American-Eurasian Journal of Scientific Research 1 (1): 01-07, 2006
ISSN 1818-6785

A Comparative Study on *Citrullus colocynthis* Plants Grown in Different Altitudinal Locations in Saudi Arabia

H.S. Al-Zahrani and K.H. Al-Amer

Department of Biology, Faculty of Science, King Abdul-Aziz University, Saudi Arabia

Abstract: The distribution of *Citrullus colocynthis* (L.) Schrad. along the Coastal Plain and Al-Sarawat High Mountains was studied in seven locations, they are: Al-Shoaebah (25 m), Wadi-Fatimah (140 m), Al-Shraie (420 m), Al-Ymaniah (770 m), Al-Haweyah (1400 m), Al-Shafa (1900 m) and Al-Hamra (2220 m above sea level). The results show clear differences for the growth characters determined in each location especially between the lowest and highest ones. The levels of some determined chemical constituents (N, P, K, Mg, Ca, Na, Fe and Cl) differed according to plant organ (root, stem, leaf and fruit) and studied location. These differences are attributing to the differences in the climatic, edaphic and geographical factors. The comparison showed significant differences between these different locations in low and high lands, suggesting that *C. colocynthis* can tolerate a wide range of environmental conditions.

Key words: *Citrullus colocynthis* · growth · altitude · Sarawat Mountains · desert plain

INTRODUCTION

Ecologists have long been interested in large-scale gradients of the effect of environmental factors which lead to growth variation and adaptation. The comparative studies of plants are important to understand the species behavior at its habitat especially in arid and semi-arid regions. It has been known from the literatures that species commonly show morphological differences when living under different environmental conditions. For example, *Achillea lanulosa* plants, living over the Sierra Nevada range in the USA, grow tall and robust at 3000 ft. and progressively reduce their size until they reach 11000 ft. altitude [1]. Alwadi and Abulfatih [2] did not found any obvious morphological differences of *Calotropis procera* plants grow in two different altitudinal ranges.

Citrullus colocynthis (L.) Schrad. is a medical plant species of *Cucurbitaceae* family. It is a common annual wild plant, procumbent herb with simple tendrils. Flowers small yellow. The fruit is very bitter; there are various medical uses of this plant. It grows fast in the sandy soils and widespread in different parts of Saudi Arabia [3]. In these habitats the environmental factors are varying such as: altitude, temperature, humidity, soil type, rainfall and salinity. Therefore, in this part of series of studies, the plant parameters of *C. colocynthis* species and soil analysis plus the concentration of some nutrients (N, P, Ca, K, Mg, Na, and Cl) in the soil and in the plant parts (fruits, leaves, stems, and roots) along an altitudinal transect (25-2220 m a.s.l.) on the west of Saudi Arabia were investigated.

STUDY AREA

This study took place on wide area about 330 km long, starting from the low land (25 m) up to high lands (up to 2200 m above sea level) on the high mountains. Along an elevation transect on the west of Saudi Arabia of the Sarawat Mountainous and Tehama Coastal Plain, seven sites of *Citrullus colocynthis* (L.) Schrad at 25, 140, 420, 770, 1400, 1900, and 2220 m a.s.l were selected for study (Fig. 1). The study transects represents three different ecological and geographical habitats as follows: the coastal plain, the west slop and the high mountains. The first site is located near the Red Sea Coast (50 km west of Makkah City) longitude 20° 47' and latitude 39° 27' which known as Al-Shoaebah, 25 m above sea level. It is flat sandy land within the mean temperatures ranges between 23°C during January and 32.8°C on August; the maximum precipitation is 36.5 mm in winter [4]. The second site is located at the middle of the coastal plain 28 km north-west of Makkah City longitude 21° 16' and latitude 39° 47', which known as Wadi-Fatimah, 140 m

Corresponding Author: Dr. H.S. Al-Zahrani, Department of Biology, Faculty of Science, King Abdul-Aziz University, Saudi Arabia

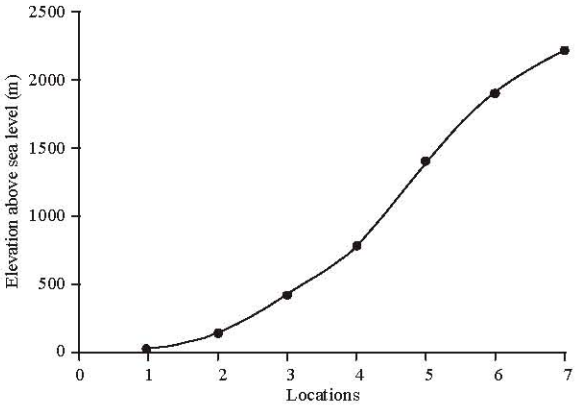

Fig. 1: Study area
1- Al-Shoaebah (25m), 2- Wadi-Fatimah (140 m), 3- Al-Shraie (420 m), 4- Al-Ymaniah (770 m), 5- Al-Haweyah (1400 m), 6- Al-Shafa (1900 m), 7- Al-Hamra (2220 m a.s.l.)

above sea level. The third site is located in the foot-hills about 10 km east of Makkah City at longitude 21° 31' and latitude 40° 04' and known as Al-Shraie, 420 m above sea level. Both Wadi-Fatimah and Al-Shraie follow Makkah metrological station. The minimum temperature is about 23.9°C in January while the maximum one is 35.8°C at July. The maximum participation is about 38.1 mm in winter. The fourth site is located in the western slope of Al-Sarawat mountains at longitude 21° 39' and latitude 40° 05' and known as Al-Ymaniah (770 m above sea level). This location lies between low and high lands in the west slope, and there are no climatic data available for this part, the habitat is rocky and subjected to severe erosion. The soil is coarse-textured and shallow except in some sites where fine sediments are found. The fifth site, however, is located in the north part of Al-Taif city at longitude 21° 26' and latitude 40° 32' that known as Al-Haweyah, 1400 m above sea level, and the soil is sandy. The sixth one is located in north-west Al-Taif city at longitude 21° 05' and latitude 40° 21' and it is called Al-Shafa, 1900 m above sea level. While the final site is located in north-east of Al-Taif city at longitude 20° 53' and latitude 40° 46' and it is known as Al-Hamra, 2220 m above sea level. The latter three sites are characterized with moderate temperature climate in summer and cold in winter within high water amount due to its highest and the maximum average is 40.3 mm on November, while the minimum water amount is 0.2 mm on February. The maximum average temperature is 29.3°C on June, while the minimum is 15.3°C on January. The maximum humidity average is 63%, while the minimum average is 25% on June. The wind direction is western with 11 nodes speed. The last two sites characterized with rocky lands, with little soil except in the valleys where the soil is sandy with little silt and clay.

MATERIALS AND METHODS

Seven sites of *Citrullus colocynthis* were studied in the year of 2004 at the western region of Saudi Arabia started from the low land of the coastal plain near the Red Sea Coast in the west up to the high land on the Sarawat Mountains in the east (Fig. 1). Data regarding the following parameters were collected during the growing season for each site: shoot length; root length; leaf area; fruit size (diameter); number of seeds per fruit; fruit, leaf, stem and root samples as well as soil samples.

In the laboratory, the leaf area was calculated by Minor Squares Style, fruit volume by the Caliper tool and the stated rule that had been applied was fruit volume = $4/3' r^3$, followed by counting the seed per fruit for each site. The digestion of the plant samples were made as Hamphries [5] method. Nitrogen was determined by digestion following the way of Delory [6], phosphors by the way of Woods and Mellon [7], cations (K, Ca, Mg, F and Na) were measured by the Atomic Absorption Spectrometer 3100 Perkin Elmer, after digestion. Finally, chloride content was determined with titration with silver nitrate [8].

Soil samples were collected from each location at one depth, from the root zone of *C. colocynthis* root. The samples were brought to the laboratory, air dried, passed through 2 mm sieve to remove gravel and debris. Soil texture was determined by mechanical analysis using different sieves to separate soil particles; Soil-water extracts at 1:5 (w/v) were prepared for determinations. pH values were measured using pH meter (HI 8314), while electrical conductivity (EC) was measured using conductivity bridge (Metter Toledo). The ion content of the soil samples were measured as mentioned above in the plant samples. The data statistically analyzed using one way analysis of variance in SPSS program.

RESULTS

Soil analysis: The elevation of the study area declines remarkably and suddenly from mountainous area in the east to the coastal plain in the west, and stay almost steadily in the sandy desert. The soil analysis show that percentages of sand in soil decreased gradually from the mountainous areas to the coastal plain areas, while percentages of silt and clay were higher in the

Table 1: Soil characters of the study locations at different altitudinal areas of *C. colocynthis* plants (Means ± SE)

Soil analysis	Elevation (m)						
	25	140	420	770	1400	1900	2220
Sand %	81.6±2.9	76.3±2.8	69.7±3.1	71.0±4.0	69.3±2.2	54.9±2.1	52.5±2.0
Silt %	11.2±3.2	16.5±3.5	23.0±2.8	24.6±3.3	28.8±2.8	28.5±1.9	35.1±2.1
Clay %	7.2±0.9	7.2±1.1	7.3±1.2	4.4±0.5	11.9±0.2	16.6±0.6	12.4±2.2
pH	7.5±0.3	7.1±0.1	7.2±0.1	7.0±0.1	6.8±0.1	6.7±0.2	6.5±0.2
EC mmols cm^{-1}	97.8±5.6	65.9±4.8	65.4±4.2	62.6±4.3	61.8±5.2	59.9±4.1	58.4±7.6
N mg g^{-1} DW	0.016±0.01	0.023±0.0	0.013±0.0	0.007±0.0	0.03±0.01	0.13±0.03	0.17±0.02
P mg g^{-1} DW	0.011±0.0	0.025±0.0	0.022±0.0	0.020±0.01	0.016±0.01	0.025±0.01	0.032±0.01
K mg g^{-1} DW	13.0±2.2	20.8±1.4	21.3±1.6	24.1±1.3	26.9±1.0	35.2±3.9	37.1±3.3
Mg mg g^{-1} DW	49.8±4.3	91.6±5.3	69.1±0.6	98.8±9.1	93.7±6.3	79.3±9.3	56.0±7.8
Ca mg g^{-1} DW	41.1±5.3	32.9±1.7	25.6±1.7	18.7±3.2	18.2±2.4	15.6±1.4	13.1±1.6
Fe mg g^{-1} DW	2.0±0.7	1.7±0.4	1.3±0.2	1.1±0.1	1.3±0.7	1.7±0.9	1.2±2.2
Na mg g^{-1} DW	166.1±8.3	19.8±0.6	19.8±0.3	18.9±0.7	18.1±0.6	12.9±0.4	10.7±2.0
Cl mg g^{-1} DW	172.8±8.2	20.5±2.1	21.7±1.1	20.8±2.2	20.1±3.7	15.6±1.5	11.4±7.5

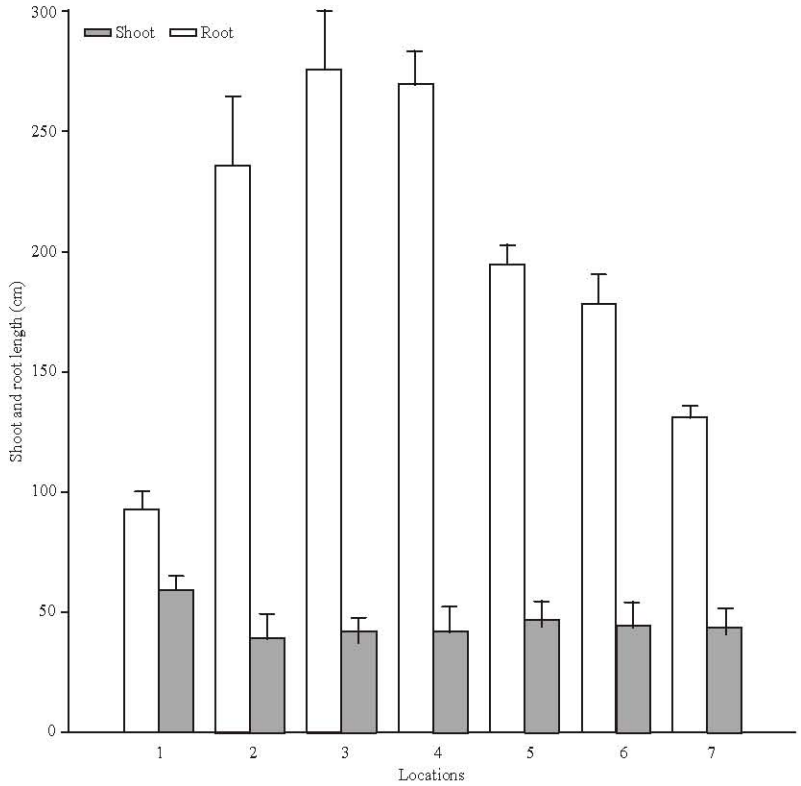

Fig. 2: Shoot and root length (cm) grown in different locations in Suadi Arabia
1-Al-Shoaebah (25m), 2-Wadi-Fatimah (140 m), 3-Al-Shraie (420 m), 4-Al-Ymaniah (770 m), 5-Al-Haweyah (1400 m), 6-Al-Shafa (1900 m), 7-Al-Hamra (2220 m a.s.l.). LSD at 5 % = shoot, 0.01 and root, 0.67

mountainous areas than that at the coastal plain (Table 1). The pH values show that the soil of the high mountain locations is low acidity and then increased to neutral and alkalinity in the coastal locations. Therefore, the electrical conductivity (EC) gives the highest value in Al-Shoaebah location (near the red sea coast, 25 m a.s.l.) and then decreased significantly with increasing altitude. The amount of N, P and Fe is low when compared with other

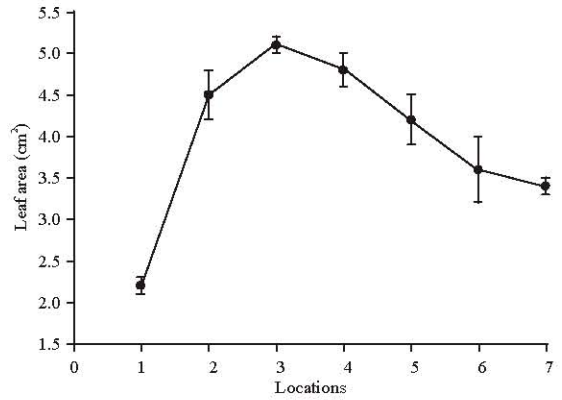

Fig. 3: Leaf area (cm^2) of *C. colocynthis* plants grown in different areas of Saudi Arabia LSD at 5% = 0.051

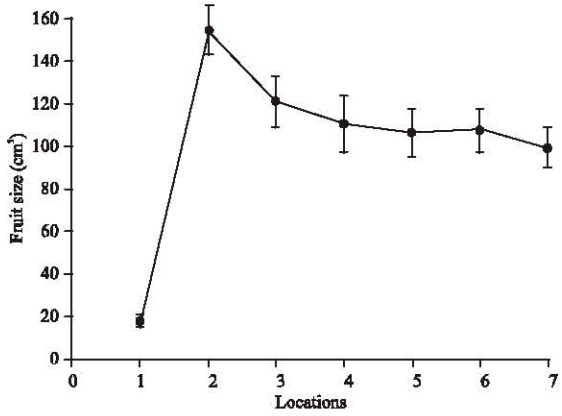

Fig. 4: Fruit size (cm^3) of *C. colocynthis* plants grown in different areas of Saudi Arabia LSD at 5% = 0.001

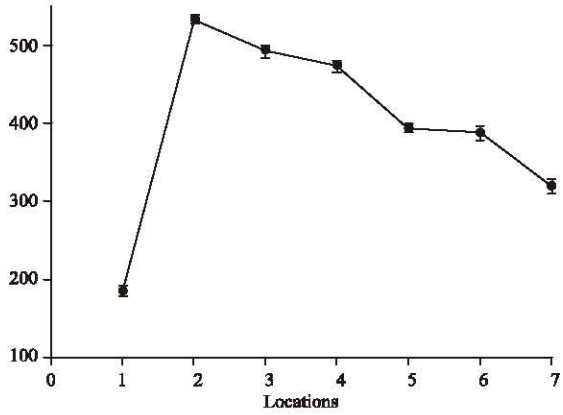

Fig. 5: Number of seeds/fuits of *C. colocynthis* plants grown in different areas of Saudi Arabia
1-Al-Shoaebah (25 m), 2-Wadi-Fatimah (140 m), 3-Al-Shraie (420 m), 4-Al-Ymaniah (770 m), 5-Al-Haweyah (1400 m), 6-Al-Shafa (1900 m), 7-Al-Hamra (2220 m a.s.l.) LSD at 5 % = 0.001

elements. The lowest amount of potassium appeared in Al-Shoaebah (25 m a.s.l.) soil and then increased significantly with elevation, while opposite value was found for Ca (Table 1). There was no trend appear for Mg values. Salinity was also higher in Al-Shoaebah site (Na, 166.1 and Cl, 172.8 mg g^{-1}) and then decreased suddenly and significantly to 19.8 and 20.5 mg g^{-1}, respectively, in Wadi-Fatimah (140 a.s.l.) and then decreased with increased elevation.

Growth characters of *Citrullus colocynthis*: Figures (2-5) show that the minimal values of shoot length, leaf area, fruit size and number of seeds per fruit were noticed in the plants collected from Al-Shoaebah location (25 m a.s.l.), while the highest ones of shoot length, leaf area and number of seeds per fruit were shown in Wadi-Fatimah (140 m), Al-Shraie (420 m), and Al-Ymanyah (770 m) locations. The plants grown in Al-Shraie location give the highest shoot length and leaf area and then decreased with increasing and decreasing elevation, while the highest fruit size and number of seeds per fruit in Wadi-Fatimah. The comparison of each character between the different seven habitats showed significant differences when tested by on way analysis of variance at $P<0.05$. Such results indicate that *C. colocynthis* plants were morphologically different at different habitats either at low or high lands, that is depend on the edaphic and climatic factors. Such behavior make the species adapt, survive and distribute in different habitats in nature. The shoot to root ratio (Table 3) indicate that the best shoot growth appeared in the slope and the foot hills locations, while the growth of the shoot decreased and with either increasing or decreasing elevation.

Plant ion contents: Data in Table (2) show that the ion concentration in different plant organs and different localities are differ. The content of nitrogen, phosphorus and iron are low (less than 1 mg g^{-1} dry wt.) in comparison with the other elements, the highest phosphorus content is determined in the tissues of the plants collected from Al-Ymaniah location (770 m), while the highest Fe content appear in the leaves in all locations. The fruit of *C. colocynthis* contains the highest K content, and the plants collected from Wadi Fatimah (140 m) has the highest K content, while the lowest appeared in the plants collected from Al-Shoaebah location (25 m). The highest Mg and Ca accumulate in the leaves of *C. colocynthis* in all locations. Finally, Na and Cl accumulate in the plants grown in the lower location (Al-Shoaebah, 25 m) in all plant organs and the content decreased with increasing elevation.

Table 2: Effect of altitudinal factor on some ion content (mg g^{-1} dry wt.) in different organs of *C. colocynthis* plants grown in different locations (Means ± SE)

	Ion concentration (mg g^{-1} dry wt.)							
Elevation (m)	N	P	K	Mg	Ca	Fe	Na	Cl
				Fruit				
25	0.13±0.02	0.04±0.01	18.0±1.0	7.8±0.1	2.4±0.4	0.35±0.1	15.8±0.6	23.3±2.5
140	0.14±0.02	0.02±0.00	65.6±2.3	3.9±0.6	2.8±0.5	0.22±0.1	8.5±2.0	21.1±2.0
420	0.15±0.02	0.03±0.00	47.8±6.8	4.8±0.3	2.5±0.3	0.28±0.1	8.9±0.7	21.1±2.0
770	0.17±0.03	0.15±0.02	47.1±9.3	4.8±0.2	2.5±0.2	0.19±0.1	8.5±0.2	16.1±1.5
1400	0.17±0.01	0.03±0.01	52.7±6.5	5.0±0.6	2.9±0.7	0.19±0.02	6.4±0.1	13.3±0.5
1900	0.12±0.02	0.05±0.01	53.1±1.2	7.8±0.0	2.2±0.1	0.19±0.04	2.6±0.1	13.3±1.0
2220	0.16±0.03	0.04±0.01	62.0±1.5	5.4±0.6	2.6±0.5	0.21±0.02	2.2±0.1	10.6±1.5
LSD	0.586	0.001	0.001	0.048	0.261	0.245	0.01	0.005
				Leaf				
25	0.11±0.02	0.06±0.1	13.7±1.6	10.4±0.1	6.4±1.0	0.35±0.03	14.9±1.0	20.0±2.5
140	0.21±0.01	0.03±0.00	26.1±7.6	10.2±2.6	17.5±1.3	0.72±0.07	10.8±3.1	17.7±1.3
420	0.20±0.00	0.02±0.00	19.7±1.5	11.4±0.9	17.4±1.6	0.31±0.04	10.4±0.7	16.7±1.0
770	0.15±0.03	0.20±0.01	20.0±3.0	11.2±0.8	16.4±0.8	0.53±0.04	10.3±0.3	15.0±1.0
1400	0.16±0.03	0.02±0.00	17.9±2.1	16.3±3.3	18.0±1.8	0.84±0.13	7.1±0.1	10.6±1.1
1900	0.18±0.03	0.04±0.00	21.2±2.8	18.4±0.4	15.2±0.2	0.39±0.09	2.4±0.2	8.9±1.1
2220	0.22±0.00	0.05±0.01	22.0±2.3	16.5±1.6	10.3±0.4	0.84±0.13	1.9±0.4	7.7±1.0
LSD	0413	0.001	0.001	0.013	0.001	0.001	0.001	0.021
				Stem				
25	0.11±0.01	0.04±0.01	14.7±1.5	8.0±0.1	4.3±1.0	0.15±0.01	14.7±0.5	17.0±2.5
140	0.16±0.01	0.03±0.01	34.6±6.4	5.4±0.9	7.7±0.8	0.29±0.03	12.7±0.3	16.7±2.3
420	0.17±0.01	0.02±0.00	25.8±6.1	5.8±0.6	10.4±1.2	0.24±0.04	12.1±2.6	15.0±1.0
770	0.18±0.02	0.17±0.01	27.9±1.7	6.5±0.6	8.2±1.0	0.44±0.03	12.4±1.7	15.6±2.4
1400	0.17±0.02	0.03±0.00	28.6±1.2	5.7±0.5	9.1±1.2	0.39±0.07	6.7±0.1	14.9±1.5
1900	0.17±0.03	0.04±0.01	26.2±0.9	8.3±0.2	7.4±1.0	0.32±.01	2.4±0.4	14.4±1.1
2220	0.19±0.01	0.03±0.00	31.7±3.1	7.2±0.4	6.1±0.6	0.42±0.1	1.9±0.3	11.7±1.7
LSD	0.093	0.001	0.001	0.317	0.01	0.038	0.001	0.778
				Root				
25	0.14±0.01	0.07±0.01	12.4±1.5	8.2±0.1	3.3±1.0	0.14±0.01	15.7±0.9	16.1±1.1
140	0.14±0.02	0.03±0.01	34.7±3.9	4.1±0.7	3.5±0.4	0.52±0.18	14.3±1.2	12.8±1.5
420	0.19±0.02	0.06±0.00	20.2±1.0	6.4±0.5	3.2±1.6	0.46±0.08	14.1±1.7	7.2±0.6
770	0.15±0.04	0.19±0.02	15.7±0.6	4.6±0.3	2.1±0.4	0.63±0.11	14.3±1.2	7.8±0.6
1400	0.18±0.02	0.04±0.00	25.0±5.2	5.1±0.3	2.8±0.4	0.33±0.02	10.9±0.4	7.4±1.1
1900	0.14±0.04	0.05±0.01	19.4±1.6	7.9±0.1	2.5±0.1	0.21±0.03	3.6±0.01	6.7±1.9
2220	0.16±0.03	0.06±0.00	30.3±6.6	5.6±1.0	2.8±0.6	0.53±0.09	3.0±0.02	6.2±0.6
LSD	0.714	0.001	0.001	0.821	0.533	0.001	0.001	0.001

Table 3: Shoot to root ratio for *C. colocynthis* plants grown in different locations

Elevation (m)	25	140	420	770	1400	1900	2220
Shoot/Root Ratio	1.6	6	6.6	6.4	4.1	4	3

DISCUSSION

There are little similar studies on the relationship between elevation and vegetation distribution in the Sarawat Mountains and Tehama dessert plain in Saudi arabia [2, 9-11]. In these previous studies, elevation was commonly considered as the important factor that may affect vegetation patterns. This study imply that also soil chemical and physical characters affects significantly vegetation patterns in the study area, these findings are in agreement with some other investigations [12]. Abd El-Ghani [13] and Xu *et al.* [12] stated that soil structure features are significant for vegetation patterns in arid zones, this finding in agreement with the results obtained in this study. In this study, some characters of *C. colocynthis* plants such as shoot and root length; leaf area; fruit size and number of seeds per fruit plus the

soil characters in seven locations from 25 m up to 2220 m above see level were studied. The study locations varied in temperature, rainfall, soil characters and latitude. *C. colocynthis* grow in sandy soil especially in low land, this kind of soil poor in the micro granules such as silt and clay as it in most parts of Saudi Arabia [14]. The soil texture, soil salinity and soil water content to be related closely with desert vegetation patterns in arid zones [12, 13]. *C. colocynthis* grow during the wet season (winter) and that is dependent on the quantity of the rainfall in each area, the precipitation content usually decreased with decreasing elevation [4], so the area near the Red Sea received little rainfall yearly. The best growth for the shoot of *C. colocynthis* is in Al-Shraie location (420 m). The shoot branches extend to about 275 cm procumbent on the soil surface. The shoot length then decreased with both increasing or decreasing elevation, the lowest shoot growth found in Al-Shoaebah location (25 m a.s.l.) near the Red Sea coast where the high salinity affect its growth because this plant species could not tolerate high salinity [15]. The shoot to root ratios indicate that the seven locations can be divided into three groups (Table 3), the best one for the shoot biomass is in the west slope in the mountain (between 140 up to 770 m a.s.l.), the second one, however, in the high mountains (between 1400 up to 2220 m a.s.l.) which give lower ratio and then lower shoot biomass, while the third group is abnormal which found in the lower elevation (25 m a.s.l.) near the Red Sea coast and give the lowest shoot biomass which may indicate that carbohydrates may immigrate to the root to produce enough biomass to extend in the sandy soil to avoid salinity and drought factors [16].

Temperature is crucial factor for the growth of *C. colocynthis* plants in Al-Sarawat mountains and Tehama dessert plain because it can influence plant growth directly or indirectly through soil development and nutrient cycling, with both low temperature in the high land and high temperature in the low land have potential effect on *C. colocynthis* growth [17, 18].

Potassium concentration in shoot and root is significantly higher than other elements; these results are in agreement with the data obtained by Abd El-Hadi [19] who mentioned that *C. colocynthis* plant accumulates high concentration of potassium due to its necessity in all the biological activities for plants. Also results showed significant decrease in Na and Cl concentrations in the fruit, leaf, stem and root with elevation, the increasing is following the same pattern for Na and Cl noticed in the soil, this indicate that this species accumulate an amount of ions (such as Na, Cl, Ca and Mg) to generate a sufficiently negative osmotic potential to maintain the turgor that is needed for continued growth in this desert habitat [20, 21]. However, the plant mineral content seems to be depending on the location characteristics than on the elevation [22].

Finally, the comparison showed significant differences between different plants collected from each location suggested that *C. colocynthis* can survive over a broad range of altitudes and endure a wide range of environmental conditions, showing some morphological differences. This behavior makes this plant species highly vigorous in most of these habitats and expresses a high potential to survive under these hard conditions.

REFERENCES

1. Clausen, J., D. Keck and W. Hiesey, 1948. Experimental studies on the nature of species. III. Environmental responses of climatic races of Achillea. Carnegic Institute, Washington, Publications No. 581, pp: 129.
2. Alwadi, H.M. and H.A. Abulfatih, 1996. Uniformity of morphological characteristics of *calotropis procera* found at two altitudinal ranges in Saudi Arabia. Arab Gulf J. Sci. Res., 14: 169-176.
3. Chaudhary, S.A. and A.A. Al-Jowaid, 1999. Vegetation of the Kingdom of Saudi Arabia. National Agriculture and Water Research Center. Ministry of Agriculture and Water. Riyadh, Saudi Arabia, pp: 689.
4. Metrology and Environment, 2004. Provisional normal, 10 years (1995-2004). Ministry of Defence and Aviation, Kingdom of Saudi Arabia.
5. Hamphries, E.C., 1956. Mineral Components and ash analysis In: K. Peach and Tracey, Modern Methods of Plant analysis. Berlin, 1: 468-502.
6. Delory, G.E., 1949. Photo-electric methods in clinical Bio-chemistry. Reviewed analyst. 74: 574. Chem. Abstr., 44: 1591-1950.
7. Woods, J.T. and M.G. Mellon, 1941. Chloros tannous blus Colour method in sulphoric acid system. In: Jackson M.L., Soil Chemical analysis, Prentice-Hall international Inc. London, pp: 141-144.
8. Jackson, W.A. and G.W. Thomas, 1960. Effect of Kcl and Dolometic limestone on growth and ion uptake of sweet potato. Soil Sci., 89: 347-352.
9. El-Karemy, Z.R. and K.M. Zayed, 1992. Distribution of Plant communities across Al-Abna escarpment, South-west of Saudi Arabia. Phyton, 32: 79-101.

10. Abulfatih, H.A., 1992. Vegetation zonation along an altitudinal gradient between sea level and 3000 meters southwestern Saudi Arabia. J. King Saud University, Sci., 4: 57-97.
11. Hajar, A.S., M.M. Youssef and N.A. Baeshin, 1998. Studies on the plant ecology and phytosciology of Al-Baha region, Sudi Arabia: I. Area along Al-Baha-Al-Qonfodah Road. Bull. Sci., Assiut University, 21: 53-84.
12. Xu, L., H. Liu, X. Chu and K. Su, 2006. Desert vegetation patterns at the northern foot of Tianshan Mountains: The role of soil conditions. Flora-Morphology, Distribution, Functional Ecology of Plants, 201: 44-50.
13. Abd El-Ghani, M.M., 2000. Floristic and environmental relations in two extreme desert zone of western Egypt. Global Ecol. Biogeogr, 172: 207-222.
14. Zahran, M.A., 1983. Introduction to plant ecology and vegtation types of Saudi Arabia. Fac. Meteorology and Environmental studies, King Abdulaziz Univ. Jeddah Saudi Arabia, pp: 142.
15. Boer, B., 1996. Plants as soil indicators along the Saudi Coast of the Arabian Gulf. J. Arid Environ., 33: 417-423.
16. Al-Zahrani, H.S., 1998. A comparative study on the response of *Calotropis procera* (Ait.) Ait. (Sadom Apple) to a combined treatments of drought and salinity. J. King Abdulaziz University (M.E.A.L.A. Sciences), 9: 45-60.
17. Larcher, W., 1995. Physiplpgical plant ecology, 4th edition. Translated by: Joy Wieser. Springer-verlag, Berline, Heidelberg, Germany.
18. Kohler, L., G. Thomas and L. Christoph, 2006. Altitudinal change in soil and foliar nutrient concentration and in microclimate across the tree line on the subtropical island mountain Mt. Teide (Canary Islands).
19. Abd El-Hadi, N.I., 1994. Seedling emergence of *Citrullus colocynthis* (L.) Schrad as affected by some growth regulators. Annals of Agricultural Science, Moshtohor, 32: 959-971.
20. Munns, R. and A. Termaat, 1986. Whole-plant responses to salinity. Aust. J. Plant Physiol., 13: 143-160.
21. Al-Zahrani, H.S., 1990. Effect of environmental factors on the physiology of the halophyte *Suaeda maritime* L. Dum. Ph.D. Thesis, University of Sussex, Brighton, UK.
22. Beyer, L. K. Tielborger and H. Blume, 1998. Geo-ecological soil features and the vegetation pattern in an arid area in the Northern Negev. Pflanzenernahr Bodenkd, 161: 347-356.