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Morphological, Physiological and Biochemical Characterization of Some Medicinal Plants

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Abstract

Morphological, physiological and biochemical characteristics of some Palestinian medicinal plants including *Teucrium polium*,*Coridothymus capitatus*, *Varthemia iphionoides*,*Capparis spinosa* and *Paronychia sinaci* were studied at two sites through the four seasons. The variables were compared between the four seasons of 2007 year, and spatially between the two study sites (Al Daherya and Sorif). Results showed significantly higher leaf area, leaf length and width, plant height and average radius in Sorif than in Dahrya during summer and spring. Stomatal density was significantly higher in Dahrya than Sorif and in spring than autumn. Total chlorophyll content was higher in Dahrya than Sorif in all plants, but difference was not significant. The chemical analysis detected 98 different components in *Teucrium polium* essential oil (alpha pinene, 3-thujene, beta pinene, beta myrcene, D-lemonene, 2(10)pinene, 1,3,6-octateriene, germacrene B). In addition, there were quantitative and qualitative differences among sites and seasons in the composition of the essential oil of *Teucrium polium*. Microhabitat also revealed an effect on the essential oil composition. Morphological and physiological attributes of Palestinian medicinal plants differ upon changes in environmental conditions. These plants showed different strategies such as lower leaf area, lower plant height and radius, higher stomata number and higher total chlorophyll content as adaptations to drought stress.

Chapter one: Literature Review

1.1 Flora of Palestine**:**

Palestine's biodiversity (including viruses) comprises about 3 % of the global biodiversity. This rich biota is composed of an estimated 2,750 species of plants in 138 families (Danin, 2004), which include 60 species of natural trees and 90 species of bushes distributed all over Palestine. They encountered 149 endemic plants that do not exist in other places in the world (ARIJ, 1997; Ali-Shtayeh, 1995), and the most common plant species are *Pistacia palaestina, Olea europea, Quercus calliprinos, Pinus halapensis, Anemone coronaria, Artemisia herba alba, Calendula arvensis, Chrysanthemum coronarium, Avena sterilis,* and *Adonis cupaniana*.(ARIJ, 2007). These plant species belong to several plant families such as Compositae, Graminea, Leguminaceae, Crucifera, Labiatae and many others (Mohammad, 2005).

1.2 Medicinal plants in Palestine :

For thousands of years herbal remedies and alternative medicines are used through out the world. Over 20000 medicinal herbs were recently inventoried by the World Health Organization (WHO, 2003), and about 250 species had been intensively studied. Traditional medicines, particularly herbal medicines, have been increasingly used worldwide during the last two decades. About 70-80% of the world population, particularly in the developing countries, rely on non-conventional medicine in their primary healthcare as reported by WHO (2003).

Said *et al*. (2002) conducted a survey among the most well known Arabic indigenous herbal practitioners in Palestine and found that there are 129 medicinal plant species still in use at their study area, most of these species grow naturally in the different regions and their properties are important in traditional Arabic medicine. The other important finding is that more than 30% of these herbs are rare.

Ali-Shtayeh, *et al*. (2000) curried out a survey in the West Bank and as a conclusion they enlarge the genetic resources available in this important part of the world and could offer an important potential of medicinal plants as a source of natural products for the use of man.

1.3 Effect of environmental factors on plant characteristics:

Climatic conditions affect plant growth and development. Morphological and physiological variations appeared as adaptation and/or acclimation of plants to different factors, such as precipitation, temperature, light intensity and altitude (Jarvis, 1981). The outdoor environment, as perceived by plants, is rarely constant, and variations in sunlight, temperature, and humidity, are often closely linked. Changes in the amount of water in the soil over periods of days or weeks may interact with the other variables and modify their influence. Consequently, it is difficult to isolate the effect of one variable from the other (Jarvis, 1981). Plants exhibit a variety of responses to abiotic stresses that enable them to tolerate and survive adverse conditions. As we learn more about the signaling pathways leading to these responses, it is becoming clear that they constitute a network that is interconnected at many levels (Knight and Knight, 2001)**.**

The shrub *Encelia farinosa* (Asteraceae) exhibits geographic variation in aboveground architecture and leaf traits in parallel with environmental variation in temperature and moisture (David et al., 2002). Measurements of plants occurring across a natural gradient demonstrated that plants in desert populations produce smaller, more pubescent leaves, and are more compact and branched than plants in more mesic coastal environments (David et al., 2002). On another study, leaf morphological and physiological responses of *Quercus aquifolioides* along an altitudinal gradient were studied by Chunyang *et al.,* (2006). Results showed non-linear responses of specific leaf area, stomatal length and index, leaf nitrogen content per unit area and carbon isotope composition. Consequently researcher suggested that 2800 m altitude is the optimum zone for growth and development of *Quercus aquifolioides* (Chunyang, et al., 2006). Drought stress is one of the most important abiotic factors which is accompanied by heat stress in dry season (Agnes et al., 2002). Semi-arid and arid regions around the world have lost a major part of their original vegetation, and about 20% of the dry lands became degraded landscapes. The semi-arid areas are characterized by low and unreliable rainfall, and hence are prone to drought. Water deficit is the main constraint on crop production in these areas (Akyeampong, 1986). Because of that, understanding the ecological mechanisms that can contribute to combat land degradation has become a global environmental priority (Anon, 2005).

In Palestine, medicinal plant characterization still lacking. The influence of environmental factors on morphological, physiological, and biochemical characteristics of medicinal plants is essential to conserve these important resources and to set management plant to utilize them.

1.4 Plant morphology:

Plants occurring in Mediterranean climates are subjected to heat and drought stresses during summer. To adapt and survive these conditions, most plants have developed morphological and physiological mechanisms (Bosbalidis and Kofidis, 2002). Morphological and physiological parameters were studied by Voloudakis *et al.,* (2002) the most drought-tolerant variety was based on its high SR and Ψ_w , and it's having the smallest total leaf area, and expression of drought-tolerance-related genes.

1.4.1 Plant height and leaf area:

Plant leaves are the interface to their environments. Some morphological characteristics are strongly modified by ecological conditions**.** Changes on features of leaves are part of the adaptation responses (Coelho et al., 2002), and these leaf parameters are leaf area, perimeter, length, maximum width, base angle, distance between maximum width and lamina base, and biomass. It is expected that plants in semi-arid areas have shorter length and smaller leaf area. Kofidis et al. (2004) agreed with these hypotheses in their study. They found that stressed leaves of avocado undergo a reduction of their total surface area to reduce transpiration.Wang and Gao (2004) conducted an experiment to examine the morphological variations of *Leymus chinensis* along ten sites differ in precipitation and geographical elevation, and found that shoot height, flag leaf length and widths increased with precipitation and decrease with aridity.

1.4.2 Number of stomata:

Adaptation to arid environment has endowed plants with specific mechanisms which allow them to successfully reduce transpiration and improve photosynthesis rate. These mechanisms include increase in the number of stomata yet better control of water loss (Kofidis G., et al. 2004) Among the most important morphological and physiological adaptations of the plants to very dry conditions are stomatal number, size, arrangement and behavior which varied widely among plants (Gurevitch, 2002). Modifications on leaf anatomy of *Coffea arabica* caused by shade of pigeonpea (*Cajanus cajan*) was investigated the leaves fully exposed to sunlight presented a large stomata number (Morais, et al. 2004).

Drought stressed olives undergo anatomical alterations, particularly in their leaves, in order to save water. Such alterations principally comprise an increase in the cuticle thickness, in the density of stomata, non-glandular scales, and epidermal cells and mesophyll cells (Artemios et al., 2002)

The results of a study which was conducted in India, showed an opposite conclusion, where stomatal frequency decreased with moisture stress (Prakash and Ramachandran, 2000).

1.5 Plant physiology:

1.5.1 Total chlorophyll content:

Reflectance assessment of leaf pigments can potentially provide useful indicators of integrated leaf physiology under a wide range of conditions (Gamon and Surfus, 1999)

Xu et al. (2000) found a reduction in chlorophyll content in the drought stressed plants compared with the control. They concluded that "stay green" trait protects the leaf from degradation of chlorophyll. However, few reports are available on how this trait protects chlorophyll under drought condition. In another study conducted by Chandrasekar et al. (2000), researchers calculated total chlorophyll content in different wheat cultivars according to Arnon (1949), and found that under water stress, the drought-tolerant genotypes showed lower reduction in chlorophyll content than susceptible ones. Moreover Richardson et al. (2004) mentioned that stress effect on trees includes changes in leaf pigments (reduced chlorophyll content) as well as an altered physiology (impaired photosynthesis).

1.6 Plant biochemistry:

1.6.1 Effect of environmental factors on essential oil composition:

Essential oils are highly concentrated and highly complex natural compounds. These chemicals are found in various parts of plant: seeds, barks, leaves, stems, roots, flowers and fruits. Essential oil protects plants from bacterial and viral infections, cleaning breaks in its tissue and delivering oxygen and nutrients into the cell (www.realessentials.com). They are mosaics of hundreds –even thousands- of different natural chemicals, all contributing to the oils well known therapeutic effect of natural oil, and each one in the same essential oil can exert different effects (www.realessentials.com). A single species of a plant can have several different chemotypes based on its chemical composition. Essential oil constituents are affected by many factors including climate, soil condition, region, altitude, harvest season, distillation process, and the part of the plant used (www.realessentials.com).

Climatic conditions, for example length of day, rainfall and field temperature, significantly influence the physical, chemical, and biological characteristics of medicinal plants (WHO, 2003).

The variability of the essential oil composition of *Myrtus communis* in natural populations of Tunisia was studied by Messaoud et al (2005). They found that the composition was similar qualitatively in all populations but different in quantitatively.

De Abrue and Mazzafera (2005) found that the level of all the compounds analyzed in *Hypericum brasiliense* increased under water stress, and varied according to the compound in response to alternating temperatures. In other study carried out by Moron et al. (2005), it was evident the qualitative composition of the essential oil of *Sideritis linearifolia* was similar in all populations, but the quantities of compounds was quite different. The climatic factors, mainly temperature and humidity, were found to affect both the content and the composition of the essential oil of *Echinacea purpurea* (Thappa et al., 2004).

1.6.2 Essential oil of *Teucrium polium*:

Teucrium polium is a deciduous shrub that grow up to 2 m, and has a flowering season from July to September. It prefers well drained soil with neutral to basic soils, but grows poorly in the shade. Variable species with a number of subspecies are found to grow in a variety of habitats from sandy places near the sea to mountain ranges (Plants for a Future, 2007). In Palestine it is considered as a wild plant and traditionally used as folk medicine. It classified into popular plant in an ethnobotanical survey in the Palestinian area which was carried out by Shtayeh et al., (2000). It was reported that *Teucrium polium* species has been used for over 2000 years in traditional medicine due to its diuretic, diaphoretic, tonic, antipyretic, antispasmodic. Moreover, the cholagogic properties of the aqueous extracts of *Teucrium polium* possess remarkable antioxidant activity in vitro (Ljubuncic, et al, 2006). In addition to that, many studies in different places in the world investigated the composition of the essential oil of *Teucrium polium* (Kabouche et al., 2007, Aburjai et al., 2006, Cozzani, 2005, Hassan et al., 1979, Teresa et al., 2004, Izabel et al., 2000). In most studies the main compounds found are α- pinene, β- pinene, p-cymene, and germacerene-D. Shakhanbeh and Atrouse (2000), found that *Teucrium polium* contains one or more potent non-selective neurotoxic agents with anti inflammatory activity. The letters effect of *Teucrium polium* on histology and histochemistry in rat stomach was studied. They founded that the histopathological investigation along with the biochemical evaluations suggests the possibility of the islets regeneration upon plant extract treatment. An other important conclusion is that high doses of *Teucrium polium* extract induce changes in the type of secretion of epithelial cells and connective tissue in the stomach and cause liver necrosis, and such high doses should be avoided in folk medicine (Dehghani.et al, 2005).Other study showed that *T. polium* crude extract is capable of enhancing insulin secretion by almost 135% following one dose of treatment at high glucose concentration (Yazdanparast et al., 2005).

1.6.3 HS-SPME-GC-MS :

Headspace solid phase microextraction (SPME) Gas Chromatography –Mass spectrometry (GC-MS) is a modern analytical tool for an effective extraction of various types of compounds (Demirici, 2005).

HSPM-GC-MS tool was used by Guoxin, *et al*. (2004) for the analysis of two traditional Chinese Medicinal plants and identified 87 compounds in *Angelica pubescns* roots and 36 compounds in *Angelica sinensis* roots. They conclude that this method only needs simple sample preparation and fast. Comparing to steam distillation it is a simple, sensitive, and rapid method suitable for the analysis of volatile constituents from traditional Chinese medicines (Guoxin, *et al*. 2004). Another study was carried out in Turkey using Headspace –SPME for the analysis of volatiles in *Artemisia sp*. The results suggested that HS-SPME is a useful technique for extracting highly volatile compounds. Consequently, HS-SPME-GC-MS coupling is a proven powerful tool for rapid and effective analysis of minute amount of complex mixtures in gas form (Demirici, 2005). In this respect, Czerwinski *et al.* (1996) used the Headspace SPME-GC-MS for the analysis of terpenoids in herbs based formulations, and found that it is fast and inexpensive technique for the isolation of organic analytes. Accordingly, HS-SPME with GC-MS can be successfully employed for the quality control of herbal medicines and other formulations containing herb extracts.

Objectives

1-To characterize (morphologically and physiologically) some medicinal plants (*Teucrium polium* الجعدة,*Coridothymus capitatus* الزحيف, *Varthemia iphionoides* الكتيلة,*Capparis spinosa* القبار, *Paronychia sinaica* رجل الحمامة) in two geographical sites (Dahrya and Sorif) and through seasons.

2- Quantitative and qualitative identification of *Teucrium polium* الجعدة essential oil components, in two sites (Dahrya and Sorif), and during the two seasons winter (1/2/2007) and summer (7/6/2007).

Chapter Two: Materials and Methods

2.1 Study sites:

Plant samples were collected from two study sites, Dahrya and Sorif. These sites represent different environmental conditions as shown in Table (1).

Table (1) : Environmental conditions at the study sites

	Dahrya	Sorif site
Location	18 Km south of Hebron city	10 Km to the west-north of Hebron city
Topography	Mountainous	Mountainous with steep slopes
Elevation	650m above sea level	500m above sea level
Relative humidity*	55-60%	60-65%
Water surface evaporation	160-180 cm/year	140-160cm/year
Rainfall	300-400 mm/year	400- 500 mm/year
Dominant species	*Poa bulbosa*, *Bromus syriacus*, and *Sarcopoterium spinosum*.	*Sarcopoterium spinosum*, *Avena sterilis*, *Loilium sp.*, *Bromus fasciculatus*, *Crepis aspera Aegilops binuncialis*
Soil	Brown Rendizanas and Pale Rendizanas	Terra Rossa, Brown Rendizanas and Pale Rendizanas
$CaCO_3$	Calcareous	10-40% CaCO3
Organic matter	Low organic matter (1.84%)	Moderate amount of O.M (6%)

There are no previous meteorological records in Sorif site

*Mean daily relative humidity, annual average (Awadallah and Owaiai, 2005)

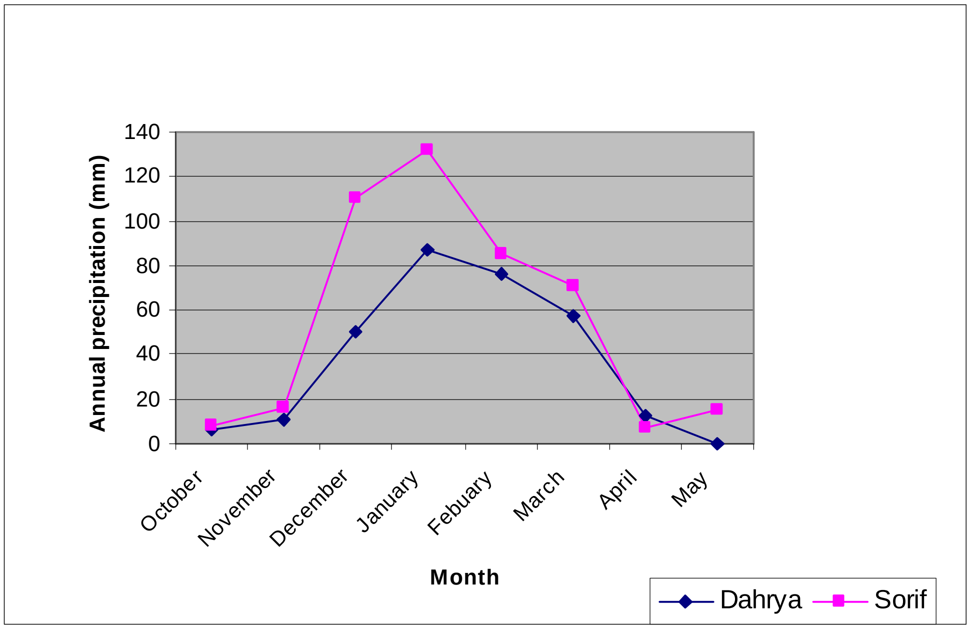


Figure (1) : Rainfall at the study sites during (2006-2007)
* Ministry of Agriculture (MOA), (2007) Rainfall data base. (Unpublished data).
There are no previous meteorological records in Sorif, data of the nearest site were used.

2.2 Plant sampling:

2.2.1 Study plants:

The following five medicinal plant species, which grow naturally in the two study sites (Dahrya and Sorif) were investigated: *Teucrium polium, Capparis spinosa, Varthemia iphionoides, Coridothymus capitatus, and Paronychia sinaica* (Table 2). Plant species were evaluated morphologically (plant height, number of branches, diameter, leaf area, leaf length, leaf width and stomata density), physiologically (chlorophyll content) and biochemical (essential oil analysis only for *Teucrium polium*) for each site. The study was conducted during the year 2007.

Table (2) : General characteristics of plants under investigation

Scientific name	Common name	Family	Physical characteristics	Flowering Period
Teucrium polium	Ja'dih, الجعدة Germander	*Labiateae*	Perennial, decidious shrub, bushy plant	July-September
Paronychia sinaica	Silver nail root , Rijil al hamama whittle-wart رجل الحمامة	*Caryophyllaceae*	Perennial herb with many crowded erect stems	March-May
Capparis spinosa	Caper bush, قبار, Egyption caper	*Capparidaceae*	Perennial, shrubby plant	April- - August
Varthemia iphionoides	Silmaniya, Ktilih كتيلة	*Compositae*	Perennial, bushy plant	May – August
Coridothymus capitatus	Thym, zohhef زحيف	*Laminaceae*	dwarf-shrub Branches are woody, growing in high density to form a tangled dome	May – October

Al-Eisawi, (1998),(http\\www. Pfaf.org) Plant for a future 2007.

Data were taken during seasons: winter, spring, summer and autumn 2007, since each plant has its special morphological and phonological characteristics which differs from the other; the measurements differ among plant species Table (3).

Table (3) : Measurements collected of the study plants during different seasons

Plant spieces	**Plant morphology**				**Plant physiology**		**Biochemical**
	Leaf parameters measurements	**Plant height**	**Plant average radius**	**Number of branches**	**Total chlorophyll content**	**Stomatal density**	**Essential oil analysis**
Teucrium polium	ü w, sp, su	ü sp, su	-	ü sp, su	ü su	-	ü w, su
Capparis spinosa	ü su, au	sp, su, a ü	-		ü su	ü su, a	-
Varthemia iphionoides	ü sp, su, a	ü sp, su, a	-	ü sp, su	ü su	-	-
Coridothymus capitatus	-	ü sp, su	ü sp, su	-	ü su	-	-
Paronychia sinaica	-		ü sp, su		ü su	-	-

w: winter, su: summer, sp : spring, a: autumn

2.2.1.1 *Teucrium polium*:

It's a perennial plant that bears its perennating buds just above the surface of the soil, it is 20-40 cm in height. Stems with branches erect, simple, elongate, each ending in a paniculate or corymbose inflorescence. Leaves 1-3 cm, sessile, oblong. Flower white or pale cream-coloured. Habitat arid hills and deserts. Distributed mainly in Mediterranean and West Irano-Turanian. (Al-Eisawi, 1998.),(http\\www. Pfaf.org) Plant for a future 2007.

2.2.1.2 *Cappris spinosa*:

Perennial shrubby plant, 20-30cm long, over 2 m broad, with many hanging, spiny stems, hairless. Leaves 2 -3 cm, dark green ovate to rounded, thick smooth. Flowers 4-6 cm in diameter, white pink, with many long spreading stamens, showy. Fruits are 3-5cm long, cylindrical. Pendulous, deep and dense root system that grow through cracks in rocks. It has short reproductive and vegetative period and it's one of a few species that grow and flower entirely in summer. Habitat: common on road sides, wast grounds.(Al-Eisawi, 1998, Rhizopoulou et al, 1996)

2.2.1.3 *Paronychia sinaica:*

Whitlow wort perennial herb with many crowded erect stems, covered by soft hairs and has a dry touch, leaves 0.5-1 cm long , lanceolate to strap like , surrounded by stipules. Flowers arranged in more or less closed heads, 0.5-1 cm in diameter, silvery in color. Habitat hills and mountains (Al-Eisawi, 1998).

2.2.1.4 *Varthemia iphionoides:*

Perennial bushy plant, 20-50 cm long with woody base and many basal, unbranched stems , hairy – sticky aromatic. Leaves oblong, simple entire, sub sessile, densely hairy , grayish, heads 2-5 cm in diameter, florest yellow – orange , surrounded by oblong involucres.

2.2.1.5 *Coridothymus capitatus* :

A dwarf-shrub from the Labiatae family 20-40 cm high. The plant grows on limestone terrain, on chalk and marl in the mountainous area, and in the coastal plain. The branches are woody, growing in high density to form a tangled dome. Leaves are narrow, hardened and pointed, growing densely on the branches. The leaf is covered with pits, containing glandular hairs giving off a characteristic smell. The pinkish-purple flowers are arranged in a dense head. The fruit is composed of four nutlets. The plant is collected throughout the year (Al-Eisawi, 1998).(http\\www. Pfaf.org) Plant for a future 2007.

2.3 Plant morphology:

2.3.1 Leaf parameters:

Leaf parameters of *Teucrium polium, Capparis spinosa, and Varthemia iphionoides* were recorded using CI-202 Area Meter. Leaf area, leaf length and width were measured for ten plants (replicates). For each replicate the average reading of ten randomly selected leaves measured three times were recorded.

2.3.2 Plant height:

Plant heights were measured in the field for *Teucrium polium*, *Capparis spinosa*, *Varthemia iphionoides*, *Coridothymus capitatus*, and *Paronychia sinaica* by taking the distance between the base and the highest point of the longest branch for ten plants (replicates) at each site.

2.3.3 Number of branches:

Number of the main branches were counted in the field for ten plants (replicates) of *Teucrium polium* and *Varthemia iphionoides* from the base of the plants.

2.3.4 Plant average radius:

The radius of the vegetative growth of *Coridothymus capitatus* and the spread of *Paronychia sinaica* was measured.

2.3.5 Stomatal Impressions:

Stomata impressions were taken from *Capparis spinosa* leaves from both sites Dahrya and Sorif. Three plants were collected randomly from each site. Samples were collected on 1stFebuary-2007, and on 1st November-2007, and kept enclosed in paper bags in refrigerator until analysis.

Three leaves were taken from each plant sample and a thick swath of clear nail polish was put on the underside face of the leaves. After drying, a square of clear tape was obtained and stuck to the area that contain the dried nail polish swath, the nail polish swath was peeled from the leaf completely , and gently leaf impression was tapped to a clean slide. Leaf impression was focused under 400x power using compound microscope and the observed stomata were counted, number of stomata was recorded in ten fields for each replicate and then averaged.

2.4 Total chlorophyll content:

The aim of this trial is to investigate the effect of two different environmental conditions; semi arid and semi humid on the total chlorophyll content of the medicinal plants *Teucrium polium, Coridothymus capitatus, Varthemia iphionoides, Capparis spinosa,* and *Paronychia sinaica.* Procedure was according to Arnon (1949).

1. 0.2 gm pieces of fresh leaves + 10 ml Acetone 80%
2. 30 min. Ultrasonic bath
3. Incubate them for over night
4. 30 min. Ultrasonic bath
5. Add 10 ml Acetone 80%
6. 30 min. Ultrasonic bath
7. Incubate them for 4 hours
8. 30 min. Ultrasonic bath
9. the volumes of the supernatants were completed with acetone 80% to a total volume of 50 ml
10. Detection was carried out at 645 nm and 663 nm using Spectrophotometer.
11. Obtained values were applied on the equation:

    mg chlorophyll /0.2gm fresh weight $=20.2A_{645NM} +8.02A_{663nm}$

    Then the values were calculated for 1 gm fresh weight by dividing them on 0.2.

Plant material was collected on 8 June -2007 and placed in the refrigerator in the Hebron university laboratory. Then 0.2 gm fresh leaves were weighed and then cut into small pieces, sample preparation and chlorophyll reading were as in appendix (a)

2.5 Analysis of the essential oil:

Three replicates from *Teucrium polium*, were collected on 1/2/2007 and 8/6/2007. Samples were placed in paper bags then air dried in the same bags by opening them for one week under room temperature. Samples were taken to Kompetenzzentrum Obstbau-Bodensee (KOB), Section: Post harvest Physiology institute in Germany for analysis.

Plant samples were immersed in liquid nitrogen and kept at -30 ˚C until analysis which was conducted within two days. For analysis, the frozen samples were placed in a pre-chilled coffee grinder and ground to a coarse powder. Fifteen ml of saturated NaCl-solution were added to 1 g of the tissue powder and mixed vigorously. The slurry was then homogenized for two minutes at 20 000x.min^{-1} and centrifuged at 14000 rpm for 15 min. at 4 ˚C. Twelve ml of the clear supernatant were placed in a 25 ml vial for extracting the volatile compounds by headspace solid phase micro extraction (HS-SPME). One microliter of the standard mixture (20 µl of cyclohexanone in 100 ml water) was added prior to extraction. Vials were conditioned for 20 minutes at 30 ˚C and stirred at a constant speed. A manual SPME device (Supelco Co., Bellefonte, PA, USA) equipped with a fused-silica fiber coated with 100 microm polydimethyl siloxane, was used. The fiber was inserted into the sample vial and exposed to the headspace for 20 min. For GC analysis, the volatile compounds were thermally desorbed from the SPME fiber for 10 min in the injection port of the gas chromatograph.

2.5.1 GC-MS conditions

The identification of compounds was conducted using a GC-MS by matching their mass spectra with the National Institute of Standards and Technology (NIST) library of standard compounds and their linear retention indices. GC-MS analysis was performed using a Shimadzu GC-2010 series (Shimadzu, Duisburg, Germany) coupled to a QP2010 MS. The separation was achieved using a Zebron capillary column: ZB-WAX, 30 m x 0.25 mm i.d, 0.25 µm film thickness (Phenomenex, Aschaffenburg, Germany). The GC oven temperature was raised from 35 ˚C, after a holding time of five minutes, to 180 ˚C at a rate of 5 °C.min^{-1}. The helium inlet pressure was 64.3 kPa, linear velocity was 40 cm. s^{-1}, total flow was 2.2 ml. min^{-1}, the column flow was 1.24 ml. min^{-1}, injection temperature was 220 ˚C, and injections were splitless. The MS-conditions were: ion source temp. = 200 ˚C, interface temp. = 190 ˚C, solvent cut time= 0.51 min., electron ionization at 70èV, and mass scan range was 40- 250m/z.

Fraction of each component in replicates:

$$\text{Fraction of aromatic compounds (\%)} = \frac{\text{Area of the peak of an aromatic components}}{\text{Total area of all aromatic components}}$$

2.6 Statistical analysis:

The experimental design was completely randomized design. Statistical analysis was done as one-way ANOVA test by using SigmaStat 2.0 for windows® program.

As there were big variances in the quantities of the essential oil components the standard deviations of the peak areas were calculated (Tables 9-12)

Chapter Three: Results

3.1 Morphological characteristics:

3.1.1 Leaf area:

For both sites Dahrya and Sorif *Varthemia iphionoides* leaf area decreased with time significantly ($p \leq 0.05$) from spring to autumn. Fig (2)

On the other hand, leaf area of *Teucrium polium* showed significant differences only in winter with higher value in Sorif comparing to Dahrya. While *Capparis spinosa* leaf area was $32.4mm^2$ in Sorif, it was significantly ($p \leq 0.05$) higher than that in Dahrya. (Fig. 3).

Results of the leaf area measurements of *Varthemia iphionoides*, *Teucrium polium* and *Capparis spinosa* showed a decline as the seasons proceeded from spring to summer to winter Table (4).

Table (4) : Average leaf area (cm^2) in Dahrya and Sorif sites in winter, spring, summer and autumn /2007

Site	Dahrya				Sorif			
plant	winter	Spring	Summer	Autumn	winter	Spring	Summer	Autumn
Varthemia iphionoides	-	9.5^a	3.5^b	2.5^b	-	12.7^a	8.2^b	3.2^c
Teucrium polium	2.2^b	5.2^a	2.8^b	-	3.9^a	4.5^a	2.9^a	-
Capparis spinosa	-	-	33.6^a	12.4^b	-	-	32.4^a	21.9^b

* Means followed by the same letter in the same raw at the same site are not significantly different, according to Fisher LSD test at $p \leq 0.05$

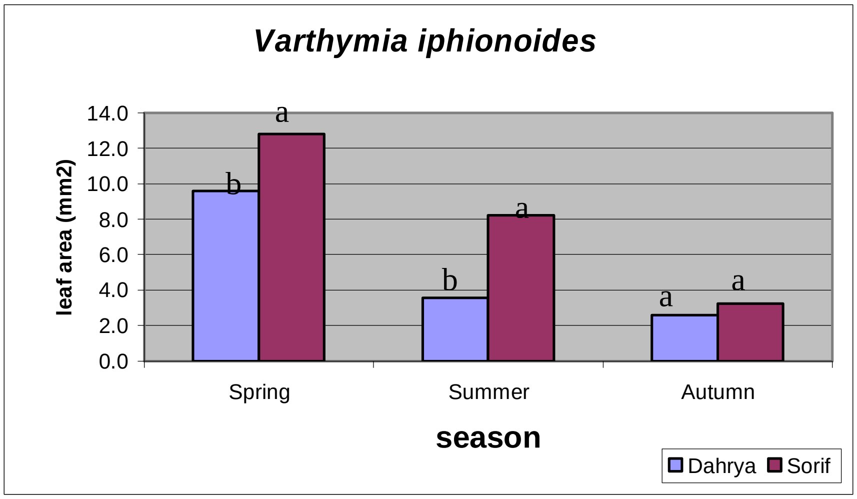


Figure (2) : Average leaf area (cm^2) of *Varthemia iphionoides* between the two sites Dahrya and Sorif in spring, summer, and autumn.

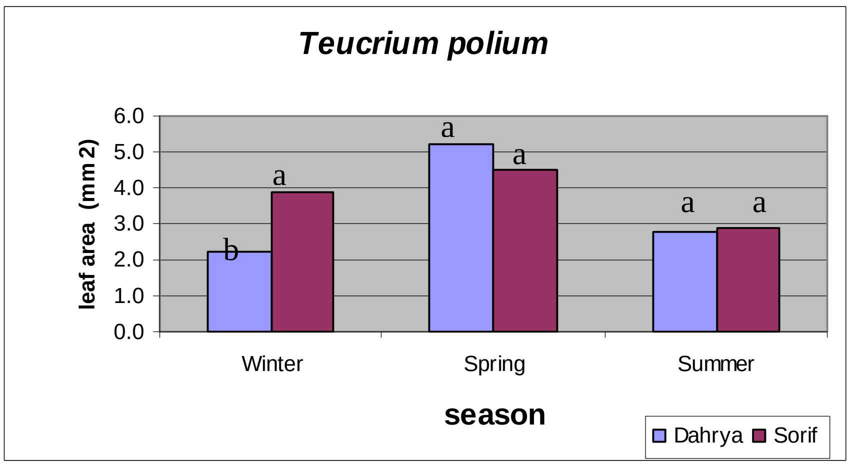


Figure (3) : Average leaf area (cm^2) of *Teucrium polium* between the two sites Dahrya and Sorif durin winter, spring, and summer

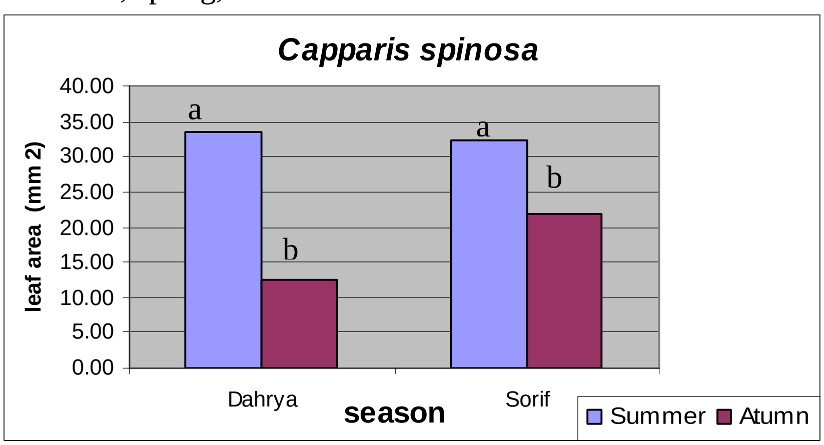
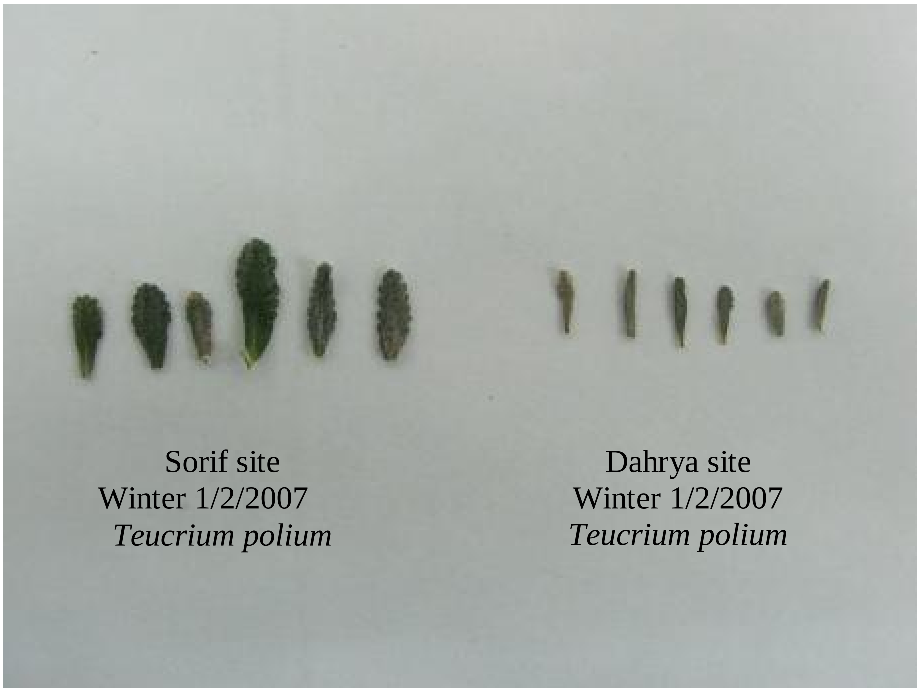


Figure (4) : Average leaf area (cm^2) of *Capparis spinosa* between the two sites Dahrya and Sorif in spring, summer, and autumn



Photos (1) : *Teucrium polium* leaves in Sorif site and Dahrya site on 1\2\2007

3.1.2 Leaf length:

For *Varthemia iphionoides* data indicated that there were no significant differences ($p \leq 0.05$) in the leaf length between the two sites in autumn, but in summer leaf area was significantly lower in Dahrya than Sorif (Fig 5). On the other hand, the difference among seasons was significant in Sorif with the highest length in spring followed by summer and then autumn; Dahrya has the same trend (Table 5).

Comparing between Dahrya and Sorif for *Teucrium polium* revealed that the difference was significant only in winter with the higher value in Sorif (Figure 5). In Dahrya, differences between seasons were significant with the highest value in spring, while there were no significant differences among seasons in Sorif site (Table 2). Moreover, data showed that there was no significant difference between the two sites in summer and autumn in the leaf length of *Capparis spinosa* (Figure 6) while in both sites, *Capparis spinosa* were significantly longer in summer than autumn (Table 5).

Table (5) : Average leaf length (cm) in the Dahrya and Sorif sites in winter, spring, summer and autumn

Site	Dahrya				Sorif			
plant	winter	Spring	Summer	Autumn	winter	Spring	Summer	Autumn
Varthemia iphionoides.	-	21.3^{a}	13.6^{ab}	9.4^{b}	-	22.7^{a}	18.7^{b}	9.8^{c}
Teucrium polium	8.9^{c}	15.4^{a}	13.8^{b}		12.3^{a}	13.3^{a}	12.96^{a}	
Capparis spinosa			17.7^{a}	11.3^{b}			17.3^{a}	13.3^{b}

* Means followed by the same letter in the same raw are not significantly different. According to Fisher LSD test at $p \leq 0.05$

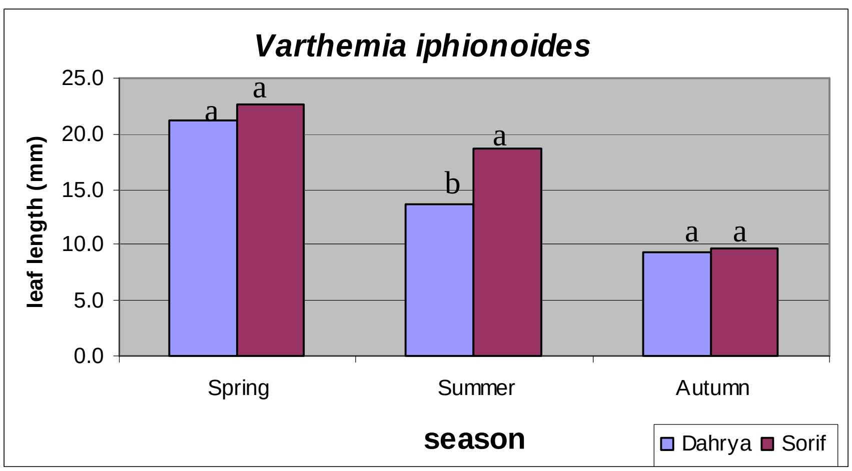


Figure (4) : Changes in average leaf length (cm) of *Varthemia iphionoides* between the two sites Dahrya and Sorif in spring, summer, and autumn

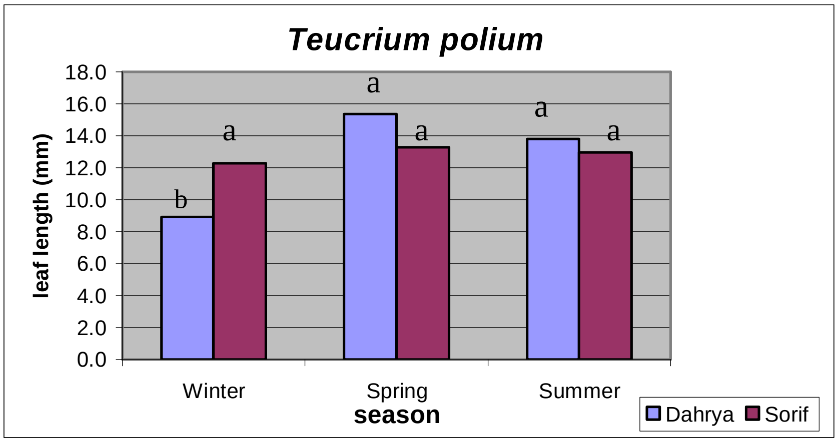


Figure (5) : Changes in average leaf length (cm) of *Teucrium polium* between the two sites Dahrya and Sorif in spring, summer, and autumn

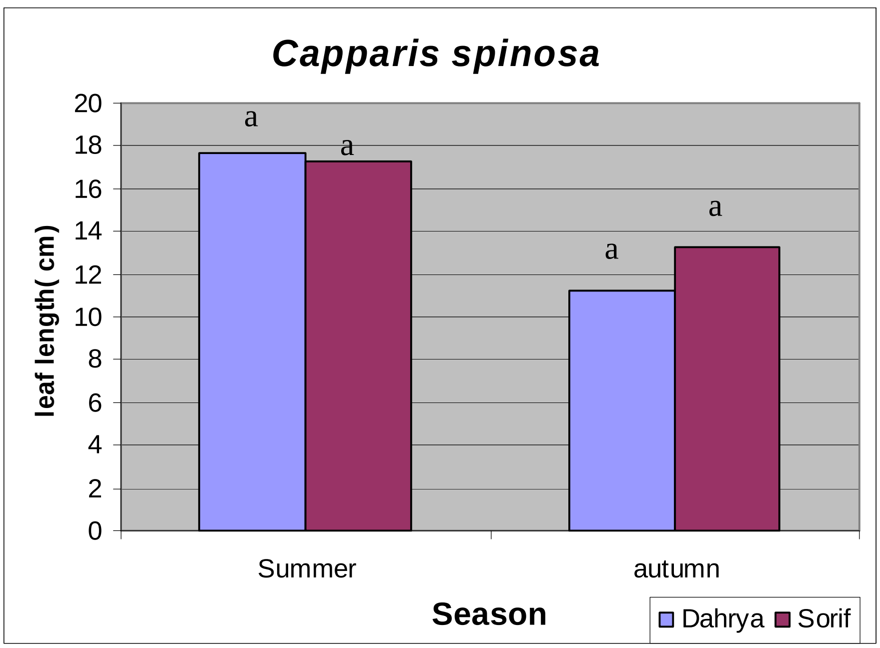


Figure (6) : Changes in average leaf length (cm) of *Capparis spinosa* between the two sites Dahrya and Sorif in spring, summer, and autumn

3.1.3 Leaf width:

The only significant difference in *Varthemia iphionoides* leaf width was regestered between Dahrya and Sorif in summer only (Fig.8). In Dahrya, the leaf width was significantly higher in spring than summer and autumn, while in Sorif it was significantly different between seasons with the largest value in spring (Table 6). Furthermore, data indicated that leaf width of *Teucrium* *polium* between the two sites was significantly higher in Dahrya in spring (Fig 8). In Dahrya site the difference was significant between spring and summer, while in Sorif the significance between winter and summer and between spring and summer. For *Capparis spinosa* there wasn't a difference in leaf width between Dahrya and Sorif in summer but in autumn it was higher in Sorif. (Figure 10). In Dahrya data shows significant differences between summer and autumn.

Table (6) : Average leaf width (cm) in Dahrya and Sorif sites in winter, spring, summer and autumn

Site	**Dahrya**				**Sorif**			
plant	**winter**	**Spring**	**Summer**	**Autumn**	**winter**	**Spring**	**Summer**	**Autumn**
Varthemia iphionoides		0.96^{a}	0.5^{b}	0.5^{b}		1.1^{a}	0.7^{b}	0.5^{b}
Teucrium polium	0.6^{ab}	0.7^{a}	0.4^{b}		0.6^{a}	0.61^{a}	0.4^{b}	
Capparis spinosa			2.9^{a}	2^{b}			2.9^{a}	2.5^{a}

* Means followed by the same letter in the same raw are not significantly different. According to Fisher LSD test at $p \leq 0.05$

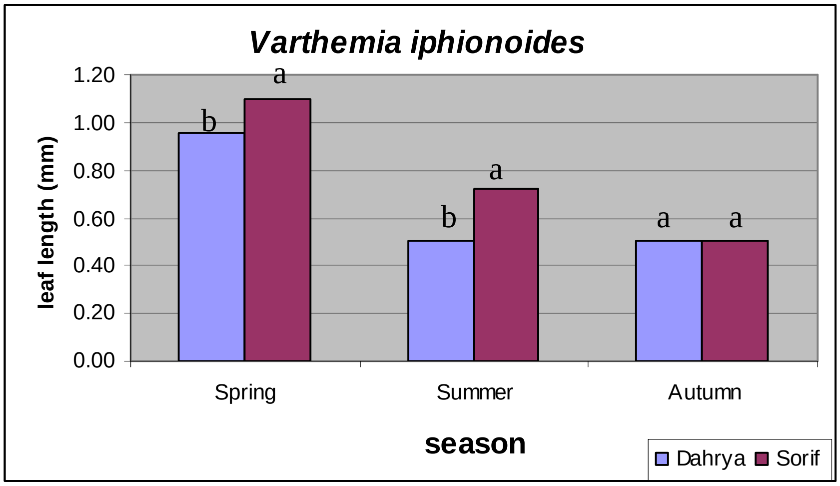


Figure (7) : Average leaf width (cm) of *Varthemia iphionoides* between the two sites Dahrya and Sorif in spring, summer, and autumn.

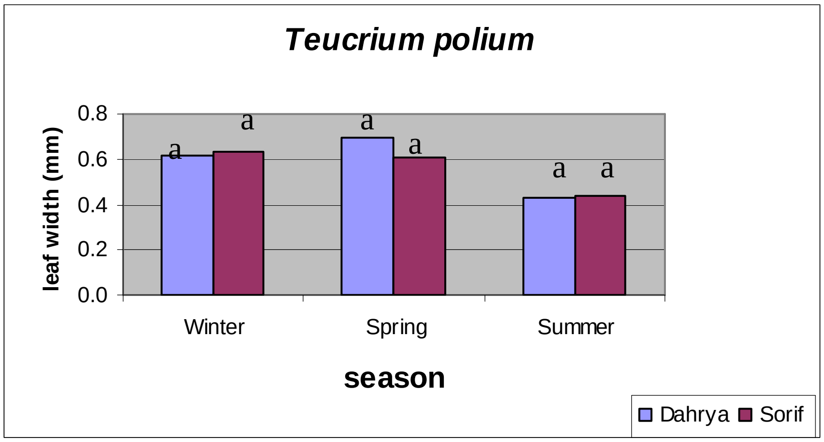


Figure (8) : Average leaf width (cm) of *Teucrium polium* between the two sites Dahrya and Sorif in spring, summer, and autumn

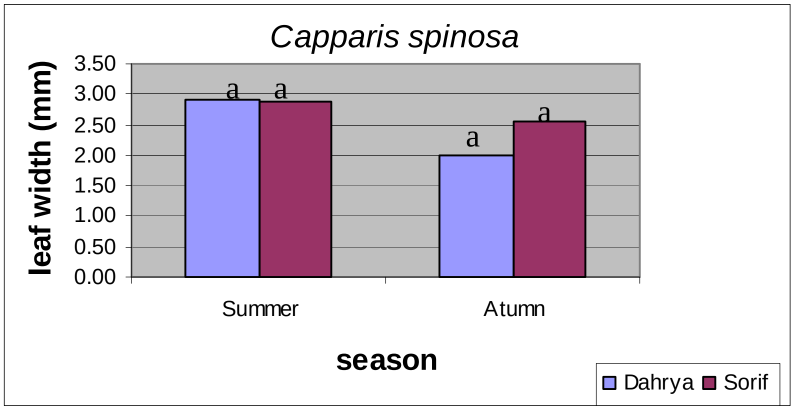


Figure (9) : Changes in average leaf width (cm) of *Capparis spinosa* in the two sites Dahrya and Sorif during spring, summer, and autumn

3.1.4 Plant height:

Data showed higher plant height in Sorif than in Dahrya for *Varthemia iphionoides* and *Capparis spinosa* (Figs 11,13). With *Teucrium polium* the change wasn't in the same direction, in spring the plant height was more in Dahrya than Sorif opposite to winter and summer (Figure 11).

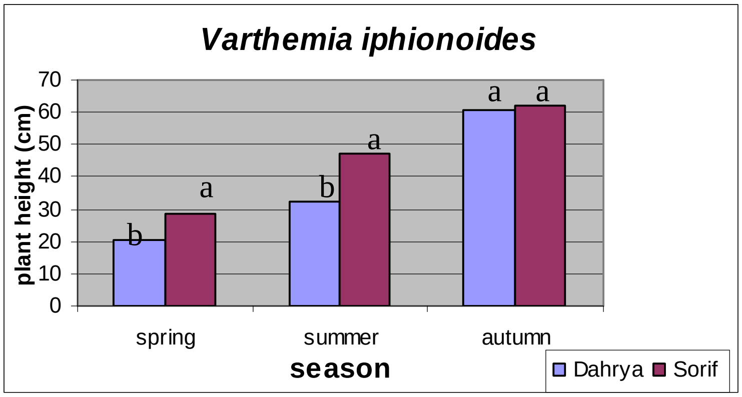


Figure (10) : Average plant height (cm) of *Varthemia iphionoides* in the two sites Dahrya and Sorif during spring, summer, and autumn.

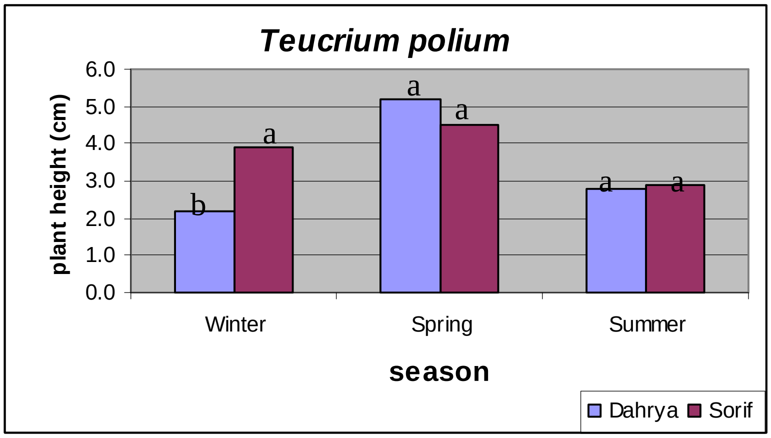


Figure (11) : Average plant height (cm) of *Teucrium polium* in the two sites Dahrya and Sorif during winter, spring and summer

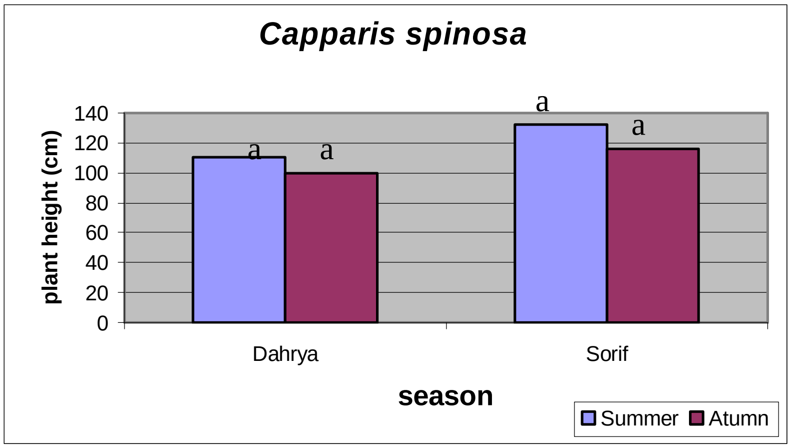


Figure (12) : Average plant height (cm) of *Capparis spinosa* in the two sites Dahrya and Sorif during winter, spring and summer

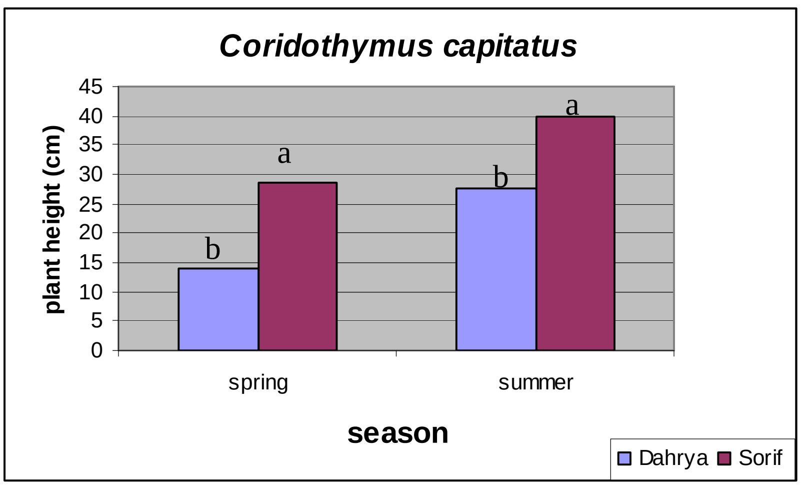


Figure (13) : Average plant height (cm) of *Coridothymus capitatus* in the two sites Dahrya and Sorif during spring and summer.

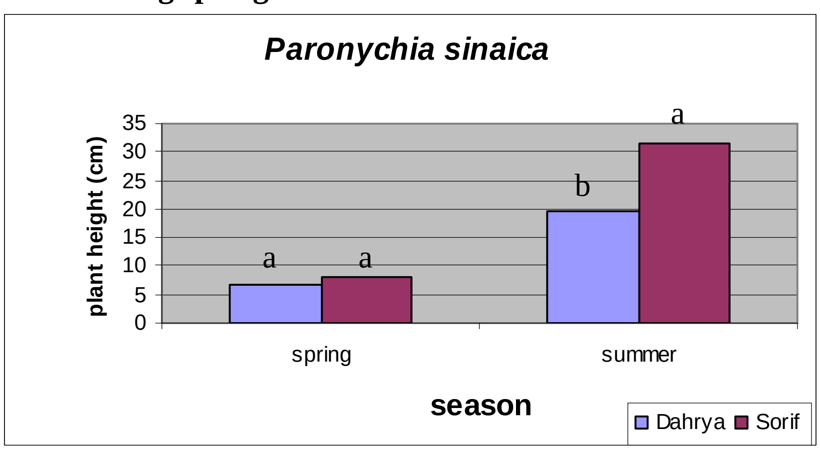


Figure (14) : Average plant height (cm) of *Paronychia scinaisa* in the two sites Dahrya and Sorif during spring and summer

3.1.5 Plant radius :

The radius for *Coridothymus capitatus* and *Paronychea sinaica* was more in Sorif than in Dahrya, and the difference was significant in spring for *coridothymus capitatus* (Fig16) and in summer for *Paronychea sinaica* (Fig 17).

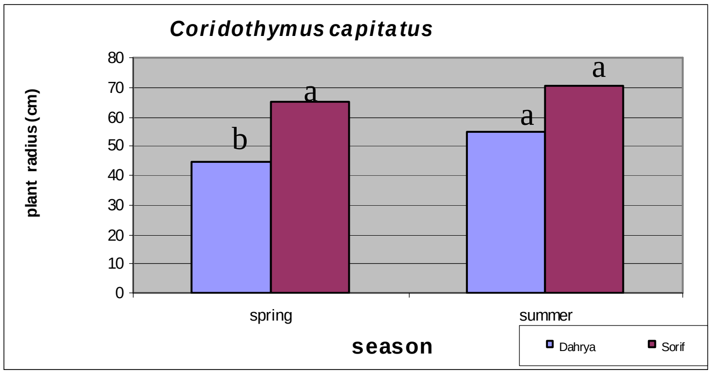


Figure (15) : Average plant radius (cm) of *Coridothymus capitatus* in the two sites Dahrya and Sorif during spring and summer.

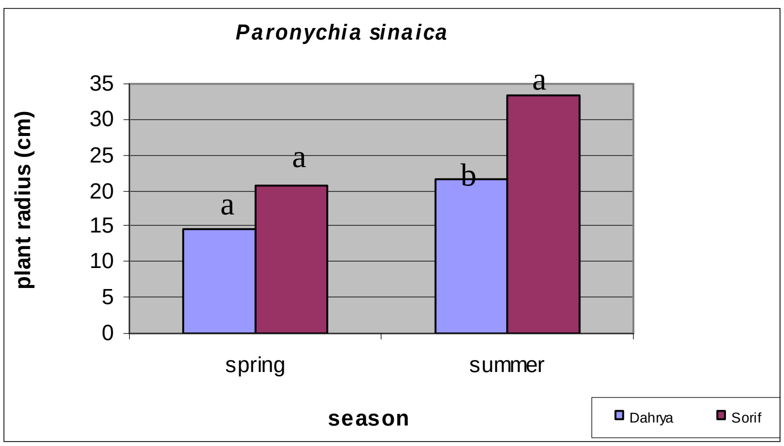


Figure (16) : Average plant radius (cm) of *Paronychia scinaisa* in the two sites Dahrya and Sorif during spring and summer

3.1.6 Number of branches:

Data on branch number of *Varthemia iphionoides* between Dahrya and Sorif showed higher value in Sorif in spring but lower in Sorif in summer (7/6/2007). On the other hand *Teucrium polium* branche number was higher in Sorif and the difference was significant in summer (Fig 19).

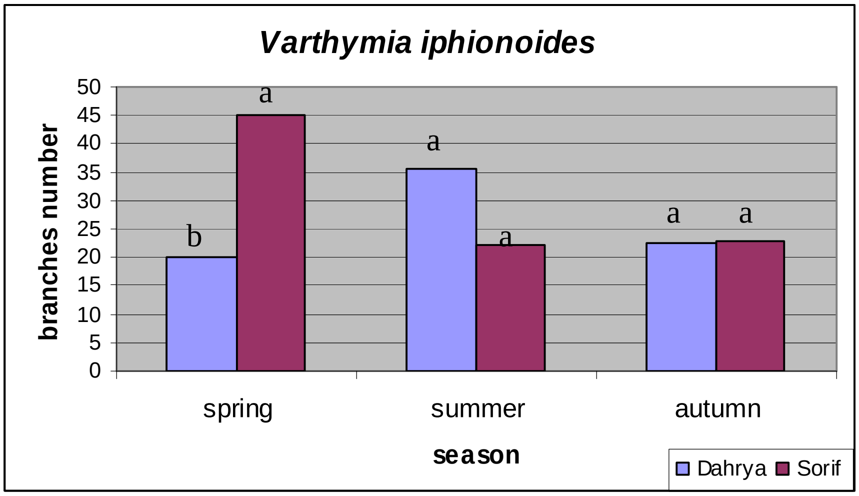


Figure (17) : Average number of branches of *Varthemia iphionoides* between the two sites Dahrya and Sorif in spring, summer, and autumn.

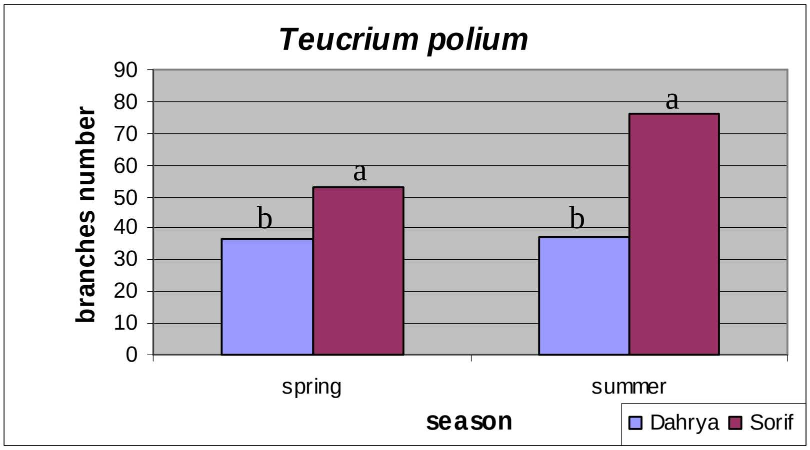


Figure (18) : Average branches number of *Teucrium polium* in the two sites Dahrya and Sorif during spring and summer

3.1.7 Stomata density:

Figure (19) showed an expressive difference in the number of stomata per field with higher values in *Capparis spinosa* growing in Dahrya than Sorif during both summer and autumn seasons.

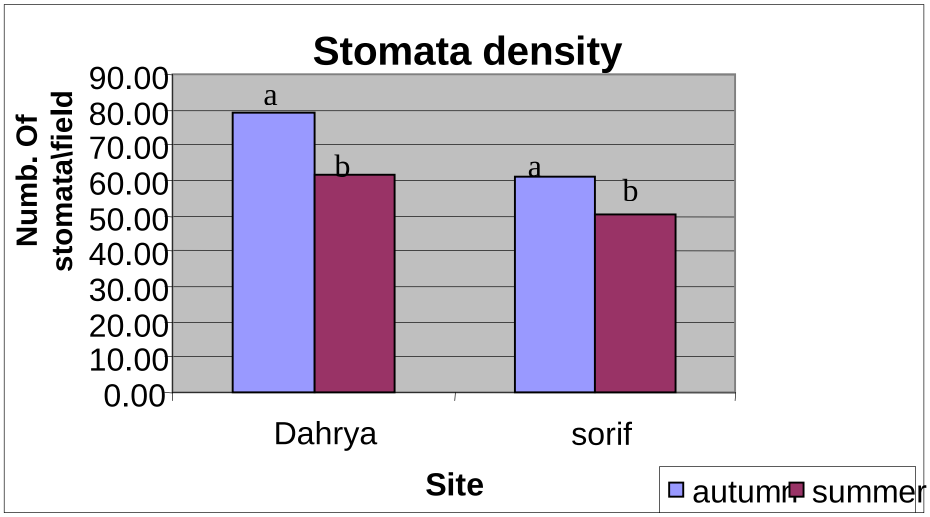


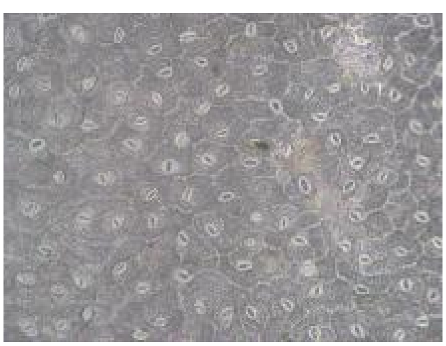
Figure (19) : Number of stomata per field in relation to sites (Dahrya and Sorif) and seasons (autumn and summer).

Table (7) : Average stomata number in Dahrya and Sorif sites in summer and autumn

	Dahrya	sorif
summer	61.8[a]	50.3[b]
autumn	79.3[a]	61.3[b]

* Means followed by the same letter in the same raw are not significantly different.

Accordingto Fisher LSD test at $p \leq 0.05$



Dahrya site
7/6/2007

Sorif site
7/6/2007

Photos (2) : Stomata density in Dahrya site and Sorif site on 7\6\2007

3.2 Total chlorophyll content:

Data showed higher total chlorophyll content in Dahrya than in Sorif for all investigated plants, (Figure 20)

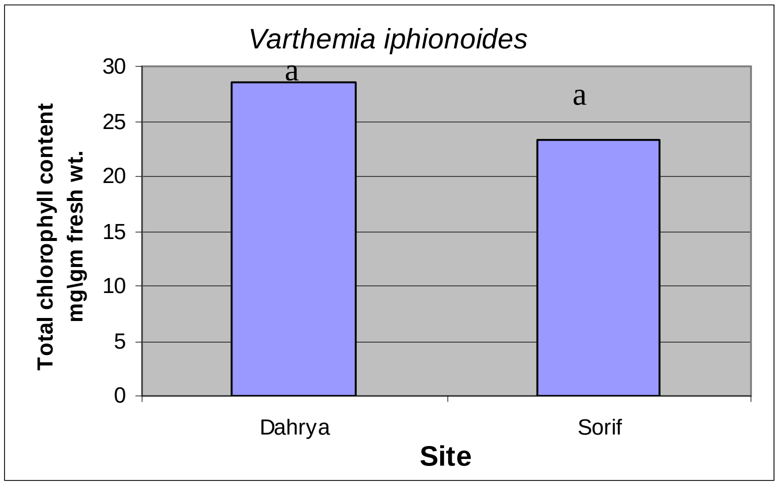


Figure (20.A)

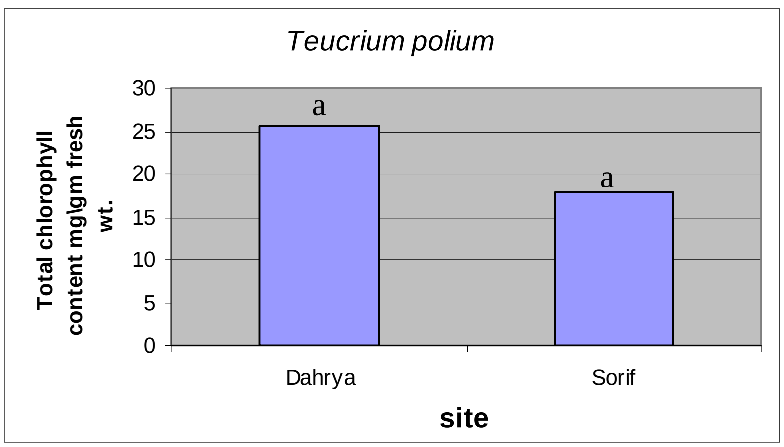


Figure (20.B)

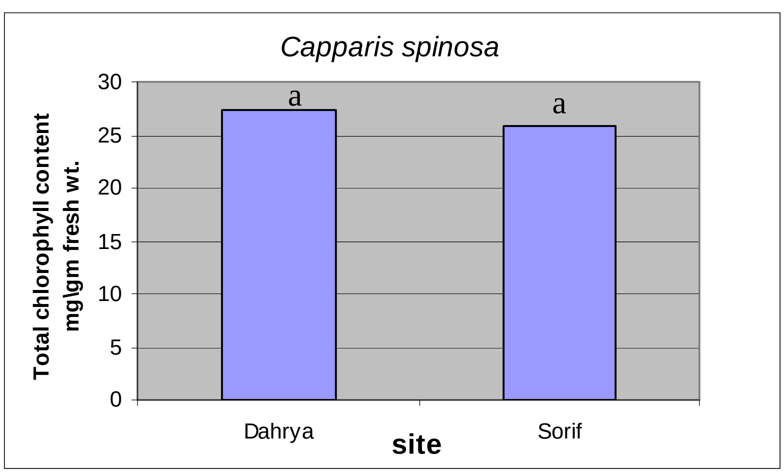


Figure (20.C)

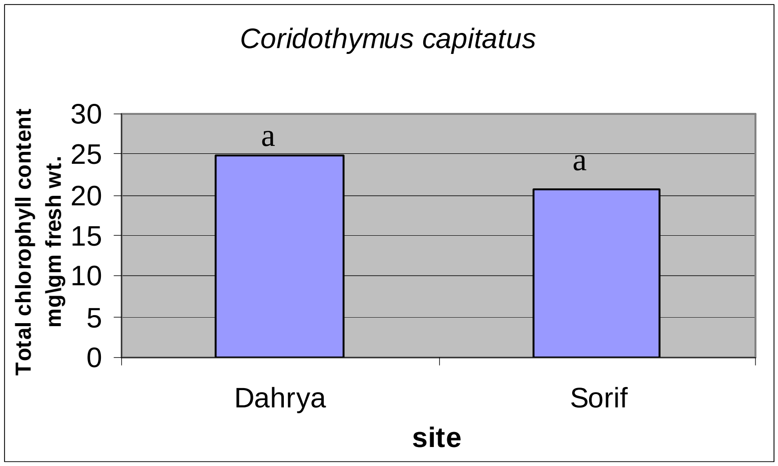


Figure (20.D)

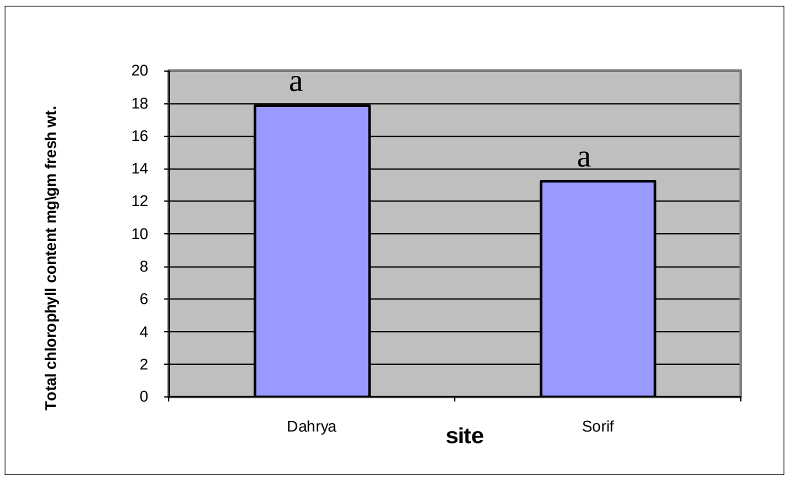


Figure (20.E)

Figure (20) Total chlorophyll content in Dahrya and Sorif in the plants ((A): *Varthemia iphionoides*,(B) *Teucrium polium* , (C) *Capparis spinosa,* (D) *Coridothymus capitatus, and(E): Paronychia sinaica* **)**

3.3 Biochemical characteristics (essential oil analysis) :

Data of the essential oil analysis of *Teucrium polium* showed a great variation in its content of aromatic compounds between the two sites and between seasons (winter and summer). The composition of essential oil for the two sites and seasons are shown in Appendix (1-12).

Peak area sum (unit) of all the components of the essential oil of *Teucrium polium* tend to be high in Sorif than Dahrya in winter and higher in Dahrya than Sorif in summer (Fig 22).

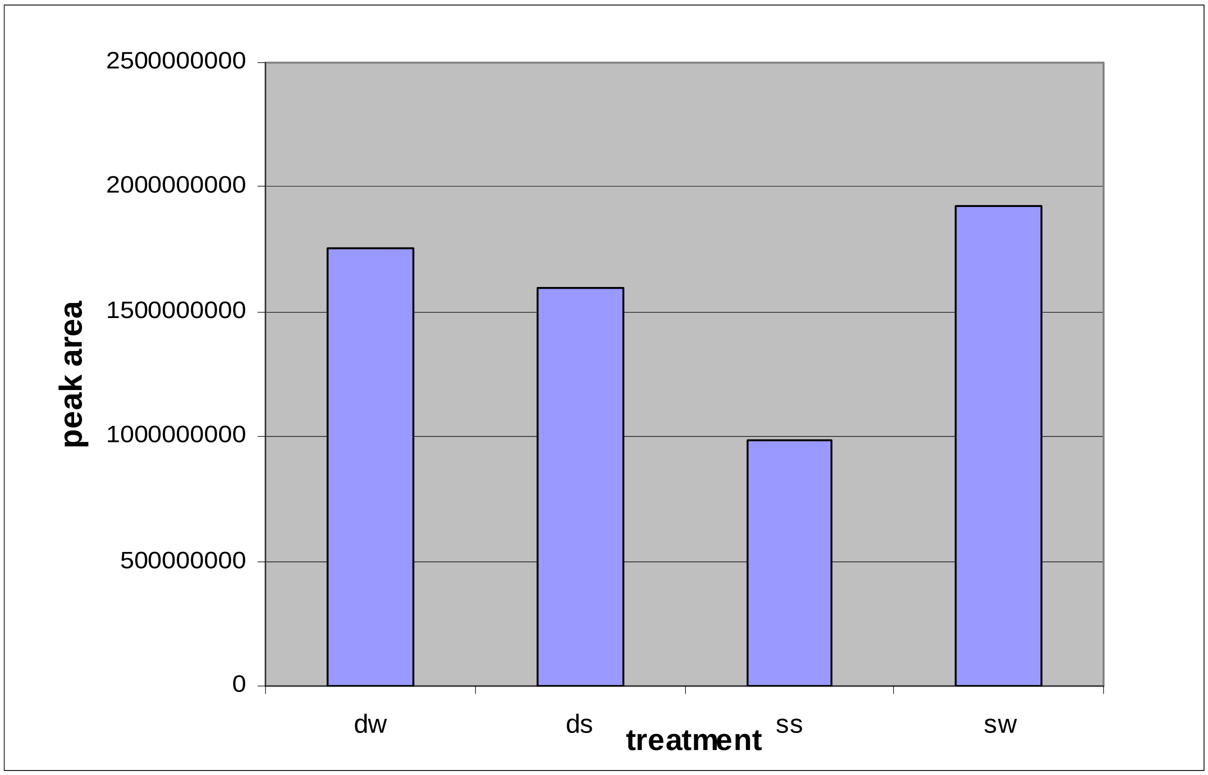


Figure (21) : Peak area sums (unit) of different treatments (dw : Dahrya winter, ds : Dahrya summer , ss Sorif summer, sw : Sorif winter.

3.3.1 Common compounds:

Comparing treatments and sampling dates there were 26 components repeated in all the replicates (at least two replicates from three in each treatment) (Table 7). These compounds showed a high variability in there peak areas between the sites and the seasons.

Table (8) : Average peak areas (unit) of the components which occured in all the treatments.

Component	winter		summer	
	Sorif	Dahrya	Sorif	Dahrya
alpha.-Pinene	109,653,637	126,570,618	22,713,126	80,487,688
3-Thujene	29,530,190	21,484,570	8,902,107	11,906,127
beta.-Pinene	179,044,611	172,649,445	47,240,873	114,724,447
2(10)-Pinene,	34,308,270	21,899,213	4,680,001	12,698,762
beta.-Myrcene	179,569,097	101,224,801	60,973,878	113,787,948
D-Limonene	173,280,936	118,408,547	24,610,835	119,059,486
1,3,6-Octatriene	25,442,382	10,339,069	6,151,197	7,549,983
Octen-1-ol	5,237,768	2,043,811	5,310,675	13,593,503
Nonanal	993,225	965,330	961,232	939,099
3-Octanol	1,053,718	1,994,525	1,534,528	1,821,823
Thujol	6,068,381	4,039,672	6,930,454	3,367,162
Thujone $	15,094,971	20,583,490	10,590,974	6,307,921
1-Octen-3-ol	33,612,064	29,297,512	18,227,243	28,181,911
alpha.-Campholenal	7,281,067	19,712,627	7,467,849	4,994,256
Benzaldehyde	25,322,453	26,613,221	24,569,523	22,982,386
2(10)-Pinen-3-one	26,931,037	64,703,929	27,635,557	24,799,973
Bicyclo[3.1.1]heptan-2-one	4,073,703	12,291,262	4,650,874	7,543,633
1-Terpinen-4-ol	37,978,493	43,036,089	28,132,635	17,855,908
(1R)-(-)-Myrtenal	16,283,736	29,492,430	22,872,651	19,490,526
1,5-Cyclodecadiene	17,465,943	9,344,871	5,035,620	20,460,928
Trans-Pinocarvyl acetate	1,517,642	1,360,160	1,569,831	2,788,040
Myrtenyl acetate	3,737,330	3,661,533	6,823,293	10,703,331
Eudesma-4(14)	13,946,741	11,573,323	24,203,008	19,036,135
Bicyclo[3.1.1]hept-2-	8,453,809	21,191,988	12,707,184	11,612,180
Germacrene B	12,071,824	2,817,138	3,565,387	15,050,597
2-Cyclohexen-1-ol, 2-methyl	6,774,032	13,727,814	4,914,815	5,693,186
Thymol	30,108,910	29,163,238	28,887,876	28,220,611

Table (9): The mean and standard deviation of the aroma compounds that occured in all the replicates in Dahrya during winter

Compound	mean	±SD
alpha.-Pinene	126570617.7	±129364389.88
3-Thujene	21484569.53	±34747850.2
2(10)-Pinene	172649445.2	±166355601.68
2(10)-Pinene	21899213.46	±22412897.3
beta.-Myrcene	101224801.1	±84977111.23
D-Limonene	118408547	±71730824.527
9,3,6-Octatrien	10339069.41	±6597860.575
Octen-1-ol	2043810.512	±1193656.7
Nonanal	965330.2839	±579831
3-Octanol	1994525.352	±1279589.14
Thujol	4039672.261	±5133422.4
Thujone	20583490.14	±20721572.244
1-Octen-3-ol	29297511.76	±8122393.142
3-Cyclopentene	19712626.82	*
Benzaldehyde	26613221.32	±1989632.768
2(10)-Pinen	64703929.33	±44475625.628
Bicyclo[3.1.1]heptan-	12291261.72	±8642634.25
p-Menth-1-en-4-ol	43036088.68	±30039175.445
(1R)Myrtenal	29492429.59	±6471730.348
1,5-Cyclodecadiene	9344870.853	±1799432.229
trans-Pinocarvyl acetate	1360160.34	±2201719.246
Eudesma-4(14),11-diene	11573322.61	±11521204.556
Bicyclo[3.1.1]hept-2-ene	21191987.88	±12914424.434
Germacrene B	2817138.104	±519274.915
2-Cyclohexen-1-ol	13727813.59	±6985341.313
Thymol	29163238.36	±9289675.088

Table (10) : The mean and standard deviation of the aroma compounds that occured in all the replicates in Sorif during summer

compound	mean	±SD
alpha.-Pinene	22713126.16	±58111.746
3-Thujene	8902107.492	±7666078.99
2(10)-Pinene	47240872.56	±35618019.418
2(10)-Pinene	4680001.401	±2429896.746
beta-Myrcene	60973877.55	±66534750.529
D-Limonene	24610835.18	±24195222.979
9,3,6-Octatrien	6151197.036	±6599387.174
Octen-1-ol	5310675.272	±3002724.488
Nonanal	961231.6856	±30618.313
3-Octanol	1534528.045	±1446229.436
Thujol	6930454.49	±4223976.172
Thujone	10590973.58	±7695636.615
1-Octen-3-ol	18227243.33	±14742796.374
3-Cyclopentene-	7467848.526	±4635111.419
Benzaldehyde	24569522.62	±2116067.049
2(10)-Pinen	27635557.22	±19749888.463
Bicyclo[3.1.1]heptan-	4650873.677	±2692376.287
p-Menth-1-en-4-ol	28132635.4	±12894613.111
(1R)-(-)-Myrtenal	22872651.32	±12899755.458
1,5-Cyclodecadiene	5035619.755	*
(-)-trans-Pinocarvyl acetate	1569830.794	±850323.277
Eudesma-4(14),11-diene	24203007.58	±6604225.198
Bicyclo[3.1.1]hept-2-ene	12707183.86	±6086123.887
Germacrene B	3565386.837	±1821588.296
2-Cyclohexen-1-ol	4914814.514	±3092122.708
Thymol	28887876.08	±23778694.718

Table (11) :The mean and standard deviation of the aroma compounds that occured in all the replicates in Dahrya during summer.

compound	mean	SD
alpha.-Pinene	80487688.03	±42462018.24
3-Thujene	11906127.42	±7968383.571
2(10)-Pinene	114724446.5	±50365050.685
2(10)-Pinene	12698762.49	±4240432.251
beta.-Myrcene	113787948.2	±51329402.532
D-Limonene	119059486.1	±151796198.444
9,3,6-Octatrien	7549982.751	±7929979.193
Octen-1-ol	13593502.98	±10891693.601
Nonanal	939098.957	±10994.935
3-Octanol	1821822.671	±885322.698
Thujol	3367161.68	±2082882.966
Thujone	6307921.02	±4550233.234
1-Octen-3-ol	28181910.88	±19407458.536
3-Cyclopentene-	4994256.313	±2703387.819
Benzaldehyde	22982385.8	±3472555.003
2(10)-Pinen	24799972.96	±6879957.437
Bicyclo[3.1.1]heptan-	7543633.272	±828972.707
p-Menth-1-en-4-ol	17855908.14	±4996017.309
(1R)-(-)-Myrtenal	19490525.57	±12725452.039
1,5-Cyclodecadiene	20460927.79	
(-)-trans-Pinocarvyl acetate	2788040.475	±2179703.324
Eudesma-4(14),11-diene	19036135.31	±16463748.985
Bicyclo[3.1.1]hept-2-ene	11612180.08	±10724474.474
Germacrene B	15050596.95	±12118247.363
2-Cyclohexen-1-ol	5693186.214	±1045432.013
Thymol	28220610.71	±5674351.734

Table (12) : The mean and standard deviation of the aroma compounds that occured in all the Replicates in Sorif during winter

compound	mean	±SD
alpha.-Pinene	109653636.9	±131148469.411
3-Thujene	29530190.2	±39305719.052
2(10)-Pinene	179044611.4	±233224225.142
2(10)-Pinene	34308270.29	±35317632.211
beta.-Myrcene	179569097.1	±232892151.917
D-Limonene	173280935.8	±194657707.363
9,3,6-Octatrien	25442382.33	±35312885.516
Octen-1-ol	5237768.397	±6022435.995
Nonanal	993224.6105	±223036.056
3-Octanol	1053718.303	±338878.847
Thujol	6068381.252	±4963493.597
Thujone	15094971.35	±10897606.422
1-Octen-3-ol	33612064.15	±30994417.681
3-Cyclopentene-	7281066.904	***
Benzaldehyde	25322453.21	±2704449.386
2(10)-Pinen	26931037.02	±10878860.682
Bicyclo[3.1.1]heptan-	4073702.961	±572580.483
p-Menth-1-en-4-ol	37978492.65	±23124120.283
(1R)-(-)-Myrtenal	16283736.16	±5367363.917
1,5-Cyclodecadiene	17465943.15	±9057818.352
(-)-trans-Pinocarvyl acetate	1517642.361	±866159.195
Eudesma-4(14),11-diene	13946741.44	±10085805.541
Bicyclo[3.1.1]hept-2-ene	8453809.287	±5408095.407
Germacrene B	12071824.41	±12433934.742
2-Cyclohexen-1-ol	6774032.455	
Thymol	30108909.65	±21059339.459

3.3.2 Main compounds:

The main components which constitute the highest five components in each replicate are showed in Tables (13-16)

Table (13) :The highest five components of replicates in Dahrya during winter

Dahrya winter Rep.1		Dahrya winter Rep 2		Dahrya winter Rep 3	
Component	%	component	%		%
Germacrene D	34.65%	beta.-Pinene	10.57%	Germacrene D	17.25%
D-Limonene	16.84%	Germacrene D	10.15%	beta.-Pinene	10.35%
beta.-Myrcene	8.16%	4(10)-Thujene	9.95%	Bicyclo[3.1.0]hexane	7.43%
beta.-Pinene	4.86%	beta.-Myrcene	8.82%	beta.-Myrcene	6.53%
Sabinene	3.75%	p-Menth-1-en-8	8.75%	alpha.-Pinene	6.48%

Table (14) : The highest five components of replicates in Dahrya during summer

Dahrya summer Rep 1		Dahrya summer Rep2		Dahrya summer Rep 3	
component	%	component	%	component	%
4(10)-Thujene	8.31%	beta.-Pinene	16.59%	Germacrene D	33.31%
Copaene	6.93%	beta.-Myrcene	16.55%	p-Menth-1-en-8-ol,	7.93%
1H-Cycloprop[e]azulen-7-ol	4.34%	D-Limonene	14.52%	D-Limonene	6.66%
Cadina-1(10),4-diene	4.29%	alpha.-Pinene	9.61%	beta.-Myrcene	5.05%
1,6,10-Dodecatriene	4.21%	Eucalyptol	4.22%	4(10)-Thujene	4.66%

Table (15) : The highest five components of replicate in Sorif during summer

Dahrya summer Rep 1		Dahrya summer Rep2		Dahrya summer Rep 3	
Component	%	component	%	component	%
D-Limonene	16.35%	beta.-Pinene	14.96%	Germacrene D	19.61%
Germacrene D	13.42%	Germacrene D	13.30%	D-Limonene	5.63%
beta.-Pinene	8.27%	4(10)-Thujene	11.48%	beta.-Pinene	4.82%
beta.-Myrcene	4.85%	alpha.-Pinene	8.99%	alpha.-Terpineol acetate	4.67%
p-Menth-1-en-8-ol	4.41%	beta.-Myrcene	8.21%	4(10)-Thujene	4.18%

Table (16) :The highest five components of replicates in Sorif during winter

Dahrya summer Rep 1		Dahrya summer Rep2		Dahrya summer Rep 3	
Component	%	component	%	component	%
2(10)-Pinen-3-one	5.75%	Germacrene D	11.44%	Germacrene D	14.28%
p-Menth-1-en-8-ol, acetate	5.59%	beta.-Myrcene	9.30%	p-Menth-1-en-8-ol,	8.80%
Naphthalene, 1,2,3,5,6,7,8,8a-	5.03%	p-Menth-1-en-8-ol,	7.66%	beta.-Myrcene	6.29%
Myrtenal	4.76%	4(10)-Thujene	7.12%	beta.-Pinene	5.62%
2(10)-Pinen-3-ol, (1S,3R,5S)	4.62%	beta.-Pinene	5.99%	beta.-Farnesene	5.30%

3.3.3 Geographic differences in the essential oil composition:

The lab analysis in general detected about 92 compounds in the essential oil in *Teucrium polium*. Some of these compounds were detected only in one site but not the other (Table 17), but about 26 compounds were detected in both sites.

Table (17) : Components that exist in one of the sites without existing in the other

Sorif	Dahrya
Eucalyptol	Bicyclo[3.1.0]hexane
2-Octene	gamma.-Terpinen
Thujone	Benzene, 2-methoxy-4-methyl-1
(S)-cis-Verbenol	beta.-Sesquiphellandrene
2-(1,4,4-Trimethyl-cyclohex-2-enyl)	1,6,10-Dodecatriene
1,E-4,Z-8-Dodecatriene	Propanal
Longipinane	
tau-Cadinol	

3.3.4 Components classification:

Components were classified into monoterpenes and sesquiterpenes, and each one subdivided into hydrocarbons or oxygenated. From the detected essential oil, (11) compounds are monoterpenes hydrocarbons, (2) oxygenated monoterpenes, and (6) sesquiterpenes hydrocarbons (Table 18).

Table (18) : Classification of the components present in all the treatments:

Monoterpenes		Sesquiterpenes	
hydrocarbons	**oxygenated**	**Hydrocarbons**	**Oxygenated**
alpha.-Pinene		beta.-Myrcene	
3-Thujene	Thymol	1,5-Cyclodecadiene	
(-)-.beta.-Pinene	Terpinen-4-ol		
2(10)-Pinene,		trans-Pinocarvyl acetate	
Nonanal			
D-Limonene		Eudesma-4(14)),11-diene	
Thujol		Bicyclo[3.1.1]hept-2-ene-2-methanol	
Thujone		Germacrene B	
2(10)-Pinen-3-one			
1R) Myrtenal			
Myrtenyl acetate			

Chapter: Discussion

4. 1 Plant Morphology:

4.1.1 Leaf parameters and plant height:

Plant morphological and physiological attributes differ upon changes in environmental conditions, and appeared to be a consequence of responses to abiotic factors such as soil moisture, air temperature, and atmospheric CO_2 concentrations (Chunyang et al, 2005)

Result showed that leaf area, length, width and plant height and diameter were higher in Sorif than in Dahrya for all investigated plants during all seasons. These results might be due to the difference in the environmental conditions between the two sites. Plants in Dahrya adapted to the lower precipitation (300-400mm), and lower relative humidity (55-60%) by reducing leaf area, length and width and plant height. These results agreed with other researches. David et al (2002) found that reducing water loss through leaves of *Encelia farinosa* populations occupying hot, dry environments produced smaller leaves than in more mesic environments. A reduction in leaf length and width for leaves suffering drought is an advantage to survive the dry condition Wang and Qiong (2004), found that precipitation and aridity are the critical factors influencing plant height, leaf length and width which are related to leaf area and plant height. Furthermore, sensitivity of cell to water stress is one of the reasons that interpreted reduction in leaf area under water stress (Akyeampong, 1986). In Ethiopia, Ayana and Bekele (2000), found that *Sorghum bicolor* plant height increased from north to south and from east to west, following the rainfall rate, temperature and growing season patterns. Leaf area of

Corchorus olitorius the cv. 'Angbadu' was significantly reduced by soil moisture stress which could be due to the fact that the smaller leaves helped in controlling excessive transpiration losses (Ayodele and Fawusi 1998). Furthermore, the smaller vegetative and reproductive organs of *Iris*, with decreased leaf height collected from Ma'daba, was considered as an adaptation to aridity; reduction in flower stem and leaf size would reduce the leaf surface exposed to radiation, and thus reduce water loss (Nabila et al. 2008). The result suggests that the size of I*ris* plants decreased going from north to south due to a decrease in rainfall rate, and the vegetative parts are the most variable characters (Nabila et al., 2008)

Almost all investigated plants are perennials, which start their vegetative phase in spring and continue to the reproductive and flower in April to September. As the first sampling date was in winter, we noticed that most of the species were dormant without leaves. However, in the second sampling date (spring) the plants were in the vegetative stage so leaf area, leaf length, leaf width, and plant height are higher than summer and autumn (Table 4, 5, 6).

On the other hand, *Capparis spinosa* has short reproductive and vegetative period and it is one of a few species that grow and flower entirely in summer. Seasonal variation for leaf parameters and plant height were affected basically with the life cycle of each plant (Sangwan et al., 2001)

4.1.2 Stomata density:

Stomatal density is sensitive to environmental changes, such as temperature, CO_2 concentration, and precepitation (Zhenget et al., 2006). Although xerophytes usually have a greater number of stomata per mm^2 of leaf surface area than do mesophytes, the average total pore area as apercentage of total leaf area is about 50% of that for xerophyts than for mesophyts. This may be an adaptation for maintaining tight control of water loss when the soil begins to dry, while still minimizing the distance CO_2 must travel to reach any photosynthetic cell (Gurevitch, 2002). Data in figure (20) shows higher stomatal density in Dahrya during summer and autumn, than in Sorif. That means an increase in stomatal density with drought condition. The reason for the higher stomata density under drought condition can greatly amplify the potential behavior control over water loss and CO_2 uptake. This agreed with the interpretation that upon water stress, stomata undergo slight increase in density to reduce the amount of CO_2 entering the mesophyll and to contribute to better control of transpiration (Artimios and Cofidis, 2002).

Opposite results were reported by Pracash and Ramachandran (2000), who showed that under water stress conditions, both the number of stomata and length and breadth of the stomata were reduced at all growth stages. Results showed lower stomata number in summer than autumn (Table 7) and the reason might be due to the life cycle of *Capparis spinosa*, which started in summer. Consequently, leaves are smaller in the beginning of the vegetative growth and the area increased until reaching the peak without changing in stomata number.

4.2 Total chlorophyll content:

Total chlorophyll content found to be higher in Dahrya as an adaptation to the drought stress. The same result was found by Mohammadian et al. (1999), who concluded that an increase in F0 initial fluorescence is characteristic of PSΠ inactivation. However, other results showed that under water stress, the dehydration of tissue can result in deterioration of chloroplast structure with associated loss in chlorophyll. (Khani and Heidari, 2007). Changes in chlorophyll fluorescence emission from photosynthetic organisms are considered frequently as indications of changes in photosynthetic activity perturbation, drought tolerant genotypes were relatively less affected, and the value of chlorophyll content, in drought tolerante genotypes were significantly higher than those in drought sensitive genotypes under drought stress (Rong-hua**,** et al., 2006).

4.3 Essential oil composition:

Seasonal variation between winter and summer of the essential oil of *Teucrium polium* was investigated beside the investigation of the composition between two different sites (Dahrya and Sorif). Results showed that essential oil yielded volatiles with more or less similar composition. (Appendix a).

4.3.1 Quantity of essential oil component:

Essential oil quantitative composition is related to the plants habitat (Karousous et al, 2005). The production of the essential oils not only depends upon the metabolic state, but also is highly integrated with the physiology of the plant (Sangwang et al 2001). As showen in Figure (22) the quantity of the essential oil was higher in Sorif during winter, and the reason for this might be that the plant was in the early vegetative growth when the samples were taken for winter reading. This is in agreement with the opinion that one of the most important characteristics of oil accumulation is its dependence on the developmental stage/phase of the plant (Sangwan et al., 2001). In almost all the cases reported so far, the net essential oil production has been reported to be associated with the early growth period, such as in *Ocimum sanctum Majorana hortensis* (Croteau, 1977), and *Cymbopogon flexuosus* (Singh et al., 1989). Moreover, it was mentioned that young leaves of *Eucalyptus citriodora* frequently have greater oil content than mature ones (Sangwan et al, 2001). In addition to that, stress induced changes in oil yield are thought to be the result of the effect of stress on plant growth and differentiation rather than a direct effect on oil synthesis. Thus the reduction in growth could be the main reason for significant decrease in oil yield in different genotypes under stress (Sangwan et al., 2001). Accordingly, oil yield decreased significantly under stress and the decrease was due to reduction in herbage (Shbbih et al., 2001).

4.3.2 Essential oil composition:

There were variation among essential oil composition even among replicates from the same site and season (Appendix b). This may lead us to conclude that the composition of the essential oil affected by plant habitat. Antunes et al (2004) conclude that there are major differences among the essential oils obtained from plants collected at the same developmental stage, even among those from the same collection sites or very close localities with similar ecological and edaphic features. This fact indicates that the chemical polymorphism of the volatile oil of *Teucrium capitatum* might be due in part to genetic characters.

Compositional alterations in essential oil content, occurring as a consequence of drought, have also been elucidated for mints (Chattopadhyay and Subramanyam 1993) and sweet basil (Simon et al., 1992). In Kenya, a larger variation in oil content between leaves of a similar age (but from different trees) has been reported (Sangwan et al., 2001 and Antunes et al., 2004). In general, terpenoids are the predominant constituent of plant essential oils, but many of these oils are also composed of other chemicals like phenylpropanoids (Sangwan et al., 2001). Results indicated that most of the repeated components are terpins, especially monoterpenes hydrocarbons (D-Limonene, beta and alpha-pinene, nonal, myrtenal, and thujene) and sesquterpine hydrocarbons (germacrene B, beta myrcene, eudesma, transpinocarvyl acetate). Upon water stress, changes may be due to the effect of the stress on enzymes involved in the biosynthesis of monoterpenes. (Shabbih et al., 2001). Leaf area in Sorif was higher than Dahrya, and this correlated with essential oil which is higher in Sorif in winter. This result can be interpreted that since oil glands are most numerous in the leaves, leaf size and number are most important factors affecting oil production. Although geranium is drought tolerant, long dry spells severely retard growth, reduce oil content, and change oil characteristics. (Sangwan et al., 2001).

In winter, higher essential oil was recorded for both study sites; it might be caused by higher soil moisture and lower temperature during this period.

Weather parameters such as atmospheric temperature and rainfall have been reported to influence oil content and composition in several aromatic plants in addition an increase in maximum temperature reduced oil content

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4.3.4 Geographic differences:

Data showed that the main compounds of the essential oil of *Teucrium polium* investigated in this research are (D-Limonene, beta and alpha-pinene, Nonal, myrtenal, and thujene) and sesquterpine hydrocarbons (germacrene B, beta myrcene, eudesma, transpinocarvyl acetate).

Kabouche, et al., (2007) found α and β-pinene, α-cadinol and 3β-hydroxy-α-muurolene to be the main components in the essential oil of *Teucrium polium*. α and β-pinene were found to be the main components by Cozzani and Muselli et al., (2005). On the other hand Aburjai et al., (2006) found 8-cederen-13-ol, β-caryophellen, germacerene-D, and sabinen to be the main components of the essential oil of *Teucrium polium*.

Conclusion

The differences in climatic conditions (precipitation, relative humidity, evapotranspiration, soil characteristics) of Dahrya and Sorif, and between seasons (spring, summer, autumn, and winter); seemed to affect plant morphology by reducing plant growth, and increasing stomata number. The effect on physiological side was by an increase in total chlorophyll content.

On the biochemical sides there were variation in the quantity and quality of the components of the essential oil, even among replicates from the same site and season. Weather parameters such as atmospheric temperature and rainfall have been founed to influence oil content and composition of *Teucrium polium.*

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Appendix (A)

Table (1) Component of *Teucrium polium* essential oil of replicate (1) brought from Dahrya site in summer

omponent	Rt.*	peak area	%*
Germacrene D	22.721	604998884	34.65%
D-Limonene	9.637	294121696	16.84%
beta.-Myrcene	8.868	142438818	8.16%
beta.-Pinene	7.072	84871087	4.86%
Sabinene	7.515	65498574.4	3.75%
alpha.-Pinene	5.111	57901408.6	3.32%
1-Octen-3-ol	16.767	50164543.8	2.87%
Eudesma 4(14),11-diene	22.879	34412433	1.97%
Benzaldehyde	18.505	25421739	1.46%
alpha.-Terpineol acetate	22.534	24329009.6	1.39%
p-Menth-1-en-4-ol	20.387	23365098.8	1.34%
1,5-Cyclodecadiene	21.117	23287816	1.33%
Naphthalene,	23.814	22110061.8	1.27%
2(10)-Pinen-3-one	19.429	21642520.9	1.24%
1,5-Cyclodecadiene,	25.283	19787594.1	1.13%
1,3,6-Octatriene,	11.29	16650871.3	0.95%
2-Isopropenyl-4a	22.997	16479733.9	0.94%
Bicyclo[3.1.0]hexan	17.021	16162824	0.93%
Bicyclo[3.1.1]heptan-3-ol	21.637	15680950.6	0.90%
Octen-1-ol, acetate	14.829	14503860.4	0.83%
Bicyclo[3.1.1]hept-3-en-2-ol,	22.212	13669297.3	0.78%
m-Cymene	11.704	13180179.3	0.75%
Thujone	16.213	11457919.9	0.66%
Bicyclo[3.1.1]heptane	7.248	11149170.9	0.64%
(1R)-(-)-Myrtenal	20.881	9563432.9	0.55%
gamma.-Terpinen	10.981	9245868.8	0.53%
Bicyclo[3.1.0]hexan	19.092	8566182.45	0.49%
Cyclobuta[1,2:3,4]dicyclopentene	18.102	7768626.6	0.44%
delta.-Selinene	24.035	7510109.95	0.43%
2-Cyclohexen-1-ol, 2-methy	25.725	6293601.65	0.36%
2,6-Octadien-1-ol,	24.987	6267095.1	0.36%
(-)-Myrtenyl acetate	22.352	5633436.9	0.32%
trans-Pinocarvyl acetate	21.442	5176923.5	0.30%

Continue table (1) Component of *Teucrium polium* essential oil of replicate (1) brought from Dahrya site in summer

Component	Rt.*	peak area	%*
Bicyclo[3.1.0]hex	5.31	5040838.25	0.29%
(+)-4-Carene	12.016	5035308.6	0.29%
Thujol	15.825	4839982.35	0.28%
alpha.-Muurolene	23.077	4733360.8	0.27%
1,6-Octadien-3-ol,	19.209	4485371.8	0.26%
Ocimene	20.629	4464929	0.26%
Bicyclo[2.2.1]heptan-2-ol,	19.757	4115666.8	0.24%
Bicyclo[3.1.1]hept-2-ene-	24.772	4028831.45	0.23%
7-Oxabicyclo[4.1.0]heptane,	16.365	3965555.3	0.23%
Propanal,	24.433	3003979.3	0.17%
alpha.-Cubebene	17.437	2801158.5	0.16%
3-Cyclopentene	17.568	2451462.65	0.14%
Naphthalene, 1,2,3,4,4a,5,6,8a-	24.207	2185456.35	0.13%
3-Octanol	15.253	2103694.95	0.12%
Naphthalene, 1,2,4a,5,6,8a	24.543	1664079.2	0.10%
2-Octenal,	16.045	1010372.65	0.06%
Nonanal	15.143	946873.55	0.05%

* Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (2): Component of *Teucrium polium* essential oil of replicate (2) brought from Dahrya site in summer

Component	Rt	peak area	%
beta.-Pinene	7.104	172,874,049	10.57%
Germacrene D	22.669	166,097,277	10.15%
4(10)-Thujene	7.533	162,791,379	9.95%
beta.-Myrcene	8.865	144,396,391	8.82%
p-Menth-1-en-8	22.533	143,110,356	8.75%
alpha.-Pinene	5.11	129,469,261	7.91%
(Z)-.beta.-Farnesene	21.897	116,536,982	7.12%
2(10)-Pinen-3-ol	21.642	43,563,251	2.66%
D-Limonene	9.632	39,078,398	2.39%
(S)-cis-Verbenol	22.204	37,593,758	2.30%
Bicyclo[3.1.0]hexan-2-o	17.021	35,019,898	2.14%
(1R)-(-)-Myrtenal	20.885	33,836,329	2.07%
2(10)-Pinen-3-one	19.424	32,691,914	2.00%
Thymol	32.888	32,232,983	1.97%
Benzaldehyde	18.506	24,518,758	1.50%
Germacrene B	25.285	24,084,842	1.47%
Octen-1-ol, acetate	14.83	24,001,447	1.47%
1-Octen-3-ol	16.764	20,961,845	1.28%
alpha.-Pinene	5.308	20,644,051	1.26%
Bicyclo[3.1.1]hept-2-ene	24.775	19,195,529	1.17%
Germacrene B	21.116	17,634,040	1.08%
beta.-Pinene	7.262	17,496,038	1.07%
p-Menth-1-en-4-ol	20.388	16,583,474	1.01%
Bicyclo[3.1.0]hexan-2-ol,	19.095	16,317,879	1.00%
(-)-Myrtenyl acetate	22.342	15,773,225	0.96%
m-Cymene	11.704	10,417,027	0.64%
Phenol, 2-methyl-5	33.477	8,457,974	0.52%
alpha.-Campholenal	17.568	7,833,759	0.48%
(+)-4-Carene	12.017	7,079,002	0.43%
(1R)-(+)-Norinon	19.645	6,957,461	0.43%
p-Mentha-6	23.342	6,534,235	0.40%
90 p-Mentha-6	25.726	6,299,926	0.39%
Isoledene	23.814	6,181,947	0.38%
Bicyclo[3.1.0]hexan-2-one	20.977	5,628,087	0.34%
1-Hydroxy-1,7	29.935	5,307,167	0.32%
(-)-Spathulenol	31.364	4,357,416	0.27%
91 Octen-1-ol	13.622	3,435,446	0.21%
Benzaldehyde	24.43	3,433,494	0.21%
p-Cymen-8-ol	26.064	3,203,340	0.20%

Continue Table (2): Component of *Teucrium polium* essential oil of replicate (2) brought from Dahrya site in summer

Component	Rt	peak area	%
Cyclopropane	24.998	3,021,075	0.18%
Carveol 2	26.375	2,798,821	0.17%
Cyclopropanemethanol	28.445	2,782,907	0.17%
beta.-Sesquiphellandrene	21.268	2,691,858	0.16%
(S)-(-)-(4-Isopropenyl	29.196	2,537,005	0.16%
Ethanone, 1-(3-methylphenyl)-	24.302	2,487,482	0.15%
(-)-trans-Pinocarvyl acetate	21.441	2,279,919	0.14%
beta.-cis-Ocimene	11.289	2,124,930	0.13%
Camphenol, 6	15.939	2,071,555	0.13%
(S)-cis-Verbenol	18.381	1,997,841	0.12%
2-Furanmethanol	16.377	1,990,496	0.12%
tau.-Cadinol	27.735	1,828,799	0.11%
2-Octenal, (E)-	16.043	1,604,730	0.10%
2,6-Dimethyl-1,3,5,7-octatetraene, E,E-	10.164	1,579,125	0.10%
tau.-Cadinol	32.26	1,463,600	0.09%
p-Cymen-7-ol	31.122	1,346,350	0.08%
alpha.-Longipinene	22.963	1,331,176	0.08%
Cedrene	28.873	1,237,524	0.08%
2-Hexenal, (E)-	10.32	1,232,020	0.08%
Nonanal	15.137	931,324	0.06%
Bicyclo[3.1.1]heptane-2	23.661	911,405	0.06%
Nerol acetate	23.963	799,479	0.05%
4-Hydroxy-3-methylacetophenone	27.403	777,634	0.05%
cis-Myrtanol	26.385	691,934	0.04%

* Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (3): Component of Teucrium polium essential oil of replicate (3) brought from Dahrya site in summer

Component	Rt	peak area	%
Germacrene D	22.678	143997096	17.25%
beta.-Pinene	7.089	86428203.8	10.35%
Bicyclo[3.1.0]hexane	7.533	62018699.7	7.43%
beta.-Myrcene	8.859	54528636.2	6.53%
alpha.-Pinene	5.117	54092394.8	6.48%
1,6,10-Dodecatriene	21.891	40216910.1	4.82%
Bicyclo[3.1.1]heptan-3-ol	21.642	32860316.7	3.94%
Bicyclo[3.1.1]hept-3-en-2-ol	22.204	30326297.7	3.63%
Thymol	32.889	24208238.1	2.90%
D-Limonene	9.627	23978363.5	2.87%
Eudesma 4(14),11-diene	22.87	21029522.2	2.52%
2(10)-Pinen-3-one	19.424	20065483.8	2.40%
Benzaldehyde	18.506	19006660.4	2.28%
Naphthalene	23.816	15249355.8	1.83%
(1R)-(-)-Myrtenal	20.884	15071814.6	1.81%
1-Octen-3-ol	16.763	13419343.4	1.61%
Eucalyptol	9.803	13351498.7	1.60%
alpha.-Pinene	5.31	10033492.5	1.20%
beta.-Myrcene	8.977	10004860.3	1.20%
Bicyclo[3.1.0]hexan-2-ol	17.018	9953122.49	1.19%
Benzene, 1-methyl-3	11.705	9601718.86	1.15%
beta.-Pinene	7.267	9451078.93	1.13%
Bicyclo[3.1.1]heptan-2-one	19.646	8129805.49	0.97%
Cyclobuta[1,2:3,4]dicyclopentene	18.095	6330924.26	0.76%
1,6-Dimethylhepta	17.926	5810444.66	0.70%
Bicyclo[3.1.0]hexan-2-ol	19.095	5571242.13	0.67%
2-Isopropenyl-4a,8	22.987	5522431.82	0.66%
Bicyclo[3.1.0]hexan-2-one	20.978	5175701.89	0.62%
2-Cyclohexen-1-one,	23.341	5000578.9	0.60%
Phenol, 2-methyl-5-(1-methylethyl)	33.478	4937364.81	0.59%
Bicyclo[5.2.0]nonane	21.134	4710085.19	0.56%
3-Cyclopentene-1	17.567	4697547.28	0.56%
1H-Cycloprop[e]azulen-7-ol,	31.364	4258431.18	0.51%
1H-Cyclopenta[1,3]	18.655	3971904.35	0.48%

Continue Table (3): Component of *Teucrium polium* essential oil of replicate (3) brought from Dahrya site in summer

Component	Rt	peak area	%
1,3,6-Octatriene	11.289	3874147.37	0.46%
3,5-Heptadienal, 2-ethylidene-6-methyl-	29.194	3410279.66	0.41%
Copaene	17.429	3323937.72	0.40%
Cyclopropaneme thanol	28.445	3149182.06	0.38%
4-Carene	12.018	2891526.78	0.35%
1-Hydroxy-1,7-dimethyl	29.934	2830792.17	0.34%
1,6-Dimethylhepta-1,3,5-triene	17.925	2811174.82	0.34%
Bornyl acetate	19.752	2618317.04	0.31%
3-Octanol	15.253	2531890.23	0.30%
Spathulenol	26.451	2490548.95	0.30%
Benzaldehyde, 4-(1-methylethyl)	24.434	2425967.12	0.29%
Octen-1-ol, acetate	14.827	2275201.97	0.27%
Longiverbenone	36.137	2199260.75	0.26%
Caryophyllene oxide	27.171	2079439.89	0.25%
Bicyclo[4.1.0]hept-	20.634	2061577.55	0.25%
Thujol	15.825	1894341.01	0.23%
Isoledene	27.734	1569414.32	0.19%
1,5-Cyclodecadiene	25.283	1279354.73	0.15%
1,6-Octadien-3-ol	19.207	1271416.8	0.15%
7-Oxabicyclo[4.1.0]heptane,	16.367	990962.037	0.12%
3,5-Heptadienal, 2-ethylidene-6-methy	30.219	956405.227	0.11%
trans-Pinocarvyl acetate	21.443	907279.067	0.11%
2-Octenal	16.043	786051.95	0.09%
Selina-6-en-4-ol	33.928	569867.35	0.07%
Bicyclo[3.1.1]heptane-2	18.95	503494.787	0.06%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (4): Component of *Teucrium polium* essential oil of replicate (1) brought from Sorif site in winter

Component	Rt	peak area	%
4(10)-Thujene	7.533	46906861	8.31%
Copaene	17.437	39147548	6.93%
1H-Cycloprop[e]azulen-7-ol	31.367	24491177	4.34%
Cadina-1(10),4-diene	23.815	24220721	4.29%
1,6,10-Dodecatriene	21.879	23750843	4.21%
Benzaldehyde	18.508	22211907	3.93%
Eudesma 4(14),11-diene	22.859	21577267	3.82%
1H-Cyclopenta[1,3]cyclopropa	18.659	20664481	3.66%
alpha.-Cubebene	16.631	18045155	3.20%
1-Octen-3-ol	16.764	16835038	2.98%
2(10)-Pinen-3-one	19.424	16411323	2.91%
L-trans-Pinocarveol	21.64	16157763	2.86%
(S)-cis-Verbenol	22.2	15639385	2.77%
Thymol	32.892	13194491	2.34%
p-Menth-1-en-8-ol,	22.514	12237643	2.17%
D-Limonene	9.623	12173266	2.16%
Isoledene	26.658	11834266	2.10%
1H-Cycloprop[e]azulene	21.113	11634679	2.06%
2-Isopropenyl-4a,	22.981	11194458	1.98%
(1R)-(-)-Myrtenal	20.883	11182973	1.98%
beta Cadin-4-en-10-ol	28.469	10740310	1.90%
Bicyclo[3.1.0]hexane, 4-methylene	7.534	9762513	1.73%
Bicyclo[3.1.0]hexan-2-ol	17.019	9715006.7	1.72%
beta.-Pinene	7.093	9424726.1	1.67%
1,6-Dimethylhepta-1,3,5-triene	17.926	8739026.5	1.55%
alpha.-Pinene	5.097	8544339.2	1.51%
p-Mentha-6,8-dien-2-one	23.34	8106526.9	1.44%
3-Cyclopentene-1-acetaldehyde	17.569	7973589.7	1.41%
beta.-Myrcene -	8.983	6341629.1	1.12%
Benzene, 1-methyl-3-	11.702	6012402.5	1.06%
Cadina-1,4-diene	24.309	5123299.7	0.91%
beta.-Myrcene	8.859	5084939.6	0.90%
Eucalyptol	9.78	4797643.7	0.85%
1,E-4,Z-8-Dodecatriene	29.119	4729002.8	0.84%
Phenol, 2-methyl-5-	33.483	4279357.7	0.76%
Spathulenol	26.453	4199049.1	0.74%
p-Mentha-6,	25.726	4117178.2	0.73%
Bicyclo[3.1.0]hexan-2-ol,	19.095	3993124.9	0.71%
Bicyclo[3.1.1]hept-2-ene-2-	24.775	3719712.3	0.66%

Continue Table (4): Component of *Teucrium polium* essential oil of replicate (1) brought from Sorif site in winter

Component	Rt	peak area	%
Bicyclo[3.1.0]hexan-2-one	20.979	3699797	0.66%
Bicyclo[3.1.1]heptan-2-one	19.646	3441644.1	0.61%
Thujone	16.219	3411189.4	0.60%
Spathulenol	31.365	3029467.8	0.54%
gamma.-Terpinen	10.983	2951663.5	0.52%
Di-epi-.alpha.-cedrene-	30.178	2875312.9	0.51%
Myrtenyl acetate	22.343	2457289.8	0.44%
3-Thujene	5.317	2243508.3	0.40%
p-Cymen-8-ol	26.061	2233376.7	0.40%
Octen-1-ol, acetate	14.829	2170005	0.38%
alpha.-Cadinol	32.566	2095210.4	0.37%
Propanal, 2-methyl-3-phenyl	24.436	1815795	0.32%
3-Cyclopentene-1	15.94	1664667.8	0.29%
Nerol acetate	23.97	1438850.1	0.25%
trans-Pinocarvyl acetate	21.434	1345815.4	0.24%
Ledol	29.45	1077263	0.19%
alpha.-Terpinen	9.07	1062477.5	0.19%
5-Hepten-2-one, 6-methyl	13.678	932241.78	0.17%
3-Octanol	15.255	899261.99	0.16%
Germacrene B	25.284	838592.98	0.15%
Nonanal	15.136	835514.3	0.15%
Cyclopentane, 1-methyl	14.096	745578.57	0.13%
Thujone	15.69	639783.41	0.11%
Thujol	15.825	565286.86	0.10%
1,3,7-Octatriene, 3,7-dimethyl	11.293	513935.31	0.09%
tau.-Cadinol	32.257	440563.12	0.08%
Acetic acid, hexyl estere	11.91	394619.09	0.07%
Benzene, methoxy	13.83	344838.2	0.06%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (6): Component of *Teucrium polium* essential oil of replicate (2) brought from Sorif site in winter

Component	Rt	peak area	%
beta.-Pinene	7.111	445,004,658	16.59%
beta.-Myrcene	8.882	444,026,337	16.55%
D-Limonene	9.653	389,572,982	14.52%
alpha.-Pinene	5.138	257,843,338	9.61%
Eucalyptol	9.759	113,236,373	4.22%
alpha.-Pinene	5.31	74,582,404	2.78%
1-Octen-3-ol	16.768	69,378,533	2.59%
beta.-cis-Ocimene	11.296	65,851,718	2.45%
2(10)-Pinene	7.277	59,281,608	2.21%
beta.-Phellandrene	7.67	49,707,637	1.85%
Bicyclo[3.1.0]hexan-2-ol,	19.096	41,397,774	1.54%
Bicyclo[3.1.0]hexan-2-ol,	17.024	38,705,658	1.44%
2(10)-Pinen-3-one	19.427	38,136,592	1.42%
2(10)-Pinen-3-ol, (1S,3R,5S)	21.641	34,970,614	1.30%
m-Cymene	11.708	28,569,116	1.06%
(S)-cis-Verbenol	22.206	27,395,910	1.02%
Benzaldehyde	18.507	27,117,359	1.01%
Thujone	16.216	24,983,436	0.93%
Naphthalene	23.815	24,447,691	0.91%
Thymol	32.892	23,435,931	0.87%
Myrtenal	20.884	21,882,930	0.82%
5-Azulenemethanol,	30.741	21,589,888	0.80%
gamma.-Terpinen	10.987	21,090,917	0.79%
1,5-Cyclodecadiene,	21.117	19,143,653	0.71%
Eudesma-4(14),	22.871	17,750,848	0.66%
2,6-Octadien-1-ol,	24.989	16,358,484	0.61%
1H-Cycloprop[e]azulen-7-ol	31.365	15,991,873	0.60%
Benzene, 1-methyl	11.704	15,861,798	0.59%
Bicyclo[3.1.1]hept-2-ene-	24.774	14,347,718	0.53%
2-Isopropenyl-4a,8-dimethyl-	21.927	13,314,396	0.50%
2,6-Octadien-1-ol,	26.01	13,287,644	0.50%
4-Carene	12.018	13,062,956	0.49%
2-Methyl-4	18.656	12,255,029	0.46%
Octen-1-ol	14.83	12,176,403	0.45%
Thujol	17.932	11,633,682	0.43%
Bornyl acetate	19.751	11,604,433	0.43%
Thujol	15.827	10,206,735	0.38%
1,5-Cyclodecadiene,	25.283	9,944,822	0.37%

Continue Table (6): Component of *Teucrium polium* essential oil of replicate (2) brought from Sorif site in winter

Component	Rt	peak area	
beta.-trans-Ocimene	10.852	9,023,130	0.34%
Naphthalene, 1,2,3,4,4a,5,6,8	29.937	8,974,210	0.33%
p-Menth-8-ene,	16.367	8,227,472	0.31%
2-Isopropenyl-4a	22.99	7,682,958	0.29%
2-Carene	20.632	7,572,090	0.28%
3-Cyclopentene-1-acetaldehyde	17.57	7,422,883	0.28%
Cyclobuta[1,2:3,4]dicyclopentene,	18.098	6,846,429	0.26%
Benzaldehyde, 4	24.435	5,873,203	0.22%
Acetic acid, geraniol ester	23.963	5,596,529	0.21%
Phenol, 2-methyl-5-(1-methylethyl)-	33.481	5,338,567	0.20%
Bicyclo[3.1.0]hexan-2-one,	20.977	4,897,469	0.18%
7,7-Dimethyl-4-methylenebicyclo[4.1.0]	22.35	4,838,068	0.18%
5-Hepten-2-one, 6-methyl	13.677	4,710,901	0.18%
Bicyclo[3.1.1]heptan-2-one	19.644	4,557,734	0.17%
1-Hexanol, 2-ethyl-	17.751	3,909,445	0.15%
1-Dodecen-3-ol	15.67	3,512,201	0.13%
2-Octenal	16.047	3,249,259	0.12%
4-Hydroxy-3-methylacetophenone	27.403	3,119,483	0.12%
5-Azulenemethanol, 1,2,3,4,5,6,7,8	32.148	3,069,335	0.11%
cis-p-Mentha-2,	22.065	2,534,138	0.09%
trans-Pinocarvyl acetate	21.442	2,456,837	0.09%
Carveol 2	26.375	2,451,966	0.09%
Bicyclo[3.1.1]hept-3-en-2-ol, 4	18.377	2,342,630	0.09%
alpha.-Bisabolol	33.222	1,971,984	0.07%
Isoledene	27.733	1,876,306	0.07%
Eugenol	32.39	1,796,584	0.07%
Benzenemethanol, 4-(1-methylethyl)-	31.125	1,680,726	0.06%
2-Octene, 2-methyl-6-methylene-	15.393	1,610,916	0.06%
3-Octanol	15.255	1,442,308	0.05%
alpha.-Muurolene	24.55	1,160,928	0.04%
Longiverbenone	36.137	1,048,457	0.04%
1,5,9-Cyclododecatriene	30.39	1,037,523	0.04%
2-Furanmethanol,	31.51	803,411	0.03%
2,3-Dehydro-1,8-cineole	9.403	414,964	0.02%
Benzene, methoxy	13.83	317,070	0.01%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (7): Component of *Teucrium poilium* essential oil of replicate (3) brought from Sorif site in winter

component	Rt	peak area	%
Germacrene D	22.7	590741619.6	33.31%
p-Menth-1-en-8-ol,	22.541	140616401	7.93%
D-Limonene	9.646	118096558.8	6.66%
beta.-Myrcene	8.875	89596014.17	5.05%
4(10)-Thujene	7.536	82709670.08	4.66%
beta.-Pinene	7.109	82704450.44	4.66%
alpha.-Pinene	5.172	62573233.34	3.53%
Thymol	32.891	53696307.59	3.03%
1,6,10-Dodecatriene,	21.889	49616359.87	2.80%
Eucalyptol	9.776	37825453.02	2.13%
Benzaldehyde	18.508	32954764	1.86%
Bicyclo[3.1.0]hexan-2-ol,	17.023	30871605.89	1.74%
Bicyclo[3.1.0]hexan-2-ol,	19.097	28254776.96	1.59%
2(10)-Pinen-3-one,	19.428	26245196.23	1.48%
1,5-Cyclodecadiene,	21.118	25567616.08	1.44%
Germacrene B	25.288	25432057.94	1.43%
beta.-Phellandrene	7.69	17424569.56	0.98%
Thujone	16.216	16890288.92	0.95%
Bicyclo[3.1.1]hept-3-en-2-ol	22.204	16381855.18	0.92%
Naphthalene, 1,2,3,5,6,8a	23.814	16180609.06	0.91%
(1R)-(-)-Myrtenal	20.886	15785306.17	0.89%
beta.-Myrcene	8.999	14894975.21	0.84%
1-Octen-3-ol	16.766	14622621.7	0.82%
Copaene	17.438	14023475.76	0.79%
Benzene, 1-methyl-3	11.712	12078229.78	0.68%
3-Thujene	5.317	11764658.29	0.66%
Phenol, 2-methyl-5-(1-methylethyl)	33.48	11271668.66	0.64%
1,3,6-Octatriene	11.297	9961493.916	0.56%
2(10)-Pinene	7.29	9334933.056	0.53%
Cyclobuta[1,2:3,4]dicyclopentene	18.102	7548254.58	0.43%
Thujol	15.827	7433121.78	0.42%
Bicyclo[3.1.1]hept-2-ene-	24.774	7293997.968	0.41%

Continue table (7): Component of *Teucrium poilium* essential oil of replicate (3) brought from Sorif site in winter

component	Rt	peak area	%
3-Cyclopentene-1-acetaldehyde,	17.57	6446727.96	0.36%
tau.-Cadinol	29.935	6084001.644	0.34%
Propanal,	24.436	5057665.764	0.29%
2-Carene	20.634	5443167.324	0.31%
Bicyclo[3.1.1]hept-3-en-	17.932	5333288.532	0.30%
Bicyclo[3.1.0]hexan-2-one,	20.98	4333663.032	0.24%
Bicyclo[3.1.1]heptan-2-one	19.647	4221730.752	0.24%
Benzenemethanol	26.064	3475846.344	0.20%
4-Carene	12.022	3294804.312	0.19%
7-Oxabicyclo[4.1.0]heptane,	16.37	3049511.304	0.17%
Naphthalenol, 1,2,3,4,4a,	27.73	2981065.284	0.17%
tau.-Cadinol	32.263	2745721.812	0.15%
Eudesma-4(14),11-diene	22.85	2512109.628	0.14%
2,3-Dehydro-1,8-cineole	9.411	2496579.588	0.14%
2-Propyl-1-pentanol	17.751	2382061.116	0.13%
Bicyclo[3.1.1]hept-2-ene,	10.86	2272244.616	0.13%
Isoledene	26.657	2251325.244	0.13%
Thujone	15.69	1844100.96	0.10%
Tricyclo[5.4.0.0(2,8)]undec-9-ene	22.957	1810596.456	0.10%
2-(1,4,4-Trimethyl-cyclohex-2-enyl)	28.991	1458006.552	0.08%
(S)-cis-Verbenol	18.387	1446989.46	0.08%
cis-p-Mentha-2,8-dien-1-ol	22.063	1435153.98	0.08%
Octen-1-ol, acetate	14.831	1366896.984	0.08%
5-Azulenemethanol, 1,2,3,3a,	33.233	1293499.824	0.07%
Nonanal	15.137	1150934.916	0.06%
Carveol 2	26.376	1076150.148	0.06%
2-Octene, 2-methyl-6-methylene	15.397	981371.796	0.06%
alpha.-Bisabolol	26.21	905392.74	0.05%
5-Hepten-2-one, 6-methyl-	13.682	862497.18	0.05%
3-Octanol	15.263	819584.436	0.05%
trans-Pinocarvyl acetate	21.44	750274.92	0.04%
Longiverbenone	33.828	668842.092	0.04%
alpha.-Cadinol	32.565	589370.388	0.03%

Rt.: Retention time

* % : Fraction of the component from whole essential oil

Table (8): Component of *Teucrium poilium* essential oil of replicate (1) brought from Dahrya site during winter

Component	Rt	peak area	%
D-Limonene	9.647	199495305	16.35%
Germacrene D	22.671	163765499	13.42%
beta.-Pinene	7.093	100944790	8.27%
beta.-Myrcene	8.873	59242796	4.85%
p-Menth-1-en-8-ol	22.522	53784071.1	4.41%
Bicyclo[3.1.0]hexane, 4-methylene	7.538	52068717.5	4.27%
p-Menth-8-en-1-ol,	9.76	49026097.5	4.02%
2(10)-Pinen-3-one,	19.427	42341437.7	3.47%
Bicyclo[3.1.1]heptan-3-ol	21.643	41041276.8	3.36%
(1R)-(-)-Myrtenal	20.887	34068634	2.79%
Benzaldehyde	18.508	30820142	2.53%
1,6,10-Dodecatriene,	21.884	26890678	2.20%
Thymol	32.89	26701592	2.19%
Bicyclo[3.1.1]hept-3-en-2-ol,	22.202	24394760.5	2.00%
1-Octen-3-ol	16.764	23554112.5	1.93%
Spathulenol	31.365	20970198.6	1.72%
2-Cyclohexen-1-ol	25.726	18667195.8	1.53%
Bicyclo[3.1.0]hexan-2-ol	19.095	18352133.7	1.50%
Bicyclo[3.1.1]hept-2-ene	24.774	17748125.2	1.45%
beta.-Phellandrene	7.69	17424569.6	1.43%
Bicyclo[3.1.0]hexan-	17.021	17385960.8	1.42%
Bicyclo[3.1.1]heptane,	7.289	12395373.4	1.02%
m-Cymene	11.71	10455191.4	0.86%
beta.-cis-Ocimene	11.296	10194303.7	0.84%
Thujone	16.216	10168273.2	0.83%
beta.-Myrcene	8.99	9929384.07	0.81%
1,6-Dimethylhepta-1,3,5-triene	17.927	9671428.79	0.79%
3-Cyclopentene-1-acetaldehyde,	17.57	9187279.5	0.75%
1H-Cycloprop[e]azulen-7-ol,	31.366	8632696.01	0.71%
Bicyclo[3.1.1]heptan-2-one	19.647	8236020.9	0.67%
Bicyclo[3.1.0]hexan-2-one	20.98	7946972.97	0.65%
Naphthalene, 1,2,3,4,4a,5,6,8a	23.811	7905144.2	0.65%
2,6-Octadien-1-ol,	24.989	7151443.89	0.59%
7-Oxabicyclo[4.1.0]heptane	16.367	6644426.25	0.54%
gamma.-Terpinen	10.992	6355904.66	0.52%
Myrtenyl acetate	22.34	4865775.72	0.40%
Propanal	24.436	4219471.06	0.35%
Benzenemethanol	26.064	3776018.63	0.31%
Cubenol	28.461	2925092.7	0.24%

.

Continue table (8): Component of *Teucrium poilium* essential oil of replicate (1) brought from Dahrya site during winter

Component	Rt	peak area	%
cis-p-Mentha-2,8	22.063	3723380.58	0.31%
Bicyclo[3.1.0]hex-3-en-	21.23	3253731.03	0.27%
4-Carene	12.022	3117179.39	0.26%
Ethanone	24.3	2691146.95	0.22%
2,3-Dehydro-1,8-cineole	9.411	2496579.59	0.20%
1,5-Cyclodecadiene	25.283	2449955.29	0.20%
2-Propyl-1-pentanol	17.751	2382061.12	0.20%
trans-Carveyl acetate	23.47	2220373.59	0.18%
Octen-1-ol, acetate	14.83	1611916.65	0.13%
trans-Pinocarvyl acetate	21.442	1538806.23	0.13%
Nonanal	15.134	1472688.6	0.12%
2-(1,4,4-Trimethyl-cyclohex-2-enyl)-ethanol	28.991	1458006.55	0.12%
3-Octanol	15.256	1455091.78	0.12%
Bicyclo[3.1.0]hex-2-ene	5.337	1414730.26	0.12%
Thujol	15.828	1374263.06	0.11%
Cubenol	32.381	1345764.96	0.11%
5-Azulenemethanol, 1,2,3,3a,4,5,6,7	33.233	1293499.82	0.11%
5-Hepten-2-one, 6-methyl	13.683	1134209.43	0.09%
beta.-trans-Ocimene	10.855	1122113.78	0.09%
tau.-Cadinol	32.259	1012374.98	0.08%
alpha.-Bisabolol	26.21	905392.74	0.07%
2-Octene, 2-methyl-6-methylene-	15.39	891123.764	0.07%
Eudesma-4(14)	22.859	705551.389	0.06%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (9): Component of *Teucrium poilium* essential oil of replicate (2) brought from Dahrya site during winter

Component	Rt	peak area	%
beta.-Pinene	7.079	362832645	14.96%
Germacrene D	22.69	322529751	13.30%
4(10)-Thujene	7.544	278543352	11.48%
alpha.-Pinene	5.148	218045055	8.99%
beta.-Myrcene	8.87	199022333	8.21%
2(10)-Pinen-3-one	19.432	115922914	4.78%
Bicyclo[3.1.1]heptan-3-ol	21.648	110034774	4.54%
D-Limonene	9.636	92494402	3.81%
Bicyclo[3.1.1]hept-3-en-2-ol	22.209	77287949	3.19%
3-Thujene	5.293	61607930	2.54%
Bicyclo[3.1.0]hexan-2-ol	17.024	54353434	2.24%
Bicyclo[3.1.0]hexan-2-ol	19.098	49884645	2.06%
Eucalyptol	9.804	48632994	2.01%
2(10)-Pinene, (1S,5S)-(-)-	7.27	47498093	1.96%
Thujone	16.217	44446554	1.83%
beta.-Myrcene	8.977	36680744	1.51%
2-Pinen-10-ol	24.776	35479237	1.46%
1-Octen-3-ol	16.765	35040911	1.44%
3-Cyclopentene-1-acetaldehyde,	17.571	30237974	1.25%
Spathulenol	31.366	23383034	0.96%
Bicyclo[3.1.1]heptan-2-one,	19.649	22215805	0.92%
1,3,6-Octatriene, 3,7-dimethyl-, (Z)-	11.293	17008122	0.70%
Bicyclo[3.1.1]hept-3-en-2-ol,	19.854	13844442	0.57%
Thymol	32.889	13648243	0.56%
Bicyclo[3.1.0]hex-3-en-2-one	21.224	12751916	0.53%
Carvacrol	33.479	11487725	0.47%
1-Cycloheptene, 1,4-dimethyl-3-	21.094	11258213	0.46%
Thujol	15.828	9957540	0.41%
Bicyclo[2.2.1]heptan-2-ol, 1,3,3-trimethyl-, (1R-endo)-	20.001	9339118.6	0.39%
D-Verbenone	29.197	7690567.9	0.32%
Octen-1-ol, acetate	14.829	3393299.3	0.14%
1,6,10-Dodecatrien-3-ol, 3,7,11	28.451	6663604.1	0.27%

Continue (9): Component of *Teucrium poilium* essential oil of replicate (2) brought from Dahrya site during winter

Component	Rt	peak area	%
Bicyclo[3.1.1]hept-3-en-2-ol,	18.385	5739164.2	0.24%
1-Naphthalenol, 1,2,3,4,4a,7,8,8a	29.935	5105494.2	0.21%
p-Cymen-7-ol	31.126	4462125.1	0.18%
Thujone	15.693	3660667.6	0.15%
Bicyclo[3.1.1]hept-2-ene,	10.854	3549516.7	0.15%
3-Octanol	15.255	3455504.9	0.14%
Cyclopentane,	14.099	3401686.8	0.14%
5-Isopropenyl-2-methylcyclopent-	30.213	2996461.4	0.12%
2-Octenal, (E)	16.046	2763889	0.11%
Isoledene	27.731	2616186.2	0.11%
3-Cyclopentene-1-acetaldehyde	14.404	1528181.9	0.06%
Longiverbenone	36.131	1133776.7	0.05%
tau.-Cadinol	32.259	1000164.7	0.04%
2-Furanmethanol, tetrahydro-	31.51	754073.03	0.03%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (10): Component of *Teucrium poilium* essential oil of replicate (3) brought from Dahrya site during winter

component	Rt	peak area	%
Germacrene D	22.677	220310640	19.61%
D-Limonene	9.633	63235934	5.63%
beta.-Pinene	7.092	54170901	4.82%
alpha.-Terpineol acetate	22.524	52458565	4.67%
4(10)-Thujene	7.533	46906861	4.18%
beta.-Myrcene	8.869	45409275	4.04%
beta.-Farnesene	21.887	40781894	3.63%
Carvacrol	33.48	38304688	3.41%
2(10)-Pinen-3-one,	19.425	35847437	3.19%
alpha.-Pinene	5.126	35096180	3.12%
Guaiol	33.121	34560377	3.08%
Thymol	32.892	31624885	2.81%
2(10)-Pinen-3-ol, (1S,3R,5S)	21.641	31388650	2.79%
(S)-cis-Verbenol	22.204	26894642	2.39%
Benzaldehyde	18.506	25882293	2.30%
Myrtenal	20.885	24916225	2.22%
1H-Cycloprop[e]azulen-7-ol	31.367	24491177	2.18%
p-Menth-1-en-4-ol	20.389	24202088	2.15%
Eudesma-4(14)-dien	22.866	22441094	2.00%
p-Mentha-6,8-dien-2-one,	23.343	18496415	1.65%
2-Isopropenyl-4a	22.987	16038049	1.43%
Bicyclo[3.1.0]hexan-2-ol	19.094	14867144	1.32%
Bicyclo[3.1.0]hexan-2-ol	17.02	14499339	1.29%
Cyclobuta[1,2:3,4]	18.1	12774393	1.14%
m-Cymene	11.706	12215605	1.09%
2-Pinen-10-ol	24.774	10348601	0.92%
5-Azulenemethanol,	30.741	9766301	0.87%
p-Mentha-6,8-dien-2-ol	25.726	8788431.4	0.78%
Isoledene	23.814	8044107.1	0.72%
1H-Cycloprop[e]azulene	21.113	7686560.2	0.68%
Thujone	16.217	7135643.7	0.64%
Norinone	19.646	6421959.1	0.57%
beta.-Myrcene	8.983	6341629.1	0.56%
Bicyclo[3.1.0]hexan-2-one	20.98	6094827.8	0.54%
2(10)-Pinene, (1S,5S)	7.266	5804173.6	0.52%
1,6-Dimethylhepta-1,3,5-triene	17.927	5534258.4	0.49%
beta.-Linalool	19.21	4707851.4	0.42%
Propanal	24.436	4677941.4	0.42%
Agarospirol	32.374	4253835.5	0.38%

continue table (10): Component of *Teucrium poilium* essential oil of replicate (3) brought from Dahrya site during winter

component	Rt	peak area	%
beta.-cis-Ocimene	11.291	3814782.9	0.34%
2-Naphthalenemethanol	30.924	3695395.5	0.33%
cis-Geraniol	24.99	3601366	0.32%
p-Cymen-8-ol	26.064	3429670	0.31%
1-Naphthalenol, 1,2,3,4,4a,7,8,8	29.933	3298827	0.29%
Cubenol	28.46	3273161.6	0.29%
Germacrene B	25.282	3184320.9	0.28%
p-Menth-1-en-4-ol, acetate	20.636	3126990.4	0.28%
Spathulenol	26.443	2988459.4	0.27%
2-(1,4,4-Trimethyl-cyclohex-2-enyl)l	28.999	2516101.2	0.22%
Ethanone, 1-(3-methylphenyl)-	24.301	2499771.4	0.22%
Longiverbenone	36.142	2465011.1	0.22%
Myrtenyl acetate	22.343	2457289.8	0.22%
p-Menth-8-ene, 1,2-epoxy	16.371	2273177.2	0.20%
2-Propyl-1-pentanol	17.747	2189375.2	0.19%
beta.-Humulene	32.144	1625104.9	0.14%
3-Thujene	5.317	1431048.5	0.13%
3-Buten-2-one,	28.786	1277132.1	0.11%
Selina-6-en-4-ol	33.932	1216842.3	0.11%
trans-Pinocarvyl acetate	21.437	1181514.5	0.11%
Octen-1-ol, acetate	14.829	1126215.6	0.10%
Copaene	26.65	1097562.2	0.10%
4-Carene	10.85	1075998.3	0.10%
3-Octanol	15.254	1072979.4	0.10%
(2E,3Z)-2-Ethylidene-6-methy	30.216	1041509.8	0.09%
4-Hydroxy-3-methylacetophenone	27.402	949516.72	0.08%
2,3-Dehydro-1,8-cineole	9.37	903997.09	0.08%
Thujol	15.823	787213.69	0.07%
Nonanal	15.135	457971.97	0.04%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (11) Component of *Teucrium poilium* essential oil of replicate (1) brought from Sorif site during Summer

Component	Rt	peak area	
2(10)-Pinen-3-one	19.425	41600837	5.75%
p-Menth-1-en-8-ol, acetate	22.516	40464874	5.59%
Naphthalene, 1,2,3,5,6,7,8,8a-	22.652	36425057	5.03%
Myrtenal	20.886	34462913	4.76%
2(10)-Pinen-3-ol, (1S,3R,5S)	21.641	33462739	4.62%
p-Menth-1-en-4-ol	20.389	31285302	4.32%
Bicyclo[3.1.1]hept-3-en-2-ol,	22.199	31006324	4.28%
Eudesma-4(14),11-diene	22.863	29818040	4.12%
Benzaldehyde	18.506	26837357	3.71%
alpha.-Panasinsen	23.852	24941500	3.45%
Bicyclo[3.1.0]hexan-2-ol,	17.021	24691903	3.41%
beta.-Pinene	7.083	23625202	3.26%
alpha.-Pinene	5.115	22754217	3.14%
Thujone	16.215	18016365	2.49%
Copaene	17.435	17648834	2.44%
2-Pinen-10-ol	24.774	17528416	2.42%
2-Isopropenyl-4a,8	21.926	14998563	2.07%
Thymol	32.891	14506206	2.00%
Myrtenyl acetate	22.335	13221225	1.83%
beta.-Myrcene	8.861	12593471	1.74%
3-Cyclopentene-1-acetaldehyde	17.569	11328378	1.56%
Eucalyptol	9.798	11103423	1.53%
Bicyclo[3.1.0]hexan-2-ol,	19.094	10803203	1.49%
Thujol	15.826	10622222	1.47%
Bicyclo[3.1.0]hex-2-ene	7.858	10578519	1.46%
Bicyclo[3.1.0]hexan-2-one,	20.98	9165078.8	1.27%
D-Limonene	9.627	8983781.8	1.24%
Cubenol	28.464	8251261.4	1.14%
Bicyclo[3.1.0]hex-3-en-2-one	21.223	8221888.1	1.14%
1-Octen-3-ol	16.764	8199332.8	1.13%
p-Mentha-6,8-dien-2-ol	25.726	6331113.2	0.87%
Bicyclo[3.1.1]heptan-2-one	19.647	6305139.1	0.87%
2-Isopropenyl-4a	22.981	6275986.2	0.87%
2-Carene	20.634	6026220	0.83%
Carene	9.111	5348136	0.74%
Phenol, 2-methyl-5-	33.481	4734100.7	0.65%
Bicyclo[7.2.0]undec-4-ene,	20.006	4683925.6	0.65%

Continue table (11) Component of *Teucrium poilium* essential oil of replicate (1) brought from Sorif site during summer

Component	Rt	peak area	%
Benzaldehyde, 4-(1-methylethyl)-	24.435	4463273.1	0.62%
Spathulenol	26.451	4386717.4	0.61%
Isoledene	26.655	3828942.9	0.53%
Longiverbenone	33.829	4255720.4	0.59%
3-Thujene	5.284	3481371.1	0.48%
p-Cymen-8-ol	26.063	3195540.9	0.44%
Bicyclo[3.1.1]heptan-3-one	18.087	3034477.5	0.42%
1H-Cycloprop[e]azulen-7-ol	27.168	3021916.6	0.42%
Isoledene	27.733	2961071.2	0.41%
beta.-Pinene	7.251	2739113.4	0.38%
1,6-Octadien-3-ol	19.21	2603235.6	0.36%
tau.-Cadinol	32.262	2520932	0.35%
1-Dodecen-3-yne	15.583	2460860.5	0.34%
Bicyclo[4.1.0]hept-2-ene	12.016	2449950.2	0.34%
Bornyl acetate	19.754	2405184.9	0.33%
1-Naphthalenol, 1,2,3,4,4a,7,8,8a-	29.934	2401717.2	0.33%
trans-Pinocarvyl acetate	21.44	2378018.2	0.33%
Germacrene B	25.284	2143146.8	0.30%
Bicyclo[3.1.1]hept-3-en-2-ol,	18.383	2101004.4	0.29%
Octen-1-ol, acetate	14.828	2063471.1	0.29%
7-Oxabicyclo[4.1.0]heptane,	16.369	1809470.6	0.25%
p-Cymen-7-ol	31.123	1736385.1	0.24%
2-Octene,	15.394	1728538.5	0.24%
Thujone	15.693	1478742.9	0.20%
Caryophyllene oxide	28.853	1451860.3	0.20%
2-Hexenal	10.322	1343837.3	0.19%
1,3,7-Octatriene	11.287	1342451.2	0.19%
2(3H)-Furanone	14.503	1236135.2	0.17%
Cyclopentane	14.099	1152874.1	0.16%
Bicyclo[3.1.1]heptane-2-	18.957	1135256	0.16%
2,6-Dimethyl-1,3,5,7-octatetraene,	10.163	1134773.5	0.16%
5-Hepten-2-one, 6-methyl	13.673	1047432.4	0.14%
Nonanal	15.13	896549.51	0.12%
Globulol	29.45	617076.98	0.09%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (12) Component of *Teucrium poilium* essential oil of replicate (1) brought from Sorif site during summer

component	Rt	peak area	
Germacrene D	22.671	168,323,959	11.44%
beta.-Myrcene	8.88	136,849,429	9.30%
p-Menth-1-en-8-ol,	22.531	112,784,065	7.66%
4(10)-Thujene	7.553	104,696,570	7.12%
beta.-Pinene	7.098	88,209,784	5.99%
Thymol	32.893	56,334,624	3.83%
D-Limonene	9.642	52,480,663	3.57%
p-Menth-1-en-4-ol	20.391	39,158,547	2.66%
Bicyclo[3.1.1]hept-3-en-2-ol	22.205	37,137,323	2.52%
Amyl vinyl carbinol	16.768	35,154,670	2.39%
Bicyclo[3.1.1]heptan-3-ol	21.643	33,334,688	2.27%
5-Azulenemethanol,	30.745	31,258,350	2.12%
Bicyclo[3.1.0]hexan-2-ol	17.023	26,384,268	1.79%
Eudesma-4(14),11-diene	22.865	25,864,200	1.76%
Myrtenal	20.886	25,180,178	1.71%
Benzaldehyde Artificial Almond Oil	18.508	24,223,283	1.65%
Cadina-1(10),4-diene	23.815	24,220,721	1.65%
Eucalyptol	9.811	23,004,364	1.56%
Naphthalene, 1,2,3,5,6,8a	23.815	17,394,116	1.18%
Copaene	17.435	16,293,540	1.11%
trans-Geraniol	26.012	16,276,457	1.11%
(S)-cis-Verbenol	22.2	15,639,385	1.06%
2,6-Octadienal	23.397	14,910,126	1.01%
2-Pinen-10-ol	24.775	14,724,625	1.00%
3-Thujene	5.324	14,322,844	0.97%
beta.-cis-Ocimene	11.3	13,675,031	0.93%
m-Cymene	11.712	13,240,109	0.90%
cis-Geraniol	24.991	12,411,206	0.84%
Bicyclo[4.4.0]dec-1-ene	32.264	11,757,819	0.80%
Bicyclo[3.1.0]hexan-2-ol,	19.096	11,563,291	0.79%
Thujone	16.217	11,105,629	0.75%

Continue table (12) Component of *Teucrium poilium* essential oil of replicate (2) brought from Sorif site during summer

Component	Rt	peak area	%
beta Cadin-4-en-10-ol	28.469	10,740,310	0.73%
Bicyclo[7.2.0]undec-4-ene,	21.87	9,391,293	0.64%
1H-Cycloprop[e]azulen-7-ol,	31.365	8,972,406	0.61%
3-Cyclopentene	17.571	8,747,956	0.59%
p-Mentha-6,8-dien-2-one	23.34	8,106,527	0.55%
Octen-1-ol, acetate	14.831	7,986,942	0.54%
Thujol	15.828	7,845,027	0.53%
3,5-Heptadien-2-ol	17.931	7,508,693	0.51%
2(10)-Pinene, (1S,5S)-(-)-	7.276	7,405,186	0.50%
Naphthalene, 1,2,3,4,4a,5,6,8a-	29.936	7,349,349	0.50%
5-Azulenemethanol,	32.148	7,342,253	0.50%
Bicyclo[3.1.0]hexan-2-one,	20.982	7,317,863	0.50%
p-Mentha-6,8-dien-2-ol, trans-	25.726	7,045,115	0.48%
1,5-Cyclodecadiene	21.119	6,997,919	0.48%
Cubenol	28.466	6,673,502	0.45%
Norinone	19.648	6,103,312	0.41%
Carene	12.025	5,889,092	0.40%
Germacrene B	25.284	5,618,561	0.38%
5-Azulenemethanol]-	33.055	5,212,552	0.35%
Cadina-1,4-diene	24.309	5,123,300	0.35%
2-Carene	20.634	4,694,524	0.32%
1,6-Octadien-3-ol	19.208	4,679,860	0.32%
Longiverbenone	33.831	4,402,868	0.30%
Phenol, 2-methyl-5-(1-methylethyl)	33.483	4,279,358	0.29%
Bicyclo[3.1.0]hex-3-en-2-one	21.23	4,274,147	0.29%
Germacrene B	23.218	4,129,171	0.28%
Benzaldehyde, 4-(1-methylethyl)	24.437	3,972,257	0.27%
Benzene, 2-methoxy	20.238	3,878,104	0.26%
(S)-cis-Verbenol	19.856	3,811,345	0.26%
Isoledene	26.658	3,488,632	0.24%
Myrtenyl acetate	22.342	3,241,982	0.22%
3-Octanol	15.257	3,147,176	0.21%
Di-epi-.alpha.-cedrene	30.178	2,875,313	0.20%
3-Acetoxytridecane	13.646	2,854,181	0.19%
Bicyclo[3.1.1]hept-2-ene	10.86	2,776,696	0.19%
5-Azulenemethanol	33.233	2,653,989	0.18%
Bornyl acetate	19.75	2,585,458	0.18%
Isoledene	27.736	2,514,870	0.17%
Benzenemethanol, 4-	31.126	2,457,249	0.17%

Continue (12) Component of *Teucrium poilium* essential oil of replicate (2) brought from Sorif site during summer

component	Rt	peak area	%
2,6-Octadien-1-ol	23.971	2,440,231	0.17%
p-Cymen-8-ol	26.061	2,233,377	0.15%
Bicyclo[3.1.1]hept-3-en	18.384	2,140,566	0.15%
alpha.-Cadinol	32.566	2,095,210	0.14%
p-Menth-8-ene	16.363	1,902,959	0.13%
trans-Pinocarvyl acetate	21.443	1,648,619	0.11%
Nerol acetate	23.97	1,438,850	0.10%
2-Octenal, (E)-	16.048	1,365,660	0.09%
2-Octene, 2-methyl-6-methylene	15.39	1,290,365	0.09%
3-Decyn-2-ol	15.138	1,217,285	0.08%
Thujone	15.697	1,205,934	0.08%
2(3H)-Furanone	14.509	1,130,227	0.08%
Azulene, 1,2,3,4,5,6,7,8	29.683	1,118,337	0.08%
Ledol	29.45	1,077,263	0.07%
tau.-Muurolol	32.566	1,076,743	0.07%
alpha.-Terpinen	9.07	1,062,477	0.07%
1-Octen-3-one	12.679	990,261	0.07%
Santolina epoxide	14.101	983,847	0.07%
cis-p-Mentha-2,8-dien-1-ol	22.059	881,225	0.06%
Myrtanal	18.957	743,819	0.05%
Carveol 2	26.379	600,015	0.04%
tau.-Cadinol	32.257	440,563	0.03%
Acetic acid, hexyl ester	11.91	394,619	0.03%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

Table (13) Component of *Teucrium poilium* essential oil of replicate (3) brought from Sorif site during summer

Component	Rt	peak area	%
Germacrene D	22.658	76,022,580	14.28%
p-Menth-1-en-8-ol,	22.52	46,849,270	8.80%
beta.-Myrcene	8.86	33,478,733	6.29%
beta.-Pinene	7.083	29,887,632	5.62%
beta.-Farnesene	21.88	28,229,461	5.30%
alpha.-Pinene	5.116	22,672,035	4.26%
Benzaldehyde Artificial Almond Oil	18.507	22,647,928	4.25%
1,5-Cyclodecadiene	23.218	20,202,670	3.80%
Eudesma-4(14),11-diene	22.861	16,926,783	3.18%
Thymol	32.892	15,822,799	2.97%
2(10)-Pinen-3-one	19.424	13,670,277	2.57%
Eucalyptol	9.798	13,387,118	2.52%
D-Limonene	9.63	12,368,061	2.32%
1-Octen-3-ol	16.764	11,327,727	2.13%
(S)-cis-Verbenol	22.201	11,097,176	2.08%
2(10)-Pinen-3-ol, (1S,3R,5S	21.641	10,121,050	1.90%
Bicyclo[3.1.0]hexan-2-ol	17.019	9,010,283	1.69%
(1R)-(-)-Myrtenal	20.884	8,974,863	1.69%
alpha.-Panasinsen	23.851	8,468,276	1.59%
beta.-Myrcene	8.977	6,935,936	1.30%
Octen-1-ol, acetate	14.83	5,881,613	1.10%
Bicyclo[3.1.1]hept-2-ene	24.774	5,868,510	1.10%
Phenol, 2-methyl-5-(1-methylethyl)-	33.48	5,351,820	1.01%
Germacrene D	19.861	5,289,587	0.99%
1,6-Octadien-3-ol	19.325	5,265,498	0.99%
Myrtenyl acetate	22.336	4,006,670	0.75%
2,6-Octadienal, 3,7-dimethyl-, (E)-	23.395	3,979,623	0.75%
2(10)-Pinene, (1S,5S)	7.258	3,895,705	0.73%
2-Isopropenyl-4a,8-dimethyl-	22.982	3,842,458	0.72%
m-Cymene	11.703	3,796,317	0.71%
Bicyclo[3.1.0]hexan-2-ol,	19.094	3,615,360	0.68%
beta.-cis-Ocimene	11.291	3,436,109	0.65%
1H-Cycloprop[e]azulen-7-ol-	31.366	3,277,948	0.62%
Germacrene B	21.112	3,073,321	0.58%
2,6-Octadien-1-ol, 3,7-dimethyl	26.01	3,038,935	0.57%
1,5-Cyclodecadiene	25.281	2,934,453	0.55%
2,6-Octadien-1-ol, 3,7-dimethyl	24.99	2,821,602	0.53%
Thujol	15.825	2,324,115	0.44%
Thujone	16.216	2,650,927	0.50%

Continue table (13) Component of *Teucrium poilium* essential oil of replicate (3) brought from Sorif site during summer

Component	Rt	peak area	%
Bicyclo[3.1.1]hept-3-en-2-ol	19.852	2,553,929	0.48%
3-Cyclopentene-1-acetaldehyde, 2	17.568	2,327,211	0.44%
Longiverbenone	36.139	2,255,076	0.42%
Bicyclo[3.1.0]hexan-2-one	20.979	2,203,620	0.41%
2-Carene	12.017	2,139,596	0.40%
Cyclobuta[1,2:3,4]dicyclopentene,	18.095	2,103,450	0.40%
Spathulenol	26.452	2,099,511	0.39%
1-Naphthalenol, 1,2,3,4,4a,7,8,8a	29.936	2,076,322	0.39%
Bicyclo[3.1.1]hept-2-en-	17.937	1,977,367	0.37%
1,6-Octadien-3-ol, 3,7	19.205	1,803,475	0.34%
2,6-Octadien-1-ol, 3,7-d	23.969	1,694,786	0.32%
Bicyclo[4.1.0]hept-2-ene	20.634	1,667,985	0.31%
7-Tetradecenal, (Z)	28.45	1,654,306	0.31%
Bicyclo[3.1.1]heptan-2-one,	19.645	1,544,170	0.29%
Bicyclo[3.1.0]hex-3-en-2-one	21.23	1,293,079	0.24%
Octen-1-ol, acetate	13.626	1,225,474	0.23%
Benzaldehyde, 4-(1-methylethyl)	24.435	1,213,058	0.23%
alpha.-Methyl-.alpha	16.375	1,017,839	0.19%
2-Octenal, (E)-	16.044	942,922	0.18%
Nonanal	15.137	769,861	0.14%
trans-Pinocarvyl acetate	21.441	682,856	0.13%
Acetic acid	19.753	641,808	0.12%
1H-Cycloprop[e]azulene	24.207	525,503	0.10%
Bicyclo[3.1.1]hept-3-en-2-ol,	18.377	439,421	0.08%
1,5-Heptadiene, 2,3,6-trimethyl	15.393	434,073	0.08%
Longipinane	29.358	425,943	0.08%
tau.-Cadinol	32.262	411,518	0.08%
Guaiol	33.123	391,066	0.07%
Bicyclo[3.1.1]heptan-3-one	18.82	371,179	0.07%
3-Octanol	15.257	352,565	0.07%
Cubenol	30.58	314,485	0.06%
Benzene, methoxy	13.83	268,303	0.05%

Rt.: Retention time

* % : Fraction of the component from whole essential oil.

الملخص باللغة العربية

تأثير العوامل البيئية على الصفات الشكلية والفسيولوجية والكيميائية للنباتات الطبية

تم عمل دراسة لخمس نباتات طبية (الجعدة*Teucrium polium* ، الكتيلة *Varthemia iphionoides*، القبار *Capparis spinosa* ، الزحيف *Coridothymus capitatus* ، رجل الحمامة*Paronychia sinacia*) في موقعين الظاهرية(جافة) وصوريف(شبة رطبة) في سنة 2007 في الفصول الأربعة (الشتاء، الربيع، الصيف ، الخريف). تم دراسة خصائص شكلية (مساحة الورقة، طول الورقة، عرض الورقة، ارتفاع النبات ، محيط النبات ، عدد الأفرع ، عدد الثغور)، وخصائص فسيولوجية (المحتوى الكلي للكلوروفيل)، وكيميائية (كمية ونوعية المركبات الكيميائية الموجودة في الزيت العطري لنبات الجعدة).

أظهرت النتائج أن أوراق النباتات الموجودة في صوريف كانت اكبر مساحة وطولا وعرضا، وان النباتات كانت أطول من النباتات الموجودة في الظاهرية. كـذلك كانت قراءات النباتات في فصل الربيع أعلى منها في الفصول الأخرى. أظهرت الدراسة أن عدد الثغور لنبات القبار أعلى في المنطقة الجافة(الظاهرية) منه في المنطقة شبه الرطبة (صوريف)، وكان عدد الثغور في فصل الخريف أعلى منه في فصل الصيف.

كما أظهرت نتائج استخلاص الكلوروفيل الكلي أن كميته كانت أعلى في المنطقة الجافة منها في المنطقة الأكثر رطوبة. أما عن الخصائص الكيميائية فقد كان هناك تأثير للموقع والفصل على كمية ونوعية المركبات المكونة للزيت العطري وقد كان التغير على مستوى البيئة المحيطة بالنبات.