Research Journal of Agriculture and Biological Sciences, 7(2): 260-270, 2011
ISSN 1816-1561
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Morphological Characteristics of Vegetative and Reproductive Growth of *Senna occidentalis* (L.) Link (Caesalpiniaceae)

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ABSTRACT

In this study, morphological information is produced as evidence for proper delimitation of *Senna occidentalis* (L.) Link taxonomy. The field work was carried out during the growing season of 2008 in order to follow up the morphology of vegetative and reproductive growth of studied species throughout the successive stages of its entire life span. Germination of seeds and yield components at harvest time were also taken in consideration. Such knowledge may fulfill information acquisition in this concern. The morphology of vegetative growth includes: plant height, length and diameter of the main stem, number of internodes of the main stem, number of primary branches developed on the main stem, lengths of primary branches at maturity, fresh weight of leafless shoot per plant, total number of leaves per plant, total leaf area per plant and fresh weight of leaves per plant. Moreover, keen observations and descriptive morphology of the root and the shoot were under consideration. The morphology of reproductive growth includes: flower bud differentiation, full blooming, fruit set and maturity. In addition, the yield characters at harvest time were investigated; *i.e.,* number of matured dry pods per plant, number of seeds per pod, number of seeds per plant, yield of matured dry seeds per plant and specific weight of seeds.

Key words: *Senna occidentalis* (L.) Link, Coffee Senna, Caesalpiniaceae, Morphology, Vegetative growth, Reproductive growth.

Introduction

Senna (from Arabic *sanā*) is a large genus of around 250 species of flowering plants in the family Caesalpiniaceae (Randell *et al*., 1998). This diverse genus is native throughout the tropics, with small number of species reaching into temperate regions. Most of *Senna* species were at one time or another placed in *Cassia*, a close relative which until recent decades served as a "waste bin taxon" to hold all *Cassiinae* (ILDIS, 2005). Typically, *Senna* species have yellowish flowers, they may be herbs, smallish trees or even a kind of liana, but typically are shrubs or subshrubs. Many of *Senna* species have extrafloral nectarines. The leaves are paripinnately compound, the leaflets opposite, often with globose to clavate or cylindrical glands on the petiole and/or the rachis. Flowers are in few -to many- flowered racemes, pedicels without bracteoles. The fruit is a legume (Egziabher *et al.*, 1989; Boulos, 1999 and Marazzi *et al.*, 2006).

Senna species make good ornamental plants and are used for landscape gardening. As for uses in medicine, *Senna* is currently used in medicine as a laxative (Spiller *et al*., 2003), act as purgatives and are similar to aloe and rhubarb in having active ingredients as anthraquinone derivatives and their glycosides.

As mentioned earlier, most of *Senna* species formerly belonged to the genus *Cassia* until reassigned by Irwin and Barneby (1982) to follow the genus *Senna*, but this process is not entirely complete and some corrections may still take place. Thus any new information about *Senna* species is urgently to be welcomed.

It is aimed in this study to bring to light more information about the morphology of *Senna occidentalis* (L.) Link. This would be an effort to proper delimitation of such species in the genus *Senna* and even more; such knowledge would be useful to specialists in various aspects of biology of such plant. Obviously, continued acquisition of new information about different botanical aspects of the genus *Senna*, which is of great interest from an economic and medicinal point of view, is required.

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Bisby *et al.* (2011) in their catalogue of life stated that the accepted scientific name is *Senna occidentalis* (L.) Link. *Cassia occidentalis* L. is one of many synonyms, and is commonly known as Coffee Senna. It is distributed as a weed throughout the tropical and subtropical regions of the world. It can be found at low and medium altitudes, as a weed in waste places, in open pastures and in fields cultivated with economic crops such as soybean, cotton, corn, sorghum and others. Thus, during the harvest it is almost impossible to prevent this plant from mixing with the cultivated crops. It grows also luxuriantly in all available spaces, such as neglected gardens, roadsides, near lakes or streams and unused grounds of public buildings. (Egziabher *et al*., 1989; Stevens *et al*., 2001 and Vashishtha *et al*., 2009).

Coffee Senna is used as a flowering shrub for landscape purposes (Hussein, 2003). It is also used as a Coffee substitute, where it has some medicinal uses as seeds are brewed into the coffee-like beverage which is used for asthma. Previous pharmacological investigations showed that *Senna occidentalis* leaf extracts have broad spectrum antibacterial, antimalarial, antifungal (Caceves *et al*., 1991; Perez and Suarez, 1997 and Tona *et al.,* 1999), antimutagenic, antiplasmodial, anticarcinogenic, and hepatoprotective activity (Sharma *et al*., 2000; Tona *et al*., 2004; Vashishtha *et al*., 2009 and Yadav *et al*., 2009). It is also used against stomach disorders, rheumatism and in treatment of liver diseases (Sara *et al*., 1994 and Jafri *et al.*, 1999). The leaves and roots are ingredients of many popular herbal liver tonics, medicines for liver and stomach disorders. Moreover, the leaves are widely used as a leafy vegetable and eaten either raw or mixed with coconut, chilly and onion. (Selvam, 2007 and Vashishtha *et al*., 2009). In addition, Coffee Senna has been used for the control of a large variety of insects (Dweivedi and Kumar, 1998) and used also to reduce the number of mosquitoes indoors at night (Paisson and Jaenson, 1999).

Therefore, the pinpoint objective of the present investigation was to carry out a phytography study of *Senna occidentalis* (L.) Link including various botanical attributes under local conditions to get a better insight on morphology of this important economic plant species throughout the consecutive periods of its entire life span.

Materials and methods

The present investigation was carried out in the wire green-house of Agricultural Botany Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the growing season of 2008 in order to introduce a phytography study including morphology of vegetative and reproductive growth of *Senna occidentalis* (L.) Link (Coffee Senna).

Seeds of *Senna occidentalis* (L.) Link were obtained from El- Orman Botanic Garden, Ministry of Agriculture, Giza, Egypt. Treatment of seeds by boiling water and then soaking in tap water for 12 hours before sowing was found the best method to soften the testa and facilitate germination. Seeds were then sown on fourteenth March, 2008 to provide the experimental plant materials.

The experiment included three replicates; each was represented by one plot. The plot was 3x3 m, 5 ridges 60 cm apart. Seeds were sown in hills spaced 30 cm. After one month from sowing date, the plants were thinned to one plant per hill. All field practices were carried out as recommended for such plant in the vicinity.

Recording of Data:

Seed Germination and Seedling Growth:

For this purpose, pot experiment was carried out. Seeds were planted in pots (5 cm diameter) filled with light loamy soil. Seedlings were taken out daily for morphological investigations up to the end of the seedling stage (14 days).

Morphological Investigations:

The field experiment was carried out for this purpose. Nine plants, three plants from each of the three replicates, were assigned at four-week intervals to follow up the morphology of vegetative and reproductive growth of Coffee Senna plant. At each sampling date, the root and the shoot systems were described morphologically. The branching system of the shoot was followed up to determine the plant habit of growth. Time taken for different reproductive developmental stages was recorded including flowering period (onset and end of flowering dates), fruit set and fruit maturity. The inflorescences were studied as to their external morphology and sites of their differentiation. In addition, the following characters were recorded monthly.

1. Plant height (cm), measured from the cotyledonary node up to the uppermost point of the plant.
2. Main stem length (cm), measured from the cotyledonary node up to the shoot apex.

3. Diameter of the main stem (mm) at its median portion by means of a clipper.
4. Number of internodes of the main stem.
5. Number of primary branches developed on the main stem.
6. Lengths of primary branches at the age of 24 weeks (full fruiting stage).
7. Fresh weight of the leafless shoot (g) per plant.
8. Number of leaves per plant.
9. Total leaf area (cm^2) per plant using leaf area meter.
10. Fresh weight of leaves per plant (g).
11. Yield characters at harvest time including:

a. Average number of pods per plant.
b. Average number of seeds per pod.
c. Average number of seeds per plant.
d. Specific weight of seeds (weight of 1000 seeds in grams)
e. Yield of seeds (g) per plant.

Statistical Analysis:

Data were subjected to conventional methods of analysis of variance according to Snedecor and Cochran (1989). Computer software designed (Microsoft Office Excel 2007) was used.

Results and discussion

I. Germination of Seeds and Seedling Growth:

Seeds imbibe water as a first step in the sequence of events leading to germination. As a result, the seed testa becomes softened and swell then ruptured. This is followed by the emergence of the radicle through the seed coat. This occurs after 30 hours of sowing. Seed germination of Coffee Senna is epigeal, the hypocotyl elongates and raises the two cotyledons above the ground accompanied by the partially enveloping remains of the seed. Cotyledons are green in colour and almost square in shape. The hypocotyl is curved inside the soil then straightens above the ground. This takes place when seedling is 8 days old. The hypocotyl is slenderical in shape. By now, the plumule is also upwards and the secondary roots develop.

At the age of 14 days, the first foliage leaf was formed and seedling stage comes to an end (Fig. 1). The first foliage leaf is paripinnately compound and green in colour with two pairs of ovate leaflets. The radicale averages 4.9 cm and the hypocotyl is some 2.6 cm long.

Fig. 1: A photograph of *Senna occidentalis* (L.) Link seedling, two weeks old, showing its epigeous pattern of growth where the two cotyledons are brought above the soil. The first foliage leaf is developed; it is paripinnately compound with two pairs of ovate leaflets.

II. External Morphology of the Root System:

The tap root of Coffee Senna develops directly below the hypocotyl and both are similar in thickness. The root is then tapering towards the apex. Lateral roots develop acropetally in four longitudinal rows. The root system is mainly composed of a stout tap root developing a large number of lateral roots of different branching degrees.

As it is difficult to get intact root samples due to their rapture when pulled out, no measurements could be taken for the root system.

III. External Morphology of the Shoot System:

1. Keen Observations on Shoot Development:

As seedling stage came to an end (age of two weeks), the plumule started a prominent development to produce the shoot. When the plants were four weeks old, 3 to 4 internodes were developed, stem erect, plant height some 11.7 cm. About 4 to 5 foliage leaves were developed. Leaves alternate, paripinnately compound. Leaflets in each of the first three leaves were found in 2 pairs, and then in 3 pairs, leaflets are ovate in shape.

At the age of 8 weeks, plant height reached 44 cm. Total internodes of the main stem almost 10 in number and 39 cm long. Number of developing leaves ranged from 10 to 12, the newly developed were paripinnately compound with 6 ovate-lanceolate leaflets.

When plants are 12 weeks old, stem reached to 79.4 cm in length and to 8.5 mm in diameter at its median portion. Number of internodes of the main stem ranged from 23 to 26. Primary branches started, being 3 to 4 in number, First branch developed on the 21st node. Total number of leaves ranged between 31 to 39. The number of the leaflets developed on the compound leaf increased from base to top from 6-8-10 ovate-lanceolate leaflets.

At the age of 16 weeks, plant height reached to 147.4 cm. Total internodes of the main stem were almost 34 in number and 134 cm long. Number of developing branches on the main stem ranged from 4 to 7. Leaves on branches are like those on the main stem, paripinnately compound with 8-10 ovate-lanceloate leaflets. Total number of leaves per plant ranged from 76 to 124. At this age, flowering stage started.

Full blooming and start of fruit formation took place at the age of 20 weeks. Yellow flowers are few in short axillary racemes in the axils of uppermost leaves on the main stem and branches. At this age, the plant almost attained its maximum height (about 216 cm). Number of internodes of the main stem ranged from 42 to 49. The main stem reached 204 cm in length and 14.5 mm in diameter at its median portion. Number of developing branches on the main stem ranged from 6 to 9. Total number of paripinnately compound leaves per plant ranged from 146 to 180.

At the age of 24 weeks, the plant attained its final height being 228 cm. Branching reached to a final number of about 8. Number of internodes of the main stem ranged from 46 to 52. Main stem reached 219 cm in length and 17 mm in diameter at its median portion. Total number of paripinnately compound leaves per plant ranged from 158 to 189. The plant was in full fruiting stage.

Harvest of fruits was done at the end of the 7th month. Plant dried and normal shrivel and abscission of leaves took place starting from the basal ones.

Coffee Senna is erect, annual herb, about 2-2.5 m high with striate branches. Leaves are paripinnately compound, leaflets are in 3-4-5 pairs, lanceolate to ovate elliptic. Petiole is about 3-4 cm long, with a large sessile globose purple gland on the upper surface near its base. Yellow flowers are in few short axillary racemes in the axils of the uppermost leaves of the main stem and branches.

The morphological description here given for shoot of Coffee Senna plant is generally in accordance with that recorded by Täckholm (1974), Townsend and Guest (1974), Egziabher *et al.* (1989), Ibrahim (1996), Ibrahim (1998), Boulos (1999), Stevens *et al.* (2001), Selvam (2007), Hall *et al.* (2009) and Kumar (2009).

2. Morphology of Vegetative Growth:

a. Plant Height:

It is clear from Table (1) that the plant height increased consistently during the entire life span of the plant. The maximum height was recorded at the age of 24 weeks (228.5 cm), which in turn being statistically indifferent with the height recorded at the age of 20 weeks (216.7 cm). No further increment was recorded till the end of the growing season (the age of 28 weeks). This means that Coffee Senna plant attains its maximum height at the age of 20 weeks.

It is obvious that the elongation of plant continued at almost a uniform rate throughout the consecutive periods. However, the elongation of plant was much higher in the periods from 12 to 16 weeks and from 16 to 20 weeks old. Through these two periods the plant height reached 89.6, 147.4 and 216.7 cm at 12, 16 and 20 weeks; respectively. The most active period of elongation occurred through flowering stage which starts at plant age of 16 weeks and continued till plant age of 20 weeks, through this period the plant height increased from 147.4 to 216.7 cm. Such increment (69.3 cm) represents 30.3% of the final plant height (228.5 cm).

b. The Stem:

1. Length of the Main Stem:

It is realized from Table (1) that a significant increment in length of the main stem occurred from the age of 4 weeks till the age of 20 weeks where the average length was 204.5 cm. The maximum length was achieved at the age of 24 weeks (219.3 cm), which in turn being statistically indifferent with the length that was recorded at the age of 20 weeks. No further increment was recorded till the end of the growing season. Worthy to note that the period of 16 to 20 weeks old was the most effective one throughout the entire growing season, since the length of the main stem increased from 133.8 to 204.5 cm. Such increment (70.7 cm), which was added during such period of plant growth, represented 32.2% of the final length of the main stem (219.3 cm).

2. Diameter of the Main Stem:

Data presented in Table (1) reveal that a significant increment in diameter continued during most of the entire life span of the plant at almost a uniform rate throughout consecutive periods. The maximum diameter was recorded at the age of 24 weeks (17.1 mm), being statistically indifferent with the diameter recorded at the age of 28 weeks (16.88 mm).

This means that no further increment was recorded till the end of the growing season and main stem of Coffee Senna plant attains its maximum diameter at the age of 24 weeks. Worthy to note that the period of 12 to 16 weeks was the most active one throughout the entire growing season, since the diameter of the main stem increased from 8.5 to 12.3 mm. Such increment (3.8 mm) which was added during this period represented 22.2 % of the final diameter of the main stem (17.1 mm).

3. Number of Internodes of the Main Stem:

Results in Table (1) indicate that a significant increment in number of internodes of the main stem of Coffee Senna plant occurred from the age of 4 weeks till the age of 20 weeks where the average number of internodes was 46.3. The maximum number was detected at the age of 24 weeks being 49.7 internodes, which in turn being statistically indifferent with the number that was recorded at the age of 20 weeks. No further increase in number of internodes was recorded till the end of the growing season.

Worthy to note that the growth rate in number of internodes of the main stem conformed to those of plant height and main stem length, previously mentioned. It was found that no substantial increase in these characters was recorded after the age of 20 weeks. This proved the determinate pattern of growth in the main stem of Coffee Senna plant.

4. Number of Primary Branches:

Up to the age of 12 weeks, Coffee Senna plant formed 3.3 primary branches. This number was almost double throughout the following period; *i.e.,* the age of 16 weeks recording 5.6 primary branches. At the age of 20 weeks, the number increased significantly reaching 7.3 branches. No substantial increment was achieved after this sampling date (20 weeks old); *i.e.,* the developing primary branches were the same till the end of the growing season. Worthy to state that lateral branches play a vital role in yield production, where any of primary branches bears from 3 to 4 second order ones.

5. Length of Primary Branches:

Data pertaining to length of primary branches of Coffee Senna plant towards the end of growing season (24 weeks old) are illustrated histogrammatically in Fig. (2). Lateral branches of Coffee Senna plant developed

in acropetal succession; *i.e.,* from the base towards the apex. The first branch, the longest one, averaged 135 cm.

The average length of primary branches then decreased gradually reaching a minimum of 62 cm for the upper most one, ninth branch.

6. Fresh Weight of Leafless Shoot:

It is clear that the average fresh weight of the leafless shoot was small till age of 8 weeks, being 21.95 g. Thereafter, a gradual significant increase in fresh weight was observed till the age of 24 weeks where the fresh weight of the leafless shoot reaching the maximum, being 1125.38 g. However, the fresh weight was decreased significantly at the age of 28 weeks, being 861.56 due to dryness induced at the end of the growing season.

Table 1: The periodic growth and statistical parameters of vegetative characters of *Senna occidentalis* (L.) Link throughout the growing season

Plant age in weeks	Plant height (cm)	Length of the main stem (cm)	Diameter of the main stem (mm)	No. of internodes of the main stem	No. of primary branches on the main stem	Fresh weight of leafless shoot (g) per plant	Total number of leaves per plant	Total leaf area (cm^2) per plant	Fresh weight of leaves (g) per plant
4	11.7 ±1.28 E	10.3 ±1.2 E	___	3.3 ±0.33 E	___	1.47 ±0.32 F	4.3 ±0.29 E	117 ±6.4 E	1.63 ±0.35 D
8	44.2 ±2.91 D	38.9 ±2.5 D	5.7 ±0.32 E	9.7 ±0.67 D	___	21.95 ±1.07 F	10.7 ±0.88 E	916 ±47.2 E	15.57 ±1.48 D
12	89.6 ±3.17 C	79.4 ±3.2 C	8.5 ±0.45 D	24.6 ±0.88 C	3.3 ±0.36 C	76.83 ±2.51 E	35.9 ±2.17 D	5529 ±1964 D	89.32 ±5.92 C
16	147.4 ±5.86 B	133.8 ±4.3 B	12.3 ±0.81 C	34.6 ±1.76 B	5.6 ±0.88 B	317.26 ±9.84 D	93.2 ±3.92 C	13563 ±512.8 C	227.11 ±13.7 B
20	216.7 ±6.93 A	204.5 ±5.1 A	14.5 ±0.76 B	46.3 ±2.19 A	7.3 ±0.92 A	948.52 ±26.39 B	161.6 ±5.63 A	22628 ±894.2 A	378.92 ±20.25 A
24	228.5 ±5.84 A	219.3 ±4.7 A	17.1 ±0.65 A	49.7 ±2.64 A	8.1 ±1.15 A	1125.38 ±41.74 A	167.3 ±6.71 A	23594 ±963.8 A	394.67 ±21.12 A
28	219.2 ±5.97 A	211.4 ±4.8 A	16.8 ±0.88 A	47.5 ±2.19 A	7.6 ±0.88 A	861.56 ±27.25 C	142.2 ±4.68 B	20198 ±812.6 B	237.52 ±17.39 B
L.S.D. (0.05)	19.64 cm	16.3 cm	2.2 mm	4.8 Internodes	1.25 Branches	52.93 g	17.9 Leaves	2196 cm^2	35.6 g

Means having the same letter are not significantly different at 0.05 level.

Worthy to note that the fresh weight of the leafless shoot increased noticeably during the period of 16 to 20 weeks, where the weight increased from 317.26 to 948.52 g. Such increment (631.26 g) represented 56.1 % of the final weight (1125.38 g)

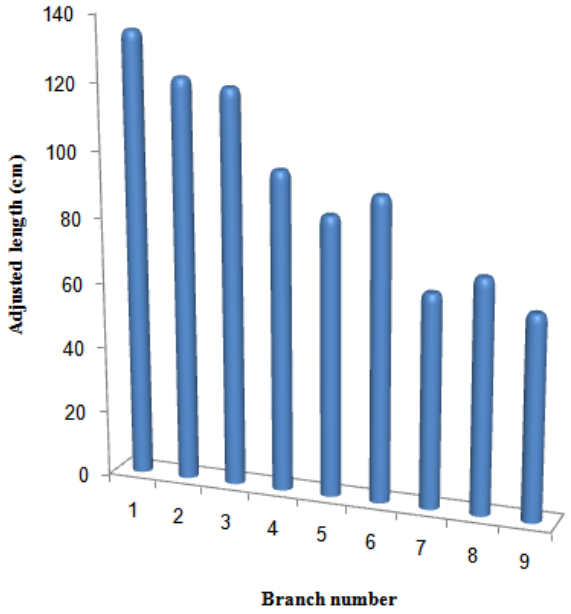

Fig. 2: Histogramme representing length of primary branches of *Senna occidentalis* (L.) Link at the age of 24 weeks

c. The Leaf:

Leaves are paripinnately compound, alternate, petiolate (Fig. 3). Rachis is 8.5-12 (-20 cm) long. Petiole is about 3-4 cm long with a large sessile globose or ovoid purple gland on the upper surface near the point of junction with the stem (Fig. 4). Leaflets are in 3-5 pairs, lanceolate to ovate-elliptic or oblong-ovate, rounded and often slightly asymmetrical at the base and at the apex acute or acuminate. Usually broadest below the middle. Midrib prominent and pilose beneath, pale green to whitish. Secondary venation very fine. Margins are glabrous or pilose at least at the lower half. Petiolules are very short, 1-2 mm long.

The above mentioned description is in accordance with that reported by Täckholm (1974), Townsend and Guest (1974), Egziabher *et al.* (1989), Ibrahim (1996), Ibrahim (1998), Boulos (1999), Stevens *et al.* (2001), Selvam (2007), Hall *et al.* (2009) and Kumar (2009).

Fig. 3: A photograph represents a well developed paripinnately compound leaf of *Senna occidentalis* (L.) Link. The leaf comprised five pairs of ovate-lanceolate leaflets.

Fig. 4: A photograph showing a large sessile globose gland on the upper surface of the petiole near the point of junction with the stem.

1. Number of Leaves / Plant:

Data presented in Table (1) clearly show a significant increase in number of leaves per Coffee Senna plant occurred from the age of 8 weeks till the age of 20 weeks where the average number of leaves per plant was 161.6. The maximum number of leaves was recorded at the age of 24 weeks, being 167.3 which did not differ statistically with that recorded at the age of 20 weeks (161.6 leaves). The number of leaves then decreased significantly towards the end of the growing season reaching 142.2 leaves at the age of 28 weeks due to normal shrivel and defoliation.

Worthy to note that the growth rate in number of leaves/ plant was much higher in the periods from 12 to 16 weeks and from 16 to 20 weeks. Through these two periods, the number of leaves per plant reached 35.9, 93.2 and 161.6 leaves at 12, 16 and 20 weeks; respectively. The most active period occurred through flowering stage which started at plant age of 16 weeks and continued till plant age of 20 weeks, through this period, the plant reached its maximum height and developed all secondary branches as well as the number of leaves per plant increased from 93.2 to 161.6. Such increment (68.4 leaves) represented 40.9% of the maximum number of leaves developed per plant of Coffee Senna (167.3 leaves).

2. Leaf Area per Plant:

Total leaf area per plant increased slightly from sowing date up to the age of 8 weeks. Values obtained were statistically indifferent, reaching 916 cm^2. As plants were 12 weeks old, a significant enhancement was

achieved in this concern. Total leaf area was 5529 cm^2. A steady increase continued throughout the following periods reaching a maximum of 23594 cm at 24 weeks old, which in turn being statistically indifferent with total leaf area recorded at the age of 20 weeks (22628 cm^2). Then a significant decrease in total leaf area was observed in the following period; *i.e.,* at the end of the growing season (28 weeks old) due to the normal defoliation of the senescent leaves.

3. Fresh Weight of Leaves/plant:

The growth pattern of leaves fresh weight per plant, as is expected, followed an identical manner to that of number of leaves as well as to that of total leaf area given earlier. Fresh weight of leaves per plant increased slightly from sowing date up to the age of 8 weeks. Values obtained were statistically indifferent, reaching 15.57 g. As plants were 12 weeks old, a significant increase was observed in this concern. Leaves fresh weight was 89.32 g. A steady increase continued throughout the following periods reaching a maximum of 394.67 g at 24 weeks old, which in turn being statistically indifferent with leaves fresh weight recorded at the age of 20 weeks (278.92 g). Then a significant decrease in fresh weight of leaves per plant was recorded in the following period; *i.e.,* at the age of 28 weeks due to the normal defoliation of the oldest leaves and dryness occurred at the end of the growing season.

3. Morphology of Reproductive Growth:

a. The Inflorescence and Flower:

Flowering onset of *S. occidentalis* (L.) Link plants took place towards the end of July. Plants were 16-18 weeks old. Full blooming and beginning of fruit setting took place at the age of 18-20 weeks.

Few flowers develop in form of short axillary racemes in the axils of upper leaves, almost umbellate; peduncle very short, 0.3-0.5 cm long, the flower number of the inflorescence developed is about 3-5 (Fig. 5).

Flowers (Figs. 5 and 6) are yellow coloured with dark veins of about 2 cm long and 3 to 4 cm wide, bisexual, perfect, nearly perigenous, irregular, and on pubescent pedicels 0.5-0.8 cm long. Bracts green, ovate lanceolate, acuminate, 1.0 cm long and 0.5 cm wide, falling late. Calyx of 5 sepals, free, in descending imbricate aestivation, yellowish-green, obovate, obtuse, glabrous, about 0.6-1.0 cm long and 0.5-0.7 cm wide. Corolla of 5 petals, free, in ascending imbricate aestivation, alternate with sepals, obovate with very short claw, obtuse, yellow with darker veins, glabrous, about 1.0-1.3 cm long and 0.5-0.7 cm wide. Androecium consists of 10 stamens in two whorls of 5 each, unequal and some of them are abortive. Fertile stamens are six. Filaments are filiform and glabrous. Anthers are unequal, basifixed, and dehiscent by two terminal pores. The one lowest (anterior) stamen included with short filament and with small basifixed straight thinner anther, it is flanked by the two largest stamens (filaments 0.6-0.8 cm long and anthers 0.6 cm long) which are prominent on the lower side of the flower, as long as petals and with large slightly curved anthers. The four median stamens which occupy the centre of the flower are included and with filaments (0.2 cm) and basifixed straight anthers (0.5 cm long). The remaining three upper (posterior) are staminodes with filaments (0.2 cm long) and poorly developed anthers. Gynoecium consists of one carpel (simple pistil); ovary unilocular with numerous ovules, stipitate, flattened, straight, pubescent, nearly perigenous. Style is short (0.3 cm long), glabrous, terete, incurved. Stigma is small and terminal. Placentation is marginal.

The aforementioned characters of Coffee Senna inflorescence and flower are in conformity with those described by Townsend and Guest (1974), Egziabher *et al.* (1989), Ibrahim (1996), Ibrahim (1998), Boulos (1999), Stevens *et al.* (2001), Selvam (2007), Hall *et al.* (2009) and Kumar (2009).

b. The Fruit and the Seed:

At the age of 18-20 weeks, *S. occidentalis* (L.) Link plant reached full blooming stage. In the meantime, the fruit formation started.

Fruit (Fig. 7) is a pod, green in color, turn into brown with light brown edges when mature (brown along the line of the seeds with paler borders), linear, distinctly compressed, straight or curved slightly upwards, about 8-12 cm long and 0.5-0.8 cm wide, cuspidate apex, valves when dry usually depressed between the seeds, not or tardily dehiscent along with the ventral and dorsal suture, septate, glabrous, coriaceous.

Seeds (Fig. 8) are ovate, almost round, compressed, 0.5 cm long and 0.4 cm wide, olivaceous or dull chestnut brown, with copious endosperm, transversely arranged, minutely pimpled and with an elliptic areole on each face, about 25-50 seeds per pod.

Fig. 5: A photograph showing the inflorescence of *Senna occidentalis* (L.) Link with an overview of an opened flower.

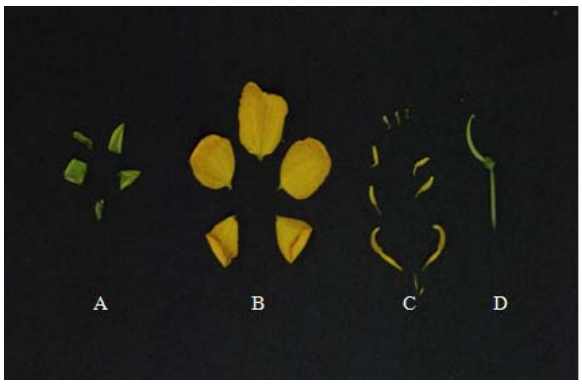

Fig. 6: A photograph showing the floral parts of *Senna occidentalis* (L.) Link. A, sepals; B, petals; C, stamens; D, carpel.

Fig. 7: A photograph showing mature pod of *Senna occidentalis* (L.) Link.

Fig. 8: A photograph showing mature seeds of *Senna occidentalis* (L.) Link.

The previously mentioned characters of Coffee Senna fruit and seeds are in harmony with those given by Täckholm (1974), Townsend and Guest (1974), Egziabher *et al.* (1989), Ibrahim (1996), Ibrahim (1998), Boulos (1999), Stevens *et al.* (2001), Selvam (2007), Hall *et al.* (2009) and Kumar (2009).

c. Yield Characters:

Results of yield characters of Coffee Senna at harvest time, the age of 28 weeks, are given in Table (2). Average number of pods per plant was 277.3, average number of seeds per pod was 34.4 and average number of seeds per plant was 9937 which yielded 183.9 g where the average weight of 1000 seeds was 18.71 g.

Table 2: Yield characters of *Senna occidentalis* (L.) Link plant at harvest time, plants aged 28 weeks.

Characters	Range	Mean	±S.E.
Number of pods/plant	143- 495	277.30	±23.9
Number of seeds/pod	22 -48	34.40	±3.6
Number of seeds/ plant	6864- 13891	9937.00	±526.3
Weight of 1000 seeds (g)	17.47 -19.93	18.71	±1.13
Yield of seeds (g) /plant	116.80 -242.67	183.92	±9.96

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