Ecological and essential oils characteristics of *Deverra tortuosa* (Desf.) DC. in Egyptian deserts

Mamdouh S. Serag*, Abdel-Hamid A. Khedr and Nesma G. Amer

Botany and Microbiology Department, Faculty of Science, Damietta University, Egypt

Email of Correspondence author: mamdouhsereg054@gmail.com - mserag@du.edu.eg

ABSTRACT

The present study aims to assess the relationship between soil chemical characteristics and associated species and the essential oils of *Deverra tortuosa* (Desf.) DC. in two Egyptian deserts.

Plant samples were collected for chemical analysis from two desert habitats differing in climatic and edaphic conditions: coastal (West of Alexandria) and inland (Wadi Hagul) in the eastern desert.

*D. tortuosa* is recoded as a common associate in most of plant communities. Higher associated plant species were recorded in the coastal desert (32 species) compared with 15 species in inland desert. Soil chemical properties were generally higher in the coastal desert except pH and sulphates showed higher values in inland desert.

Forty essential oils from *D. tortuosa* were recorded in both inland and coastal desert habitats, of which 21 were restricted to inland desert, 10 were found in coastal desert and nine are represented in both habitats. The obtained results will optimized the application of *Deverra tortuosa* as a source of essential oils.

Keywords: Apiaceae, *Deverra tortuosa*, Egyptian deserts, essential oils, soil variables.

INTRODUCTION

Desert vegetation is particularly sensitive to the natural and human interventions. Many species are of economic importance in the arid regions playing a significant role in soil protection and sand dune stabilization against movement by wind or water. In addition, they provide a source of forage for animals, fuel and food for local inhabitants and have medicinal and potential industrial value (Laudadio *et al.*, 2009a,b; Barakat *et al.*, 2010; Bansi *et al.*, 2014).

*Deverra tortuosa* is used by the Egyptians for the preparation of a carminative drink and is occasionally eaten by grazing animals (Ahmed *et al.*, 1969). It is also used for relief of stomach pains, as an anti-asthmatic, against scorpion stings (Boukef *et al.*, 1982), against intestinal parasites, when blood is excreted in the urine or when coughing blood, and for the regulation of menstruation (Pathak *et al.*, 1974). *Deverra* species are used in traditional medicine for the treatment of fevers, hepatitis, asthma, diabetes digestive difficulties and rheumatism (Vérité *et al.*, 2004). The species is known in traditional local medicine for the treatment of hypertension, against constipation, and in the case of bites (El-Mokasabi, 2014).

Essential oils, i.e. volatile secondary substances of plant origin, can have wide ranging applications in traditional folk medicine and food, flavoring, cosmetic and fragrance industries. Recently, many
essential oils and their constituents have been investigated for their multifunctional properties (Hajji et al., 2010).

Plants, naturally, produce essential oils to protect themselves from pathogen micro-organisms. These essential oils have been used in the folk medicine since thousands of years as antimicrobial (Fisher and Phillips, 2008). Essential oils were frequently referred to as the natural and environmentally friendly cleaning solutions. They are used as a substitute to chemicals to disinfect and spread a pleasant scent in the air (Segvic Klaric et al., 2007). They are also used to control human diseases of microbial origin and to cure such diseases as atherosclerosis and cancer (Warnke et al., 2006).

Due to the high economic potentialities of Deverra tortuosa in particular the medicinal value, the present study was undertaken to compare the essential oil composition of Deverra tortuosa in relation to soil chemical variables and climatic conditions in two Egyptian deserts.

MATERIALS AND METHODS

1. Study species:

Deverra tortuosa (Desf.) DC. Synonym: Pituranthos tortuosus (Desf.) known in Arabic as “Guezzah”, Strongly aromatic glabrous shrub, 30-80 cm; stems dichotomously branched, striate; leaves caducous; basal leaves 3-8 cm, 2-pinnatisect into linear-subulate, acute lobes; petiole sheathing, with broad scarious margin; lower cauline leaves with sheaths to 1.5 cm; blade 1-2.5 cm, ternatisect, the lobes linear-subulate; upper leaves reduced to sheaths with filiform apices; umbels mostly terminal; peduncle 1.5-4 cm, stout; umbel-rays 6-10, 1-2 cm, subequal; bracts 2-3 x 1-1.5 mm, triangular, the margin scarious, the apex mucronate; bracteoles minute; bracts and bracteoles persistent; pedicel 0-1.5 mm; flowers hardly opening; petals almost glabrous; styles longer than the depressed stylopodium; fruit 1-1.5 mm, globose, hirsute (Täckholm, 1974; Boluos, 1999 and 2002). It grows in almost all the phytogeographical regions of Egypt especially desert wadis, sandy and stony plains (Boluos 2000).

2. Study area

2-1 West Alexandria along Northwestern Mediterranean Coast

The Mediterranean coastal land of Egypt, in general, belongs to the semi-arid climatic zone of Koppen’s (1931) classification system (as quoted by Trewartha, 1954), and the Mediterranean bioclimatic zone of Emberger (1955). The bioclimatic map of UNESCO/FAO (1963) indicates that it is of a sub-desert warm climate. The maximum amount falls during either January or December and varies appreciably between the different stations. Rainfall of torrential nature may be expected—“values (in one day) up to 120.8 mm (Shaltout, 1983) (Table 1).

Table 1.Climatic data of meteorological stations (West of Alexandria and Wadi Hagul), Anonymous,(1980).

| Meteorological variable        | West of Alexandria | Wadi Hagul |
|-------------------------------|--------------------|------------|
| Maximum air temperature (ºC) | 24.9               | 27.6       |
| Minimum air temperature (ºC) | 14.9               | 17.6       |
| Relative Humidity (%)         | 72                 | 51.0       |
| Evaporation (mm/day)          | 5.2                | 11.5       |
| Rainfall (mm/month)           | 192.1              | –          |
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2-2 Wadi Hagul

Wadi Hagul occupies an area of approximately 345 km², in the Eastern Desert and lies at the Northwestern part of Suez Gulf. Wadi Hagul lies within arid desert climate with very low rainfall, high temperature and high evaporation rate. The metrological data of neighboring Suez station (climatic average of 28 years from 1985 to 2013) showed that the climate is obviously hot and dry. The mean annually air temperature is 23.5 °C; January is the coldest month with an average temperature of 14.7 °C; while August is the hottest one with temperature of 34.5°C. Rainfall is scarce, patchy and usually cascades during the winter. The average annual rainfall is 2.7 mm (Table 1).

![Location map of Egypt showing the different habitats of *Deverra tortuosa* in A: West of Alexandria (Coastal desert) and B: Wadi Hagul (Inland desert).](image)

2-3 Field study

The present study was carried out at locations illustrated in Figure (1). Six individuals of *Deverra tortuosa* were sampled and composite soil samples were collected from the rhizosphere of the target species. In each habitat the associated species were recorded and voucher specimens were identified and deposited in the Herbarium of the Botany and Microbiology Department, Faculty of Science, Damietta University, Egypt. Identification and nomenclature of the plants were following Täckholm (1974); Boluos (1999, 2000, 2002).

3. Laboratory analyses

Soil samples were air dried, passed through 2 mm sieve and analyzed for pH, conductivity (EC), chlorides and sulphates following the procedures of United States Salinity Laboratory (Jackson 1962; Piper1974), Total Nitrogen according to Microkhjeldahl method of Hawk *et al.*, (1947), Total Phosphorus according to The adopted method of the American Public Health Association (1992). Concentrations of the cations: Na⁺, K⁺, Ca⁺² and Mg⁺² were determined using a Corning 410 Flame
Photometer Model Jenway PFP7 (Rowell, 1994).

4. Essential oil isolation

Two samples of freshly aerial parts of *Deverra tortuosa* from Wadi Hagul representing Inland desert (400 g) and West Alexandria representing Coastal desert (300 g) were subjected to hydro-distillation for 8 hr using a Clevenger-type apparatus giving their essential oils, which yielded after drying over anhydrous sodium sulphate. The essential oils were stored in dark glass tubes under refrigeration (4°C) until use. The steam distilled oils were subjected to GC/MS analysis.

5. GC/MS analysis of the essential oils

GC/MS analysis for the essential oils was carried out using a Varian GC interfaced to Finnegan SSQ 7000 mass selective Detector (SMD) with ICIS V2.0 data system for MS identification of the GC components. The column used was DB-5 (J&W Scientific, Folosm, CA) cross-linked fused silica capillary column (30 m long, 0.25 mm internal diameter) coated with ploy dimethyl siloxane (0.5μm film thickness). The oven temperature was programmed from 50°C for 3 min. isothermally, then heating by 7°C/ min. to 250°C and isothermally for 10 min., at 250°C. Injector temperature was 200°C and the volume injected was 0.5 μl. Transitionline and ion source temperature were 250°C and 150°C, respectively. The mass spectrometer had a delay of 3 min. to avoid the solvent peak and then scanned from m/z 50 to m/z 300. Ionization energy was set at 70 eV.

RESULTS

In Egypt, *D. tortuosa* is one of the most widespread plant species in different phytogeographical regions. The abundance and vigor of the plant vary depending on the environmental conditions that prevail in each region. Thirty seven species are recorded with *D. tortuosa* in both habitats of which 32 were recorded in the coastal desert and fifteen species in inland desert (Table 2).

In the western Mediterranean coastal desert, where climate is semi-arid with relatively high rainfall (mean annual = 150-300 mm), associated with relatively low temperature (mean annual = 20°C), *D. tortuosa* grows as associated species with several psammophytes and halophytes dominating by e.g. *Ammophila arenaria*, *Atriplex xhalimus*, *Suaeda pruinosa*, *Thymalaea hirsuta* and *Zygphyllum album*.

*D. tortuosa* grows as associated species in the eastern desert wadis e.g. Wadi Hagul which is extremely arid (mean annual = 15-30 mm), associated with high temperature (mean annual = 25°C), *D. tortuosa* with true xerophytic plant species e.g. *Artemisia herbaalba*, *Echinops spinosisssmus*, *Retama raetam*, *Zygophyllum decumbens* and *Zilla spinsa*.
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Table 2. Plant species associated with *Deverra tortuosa* in Egyptian deserts.

| Species                  | Coastal desert | Inland desert | Species                  | Coastal desert | Inland desert |
|--------------------------|----------------|---------------|--------------------------|----------------|---------------|
| Ammophila arenaria       | +              | -             | Lycium shawii           | +              | -             |
| Artemisia herba alba     | +              | +             | Lygeum sibiricum        | +              | -             |
| Asphodelus microcarpus   | +              | -             | Meltoniopsis ciliata    | +              | -             |
| Atractylis cardus        | +              | +             | Noaea mucronata         | +              | +             |
| Atriplex halimus         | +              | -             | Panicum turgidum        | -              | +             |
| Crucianella maritima     | +              | -             | Pennisetum divisum      | -              | +             |
| Deverra tortuosa         | +              | +             | Reaumuria hirtella      | +              | +             |
| Echinops spinosissimus   | +              | +             | Reseda alba             | +              | +             |
| Echiochilon fruticosum   | +              | -             | Retama raetam           | +              | +             |
| Echium sericium          | +              | -             | Salsola kali            | +              | -             |
| Elymus farctus           | +              | -             | Salvia lanigera         | +              | -             |
| Euphorbia paralias       | +              | -             | Suaeda pruinosa         | +              | -             |
| Globularia arabica       | +              | -             | Teucrium pollium        | +              | -             |
| Gymno carpos decandrum   | +              | -             | Thymala ahirsuta        | +              | -             |
| Helianthemum lipsii      | +              | -             | Zygophyllum album       | -              | +             |
| Launaea nudicaulis       | +              | +             | Zygophyllum decumbens   | -              | +             |
| Launaea spinosa          | -              | +             | Zilla spinosa           | -              | +             |
| Limoniastrum monopetalum | +              | -             |                         |                |               |
| Limonium prunosum        | +              | -             |                         |                |               |
| Lotus polyphyllus        | +              | -             |                         |                |               |

| Number of strands in     | Coastal desert | Inland desert |
|--------------------------|----------------|---------------|
|                           | 3              | 3             |

| Total number of species  | Coastal desert | Inland desert |
|--------------------------|----------------|---------------|
|                           | 32             | 15            |

Table 3. Chemical characteristics of soil that support *Deverra tortuosa* in Egyptian deserts.

| Parameter               | Sites I | Site II | Site III | Site I | Site II | Site III |
|-------------------------|---------|---------|----------|--------|---------|----------|
| pH                      | 7.56    | 7.55    | 7.46     | 7.81   | 7.97    | 7.96     |
| EC (mS/cm)              | 0.59    | 0.49    | 0.36     | 0.21   | 0.49    | 0.38     |
| Total N (%)             | 0.28    | 0.27    | 0.29     | 0.13   | 0.14    | 0.21     |
| Total P (%)             | 0.41    | 0.56    | 0.31     | 0.26   | 0.12    | 0.14     |
| Cl (%)                  | 0.35    | 0.92    | 0.55     | 0.22   | 0.63    | 0.32     |
| SO₄²⁻ (%)               | 0.03    | 0.04    | 0.02     | 0.12   | 0.23    | 0.19     |
| Na⁺ mg/100g soil        | 0.22    | 0.36    | 0.26     | 0.19   | 0.08    | 0.04     |
| K⁺ mg/100g soil         | 0.12    | 0.09    | 0.06     | 0.14   | 0.07    | 0.03     |
| Ca²⁺ mg/100g soil       | 3.21    | 2.91    | 2.88     | 2.11   | 1.88    | 1.73     |
| Mg²⁺ mg/100g soil       | 2.41    | 5.17    | 6.03     | 4.11   | 3.09    | 3.29     |

Table (3) shows the chemical properties of the soil supporting the growth of *D. tortuosa* in coastal and inland desert of Egypt. Soil chemical properties were generally higher in the coastal desert except pH and sulphates showed higher values in inland desert.

GC/MS analysis for the essential oils of aerial parts of *D. tortuosa* in two different localities in Egypt indicated the presence of 40 compounds; twenty one compounds were found in essential oil from inland desert only, ten compounds were found in essential oil from coastal desert and the rest nine compounds were found in the two localities e.g. (γ-terpinene, terpinen-4-ol and α-selinene) (Table 4).
Table 4: Comparison of essential oil components of *Deverra tortuosa* in Egyptian deserts.

| No | Essential Oil component name                                      | R.T | Coastal desert | Inland desert | M.F  | M.W  |
|----|------------------------------------------------------------------|-----|----------------|---------------|------|------|
| 1  | 3,5-heptadienal, 2-ethylidene-6-methyl                           | 6.35| -              | +             | C_{10}H_{14}O | 150  |
| 2  | bicyclo[2.2.1]heptane-2,5-diol, 1,7,7-trimethyl                 | 6.77| -              | +             | C_{10}H_{16}O | 170  |
| 3  | 6-camphenol                                                      | 6.87| -              | +             | C_{10}H_{16}O | 152  |
| 4  | exo-2,7,7-trimethylbicyclo[2.2.1]heptan-2-ol                     | 8.03| -              | +             | C_{10}H_{16}O | 154  |
| 5  | (-)-myrtenol                                                    | 8.12| -              | +             | C_{10}H_{16}O | 152  |
| 6  | 2-pinene-4-one                                                  | 8.41| -              | +             | C_{10}H_{16}O | 150  |
| 7  | cis-carveol                                                     | 8.52| -              | +             | C_{10}H_{16}O | 152  |
| 8  | (Z)-p-mentha-1(7)-8-dien-2-ol                                    | 9.15| -              | +             | C_{10}H_{16}O | 152  |
| 9  | α-linalene                                                      | 10.82| -            | +             | C_{15}H_{24} | 204  |
| 10 | α-copaene                                                       | 11.36| -            | +             | C_{15}H_{24} | 204  |
| 11 | β-copaene                                                       | 11.54| -            | +             | C_{15}H_{24} | 204  |
| 12 | α-calacorene                                                    | 14.29| -            | +             | C_{15}H_{24} | 200  |
| 13 | 7-isopropyl-1,4-dimethyl-Azulene                                 | 16.49| -            | +             | C_{15}H_{18} | 198  |
| 14 | 6-epi-shyobunol                                                 | 12.52| -            | +             | C_{15}H_{26}O | 222  |
| 15 | 4-epi-cubedol                                                   | 13.47| -            | +             | C_{15}H_{26}O | 222  |
| 16 | caryophyllene oxide                                             | 15.04| -            | +             | C_{15}H_{26}O | 220  |
| 17 | isoaromatendrene epoxide                                        | 15.31| -            | +             | C_{15}H_{26}O | 220  |
| 18 | 1,6-[1-(Hydroxymethyl)vinyl]-4,8a-dimethyl naphthla              | 15.57| -            | +             | C_{15}H_{24}O | 236  |
| 19 | aromatendrene oxide-(2)                                         | 15.88| -            | +             | C_{15}H_{24}O | 220  |
| 20 | 8-isopropenyl-1,3,3,7-tetramethyl-bicyclo[5.1.0]oct-5           | 16.63| -            | +             | C_{15}H_{24}O | 218  |
| 21 | 2,5-octadecadiynoic acid, methyl ester                          | 16.89| -            | +             | C_{16}H_{30}O | 290  |
| 22 | 4-methoxy-6-(2-propenyl)-1,3-benzoxoide                         | 13.86| -            | +             | C_{16}H_{22}O | 192  |
| 23 | butylidenephalide                                               | 16.59| -            | -             | C_{16}H_{22}O | 188  |
| 24 | 1,4-isopropyl-1,3-cyclohexadien-1-ylmethanol                    | 9.62 | +            | -             | C_{10}H_{16}O | 152  |
| 25 | citral                                                          | 9.34 | +            | -             | C_{10}H_{16}O | 152  |
| 26 | β-eudesmol                                                      | 16.17| +            | -             | C_{16}H_{22}O | 222  |
| 27 | cis-sabinene hydrate                                            | 8.01 | +            | -             | C_{10}H_{16}O | 154  |
| 28 | p-mentha-1,4-dien-7-ol                                          | 10.49| +            | -             | C_{10}H_{16}O | 152  |
| 29 | cis-p-menth-1-en-3-ol                                           | 8.26 | +            | -             | C_{10}H_{16}O | 154  |
| 30 | trans-ligustilide                                               | 17.67| +            | -             | C_{10}H_{16}O | 190  |
| 31 | cis-p-menth-2-en-1-ol                                           | 6.74 | +            | -             | C_{10}H_{16}O | 154  |
| 32 | cis-verbenol                                                    | 7.27 | +            | +             | C_{10}H_{16}O | 152  |
| 33 | cis-Z-α-bisabolene epoxide                                      | 16.28| +            | +             | C_{15}H_{20}O | 220  |
| 34 | perhydrofarnesyl acetone                                        | 19.06| +            | +             | C_{10}H_{16}O | 268  |
| 35 | γ-terpinene                                                     | 5.65 | +            | +             | C_{10}H_{16}O | 136  |
| 36 | p-cymen-7-ol                                                    | 9.80 | +            | +             | C_{10}H_{16}O | 150  |
| 37 | (E)-p-menth-2,8-dien-1-ol                                       | 8.76 | +            | +             | C_{10}H_{16}O | 152  |
| 38 | Ledene oxide-(II)                                               | 14.94| +            | +             | C_{10}H_{16}O | 220  |
| 39 | terpinene-4-ol                                                  | 7.77 | +            | +             | C_{10}H_{16}O | 154  |
| 40 | α-selinene                                                      | 13.37| +            | +             | C_{14}H_{24} | 204  |

**DISCUSSION**

In ecological studies of certain habitats of the Mediterranean coastal region of Egypt; variations in the distribution of vegetation type have been recognized in association with edaphic and topographic variations. These studies were either extensive general surveys, or intensive with the objective of correlating vegetation and environmental variables, all were dealing
with specific types of habitat or confined to limited locations. The local distribution of communities in different habitats is linked primarily to physiographic variations. Ayyad (1973) reported that according to these variations two main sets of habitats might be distinguished in the western Mediterranean region of Egypt, one on ridges and plateaus, and the other in depressions. Ridge and plateau habitats may be further differentiated into two main types: (1) the coastal ridge, composed mainly of snow-white oolitic calcareous grains overlain by dunes in most of its parts, and the inland less calcareous ridges, and (2) the southern tableland.

Kamal and El-Darier (1995) recorded 91 species (52 perennials and 39 annuals) in the part of the western Mediterranean desert at about 65 km west of Alexandria. The most common perennials were Thymelaea hirsuta, Noaea mucronata, Deverra tortuosa, Echinops spinosus, Anabasis articulate and Anabasis oropediorum. The most common annual species were Lobularia arabica, Adonis dentatus, Filago desertorum, Picris radicata and Cutandia dichotoma. Hammouda (1982) reported that the most common perennials in the vegetation of the western Mediterranean coastal land were Thymelaela eahirsuta, Deverra tortuosa, Anabasis articulata, Gymnocarposdecander and Salvia lanigera, and the most rare were Stipagrostis ciliata, Diplotaxis simplex, Heliotropium bacciferum, Polycarpaea repens, Sonchus oleraceaus, Atriplex semibaccata, Anchusamilleri and Polycarpon suculentum.

Wadi Hagul is one of the most notable and dry diverse wadis in the Eastern Desert. It includes most of the prospective projects areas in Egypt for relieving the overpopulation problem in the narrow strip of the Nile Delta. Two previous studies have been performed to evaluate the flora and soil-vegetation relationship in Wadi Hagul. Kassas and Zahran (1962) have been conducted a vegetation survey on the Red Sea coastal region, including Wadi Hagul. Later study by Abdelaal (2017) assessed the real status of floristic inventory in Wadi Hagul and defined the prevailing plant clusters and relate to soil and anthropogenic factors.

The results indicated that the chemical composition of essential oils from two deserts (coastal and inland) was different, this agrees to Al-Gaby and Allam (2009) who indicated that the volatile oils of Deverra tortuosa from Southern Sinai have a different composition from other regions in Egypt with camphene (31.0%) as the major constituent. The chemical composition of essential oils of the same plants may vary widely depending on geographical location, season, environmental conditions and nutritional status of the plants (Perry et al., 1999).

According to Al-Gaby and Allam (2000), the essential oil of D. tortuosa from Egypt is a mixture of a number of volatile components, mainly terpenoids, with camphene (31%) as the major constituent of the oil. According to krifat et al. (2015), the essential oil contained sabine, δ-pinene, limonene and terpinen-4-ol as major constituents. Sabine and 4-terpineol (Abdelgaleil et al., 2012).

Previous reports on the chemical composition of D. tortuosa included the investigation of its phenolic, hydrodistilled essential oil and sesquiterpene lactone contents (Mahran et al., 1989; Abdel-Mogib et al., 1992; Abdel-Ghani and Hafez, 1995; Singab et al., 1998). The chemical composition of essential oils from aerial parts of D. tortuosa grown in some areas of Egypt has shown a wide range of variations even in their major constituents (Abdallah and Ezzat, 2011; Abdel-Ghani and Hafez, 1995; Al-Gaby and Allam, 2000).
The present study has attempted to indicate the effect of soil chemical variables and climatic conditions on the composition of essential oils of *Pituranthos tortuosus* in the coastal and inland desert in Egypt. The results contribute to improving the application of the plant as a source of essential oils.

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الخصائص البيئية وخصائص الزراعة الطبية لنبات القزاح في الصحرا العربية

مذدوح سالم سراج، عبد الحميد عبد الفتتح خضر، نسمه جلال عبمر
قسم النبات والميكروبيولوجي - كلية العلوم - جامعة دمياط

المستند

تهدف هذه الدراسة إلى تقييم العلاقة بين الخصائص الكيميائية للترطيب بالأدوية المرتبطة بها على الزراعة الطبية المستخلصة من نبات القزاح في تنويع من الصحراء المصرية. تم جمع عينات نباتية من موائل صحراوية مختلفة في الظروف المناخية والتنافضية: الطرطاسية (غرب الإسكندرية) والداخلية (وادي حور). أشارت الدراسة الحقلية إلى أن نبات القزاح موسع على نطاق واسع وكان عدد الأدوية النباتية المرافقه له أعلى في الصحراء الصغيرة (32 نوعا) مقارنة بـ 15 نوعا في الصحراء الداخلية. وقد كانت الخواص الكيميائية للترطيب أعلى عوضاً في الصحراء الساحلية باستثناء الأبشيدوجيني والكربيتات التي أظهرت قيادات أعلى في الصحراء الداخلية. تم استخلاص 40 مركب من الزراعة الطبية في كل من الموائل الصحراوية الداخلية والداخلية، منها 21 مركب مقتصر على الصحراء الداخلية. 10 مركبات موجودة في الصحراء الساحلية وال นอกจาก ذلك تم الحصول عليها سوف تُطبق استخدم نبات القزاح كمصدر للزيوت الطبية.
Ecological and essential oils characteristics of *Deverra tortuosa* (Desf.) DC. in Egyptian deserts