assemblage is found on slopes with fissures habitats of Al-Maserday and W. Garagneia. This assemblage has average altitude of 1876m.a.s.l. with exposure degree ranging from 20^{o} to 120^{o}(North, North-Eastern) and average of slope degree of 13.33^{o}.This assemblage is characterized by lowest (medium sand)(26.07%), fine sand (15.45%), moisture content

(1.13%), and stones percentage (2%).Most sites where this assemblage was recorded have a low percentage ofboulders (32%) covering the surface area. This assemblage is characterized by high coarse sand(46.39%), silt and clay (12.08%), calcium (23.84%), magnesium (8.6%), bicarbonate (5.88%), chloride (16.88%), and gravel percentages (19.14) and high electricalconductivity (2640.33).

3- Classification of species

The TWINSPAN technique revealed that all species can begrouped into seven groups at the third level of classification. The first group comprises onespecies includes;*Chiliadenusmontanus,*the second group comprises four species includes *Echinopsspinosus,Gomphocarpussinicus,Stachysaegyptiaca,Teucriumpolium.* The third group comprises fourty–fourspecies including *Achilleafragrantissima*,*Andrachneaspera*, *Arenariadeflexa*, *Atraphaxisspinosa* and*Bufoniamulticeps*. The fourth group contains eight species includes;*Ballota undulate*, *Centaureascoparia,Seriphidiumherba-album, Fagoniamollis, Gymnocarposdecandum, Matthiolaarabica, Onopordumambiguum, Teucriumpolium.* The fifth group comprises only one species includes*Alkannaorientalis.* The sixth group comprises fifteen species includes*Adiantumcapillus-veneris,Artemisia judaica,Capparisspinosa, Crateagus x sinaica,Cynodondactylon, Ficus pseudo-sycomorus, Funariasp,Farsetiaaegyptia, Hypericumsinaicum, Juncusacutus, Menthalongifolia, Nepetaseptemcrenata, Verbascumsinaiticum*, etc.The seventh group comprises of only four species.

4- Stands-environmentrelationship

CCA shows the species-environmental variables relationships by calculating axes that are products of the species composition and linear combinations of the environmental variables. To explain these relationships CCA axes number I and II is considered in the interpretation. The reason is that the eigenvalues of the CCA axis I is (0.352) and the CCA axis II (0.211) and the CCA AxisIII (0.187).

Stands were classified by TWINSPAN technique at the second level into four community types (assemblages). The ordination diagram (Figure 6) shows the position of these assemblages and their interrelation with environmental factors. The first assemblages (*Teucriumpolium*) is found in the center of the diagram and associated with sand and silt fractions of soil texture, elevation, exposure, slope, EC, calcium, HCO_3, Cl, and gravel.It occurs along axis1 and axis2 and so it occupies thehigher left-hand corner in axis1-axis2 plane. The assemblages II, III and IV(*Chiliadenusmontanus*, *Hypericumsinaicum* and *Origanumsyriacum-Menthalongifolia*) occur along axis1 and axis2 and so it occupies the lower right-hand corner in axis1-axis2 plane of the diagram.

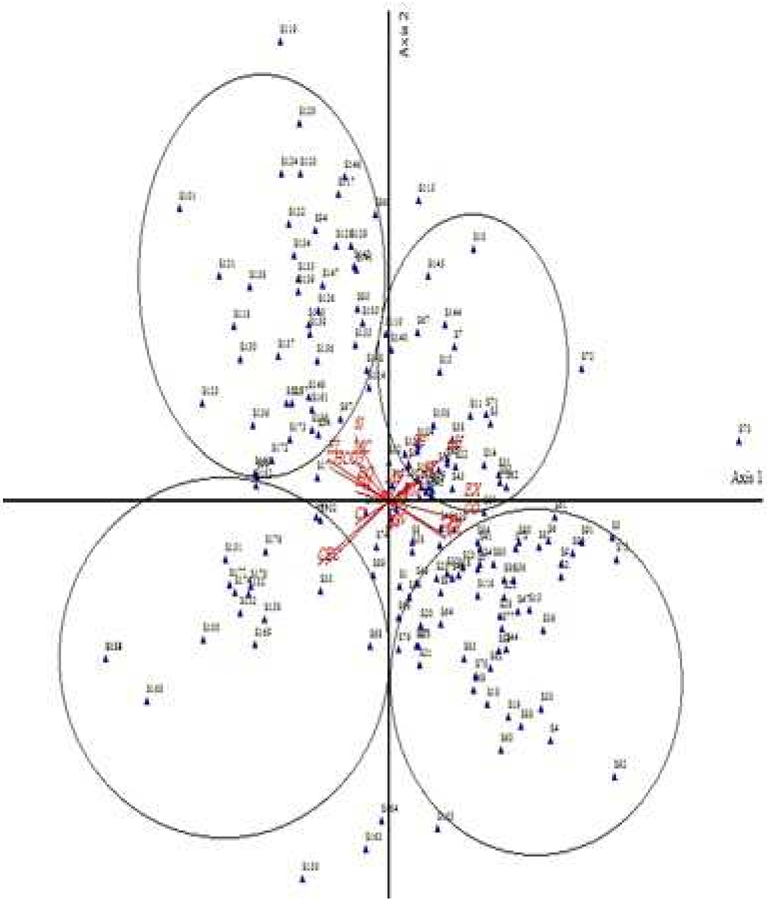

Figure 6: Output of Canonical Correspondence Analysis (CCA) diagram (axis1 – axis2 plane). Thestands are representedby (**Δ**).

5- Species - environment relationship

In the ordination diagrams (Figure 7) twenty-two environmental factors landform type, exposure degree, elevation (m), slope degree,nature of soil surface, soil texture, soil moisture content, organic matter content,acidity (pH), electric conductivity (EC), calcium, magnesium, bicarbonate and chloride.

In this graph species as *Heliotropiumarbainense*, *Sileneleucophylla*, *Stachysaegyptiaca* exhibit high correlation with calcium, electrical conductivity(EC), *Hypericumsinaicum*,*Origanumsyriacum*, *Menthalongifolia, Phlomisaurea,* while are not correlated, while species as *Poasinaica*, HCO3,exhibit high elevation, magnesium, chloride, high slope, boulders, moisture content. Species as *Zillaspinosa* are not correlated. Other species as *Teucriumpolium* exhibit high correlation with areas with high exposure, silt and clay, pH, medium sand, coarse sand , gravels, while other as,*Gomphocarpussinicus*, *Tanacetumsinaicum* are correlated. While other species as *Cotoneaster orbicularis* is not correlated.

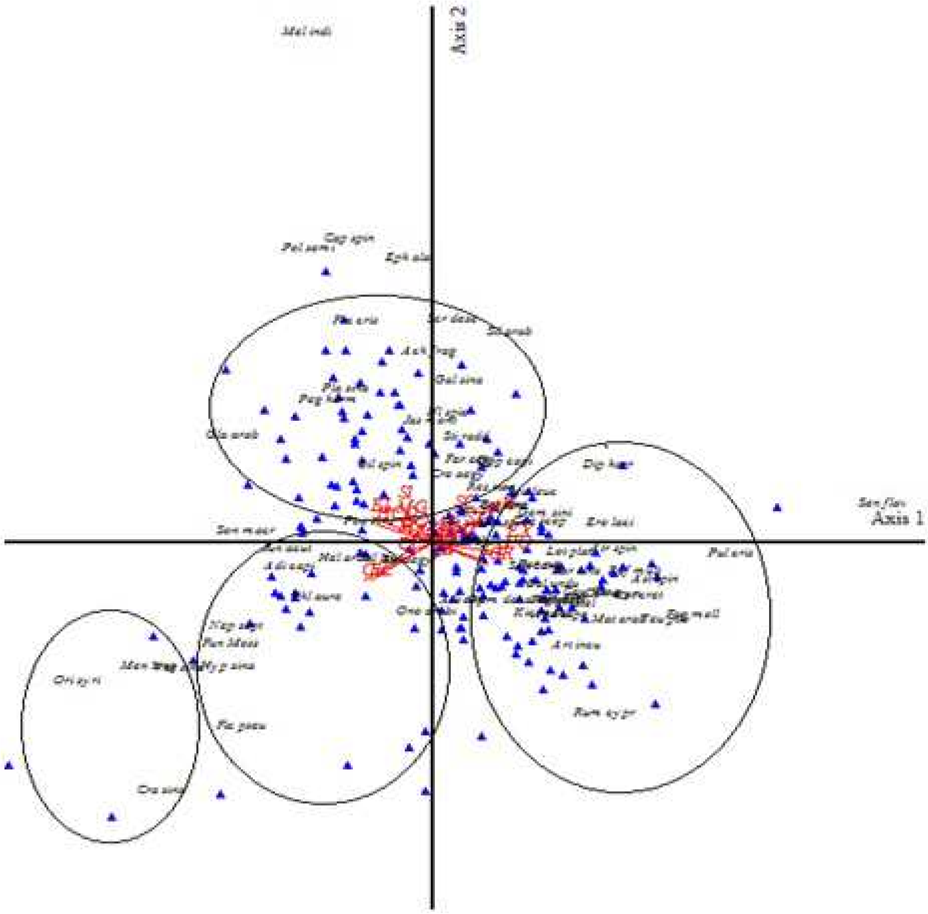

Figure 7: Ordination (CCA) diagram (axis1-axis2 plane) with plant species represented as (Δ) and environmental variables as centroid lines (Abbreviations are listed in table 4).

DISCUSSION

Sinai Peninsula is floristically one of the richest of all phytogeographical regions of Egypt.Contact with different floras, past climatic changes, and present local influence of habitat could favor plants from different floras and increase the number of species (Danin, 1978).According to Boulos (1995) species growing in Sinai belong to 121 families comprising 742 genera. Out of these, 63 species are endemic distributed in different phytogeographical regions of Egypt. More than 65% of these endemic species (41) occur in Sinai: 25 species in Sinai only and 16 species in Sinai and other regions of Egypt (Boulos, 2005). Most of the endemic species of Sinai (>70%) are recorded from the Southern mountainous area.

The mountains (encompassing the study area) represent a great harbor of endemism (Zohary, 1973; Shmida, 1984). In this area, 33 species are endemic, and another four endemic species are known from Sinai and other regions in Egypt (Boulos, 1995). This area has a wetter climate than that of most Sinai that influenced by the orographic impact of the high elevation of the mountains (Moustafa*et al*., 2001a).

The results of vegetation survey of the present study identified 77 plant species during the study period in the chosen stands. The identified species belong to 27 families. Compositae, Labiatae, Caryophyllaceae and Leguminosae are the families that are represented by the largest number of species, respectively. Zaghloul (1997) identified 132 species throughout the area of Saint Catherine mountainous area belonging to 31 family including Compositae, Labiatae and Gramineae.

Although the endemic species represent 3.2% of the total flora of Sinai (Danin, 1986) and 3.8% of the upper Sinai massif flora (Danin, 1986 and 1987), in the present study,fromthe identified 77 species, 7 species are endemic according to Täckholm (1974) and Boulos (1995,1999,2000,2002,and 2005) with a percentage of 10%. On the other hand,Zaghloul(1997) identified 13 endemic species (12.2%).

The seventy-seven recorded species included thirty species vulnerable, sixteen species are endangered,sixteen species are common, fourteen species are rare, seven species are endemic, and five species are critically endangered.Within these threatened species there are thirteen medicinal species are vulnerable(*Achilleafragrantissima*, *Alkannaorientalis, Artemisia judaica,Chiliadenusmontanus, Ephedra alata,Lactucaspinosa,Plantagosinaica, Pituranthostortuosus,Scrophulariasinaica,Teucriumleucocladum,Teucriumpilosum, Trigonellastellata* and *Zillaspinosa*),ten medicinal species are endangered (*Andrachneaspera,Astragalusspinosus, Atraphaxisspinosa,Glauciumarabicum,Juncusacutus, Menthalongifolia, Melilotusindica,Nepetaseptemcrenata, Teucriumpolium*and *Verbascumsinaiticum*), eight medicinal species are rare (*Adiantumcapillus-veneris*,*Centaureascoparia*, *Ficus pseudo-sycomorus*,*Francoeuriacrispa*,*Gomphocarpussinaicus*, *Gypsophillacapillaries* subsp.*Antari*, *Polypogonsemiverticillata, Pulicariacrispa*) and four medicinal species are critically endangered (*Bufoniamulticeps*, *Hypericumsinaicum*, *Origanumsyriacum* subsp. *sinaicum*and *Polygala sinaica*).

To understand the behavior of the study species along the environmental gradient, the collected vegetation data were subjected to multivariate analysis techniques, that classification by TWINSPAN computer program and ordination by CAA computer program. In general, distribution of these vegetation groups or plant communities were more related to altitude, slope degree, exposure degree, soil moisture, soil organic matter, sand, silt and clay fractions and gravel percentage rather than to soil reaction (pH and EC).

These findings are in agreement with many previous studies indicated that distribution of plant communities in arid ecosystems are controlled by edaphic conditions, physiographic features, and topographical irregularities, which all act through modifying the amount of available moisture (Kassas and Batanouny, 1984; Salama and Fayed 1989 and 1990; El-Ghareeb and Shabanna, 1990; Salama and El Naggar, 1991, Moustafa and Klopatek, 1995 and Salama*et al.,* 2005). The main results of the vegetation analysis identified four main assemblages were;*Teucriumpolium* is the main significant species characterizing vegetation assemblage I as while the important species are *Chiliadenusmontanus*, *Artemisia herba-album*, *Matthiolaarabica*, *Stachysaegyptiaca* and *Galiumsinaicum*. This assemblage *Teucriumpolium* is found at elevation (1746 m a.s.l) on ridges with fissures, steep slope, gorge and terraces habitats and North exposure, and characterized by having the highest percent of high organic matter content, gravels percentage, pH, and cobbles. This assemblage characterized a high percentage of boulders covering the surface area.

Chiliadenusmontanus assemblage, associated with *Teucriumpolium*, *Stachysaegyptiaca*, *Plantagosinaica, Origanumsyraicum* and *Tanacetumsinaicum* are associated species, occupies habitats of different landforms with north, north-western, south-eastern aspects with altitude of 1762 m a.s.l. The prominent characters of this assemblage are the low organic matter.

In the third assemblage, *Hypericumsinaicum* is the dominant while *Menthalongifolia*, *Teucriumpolium*, *Alkannaorientalis*, *Juncusacutus*, *Ficus pseudo-sycomorus*, *Stachysaegyptiaca*, *Plantagosinaica* and *Verbascumsinaiticum* are the most prominent associated species. This assemblage is usually found in a very narrow scope of environmental factors with exposure north, north-western, south-eastern, high boulders and high medium sand percentage.

Origanumsyriacum- *Menthalongifolia* assemblage includes *Hypericumsinaicum*, *Galiumsinaicum*, *Phlomisaurea* and *Verbascumsinaiticum*, *Adiantumcapillus-veneris* as associating species, is very restricted to main wadiGaragneia and Al-Maserday parts and the slope with fissured habitats. This assemblage is found on north, north-eastern exposure, the prominent characters of this assemblage are the low medium sand, fine sand, moisture content, cobbles and stones. This assemblage characterized a high percentage calcium, magnesium, bicarbonate and electrical conductivity. Moustafa (1990) recorded *Origanumsyriacum* - *Plantagoarabica* assemblage as a disjunct assemblage. Moustafa and Zaghloul (1993) recognized a cluster of *Tanacetumsantolinoides* - *Origanumsyriacum* assemblage, *Origanumsyriacum* - *Fagoniamollis*, and *Menthalongifolia* - *Origanumsyriacum* as disjunct assemblages.

According to Baskin and Baskin (2004), different germination behaviors were detected that can be attributed to the conditions under which each of the species grows. The release of dormancy and promotion of germination in unfavorable conditions is achieved by a variety of promontory treatments, including pre-chilling, light, GA3 which are usually effective in species of the family Labiatae (Ellis *et al*., 1985; Takano *et al*., 1990).

In present study, the results of germination *Origanumsyriacum* seeds, it was obvious that fluctuating temperature regime resulted in higher germination percentage than the constant temperature.

Our results showed that maximum germination rate of *Origanumsyraicum* seeds in incubator at constant temperature of 15 ± 2°C reached 84%, while it was only 74%when seeds weregerminated in room temperature. Washing seeds of *Origanumsyraicum* in tap water for 8h resulted in 68% germination in room temperature, while it was 66% when seeds were germinated in incubator at constant temperature of 15 ± 2°C. Increasing GA3 concentration resulted in increased germination percentage.Figuérédo*et al* ., (2005)showed that germination of *Origanumsyriacum* seeds in room temperature resulted in germination ratio (74%) after wet chilling for six weeks. Higher germination rate (>90%) resulted by pre- chilling seeds in light conditions and fluctuating temperature for eight weeks.

Conservation of plant genetic resources comprises two types of approach; *in situ* and *ex situ* conservation. *In situ* conservation has been defined as the conservation of whole ecosystems and natural habitats where wild or cultivated species are maintained and may continue to evolve. *Ex situ* conservation maintains germplasm outside its original habitats, in the form of whole plants in botanical gardens and field genebanks, seeds as in seed genebanks, or certain other parts of the plant such as roots, dormant buds, pollen, explants as in vitro genebanks, or possibly as DNA. Knowledge of the seed storage behavior of a target species is required in order to determine whether or not seed storage is suitable as a method of genetic conservation, and how to handle seeds during collection and germplasm exchange (Hong *et al.*, 1996).

The results of seed moisture content and the response germination rates of seeds after incubation in different moisture present leveled a clue that the seeds of the studied species may be classified as orthodox. Orthodox seeds can be dried, without damage, to low levels of moisture content and, over a wide range of environments, their longevity increases with decrease in seed storage moisture content and temperature in a quantifiable and predictable way (Roberts, 1973). The latter is defined by the improved seed viability equation (Ellis and Roberts, 1980). In essence, in order for seed storage behavior to be defined as orthodox two conditions must be satisfied:

First; matureseeds survive desiccation to low moisture contents, at least to 2-6% depending on the species. Above this value (but within the air-dry range) there is a negative logarithmic relation between seed moisture content and longevity (Ellis and Roberts 1980; Ellis *et al*., 1988; Ellis*et al*., 1991).

Second;withregard to the effect of temperature on longevity, there is a negative relation between temperature (at least between –20 and 90°C) and seed longevity at constant moisture content (Roberts, 1973). The precise form of this relation is a negative semi-logarithmic relation modified by a quadratic term such that the relative benefit to longevity of a reduction in temperature declines the cooler the temperature (Ellis and Roberts 1980;Ellis *et al*., 1985; Ellis, 1988).

Storage environment is obviously very important in extending the life of seeds. The general objective is to reduce the metabolism of the seeds as much as possible without damaging them and to prevent attack by microorganisms. The ideal metabolic rate in storage will conserve as much of the stored food reserves in the seeds as possible, yet operate at a level that maintains the integrity of the embryos. Seed moisture is the most important factor in maintaining viability during storage; it is the primary control of all activities. Metabolic rates can be minimized by keeping seeds in a dry state. For true orthodox and sub-orthodox seeds, optimum moisture contents for storage are 5 to 10%(Hong *et al.*, 1996).

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