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AUTECOLOGY AND BIOLOGY OF SENNA (*Cassia italica Mill)* DESERT PLANTS

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Abstract: The present study was carried out in wadi Abu Salam (63 Km.) east of Berber, River Nile State, and in the nursery of the Faculty of Agriculture, Nile Valley University, Northern Sudan, during 2004/05 and 2005/06 seasons. The objectives of this study were to describe, analyze and understand mechanisms of Senna (*Cassia italica Mill.*) distribution in relation to soil characteristics. Study area (wadi Abu Salam) was divided into three sections; upper, middle and lower.

The soil can be classified as sodic soil, containing a high percentage of clay in the upper section, equal percentage of clay and sand in the middle section and high percentage of sand in the lower section. The distribution of Senna plants was found only in the middle section during the first season and in both upper and middle sections in the second season. The rate of plant photosynthesis increased during the first stage of growth, reached its maximum (1.89-2.0 g /day) during the 8th week from the start of germination, and then started to decline till it reached its minimum rate (0.11-0.13 g/day) at the maturity stage. Plant root growth started at a low rate, then increased with plant development and it decreased until reached its lowest rate at the stage of maturity.

Re-vegetation should start in such promising areas of the Northern Sudan where moisture is not a limiting factor and the soil is light with a good proportion of clay and sand and suitable ecological conditions.

Key word: *Cassia italica Mill,* autecology, biology.

Introduction

In Sudan, senna (*Cassia italica Mill.*) grows in deserts and scattered in low places where water is found. It is indigenous to the equatorial region and areas around. It grows wildly or cultivated in Northern Sudan and Kordofan (Abu Zeid, 1986; Farnsworth *et al*, 1992 and Huange, 1994).

The ecology of wadi Abu Salam area was studied as a representative of the many similar areas in Northern Sudan. Running through the Nubian Desert, the wadi receives sporadic low rainfall. The soil of the wadi are generally classified as entisols, formed in situ by colluviums and alluvium and are mainly affected by wind erosion due to the low vegetation cover (Mohamed,

1989). Cloudily-Thompson (1965) reported that, this type of desert sand dune usually occurs where sand is relatively scarce and the wind direction is constant. The wadi is used by different groups of nomads, semi-nomads and seasonal cultivations. Herbs and grasses compose 75% of wadi Abu Salam vegetation, many of which are of high nutritive value and palatable to grazing animals. They often support the indigenous animal population for a considerable part of the year. The main sources of income for the habitats are the sale of livestock and/or agricultural crops to satisfy the essential requirements (Mohamed, 1989).

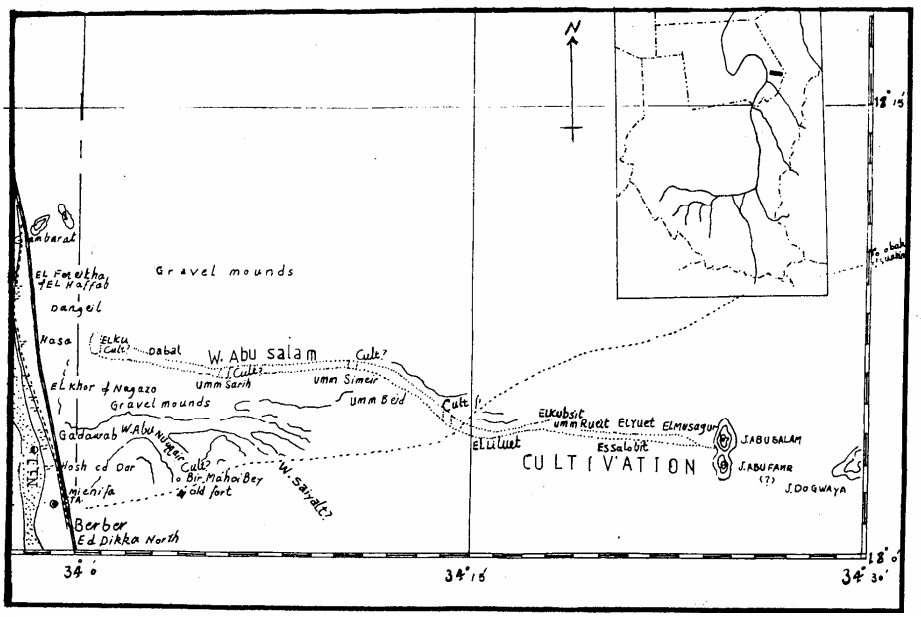
Due to overgrazing and over cultivation, combined with prolonged drought, the vegetation cover of the wadi was greatly reduced. This led to many problems, the most dangerous of which are soil erosion in cultivated areas and sand encroachment over different places.

Due to its economical viability, senna plant is being subjected to heavy pressures of harvesting. It is used in indigenous medicines as purgative (Chopra *et al.*, 1956) and shown to be anti-inflammatory, antiviral and antipyretic (Gupta *et al.*, 1980 and Mahdi *et al.*, 1994) and harvested for domestic use and for export. As senna plant autecology's and biology are not much known, the investigation of its biology becomes important to lay a foundation for their preservation as part of Sudan's efforts to study and preserve its biodiversity. Therefore, the objectives of this study are to describe, analyze and understand mechanisms of senna plant distribution in relation to soil characteristics.

Materials and Methods

The experiment was carried out during the two successive seasons 2004/2005 and 2005/2006 on Wadi Abu Salam (Valley), Berber Locality, River Nile State, Northern Sudan (Latitude 17^0 22 N, Longitudes 25^0 36 E).

Wadi Abu Salam (Fig. 1) is geographically divided into eleven parts, the parts name according to, GPS (GARMIN, GPS, 12 XL. Personal Navigator, 1998 GARMIN Corporation (Table 1). For the purpose of this study, Wadi Abu salam was divided into three equally major sections; upper, middle and lower. The area of each section is about 21^2. kilometers. The whole wadi area was subdivided into eleven parts according to ecological similarity. The upper section covers the area from Jebal Abu Salam to Umm Rueit and composed of four parts, the middle section which composes four parts extended from EL Kubsit to Umm Simera and the lower section included three parts and extended through Umm Sarih, Dabal, and EL ku.



Source: Survey Department – Khartoum (2004) (sheet No. 45G)

Fig.(1): Locality Map of Wadi Abu Salam (Valley), River Nile State, Sudan.

Data collection included the following:

Field distribution in relation to soil characteristics:

Sampling points were randomly selected in the upper, middle and lower sections of the wadi to study plants density and major soil conditions.

Soil sampling and analysis:

Eight soil samples were collected randomly from each sampling transects at two depths (layers): 0 – 30 and 30 – 60 cm. One kg of a composite sample was extracted from each layer from each of the eleven parts. Soil physical and chemical characteristics were analyzed at the Soil and Chemistry Department, Hudeiba Research Station, Sudan. Standard analytical methods (as described by Ryan *et al.,* 2001) were used to determine sand, clay, and loamy soil, pH, saturation percentage (SP), electric conductivity (EC), soluble cations and anions, sodium adsorption ratio (SAR) and exchangeable sodium percent (ESP).

Table(1): Research area sections, name, GPS and distance from river Nile Bank

Section	Part no.	*Site Name*	GPS	Dist. from Nile bank/Km
Upper	1	EL Musgur	N 18^0,00', 103" E 34^0,28,659"	63.60
	2	EL Yuet	N 18^0,03', 410" E 34^0,19', 637"	54.70
	3	ELSalobit	N 18^0,20', 718" E 34^0,19', 625"	51.70
	4	Umm Rueit	N 18^0,20', 718" E 34^0,19', 626"	47.50
Middle	5	EL Kubsit	N 18^0,01', 680" E 34^0,17', 694"	42.80
	6	EL Lilueit	N 18^0,03', 042" E 34^0,16', 006"	37.20
	7	Umm Beid	N 18^0,02', 962" E 34^0,13', 223"	33.60
	8	Umm Simeira	N 18^0,50', 800" E 34^0,11', 906"	28.50
Lower	9	Umm Sarih	N 18^0,06', 176" E 34^0,08', 902"	22.70
	10	Dabal	N 18^0,06', 457" E 34^0,05', 364"	20.70
	11	EL Ku	N 18^0,07', 738" E 34^0,04', 272"	18.20

Soil moisture:

Wet soil samples were randomly collected from each sampling transect at two depths 0-30 and 30-60 cm, parallel to the density sampling. Samples were dried in an oven at 105ºC for 24 hours to obtain moisture content.

Plant density:

Plant density was computed by counting the individual plants, which were then related to the area of the transect (plants/m^2) through stages of plant growth.

Physiological behavior:

This experiment was conducted in the nursery of Faculty of Agriculture, Nile Valley University. It aims to study regularly, at 2 weeks interval, the followings:

The rate of photosynthesis:

The rate of photosynthesis of each plant was calculated by the net assimilation rate equation (NAR) according to Watson, (1952)

$$NAR = \frac{wi - wi_{-1}}{Ti - Ti_{-1}} \times \frac{2.3\log Ai - 2.3\log Ai_{-1}}{Ai - Ai_{-1}}$$

Where:

w: Dry weight of plants (g).

A: Leaves surface area.

T: Time (weeks).

I: Time of sample (day).

2.3 log: Naberian logarithm.

Four samples were taken to calculate leaf area by Area-meter (LI-COR/inc. Lincoln, Nebraska, USA. Model 3100). The dry weight of samples was estimated using an oven at 80˚C for 24 hours.

Shoot /root ratio:

Four samples were taken fortnightly, to calculate shoot/root ratio.

Statistical analysis:

Data were subjected to probability analysis (MSTAT- C program, 1991) and Duncan's Multiple Range Test.

Results And Discussion

Soil physical characteristics:

Physical analysis of the soil of the wadi is presented in Table 2. The top layer (0-30cm.depth) soil of the upper section constituted 51-57% clay, 40.5-43% sand and 2.2-6% silt, while the bottom layer (30-60cm. depth) constituted 50-63% clay, 36.6-45% sand and 2.9-9.4 % silt. The soil of this section can be described as clay and sandy at both depths. In the middle section of the wadi, the top layer of the soil constituted 32.6-51% clay, 40.8-65% sand and 2.4-10.4% silt, and the bottom layer constituted 36.6-56% clay, 44-60% sand and 3.0-9.0% silt. So, the soil of this section can be described as clay, sand, and silt soil. In the lower section of the wadi the percentage of sand is higher than clay. The top layer of the soil is formulated of 71-74.6% sand, 25-31% clay and 0.3-2.7% silt. The bottom layer is 60.4-64.2% sand, 34.8-36.2% clay and 0.4-5.6% silt. The soil of this section of the wadi can be described as sandy-clay soil.

Results showed that, the percentage of clay in the soil decreases and the percentage of sand increases as we go closer to River Nile banks. In the middle section, however; both constituent's, clay and sand, were nearly equal . The soil texture of the lower section can be described as sandy clay loam while, that of the middle section as sandy clay and of the upper section as clay. These results which are in agreement with the findings of Mohamed (1989), might be explained mainly to the presence of sandy layers of the soil due to deposition of depressions by East-North and North winds.

Table(2): Soil physical characteristic of Wadi Abu Salam.

Section of Wadi	Site	Distance from Nile (Km.)	Depth Cm.	Sand %	Clay %	Silt %
Upper	1	60.6	0-30 30-60	42.8 44.0	55.0 53.1	2.2 2.9
	2	51.7	0-30 30-60	42.8 36.6	51.2 63.0	6.0 9.4
	3	48.7	0-30 30-60	43.0 39.8	54.4 54.6	2.6 5.6
	4	44.5	0-30 30-60	40.5 45.0	57.2 50.0	2.3 5.0
Middle	5	39.8	0-30 30-60	47.6 41.0	44.4 56.0	8.0 3.0
	6	34.2	0-30 30-60	40.8 44.0	51.0 46.8	8.2 9.2
	7	30.6	0-30 30-60	65.0 60.0	32.6 36.6	2.4 3.4
	8	25.5	0-30 30-60	49.6 44.8	40.0 51.2	10.4 04.0
Lower	9	19.7	0-30 30-60	71.0 60.4	27.0 34.8	2.0 5.6
	10	17.7	0-30 30-60	66.2 61.0	31.1 36.2	2.7 2.8
	11	16.2	0-30 30-60	74.6 64.2	25.1 35.4	0.3 0.4

Soil chemical characteristics:

The soil chemical characteristics of the three sections of the wadi can be described as non saline and non sodic (Table 3). The soil is mainly alkaline (PH 8.1- 8.7). The electric conductivity (EC) is 0.26-0.90 mmhos/cm in the top layer and 0.33-1.0 mmhos/cm in the bottom layer, at 25ºC. The exchangeable sodium percentage (ESP) was in the range of 0.06 to 10.01 in the top layer and 0.06 to 12.32 in the bottom layer. It has been demonstrated by Mohamed (1989) that the pH of wadi Abu Salam soils exceeded 9.00. This could be attributed to the presence of carbonate and bi-carbonate ions. The good soil properties could also be attributed to the gentle slope of the wadi (0.03m/km) which enhanced precipitation of fertile soil. Excess soil salts is also leached by annual run-off.

Soil moisture:

The results of soil moisture content of wadi Abu Salam during the two seasons are shown in Table (4). While, very low moisture content was recognized in the first season in both, upper

Table(3): Soil chemical analysis of wadi Abu Salam area

Section	Site No	Depth	S.P.	PH	Ec	Mineral ions meq/litre			SAR	ESP
						Na	Ca	Co		
Upper	1	D1	34.0	8.10	0.71	0.65	2.40	2.00	1.00	0.79
		D2	45.0	8.30	0.74	5.00	0.60	2.00	9.00	10.88
	2	D1	53.0	8.4	0.53	1.52	7.00	7.00	1.00	0.60
		D2	53.0	8.5	0.85	4.34	1.00	4.00	5.00	5.55
	3	D1	47.0	8.5	0.46	3.40	2.60	3.00	3.00	3.00
		D2	43.0	8.6	0.42	6.30	2.40	3.00	6.00	6.73
	4	D1	48.0	8.5	0.26	2.40	1.20	4.00	3.00	3.20
		D2	35.0	8.5	0.34	4.34	2.80	4.00	4.00	4.00
Middle	5	D1	40.0	8.6	0.36	4.80	1.20	4.00	6.00	7.30
		D2	48.0	8.6	0.33	5.90	0.80	4.00	9.00	11.11
	6	D1	45.0	8.7	0.35	2.60	0.40	4.00	6.00	6.82
		D2	43.0	8.3	0.50	3.04	1.00	3.00	4.00	4.84
	7	D1	30.0	8.7	0.60	4.60	1.60	3.00	5.00	5.95
		D2	30.0	8.6	0.65	5.44	1.40	3.00	7.00	7.69
	8	D1	37.0	8.5	0.70	3.26	2.00	3.00	3.00	3.43
		D2	33.0	8.7	1.00	4.80	0.40	3.00	11.00	12.12
Lower	9	D1	28.0	8.5	0.90	1.72	1.40	2.00	2.00	1.78
		D2	28.0	8.6	0.85	1.95	0.40	3.00	4.00	4.92
	10	D1	23.0	8.4	0.70	4.60	0.60	3.00	8.00	10.01
		D2	25.0	8.4	0.64	10.65	1.00	3.00	15.0	12.32
	11	D1	28.0	8.5	0.91	1.10	3.20	2.00	1.00	0.06
		D2	25.0	8.2	0.65	1.10	3.00	1.00	1.00	0.06

D1 = 0-30cm depth, D2=30-60cm depth, S.P=Saturation percentage, Ec = Electrical conductivity(mmhos/cm), SAR = Sodium adsorption ratio, ESP = Exchangeable sodium percentage.

and lower, sections of the Wadi, higher levels of 10.9-38.33% and 8.56-26.46% of moisture were recorded at 0-30 cm and 30-60cm depths, respectively in the middle section. This phenomenon could be attributed to the limited rainfall over the middle section. In this region of the country, the seasonal rainfall sometimes does not cover the whole area. However, in the second season, the higher levels of moisture content recorded for the three sections of the research area could be related to the rainfall that covered the whole area of the wadi in that season. The highest soil moisture content was observed at the lower section 30-60cm depth (44%) and at the middle section 0-30cm depth (8.27%).

Distribution of senna:

Distribution of senna plant in Abu Salam area at different growth stages was illustrated in Fig. 2a and 2b. Distribution of senna was only confirmed to the middle section in season 2004/05 because no rainfall was recorded in the other two sections. In the 2005/06 season, although rain covered the

Table(4) : Soil moisture content of Wadi Abu Salam during 2004/05 and 2005/06 seasons at different plant growth stages.

Season	**2004 /05**						**2005 / 06**					
Section	Upper		Middle		Lower		Upper		Middle		Lower	
Growth stage	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
Emergence	0.00	0.00	26.46	38.73	0.00	0.00	31.30	38.00	34.00	41.50	37.00	44.00
First 2- 4 Leaves	0.00	0.00	20.59	32.61	0.00	0.00	23.00	33.20	26.20	36.14	25.00	39.50
First Flowering	0.00	0.00	17.65	27.80	0.00	0.00	15.80	28.24	19.08	27.25	18.45	24.39
First Fruits Setting and 2nd Flowering	0.00	0.00	13.88	21.19	0.00	0.00	14.11	25.33	16.52	25.00	14.45	22.03
First Seeds Formation and 2nd Setting	0.00	0.00	10.91	16.00	0.00	0.00	11.97	18.81	10.16	22.00	11.54	18.65
2nd Seeds Formation	0.00	0.00	08.55	10.90	0.00	0.00	10.12	17.91	08.27	17.34	09.86	16.42

D1= 0-30 cm depth, D2= 30-60 cm depth

whole wadi area, senna plant was observed to spread in the upper and middle sections, but not in the lower section of the wadi. Knowing that there were no differences in the levels of soil moisture of the three sections, the absence of senna plant in the lower section of the wadi could only be explained by the higher percentage of sand that covers this section. The high level of sand in the soil which was observed in the lower section, about 75%, is not suitable for the growth of senna plant. Probably, soil of about 50 % sand, as that of the upper and middle sections of the wadi will be more suitable for better growth of senna plant. This agrees with the conclusions reported by Hashim (2004) who confirmed the suitability of soils which are a mixture of clay and sand for the growth of this plant.

Density of senna:

The density of senna (plant /m^2) in research site during the two seasons is illustrated in Fig. 3. The plant density in the first season was 0.49-0.5 plants/m^2 in the middle section and 1.1- 2.24 plants/m^2 and 1.6- 1.9 plant/m^2 in the second season for the upper and middle sections, respectively. It is observed that, there were no signs of senna plant growth at upper and lower sections in the first season, and at lower section in

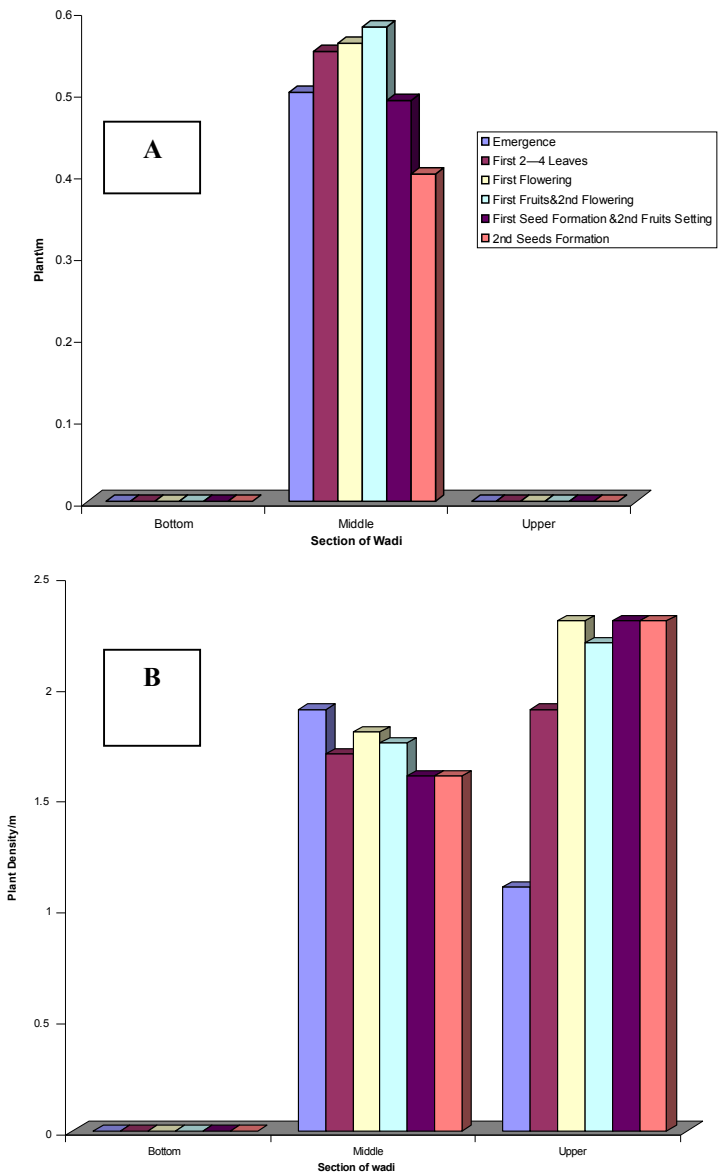
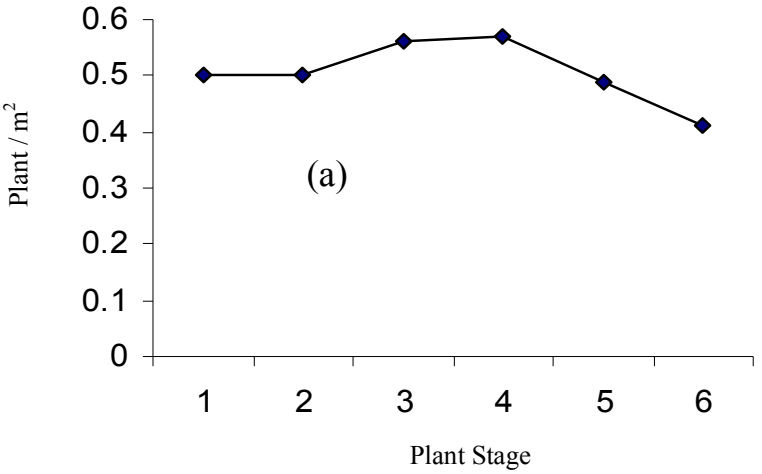


Fig.(2): Distribution of Senna plants in Wadi Abu Salam at different growth stages {(a) Season 2004/05 and (b) Season 2005/06}



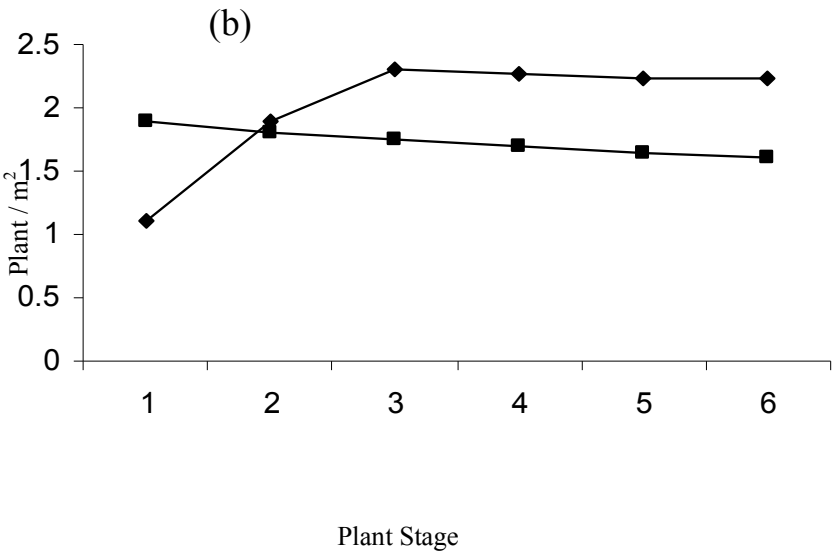


Fig.(3): Density of senna plant at research site at different growth stages. {(a) season 2004/05 (b) season 05/06 (middle section (——◆) upper section (——■), 1/ emergence 2/ first 2- 4 leaves 3/ first flowering 4/ first fruits setting and 2nd flowering 5/ first seeds formation and 2n fruits setting 6/2nd seeds formation }

the second season. During both seasons, senna plant density was high between first flowering stage and first fruit setting stage where the plant fixes itself, and then the density became lower due to decrease in moisture content.

The mean plant density (plants/m^2) was significantly different ($P< 0.05$) between the three sections (Table 5). The highest density (2.0 plants/m^2) was observed in the upper section during the second season, while the lowest mean plant density was attained in the middle section 0.5 plants/m^2 and 1.73 plants/m^2 for the first and second seasons, respectively. There was no evidence of plant growth in the upper and lower sections in the first season due to the lack of rain in both sections. In middle section, there was no significant difference ($P > 0.05$) in the relation between plant density and soil moisture content, however the relation appeared positive. In the second season, there was a significant difference ($P < 0.05$) between plant density and soil moisture content at the two depths. There were negative correlation in the upper section and positive relation in the middle section, with significant difference ($P< 0.05$) between plant density and soil moisture content. In the lower section, there was no correlation due to any plant growth despite moisture availability. Mohamed (1989) found that the frequency of senna plant was 5.2 % only in the middle section of wadi Abu Salam with the density of 400 plants/ha.

The rate of photosynthesis:

The rate of photosynthesis was not significantly different in both seasons as shown in Fig. 4. The photosynthetic rate at first growing stages increased with increasing plant age. It reached the maximum rate during the 8th week of growth, which was 1.98 and 2.00 gm/day for 2004/05 and 2005/06 seasons, respectively. The rate of photosynthesis started to decline afterwards, at the flowering stage during the 10$^{th.}$ week of growth and continued to do so till reaching the maturity stage during the 14$^{th.}$ week of growth. The minimum rate of photosynthesis recorded was 0.11 and 0.13gm/day for seasons 2004/05 and 2005/06, respectively. That could be attributed mainly to plant leaf senescence, fading, dropping and the effect of leaves shading each other. These results agreed with the findings of Hassanin (1993) who concluded that the plant growth is directly related to leaf area which is in turn, considered as the basic photosynthesis measuring system.

Shoot /root ratio:

Fig. 5 illustrates the shoot / root ratio of senna plant during different growth stages. At the beginning of growth, for a single plant, the numbers of roots exceeded the number of shoots. The shoot/root ratio was 0.55 and

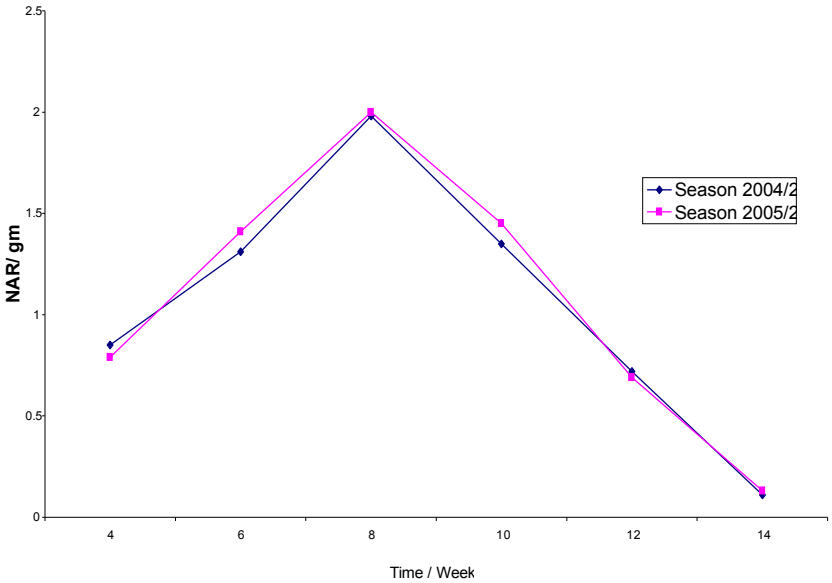


Fig.(4): The net assimilation rate for senna plant.

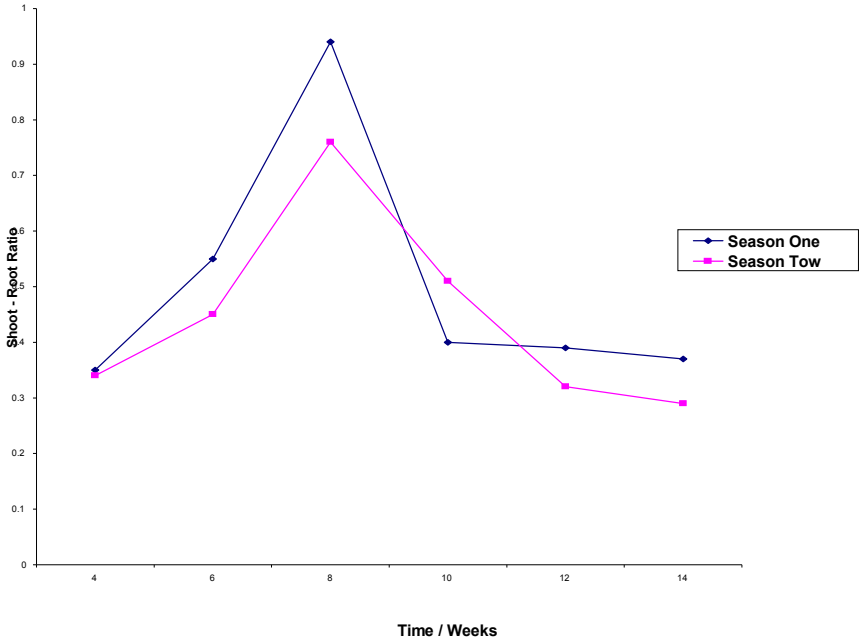


Fig.(5): Shoot/root ratio of senna plant.

Table(5): The plant density of senna as affected by different wadi sections

Section	Mean Density		
	Season 2004/05		Season 2005/06
Upper	0.00 a		2.00 a
Middle	0.50 b		1.73 b
Lower	0.00 a		0.00 c

Means within the same column having the same letter are not significantly different at P = 0 .05 according to Duncan's Multiple Range Test .

0.35 for the first and second seasons, respectively. That could be attributed to the priority for the plant to develop more roots to enable absorbing water and nutrients. As the vegetative stages proceeded, the plant appears to develop more branches till reaching the highest shoot /root ratio which were 0.94 and 0.76 for season 2004/05 and 2005/06, respectively. This occurred at the age of 8th weeks where the plant was at the peak of its vegetative growth. As the plant proceeded to the maturity stage, where the plant reached the age of 14 weeks, the shoot/root ratio decreased sharply to 0.39 - 0.31 during the first and second seasons, respectively. That could be explained by leaf senescence and dropping of the old branches. The plant age and shoot/root ratio with time in both seasons was not significantly different (P< 0.05).

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ايكولوجية وبيولوجية نبات السنا مكة الصحراوي

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أجريت هذه الدراسة خلال موسمي (٠٥/٢٠٠٤) و(06/٢٠٠٥) في وادي أبو سلم علي بعد(٦٣ كلم) شرق مدينة بربر، ولاية نهر النيل، ومشتل كلية الزراعة جامعة وادي النيل علي احد أنواع النباتات الصحراوية السنا مكة (*Cassia italica Mill.*). قسم الوادي إلي ثلاثة أقسام أعلى، أوسط وأسفل. أوضحت نتائج التحليل الفيزيائي للتربة أن تربة القسم الأعلى من الوادي تحتوي علي نسبة عالية من الطين بينما تساوت نسبة الطين والرمل في القسم الأوسط كما احتوت تربة القسم الأسفل علي نسبة عالية من الرمل، وتربته تصنف ضمن التربة القاعدية (تركيز ايون الهيدروجين ٨,٧-٨,١). وأظهرت النتائج ظهور نباتات السنا في الموسم الأول في القسم الأوسط فقط وذلك لعدم هطول أمطار في الأقسام الأخرى. أما في الموسم الثاني فقد هطلت الأمطار في كل أقسام الوادي مما أدي لنمو نباتات السنا في القسمين الأعلى والأوسط مع عدم وجودها في القسم الأسفل. كما وجد إن كثافة نباتات السنا ٠,٥-0.49 نبات/متر^{٢} في الموسم الأول بينما كانت في الموسم الثاني ٢,٢٩-١,١ و ١,٩-١,٦ نبات/متر^{٢}، في القسمين الأعلى والأسفل على التوالي. معدل التمثيل الضوئي تزايد في مراحل النمو الأولي حتى بلغ أقصي معدل له في الأسبوع الثامن من عمر النبات (٢,٠-١,٩٨ غرام/يوم) ثم انخفض حتى وصل أدني معدل له (٠,١٣-٠,١١ غرام/يوم) في مرحلة النضج بالنسبة لنباتات السنا في كلا الموسمين. نسبة الأفرع للجذور بدأت منخفضة ثم تزايدت مع تطور نمو النباتات وقد تساوت النسبة بينهما تقريبا بعد الأسبوع السابع من عمر النباتات وبعد ذلك بدأت في الانخفاض ووصلت لأدني معدل في مرحلة النضج في كلا الموسمين. توصي الدراسة بالبدء في استزراع المناطق التي تتوفر فيها المياه ذات التربة الخفيفة المحتوية على الرمل و الطين في أودية شمال السودان.