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Adaptation of *Deverra tortuosa* (Desf.) DC. (Apiaceae) to its natural localities in Egypt

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Abstract

Deverra tortuosa (Desf.) DC. Is a widespread desert species and salt tolerant plant able to grow in different habitats. The present study aims to determine the effect of different environmental factors (edaphic) on the internal structure of *Deverra tortuosa* plant organs. Plants in the present study was collected from their natural desert localities which represent different habitats; cultivated fields (fig, olive and barley fields), wadi slopes, sandy plains, and dunes, salt marshes, roadsides and wadi bed. The effect of edaphic factors (soil texture, ionic content, pH, EC, and organic matter) on the anatomical features was studied. Results showed that there were variations among the anatomical features (epidermal features, root diameter, vesicular bundles diameter and cortical thickness) of the plant in accordance with the significant differences among the edaphic factors mainly EC, ionic content and soil texture.

Keywords: anatomical feature, *Deverra tortuosa*, edaphic factors, natural localities.
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1. Introduction

Habitat diversity in Egypt, is resulted from different geographic, physiographic, edaphic, and climatic conditions, is reflected upon the plant life and for each plant species, there is a range of ecological conditions under which it can grow and adapt itself to a certain habitat; climatic factors are important for determining the development, distribution, and density of vegetation on the earth [1].

Under natural conditions, plant can expose to a variety of environmental stresses, such as drought, low or high temperature, excessive salinity. These abiotic stress factors generate secondary stress; i.e. osmotic and oxidative stress, which have negative influence on the plant, causing changes in its proper growth, development, and metabolism [2].

Every plant organ is designed to fulfill metabolic and physiological processes in specific environmental conditions such as in arid environments, plant survival depends on the ability to harmonize structure and function to withstand desiccation without permanent damage [3].

Plants are continuously exposed to environmental stimuli that influence development and growth and determine productivity. High and low temperatures, mineral imbalance, excess or insufficient, and lack of water are stressors that compromise productivity [4].

Deverra tortuosa is known in Arabic as "Shabat El-Gabal". It grows in almost all the phytogeographical regions of Egypt especially desert wadis, sandy and stony plains. It is highly palatable by livestock, especially camels, and constitutes an important range plant during summer time. The tender shoots and leaves used as a condiment [5].

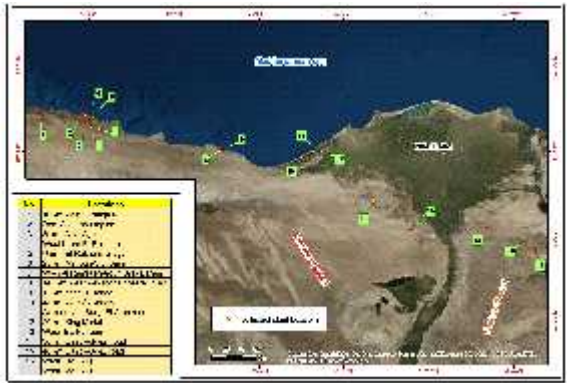
2. Materials and methods:

A: Sample collection

The aerial parts (at the flowering & fruiting stages) and roots of *D. tortuosa* and soil samples were collected from 17different localities represented the different habitats along the North Western Coast, Western deserts and Eastern desert in Egypt to represent most variations of different habitats (Map.1 & Table.1).

B: Soil analysis

Soil samples supporting growth of *D. tortuosa* from different habitats were taken from the zones at a depth of 0-30cm and mechanically analyzed in order to determine the particle size (sand, silt and clay) of the soil samples using Sieves method [6,7].



Map 1: Showing locations of the collected plant (*Deverra tortousa*).

The soil water extract (1:5) was prepared according to the method described by [7]; for determining Soil moisture content [8], electrical conductivity (EC), hydrogen ion concentration (pH), the concentration of Na+ and K+ and soluble bicarbonates was determined [8]. The hydrogen ion concentration (pH) of soil extract was measured using pH meter (Orion Research SA210). Total Dissolved Salts (T.D.S) was determined by using the following equation: T.D.S = EC ×640 ppm [6].Both Ca^{+2} and Mg^{+2} contents were determined by titration with ethylene diamine tetra-acetic acid acid disodium salt (EDTA)[9]. P^{+3} was calorimetrically determined using ammonium molybdate and ascorbic acid by using spectrophotometer (Metertek sP-850) [10]. Total nitrogen percentage was determined using Kjeldahl method [11]. The percentage of total carbonates (CO_3^{-2}) and chloride was determined [6]. Sulphate content was precipitated as barium sulphate according to the turbidimetric method using spectrophotometer Metertek sP-850 [12]. The concentration of some microelements such as Fe^{+2} and Mn^{+2} was determined using Atomic Absorption Spectroscopy UN/CAM929-SOLAR [7]. The organic carbon percentage was determined using ferrous ammonium sulphate [13].

C: Anatomical studies

Samples for anatomy anatomical studies of roots, stems as well as leaves of *D.tortuosa* were collected from different habitats. Fresh materials were fixed by using formalin, glacial acetic acid, and ethyl alcohol (F.A.A.; 5: 5: 90). After fixation, specimens were transformed in ethyl alcohol series, and then embedded in paraffin wax. Plant organ were sectioned at 10-15 µm. Cross sections were dehydrated in alcohol xylol series, and then stained in safranin and light green [14]. The transverse sections were examined using light microscope and photographed by Olympus light microscope. A planimeter was used for estimating of each tissue in the section area [15, 16,17].

3. Results

Soil analysis:

The physical characters of the studied soils in different localities (Table 2) indicated that soils were sandy in texture, except in wadi bed of wadi Hagul (1) where it was gravel. The moisture content of studied soils in different localities was very low (< 1%), the highest moisture content was recorded in wadi slopes soil at wadi Umm El-Rakham (0.93 ± 0.015%), while, the lowest was recorded in sand dunes soil at 48km west Alex (0.07± 0.021%). There is high significant difference at $P \leq 3*10^{-11}$. (Figure 1).

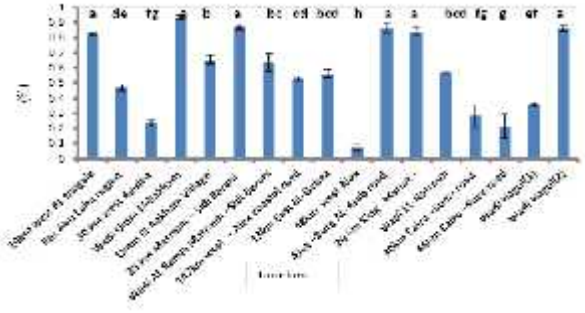


Figure. 1: Moisture content (%) of the studied soils supporting growth of *Deverra tortuosa* collected from different localities (Mean±SD). Bars labeled with different letters are significantly different at $P \leq 3*10^{-11}$. Values with the same letters are non-significant. Error bars indicate SD.

The highest content of Na^{+} was recorded in slighty saline habitat at Alex-Burg El-Arab road (0.42± 0.077mg/100g),while, the lowest was recorded in wadi bed soil at wadi Hagul(2) (0.02± 0.007mg/100g).The highest content of K+ was recorded in barley fields soil at 25km Matrouh- Sidi Barani (0.23±0.005mg /100g),while, the lowest was recorded in wadi bed soil at wadi Hagul(2) (0.01±0.003mg/100g) and the high significant difference at $P \leq 3*10^{-11}$. The highest content of Mg+2 was recorded in slighty saline habitat at Alex-Burg El-Arab road (6.16± 1.048mg/100g), while, the lowest was recorded in barley fields soil at 25km Matrouh- Sidi Barani (1.67± 0.767mg/100g) with high significant difference at $P \leq 0.00001$. The highest content of P^{+3} was recorded in sandy plains soil at 30km Cairo-Suez road (0.34±0.006mg mg/100g), while, the lowest was recorded in wadi bed soil at wadi Hagul(2) (0.002±0.0008/100g).

The highest content of HCO^{-3} was recorded in fig fields soil at Ras Abu Lahu, 30km west Aguiba (11.18±0.0885mg/100g), while, the lowest was recorded in roadsides soil at wadi Al Ramla Matrouh Sidi Barani (3.53±0.088mg/100g) with high significant difference at $P \leq 9*10^{-6}$. The highest content of Fe^{+2} was recorded in wadi bed soil at wadi Hagul(1) (1.18±0.105mg/100g),while, the lowest was recorded in sandy plains soil at 46km Cairo-Suez road (0.01±0.0005 mg/100g) with high significant difference at $P \leq 3*10^{-11}$ (Table 4).

Anatomical features:

1. Root anatomy:

The internal structure of *D. tortuosa* roots showed secondary growth in all the collected specimens. The outer most layer formed from thickened cell wall and the periderm which its width reached to 369µm in specimens collected from slightly saline at Alex –Burg- EL-Arab road. The periderm layers contain tanniniferous cells and the subsequent chemical analysis of *D. tortuosa* showed that the plant contained tannins. There are numerous secretory ducts distributed in the cortex. The vascular tissues are arranged in a compact vascular cylinder interrupted by narrow medullary rays. The phloem either represented as discrete patches or forming continuous layer around the xylem. Xylem tissue represented mostly

by fibers. Xylem arches separated by narrow rows of ray parenchyma. The length of xylem arch is ranging between (240-1600µm) in specimens collected from Fig fields at 13 km east El-Dabaa and sandy plains at 30km Cairo–Suez-road and its width is ranging between (23-87µm) in specimens collected from sandy plains at 30km Cairo–Suez–road and Fig fields at 13 km east El-Dabaa . Pith is parenchymatous with thin walled parenchyma cell. It is represented only in specimens collected from wadi EL-Natroun, 30km Cairo-Suez-road and 46km Cairo-Suez-road (Table 5 and plate 1).

2. Stem anatomy:

The stem in transverse sections is cylindrical, wavy, and glabrous outside. The epidermis of all studied specimens covered with cutin. The epidermis unilayered, cells were tangentially arranged and tetragonal in shape, varied from (13-21µm) in thickness. Cortex was differentiated into collenchyma, chlorenchyma and scelerenchym tissues. Collenchyma is represented by two rows of oval or rounded cells. Sclerenchyma tissue alternate with chlorenchymatous tissue. Chlorenchyma cells were palisade in shape and consists of 3-4 rows. Secretory ducts represented in the cortex facing the phloem. The number of secretory ducts ranging between (29–40). Vascular tissue is represented by discrete vascular bundles interrupted by narrow medullary rays. The main vascular bundles alternate with small secondary vascular bundles formed by interfascicular cambium. The number of main vascular bundles ranging between (29-40). The length of main xylem arch ranging between (53-135µm). The diameter of xylem vessel is ranging between (22-41µm). Pith is parenchymatous with its cells containing a number of solitary and druses crystals. There are tanniniferous ducts distributed in epidermis, cortex and pith (Table 6 and plate 2).

3. Leaf anatomy:

The leaf is crescent-shape in the cross section. The leaf is dorsiventral. The upper epidermis is a glabrous consisted of one layer of compact thin walled rectangular or pentagonal cells. The lower epidermis consists of a single row of elongated cells, arranged closely to each other, varied from (16-25µm) in thickness and protected with thick cuticle and interrupted with sunken stomata. Both upper and lower epidermis followed by one or two layers of oval collenchymatous cells, which extend inside to vascular bundles from the lower epidermis. The width of collenchymatous arch ranging between (36-60µm). Mesophyll tissue represented by parenchymatous tissue and palisade tissue. Parenchyma cells are hexagonal, and its width is ranging between (141-255µm). The lower epidermis followed by two layers of palisade tissue, containing abundance of chloroplasts. in Vascular bundles 10-16 in number. The secretory ducts are distributed the phloem and its number is (10-16). The diameter of secretary ducts is ranging between (19-48µm) Solitary crystals and tanniniferous cell are distributed in the lower epidermis and mesophyll tissue (Plate 3).

4. Discussion

Deverra tourtosa is one of the species that has a wide ecological amplitude as the species can grow in almost all the phytogeographical regions of Egypt especially deserts [5]. The species can survive saline conditions (facultative halophyte) to some extent however, the plant is originally belonging to xeric environments.

The transverse sections of *D. tortuosa* root showed a presence of thick periderm which varying in its thickness from one location to another, thus protecting the plant from the pressure and desiccation of soil [18]. The internal structure of roots of some desert plants indicated that the peripheral layer may become hard and corky [19]. Scan electron micrographs of the thicker roots of chaparral shrubs showed a marked exfoliation common to many arid species [20]. It is possible that the leathery exfoliating bark will reduce water loss from the roots. Dark red deposits were detected in the periderm of root of D. tortuosa. The subsequent chemical analysis of D. tortuosa showed that the plant containing tannins. These results were in harmony with [21] who reported dark cells in the cortical and pith parenchyma of Nitraria [22, 23] and identified these contents are tannins.

The cortex width in the roots of *D. tortuosa* was greater in samples collected from saline habitat and wadi slopes in many locations, that characterized by high soil moisture content, so the cortex became spongy and functions as water storage tissue. Cortex increases in secondary growth in desert plants, in order to store water and usage it in growth reproduction during the dry period [24]. The roots of D. tortuosa contain well-developed vascular system. Xylem tissue represented mostly by fibers, which may be an adaptation to drought. This mechanism helps in protection of water columns from embolism. The presence of lignified cells in high percentage of the old root may be an important for providing rigidity to these organs [21, 25].

The lignin might confer resistance to the cell walls. This resistance is important in supporting and counteracting the high osmotic pressure levels, which the halophytes suffering from in rhizosphere. This makes the root is the most important interface between the plant and the hyper-saline medium [26].

The epidermis of stem of *D. tortuosa* was thicker in sample collected from sand dunes of 48km west Alex where the moisture content was very low. The cuticle layer in the stem collected from sandy plains of 30km Cairo-Suez road was (20µm) which was thicker than any other plant samples and this could be attributed to the lowest moisture content (0.28%) of the associated soil in order to decrease the water loss.

Many xerophytes and plants growing under lower humidity conditions characterized by thick cuticle layers, which may be a mechanism to conserve water in the drier regions [27, 28]. Palisade shape chlorenchyma in the cortex indicated that the stem is the main photosynthetic organ, which could be an adaptation to arid conditions due to the absence or reduction of leaves in this plant [29].

Sclerenchyma tissues alternate with chlorenchymatous tissue and the smallest width of scelerenchyma tissue was (123µm) in specimens collected from Fig fields at 147km west Alex coastal road and the largest was (184µm) in specimens collected from sandy plains at 46km Cairo–

Suez-road locations, respectively. This may due to the presence of sclerenchyma around the vascular cylinder provide a good support and help in avoiding drought periods [30]. In the same context [31] reported that presence of sclerenchyma in stems is very important for phloem in order to avoid damage from high temperature, intense radiation, and drought.

The xylem area recorded variable values in relation to the moisture content of the supporting soils. The smallest diameter of xylem vessels in specimens of *D. tortuosa* was recorded in slighty saline habitat at Alex- Burg EL-Arab road with the soil characterized by the highest Na+ content. The largest diameter of xylem, vessels was recorded in the stem of *D. tortuosa* growing in Fig fields at 10km west AL Naigala which characterized by high water content. The vascular tissues are compressed under dry soil conditions [32] and increase in size and number with high water content of soil [33].

The anatomy of the plant stem indicated the presence of solitary and druses crystals distributed in the cortex and pith. It can be assumed that calcium ions are involved in increasing the salt tolerance in different ways. [21] Showed an increase in the number of druses crystals (calcium oxalate) in Z. album organs. Crystals composed of calcium oxalate are the most common indicating of biomineral occurring in plants [34]. These structures have been related to the regulation of calcium activity in tissues [35] as well as these structures can be used in protection against herbivores and pathogens [36]. Chemical and biological parameters such as light intensity, temperature range, pH value, ion concentration and herbivory may affect the distribution, size and other properties of crystals in plant [37, 38]. All these structural features are considered ecological adaptations to facilitate the growth of D. tortuosa in xeromorphic habitats in different locations in Egypt.

The anatomy of *D.tortuosa* leaf had crescent-shape in the cross section, and this shape tends to minimize heating caused by intense radiation to the leaves. The lower epidermis consists of a single row of elongated cells, arranged closely to each other, protected with thick cuticle, and interrupted with sunken stomata. This agreed with the previous studies on the plants of arid and semiarid environments that show sunken stomata, often covered by resinous masses and wax layers or confined in deep crypts of the lamina [39, 40].

Table (1): Localities, habitats and GPS data of collected *Deverra tortuosa*

No	Localities	Habitats	GPS Data
1	10 km west Al Naigala Matrouh –Sallum road	Fig fields	N 31 27 449, E 26 25 323, Alt: 86m
2	Ras Abu Lahu region	Sand plains	N 31 26 346, E 26 55 649, Alt: 18m
3	Ras Abu Lahu, 3okm West Aguiba	Fig fields	N 31 25755, E 2657 839, Alt: 37m
4	Wadi Umm El-Rakham	Wadi slopes	N 31 23 919, E 27 01 102, Alt:18m
5	Umm El-Rakham village	Olive fields	N 31 23 969, E 27 01910, Alt: 3m
6	25 km Matrouh-Sidi Barani	Barley fields	N 31 17 300, E 27 01 571, Alt: 151 m
7	Wadi Al Ramla Matrouh Sidi-Barani	Roadsides	N 31 15 972, E 27 07 893, Alt: 120m
8	147 km west Alexandria coastal road	Fig fields	N 31 00 905, E 28 33 573, Alt: 12m
9	Alexandria-Matrouh coastal–road, 13 km east El-Dabaa	Fig fields	N 31 00 895, E 28 34 707, Alt: 22m
10	48 km west Alexandria	Sand dunes	N 30 56 543, E 29 30 113, Alt: 20 m
11	Alexandria – Burg El-Arab road	Slightly saline	N 31 00 631, E 29 39 200, Alt: 2m
12	20 km King Mariut - Burg Al-Arab road	Slightly saline	N 31 00 725, E 29 44 947, Alt: 34m
13	Wadi EL-Natroun- Cairo-Alexandria desert road	Sandy plains	N 30 24 231, E 30 21 872, Alt: 49m
14	30 km Cairo –Suez road	Sandy plains	N 30 06 538, E 31 41 118, Alt: 237m
15	46 km Cairo –Suez road	Sandy plains	N 30 05 773, E 31 49 896, Alt: 230m
16	Wadi Hagul (1)	Wadi bed	N 29 58 261, E 32 07 991, Alt: 325m
17	Wadi Hagul (2)	Wadi bed	N 29 51 285, E 32 15 379, Alt: 167m

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Table (2): Physical characters of soil samples supporting growth of *D. tortuosa* collected from different localities (Mean±SD). Different letters above the numbers are significantly and values with the same letters are non-significant. 1=10 km west ALNaigala, 2= Ras Abu Lahu region, 3=30 km west Aguiba, 4=Wadi Umm EL-Rakham, 5=Umm EL-Rakham Village, 6=25 km Matrouh – Sidi Barani, 7=Wadi AL Ramla Matrouh –Sidi Barani, 8=147km west – Alex coastal road, 9=13 km east El- Dabaa, 10= 48km west Alex, 11= Alex–Burg – ELArab road, 12= 20 km King Mariut –Burg EL-Arab road, 13= Wadi EL-Natroun, 14= 30km Cairo –Suez- road, 15= 46km Cairo –Suez-road, 16=Wadi Hagul (1) and 17 = Wadi Hagul (2).

locality	Soil texture (%)							
	Coarse gravel	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt and Clay	Texture
1	3.02±0.006a	4.17±0.006a	14.09±0.015a	11.03±0.015ab	18.86±0.031a	43.71±0.045a	4.99±0.01a	Sandy
2	3.21±0.01b	4.04±0.01b	5.96±0.01b	16.65±0.025bcd	17.82±0.006b	44.19±0.01b	8.61±0.006b	Sandy
3	1.72±0.015c	2.36±0.01c	11.47±0.021c	14.07±0.021bc	24.27±0.015c	30.97±0.01c	5.97±0.015c	Sandy
4	1.38±0.015d	2.73±0.0`15d	37.98±0.032d	20.58±0.01cd	20.92±0.01d	10.44±0.01d	15.14±0.045d	Sandy
5	2.14±0.01e	4.32±0.015e	10.85±0.01e	13.46±0.015bc	38.56±0.01e	27.47±0.026e	3.21±0.031e	Sandy
6	1.65±0.017f	1.67±0.01f	7.96±0.031f	13.44±003bc	34.49±0.013f	37.93±0.01f	2.89±0.006f	Sandy
7	2.46±0.012g	3.47±.0.01g	8.19±0.014g	20.18±0.001bc	23.28±0.012g	38.98±0.072g	8.44±0.026b	Sandy
8	2.18±0.01e	2.52±0.01h	12.88±0.021h	13.57±0.013bc	17.47±0.021h	36.71±0.045h	14.67±0.01g	Sandy
9	2.24±0.012h	3.33±0.071i	19.45±0.015i	14.93±0.021bcd	47.91±0.01i	7.21±0.01i	4.93±0.061a	Sandy
10	0.74±0.001i	0.12±0.015j	0.16±0.01j	66.25±0.035e	24.92±0.01j	7.54±0.015j	0.27±0.009h	Sandy
11	0.17±0.025j	0.68±0.015k	1.16±0.01k	23.44±0.021d	34.34±0.046k	30.26±0.031k	9.97±0.032i	Sandy
12	22.15±0.025k	0.43±0.021l	1.18±0.022k	15.62±0.01bcd	35.95±0.012l	18.43±0.017l	6.24±0.012j	avely sand
13	1.83±0.01l	0.68±0.012k	5.46±0.01l	14.23±0.01bc	33.66±0.025m	42.02±0.01m	1.12±0.01k	Sandy
14	10.03±0.01m	0.98±0.01m	2.87±0.02m	18.17±0.015bcd	41.72±0.01n	22.36±0.01n	3.76±0.211l	Sandy
15	0.84±0.011n	0.15±0.012j	0.13±0.01j	4.33±0.012a	51.94±0.021o	38.76±0.031o	3.88±0.01l	Sandy
16	38.22±0.015o	2.86±0.011n	2.95±0.01n	21.77±0.045cd	17.19±0.01p	14.37±0.02p	2.63±0.015m	Gravely
17	6.15±0.01p	1.31±0.021o	2.64±0.01o	19.95±0.025cd	14.85±0.025q	45.56±0.021q	12.55±0.076n	Sandy

Table (3): Chemical characters of soil samples supporting growth of *D. tortuosa* collected from different localities (Mean±SD). Different letters above the numbers are significantly and values with the same letters are non-significant. 1=10 km west ALNaigala, 2= Ras Abu Lahu region, 3=30 km west Aguiba, 4=Wadi Umm EL-Rakham, 5=Umm EL-Rakham Village, 6=25 km Matrouh – Sidi Barani, 7=Wadi AL Ramla Matrouh –Sidi Barani, 8=147km west – Alex coastal road, 9=13 km east El- Dabaa, 10= 48km west Alex, 11= Alex–Burg – ELArab road, 12= 20 km King Mariut –Burg EL-Arab road, 13= Wadi EL-Natroun, 14= 30km Cairo –Suez- road, 15= 46km Cairo –Suez-road, 16=Wadi Hagul (1) and 17 = Wadi Hagul (2)

Locality	pH	EC (ms/cm)	T.D.S. (ppm)	Total nitrogen (%)	Organic carbon (%)
1	7.68 ± 0.015abcd	0.249 ± 0.001a	159.36 ±0.64a	0.11±0.006a	0.16±0.040abcd
2	7.66 ± 0.061abcd	0.219 ± 0.015b	139.94 ±9.628b	0.27±0.06b	0.44±0.000fg
3	7.92 ± 0.012ef	0.336 ± 0.001c	215.04 ±0.64c	0.25±0.05b	0.51±0.026g
4	7.75 ± 0.015cde	0.258 ± 0.000d	165.33 ±0.369d	0.03 ± 0.0005c	0.57±0.032g
5	7.97 ± 0.029f	0.306 ± 0.001e	195.84 ±0.64e	0.03 ± 0.0005c	0.49±0.029g
6	7.96 ± 0.021f	0.274 ±0.001f	175.36 ±0.64f	0.12 ± 0.01a	0.18±0.060abc
7	7.54 ± 0.047agh	0.398 ±0.000g	254.93 ±0.369g	0.23±0.015b	0.16±0.014abcde
8	7.44 ± 0.017abcg	0.507 ±0.001h	324.48 ±0.64h	0.12±0.01a	0.18±0.029abcde
9	7.83 ± 0.045def	0.395 ± 0.001g	252.59 ±0.977g	0.03±0.0005c	0.43±0.023fg
10	7.58 ± 0.005abcg	0.196 ± 0.002i	125.65 ±1.478i	0.12 ±0.006a	0.31±0.039ef
11	7.45±0.01gh	0.599 ± 0.001j	422.77 ±0.977j	0.12 ±0.006a	0.57±0.032g
12	7.55 ± 0.025abg	0.488 ± 0.001k	312.32 ±0.64k	0.28±0.006b	0.31±0.012cdef
13	7.36 ± 0.021h	0.382 ± 0.001l	244.48 ±0.64l	0.13±0.015a	0. 26±0.055 cde
14	7.83 ± 0.061def	0.594 ± 0.003m	380.16±1.92m	0.27±0.000b	0.11±0.012a
15	7.71 ± 0.006abcd	0.466 ± 0.001n	298.45 ±0.977n	0.22±0.01b	0.11±0.009ab
16	7.91 ± 0.00ef	0.299 ± 0.0005o	127.36 ±0.64o	0.26±0.040b	0.26±0.020bcde
17	7.74 ±0.017bcde	0.148 ±0.000p	94.51 ±0.369p	0.22±0.01b	0.47±0.08g

Locality /elements	Mg/100g										
	Na^{+}	K^{+}	Ca^{+2}	Mg^{+2}	P^{+3}	$HCO3^{-}$	Total CO_3^{-2} (%)	SO_4^{-2}	Cl^{-}	Fe^{+2}	Mn^{+2}
1	0.077 ±0.005ab	0.07±0.007ahi	2.67±0.289abcd	4.0±0.5abc	0.19±0.0004a	6.61 ±0.088abcd	5.28±0.000abc	0.0149±0.002a	0.35 ±0.000ab	0.03±0.015abc	0.02±0.0005a
2	0.36±0.032fgh	0.09±0.005bd	2.67±0.763abcd	3.5±1.041bc	0.16±0.002b	7.12 ±0.088abcd	5.26±0.069ab	0.0141±0.001a	0.61±0.046de	0.09±0.006abcd	0.03±0.0006cd
3	0.32 ±0.007efg	0.18±0.005c	2.9±0.76bcd	3.0±0.866bc	0.12±0.0002c	11.18±0.0885e	5.6 ±0.069bcde	0.0136±0.0001a	0.75±0.077ef	0.05±0.01abc	0.03±0.0006c
4	0.15±0.005bc	0.08±0.007ab	1.83±0.289ab	3.83±0.289abc	0.07±0.001d	5.59±0.088abc	5.56±0.125bcde	0.0135±0.0002a	0.60±0.015cde	0.00	0.02±0.0006f
5	0.19±0.005c	0.12±0.007d	2.66±0.577abcd	4.0± 1.154ab	0.04±0.004e	7.63 ±0.000bcde	5.58±0.103bcde	0.0134±0.0001a	0.49±0.041bcd	0.00	0.04±0.000h
6	0.24 ±0.007cde	0.23±0.005e	1.33±0.28a	1.67±0.767c	0.09±0.000f	7.12 ±0.088abcd	5.32±0.124bcd	0.0279±0.0021b	0.58 ±0.041cd	0.17 ±0.005d	0.03±0.0006cd
7	0.37±0.005fgh	0.15±0.005f	3.00±0.5bcd	3.17±0.764bc	0.20±0.007a	3.53±0.088a	5.46±0.104bcde	0.0235±0.0021c	1.02±0.041hi	0.017±0.005a	0.03±0.0006b
8	0.39±0.005gh	0.17±0.007c	2.66 ±0.288abcd	4.0± 1.323abc	0.05±0.002g	5.08±1.761abc	5.54±0.069bcde	0.0144±0.0003a	1.18±0.132i	0.13 ±0.01bcd	0.03±0.0006c
9	0.29±0.007def	0.15±0.005f	2.67±0.887abcd	3.67±0.289abc	0.03±0.002e	7.63±1.525bcde	5.64±0.103de	0.0139±0.0002a	0.83±0.041fg	0.02 ±0.000a	0.02±0.0005a
10	0.21±0.09cd	0.02±0.005gj	2.33±0.28abcd	2.5±0.5bbc	0.04±0.0008eg	8.64±0.088cde	5.62±0.035cde	0.0135±0.0001a	0.33±0.067a	0.31±0.000e	0.02±0.0006g
11	0.42±0.077h	0.06±0.007hi	3.5±0.5d	6.16±1.048a	0.09±0.007f	3.56±0.088a	4.44±0.159f	0.0159±0.003a	1.19±0..000i	0.13±0.005cd	0.03±0.0006d
12	0.36±0.005fgh	0.06±0.007i	2.83±0.577 bcd	4.83±0.577ab	0.09±0.001f	4.07±0.087ab	5.68±0.069e	0.0151±0.0001a	0.65±0.031de	0.13±0.015bcd	0.01±0.000j
13	0.15 ±0.005bc	0.08±0.005ab	2.0±0.5abc	6.0±0.5a	0.23±0.0004h	5.59±0.088abc	4.96±0.227a	0.0145±0.0001a	0.58±0.055cd	0.02±0.005a	0.04±0.0007e

14	0.33±0.005fgh	0.11±0.005bd	3.0±0.5bcd	6.0±0.5a	0.34±0.006i	8.13±2.329cde	3.48±0.208g	0.0156±0.0007a	0.93±0.000gh	0.03±0.000ab	0.02±0.000i
15	0.23±0.005cde	0.09±0.005bd	3.33±0.288cd	6.0±0.5a	0.16±0.0008b	9.66±2.329de	4.2±0.000f	0.0159±0.0001a	0.62±0.031de	0.01±0.0005a	0.03±0.0006cd
16	0.05±0.005a	0.03±0.005g	3.0±0.5bcd	5.0±1.323ab	0.06±0.009j	5.59±0.088abc	5.4±0.159bcde	0.0141±0.0003a	0.45±0.000abc	1.18±0.105f	0.02±0.0006i
17	0.02±0.007a	0.01±0.003j	3.5±0.5d	3.83±1.041abc	0.002±0.000k	3.56±0.081a	5.6±0.034bcde	0.0135±0.0001a	0.31±0.041a	0.02±0.000a	0.03±0.000d

Table (4): Chemical characters of soil samples supporting growth of *D. tortuosa* collected from different localities (Mean±SD). Different letters above the numbers are significantly and values with the same letters are non-significant. 1=10 km west ALNaigala, 2= Ras Abu Lahu region, 3=30 km west Aguiba, 4=Wadi Umm EL-Rakham, 5=Umm EL-Rakham Village, 6=25 km Matrouh – Sidi Barani, 7=Wadi AL Ramla Matrouh –Sidi Barani, 8=147km west – Alex coastal road, 9=13 km east El- Dabaa, 10= 48km west Alex, 11= Alex–Burg – ELArab road, 12= 20 km King Mariut –Burg EL-Arab road, 13= Wadi EL-Natroun, 14= 30km Cairo –Suez- road, 15= 46km Cairo –Suez-road, 16=Wadi Hagul (1) and 17 = Wadi Hagul (2).

Table (5): Anatomical characters of *Deverra tortuosa* roots collected from different localities. 1=10 km west ALNaigala, 2= Ras Abu Lahu region, 3=30 km west Aguiba, 4=Wadi Umm EL-Rakham, 5=Umm EL-Rakham Village, 6=25 km Matrouh – Sidi Barani, 7=Wadi AL Ramla Matrouh –Sidi Barani, 8=147km west – Alex coastal road, 9=13 km east El-Dabaa, 10= 48km west Alex, 11= Alex–Burg – ELArab road, 12= 20 km King Mariut –Burg EL-Arab road, 13= Wadi EL-Natroun, 14= 30km Cairo –Suez- road, 15= 46km Cairo –Suez-road, 16=Wadi Hagul (1) and 17 = Wadi Hagul (2).

Locality	Periderm width	Cortex width	Phloem width	Xylem		Pith diameter
				Xylem arch length	Vessel diameter	
1	212	530	91	254	57	-
2	265	424	89	408	52	-
3	345	340	96	560	41	-
4	125	650	125	372	59	-
5	129	425	108	538	46	-
6	280	625	104	318	38	-
7	295	505	98	660	82	-
8	343	325	104	698	58	-
9	329	407	150	240	87	-
10	223	288	56	548	44	-
11	369	725	125	423	52	-
12	230	570	112	621	49	-
13	240	407	138	683	35	800
14	342	370	94	1600	23	675
15	350	340	88	1372	20	575
16	334	400	63	360	27	-
17	129	575	144	332	57	-

Table (6): Anatomical characters of *Deverra tortuosa* stem collected from different localities. 1=10 km west ALNaigala, 2= Ras Abu Lahu region, 3=30 km west Aguiba, 4=Wadi Umm EL-Rakham, 5=Umm EL-Rakham Village, 6=25 km Matrouh – Sidi Barani, 7=Wadi AL Ramla Matrouh –Sidi Barani, 8=147km west – Alex coastal road, 9=13 km east El- Dabaa, 10= 48km west Alex, 11= Alex–Burg – ELArab road, 12= 20 km King Mariut –Burg EL-Arab road, 13= Wadi EL-Natroun, 14= 30km Cairo –Suez- road, 15= 46km Cairo –Suez-road, 16=Wadi Hagul (1) and 17 = Wadi Hagul (2).

Locality/ character (µm)	Cuticle width	Epidermis width	Cortex			secretory ducts		Phloem width
			Collenchyma width	Palisade tissue width	Fiber width	Number	diameter	
1	7	13	12	140	146	26	50	43
2	12	16	22	121	132	30	38	35
3	16	18	20	138	148	28	31	33
4	11	17	20	144	154	29	54	60
5	13	13	14	122	129	29	31	47
6	12	14	12	166	172	29	54	39
7	14	20	20	160	170	33	50	40
8	15	18	14	116	123	25	38	50
9	12	20	14	162	169	30	39	65
10	18	22	26	147	160	38	38	37
11	19	17	28	133	147	34	32	40
12	14	19	14	135	142	33	46	46
13	12	17	10	171	176	26	62	43
14	20	21	29	130	145	34	45	40
15	19	19	26	175	184	40	43	56
16	15	19	24	128	140	32	51	46
17	10	18	18	130	143	28	59	68

Locality/ character(µm)	Cambium		Xylem			Pith diameter
	Layers	Width	vascular bundle number	Xylem arch length	Vessel diameter	
1	4	27	26	103	41	1650
2	3	23	30	53	22	1150
3	4	40	28	74	26	1100
4	4	38	29	123	31	1200
5	3	28	29	133	27	1610
6	4	19	29	90	32	1050
7	5	33	33	58	28	1700
8	5	35	25	118	30	1250
9	5	41	30	127	32	480
10	4	22	38	86	22	1300
11	2	14	34	64	23	950
12	5	40	33	99	28	700
13	4	28	26	113	32	1300
14	6	32	34	135	27	1800
15	6	75	40	127	41	1650
16	3	36	32	103	26	1100
17	4	27	28	125	33	1200

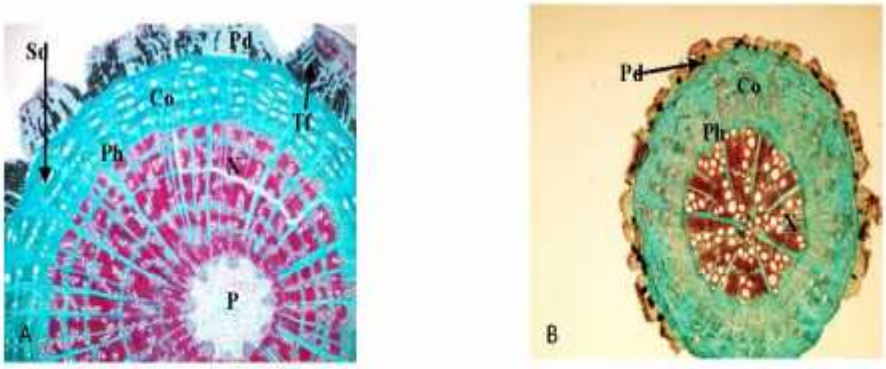

Plate 1: Cross section of roots in *Deverra tortuosa* collected from A: 30km Cairo –Suez- road B:wadi Umm EL-Rakham. Pd (Periderm), Co (Cortex), Sd (Secretory ducts), Ph (Phloem), X (Xylem), P (Pith) and Tf (tanniniferous cells) . Magnification =10X.

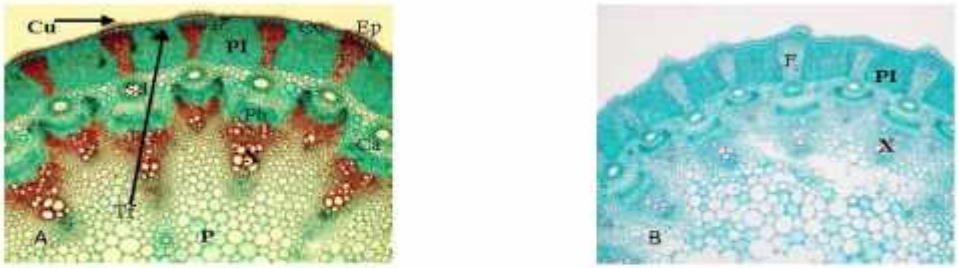

Plate 2: Cross section of stem in *Deverra tortuosa* collected from A: 30km Cairo Suez- road :Wadi EL-Natroun habitats. Cu (Cutin) , Ep (Epidermis), Co (Collenchyma),PI (P tissue), F (Fibers), Sd (Secretory ducts), Ph (Phloem), Ca (Cambium), X(Xylem), F Tf (Tanniniferous cells). Magnification = 10X.,

Plate 3: Cross section of leaf in *Deverra tortuosa* collected from A: 46 km Cairo–Suez-road and B: 13 km east El-Dabaa . Uep (Upper epidermis), UCo (Upper Collenchyma), Par (Parenchyma), X (Xylem), Ph (Phloem), Sd (Secretory ducts), PI (Palisade tissue), Co (Collenchymatous arch), Lco (Lower collenchyma), Lep (Lower epidermis), Lcu (Lower cuticle), Sus(Sunken stomata) and Tf (Tanniniferous cells). Magnification = 10X.

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