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Phenology and reproductive biology of three *Sesbania* species

Sontosh C. Chanda*, Ashaduzzaman Sagar, M. Mozahidul Islam, M. Alamgir Hossain and A.K.M. Golam Sarwar

Laboratory of Plant Systematics, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh.

**E-mail: sontoshchanda@gmail.com*

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ABSTRACT

An experiment was conducted at Field and Plant Systematics Laboratories of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, to study the phenology and to search for new descriptors from reproductive morphology for convenient field identification of Sesbania species. Seeds of one hundred and five accessions from three Sesbania species viz. S. bispinosa, S. cannabina and S. sesban, were collected and used as experimental materials. Seeds were sown at the spacing 50 cm (row–row) × 15 cm (plant–plant). Ratoon, the re-growth of shoot from previous year's harvest, was observed only in S. sesban and also used as experimental material. Results revealed that the days required for 50% inflorescence bearing, flower & pod initiation and pod maturation were higher in S. sesban ratoon and lowest in S. sesban; S. sesban ratoon also produces the largest flowers and the smallest in S. bispinosa. Pollen grains are monad, tricolporate, prolate and exine sculpture reticulate. Pollen grains of S. bispinosa possess the thickest exine (2.47±0.47 µm) with the highest value of P/E ratio (1.81) and the lowest in S. cannabina (1.16±0.21 µm and 1.57, respectively). The highest pod setting was found in S. cannabina (50.35%) and the lowest S. sesban ratoon (21.68%). However, seed setting was higher in S. bispinosa (91.06%) and the lowest S. cannabina (87.78%). The heaviest 1000-seed weight was obtained from S. sesban (20.03±2.06 g) and the lowest from S. cannabina (16.28±2.20 g). A dichotomous key was made for the identification of these Sesbania species.

***Keywords* :** *Sesbania* species, *S. sesban* ratoon, floral parts, color, length, width

INTRODUCTION

Sesbania belongs to the family Fabaceae, is a genus of *ca*. 60 species encompassing annuals, perennials, herbs, shrubs and trees (Evans, 1990). Among these *Sesbania* species, five *viz*. *S. sesban* (L.) Merr., *S. bispinosa* (Jacq.) W. Wight [former *S. aculeata* (Wild.) Poir.], *S. cannabina* (Retz.) Poir., *S. grandiflora* (L.) Poir. and *S. javanica* Miq., are found in Bangladesh (Ahmed *et al*., 2009); and *S. bispinosa* is the commonest one (Chanda *et al*., 2018). Being a member of legume crops, *Sesbania* capable to fix nitrogen through Legume-*Rhizobium* symbiosis, improves soil organic matter status and other uses for fodder, fuel, wood, firewood, mulch, ground cover and others in traditional agro-forestry (Ndoye *et al*., 1990; Sarkar *et al*., 2017).

The inflorescence is dropping raceme, pedicel slender, shorter or a little longer than calyx. *Sesbania sesban* has notable variations from *S. bispinosa* and *S. cannabina* for various morphological and phenological descriptors (Ahmed *et al*., 2009). In *S. cannabina*, corolla is yellow or orange-yellow, mottled or speckled with reddish brown or purple, wings bright yellow, keels pale yellow. On the other hand, *S. bispinosa*, corolla is yellow or pale yellowish, brownish or purplish spotted, violet, flecked, wings yellow (Joshi-Saha and Gopalakrishna, 2007; Srivastava and Kumar, 2014). The fully developed flowers have yellow keels, wings bright yellow. The petals are modified into a vexillum, wings and keel, stamens diadelphous (9+1), with the reproductive structures being enclosed by the keel (Ahmed *et al*., 2009). The stamens are arranged in two whorls, the outer consists of 9 and the inner is short one. The flower has a carpel including ovary. Knowledge of floral morphology is very important for plant characterization and species identification as well (Heering, 1994). Despite of its wide adaptation and various uses, little work has been done on the floral morphology of *Sesbania* species (Heering, 1994; Veseay *et al*., 2001).

Apart from taxonomic research/identification, a little work has been done for *Sesbania* species characterization and identification in Bangladesh (Sarwar *et al*., 2015; Chanda *et al*., 2017, 2018); hitherto, no research has been conducted on phenology and reproductive biology of *Sesbania* species. A continuous overlapping in the classic flower morphological descriptors makes the identification of *Sesbania* species problematic in the field (Chanda *et al*., 2017). To address these confusing facts, the present study was undertaken to search for new descriptors in the floral and reproductive features pertinent for convenient field identification of *Sesbania* species.

MATERIALS AND METHODS

The experiment was conducted at Field and Plant Systematics Laboratories of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, in two consecutive years 2016 and 2017; however, the experimental data from only the year 2017 have been presented here to avoid the overcrowding of data. Seeds of 105 accessions of three *Sesbania* spp. *viz*. *S. bispinosa* (ninety accessions), *S. cannabina* (nine accessions) and *S. sesban* (six accessions), were collected from different regions of Bangladesh (detailed collection information available upon request). Seeds of each accession were sown @ 30 kg/ha in 4 lines on 2 × 2.5 m^2 plot. The emergence of seedling commenced at 3–5 days after sowing (DAS). Seedlings were thinned to maintain a uniform spacing of 50 cm (line–line) × 15 cm (plant–plant). Intercultural operations were done properly. The final harvest was done at the maturation of pods, more than 80% attain characteristics brown color. Ratoon, the re-growth of shoot from previous year's harvest, was observed only in *S. sesban* and also used as experimental material for the year 2017.

Phenological descriptors *viz*. inflorescence initiation, 50% inflorescence bearing, flower initiation, first flowering, flowering duration, time of floral opening and pollen release, and pod initiation and maturation, were recorded. Longevity of flower was determined by calculating the time of opening and shedding flowers. Data on both qualitative descriptors *e.g*., colour, shape, spots on corolla, etc, and quantitative descriptors *viz*. length and width of different floral parts, pollen grains, pods and seeds, were recorded from randomly selected 10 flowers at least 5 individual plants.

Unopened flowers (buds) were collected for pollen morphological study. The flowers/buds were preserved with 50% ethanol solution. Pollen grains were collected from the anther of the buds by teasing with needle and forceps. Pollen grains were mounted in glycerin and measured with a light microscope. The photo micrographs of pollen grains were taken by using an Olympus BX41 microscope fitted with a digital camera. Pollen morphology *viz*. polar length, equatorial diameter and exine thickness of pollen grains were measured according to Jahan *et al*. (2013) and the P/E ratio was also calculated. The terminology for pollen descriptor was used following Erdtman (1952) and Punt *et al*. (2007).

Pod setting (%) and seed setting (%) was calculated and 1000-seed weight was measured. The percentage of fruit set and seed set was calculated by the following formula (Singh *et al*., 2014).

$$\text{Fruit set}(\%) = \frac{\text{Number of fruits per inflorescence}}{\text{Number of flowers per inflorescence}} \times 100$$

$$\text{Seed set}(\%) = \frac{\text{Number of seeds per fruit}}{\text{Number of ovules per pistil}} \times 100$$

Data were statistically analyzed by using the computer program with Excel application to determination of arithmetic mean, standard deviation, coefficient of variance, and range among the accessions (*de* Melo *et al*., 2016).

The weather data *viz*. air and soil temperature, relative humidity, rainfall and sunshine hour, were collected from Weather Yard, Department of Irrigation and Water Management, Faculty of Agricultural Engineering & Technology, BAU, Mymensingh (Table 1).

RESULTS AND DISCUSSION

Phenology of *Sesbania* spp.

Sesbania sesban bloomed in August, when temperature ranges from 26.74^0 to 32.15^0 C with

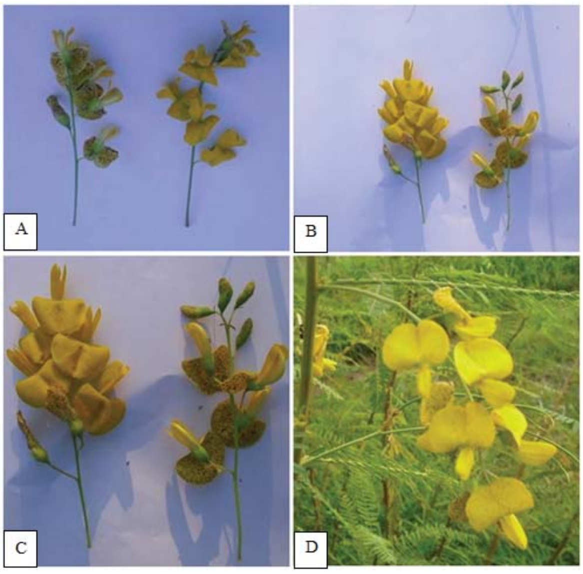

Fig. 1: Flowers of *Sesbania* species. (a) *S. bispinosa*, (b) *S. cannabina*, (c) *S. sesban* and (d) *S. sesban* ratoon.

Fig. 2: Pollen grains of *Sesbania* species. (a) *S. bispinosa*, (b) S. *cannabina*, (c) *S. sesban* and (d) *S. sesban* ratoon.

79.65 to 94.74% relative humidity (RH), 387 mm rainfall, 3.4 sunshine hrs and soil temperature 30.23^0 C (Table 1). On contrary, *S. bispinosa* and *S. cannabina* bloomed one month later than *S. sesban*. September is the peak of flowering period for *S. bispinosa* and *S. cannabina* when temperature ranges from 26.43^0 to 32.66^0 C with 74.03 to 96.03% RH, 300 mm rainfall, 4.0 sunshine hrs and soil temperature 31.07^0 C. During flowering period, comparatively high rainfall and low sunshine hour was occurred than vegetative period. Excessive rainfall in flowering period may hamper for pollination. *de* Souza *et al*. (2016) agreed and opined that pollination obstruct due to heavy rainfall in *S. virgata*. The maximum fruiting of *S. sesban* occurred in September and of *S. bispinosa* and *S. cannabina* in October (temperature ranges from 24.13^0 to 31.48^0 C with 68.71 to 96.71% RH, 186 mm rainfall, 6.9 sunshine hrs and soil temperature 29.82^0 C).

Sesbania sesban ratoon (253.86±3.02 days) requires the longest time period for 50% inflorescence bearing followed by *S. cannabina* (123.00±4.64 days), *S. bispinosa* (121.23±4.69 days) and *S. sesban* (100.67±2.66 days) (Table 2). It may occur due to the re-growth tiller of *S. sesban* ratoon sprouted five month earlier than normal seed sowing of other *Sesbania* species. Similar trend observed in flower and pod initiation as well as pod maturation period in *Sesbania* species. The maximum flowering of *S. sesban* was occurred in August, however, both *S. bispinosa* and *S. cannabina* in August to September. The highest inflorescence initiation to flowering time range was found in *S. bispinosa* (7-18 days) and the lowest in *S. sesban* (6-8 days) (Table 2). Girma (1999) reported that *S. sesban* required 7 to 10 days from anthesis to pod initiation and about 90 days to develop into a mature pod. In the ratoon plants flowering occurs twice in a year, April to May and August to September. However, first time flowering of *S. sesban* ratoon produced pods without any seeds. It may happen due to failure in pollination or fertilization or embryo development, excess or absence of phyto-hormones, and/or photoperiodic affect as well. Bonde (2008) confirmed the role of GA_3 in the development of parthenocarpic fruits in pea plants, and gibberellic acid caused the formation of seedless pods. Nico *et al*. (2016) reported that photoperiod extension reduced pod number on the primary racemes and negative effect could be related to extreme long pod development and small pods are still susceptible to abortion, and have been exposed to the environment's adversities. The flower opens in the afternoon and remains fresh for 2 to 4 days and pollination occurs

Table 1. Weather data of years 2016 and 2017.

Month	Air Temperature (^{0} C)*				Relative Humidity (%) *				Rainfall (mm)**		Sunshine (hrs)**		Soil Temperature (at 5cm depth)*	
	Maximum		Minimum		Maximum		Minimum							
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
January	23.5	25.9	12.0	12.8	97.0	94.2	56.0	44.7	18.3	0.0	84.7	167.4	19.0	19.7
February	27.8	28.3	16.8	15.8	96.0	95.4	52.0	42.1	4.3	0.2	137.8	156.8	22.7	22.2
March	31.0	28.0	20.1	18.6	94.0	94.0	52.0	57.9	104.8	163.7	190.2	155.0	26.8	24.6
April	32.4	30.4	24.3	22.2	92.0	92.9	65.0	67.1	25.0	329.5	171.2	123.0	30.3	36.9
May	32.0	32.8	23.7	25.4	93.0	93.4	65.0	70.2	331.1	594.3	165.3	124.0	30.2	31.2
June	32.7	31.9	26.2	25.7	94.0	94.5	70.0	73.7	388.8	495.7	149.5	99.0	32.1	31.0
July	31.6	31.7	26.5	26.5	95.0	95.0	74.0	75.0	522.7	366.7	101.8	89.9	31.2	31.1
August	33.2	32.1	26.8	26.7	92.0	94.7	66.0	74.2	97.0	437.4	179.6	93.0	41.7	31.4
September	32.0	32.4	26.1	26.4	95.0	96.0	73.0	74.0	408.6	433.8	125.6	102.0	31.1	31.1
October	32.4	31.5	24.2	24.1	96.0	96.7	64.0	68.5	31.0	214.5	200.9	167.4	30.2	29.8
November	29.5	29.8	18.1	18.4	97.0	96.8	52.0	53.8	1.2	25.1	204.8	195.0	25.5	25.7
December	27.5	26.8	14.6	15.9	97.0	95.3	48.9	57.1	0.0	33.7	180.3	155.0	21.9	22.6

* Monthly Average; **Monthly Total.

Table 2: Days required for different phenological changes of different *Sesbania* species and standard deviation with minimum–maximum values in parenthesis.

Species	Sowing to Inflorescence (50% bearing)	Sowing to Flowering (50% bearing)	Sowing to Pod initiation	Sowing to Pod maturation	Inflorescence to Flowering	Flowering to Pod initiation	Pod initiation to Pod maturation
S. bispinosa	121.23±4.69 (113-132)	130.53±4.77 (123-144)	136.10±4.98 (128-149)	203.27±3.73 (194-211)	9.30±1.56 (7-18)	5.57±1.16 (4-9)	67.17±3.30 (59-75)
S. cannabina	123.00± 4.64 (116-130)	131.44±4.33 (126-138)	136.78±5.07 (131-144)	204.22±2.49 (199-207)	8.44±1.51 (6-11)	5.33±1.12 (4-7)	67.44±4.19 (63-73)
S. sesban	100.67±2.66 (98-105)	107.83±2.86 (105-113)	114.00±3.10 (111-120)	174.83±4.62 (172-184)	7.17±0.75 (6-8)	6.17±1.17 (5-8)	60.83±1.72 (59-64)
S. sesban ratoon	253.86±3.02 (249-258)	266.71±1.80 (264-269)	272.00±2.71 (269-276)	330.43±2.51 (328-335)	12.86±1.86 (10-15)	5.29±1.38 (3-7)	58.43±3.60 (55-66)

Table 3: Variation in floral morphological features of *Sesbania* species showing mean value in mm and standard deviation.

Species	Flowers/ Inflorescence No.	Flower length	Calyx length	Standard		Wing		Keel		Stamen length		Carpel length	Ovary
				Length	Width	Length	Width	Length	Width	(9)	1		Ovary
S. bispinosa	5.89±0.93	18.37±1.07	5.10±0.53	11.71±0.81	11.14±0.70	11.62±0.72	4.53±0.57	10.88±0.57	4.95±0.41	10.95±0.51	9.21±0.51	11.69±0.99	9.93±0.89
S. cannabina	4.25±0.49	20.06±1.33	5.19±0.60	13.41±0.54	12.86±0.58	12.77±0.98	4.61±0.35	12.53±0.88	5.81±0.33	11.05±0.87	9.40±0.93	12.00±0.85	10.28±0.60
S. sesban	8.45±0.92	32.58±3.40	9.27±0.73	20.98±1.35	20.75±1.14	19.47±0.99	5.57±0.50	18.20±1.00	8.33±0.48	16.55±0.45	14.37±0.31	14.25±1.31	12.53±1.45
S. sesban ratoon	8.07±0.76	35.60±2.50	10.13±0.52	22.00±1.70	23.00±1.20	20.00±1.72	6.00±0.33	18.00±0.74	9.00±1.05	18.00±0.50	16.00±0.44	21.00±1.42	19.00±1.56

during this time. Heering *et al*. (1996) also observed similar results in *Sesbania* spp. Time required for flowering to pod initiation was the maximum in *S. sesban* (6.17±1.17 days) and minimum in *S. cannabina* (5.33±1.12 days); pod initiation to pod maturation the longest in *S. cannabina* (67.44±4.19 days) and the shortest in *S. sesban* ratoon (58.43±3.60 days) (Table 2). These results matched with the results of Heering *et al*. (1996).

Reproductive morphology of *Sesbania* spp.

The inflorescence of *Sesbania* spp. is dropping raceme. The number of flowers/inflorescence emerged as an important descriptor for species identification and varied among these three species (Table 3). The highest flowers/inflorescence (8.45±0.92) was observed in *S. sesban* followed by *S. sesban* ratoon (8.07±0.76), *S. bispinosa* (5.89±0.93) and the lowest in *S. cannabina* (4.25±0.49). This difference might be due to the genetic effect of these species. Flowers of *Sesbania* species are pedicellate, hermaphrodite, zygomorphic, having a corolla whorl including a vexillum, two wings and keels, diadelphous androecium, anthers with longitudinal dehiscence, and inconspicuous stigma. *Sesbania sesban* ratoon produced the largest flower (35.60±2.50 mm) and the lowest (18.37±1.07 mm) in *S. bispinosa* (Fig. 1, Table 3). The highest calyx length was found in *S. sesban* (10.13±0.52 mm) and the shortest in *S. bispinosa* (5.10±0.53 mm). Standard of *S. bispinosa* was yellow or pale yellowish with brownish or purplish spotted, violet, flecked and wings were yellow in color, however, standard of *S. cannabina* was yellow or orange-yellow, mottled or speckled with reddish brown or purple, wings were bright yellow and keels were pale yellow in color (Fig. 1). In *S. sesban*, standard was yellow with purple or brown streaks. Floral morphological features – length and width of standard, wing, keel, as well as length of stamen, carpel and ovary were significantly differed among the *Sesbania* species (Table 3). Floral morphological descriptors are found to be very effective to differentiate species within the genus (Ahmed *et al*., 2009) and/or among the genera (Fakir *et al*., 2018). The highest values of length and width of standard (22 mm × 23 mm), wing (20 mm × 6 mm) and keel (18 mm × 9 mm), were found in *S. sesban* ratoon and the lowest in *S.*

Table 4: Variation in pollen morphological features of *Sesbania* species showing mean value in µm and standard deviation.

Species	Polar length (P)	Equatorial diameter (E)	P/E	Exine thickness	Colpus length
S. bispinosa	83.50±4.23	46.21±4.86	1.81	2.47±0.47	61.92±5.90
S. cannabina	86.40±2.56	55.03±4.74	1.57	1.16±0.21	69.59±3.88
S. sesban	87.61±5.52	53.48±3.59	1.64	1.61±0.25	69.16±3.97
S. sesban ratoon	75.46±3.21	43.41±3.21	1.74	2.39±0.45	59.34±3.98

bispinosa (11.71 mm × 11.14 mm; 1.62 mm × 4.53 mm; 10.88 mm × 4.95 mm, respectively). The number of stamens is ten, diadelphous (9+1); nine united stamens usually longer than the free ones. The longer stamen was found in *S. sesban* ratoon (18.00±0.50 mm) followed by *S. sesban* (16.55±0.45 mm), *S. cannabina* (11.05±0.87 mm) *and S. bispinosa* (10.95±0.51 mm) (Table 3). Similar trend was observed in carpel length of three *Sesbania* species. The highest carpel length was found in *S. sesban* ratoon (21.00±1.42 mm) followed by *S. sesban* (14.25±1.31 mm), *S. cannabina* (12.00±0.85 mm) and *S. bispinosa* (11.69±0.99 mm). The larger ovary was produced *S. seban* ratoon (19.00±1.56 mm) and shortest in *S. bispinosa* (9.93±0.89 mm). In *S. sesban* ratoon, the carpel length is longer than stamen length (Table 3). It might be one of the causes for non-bearing pods during first flushing. Lavin and Delgado (1990) reported that the pistil is longer than the stamens, the stigma extends beyond the anthers, avoiding self-pollination and the upper part of the style develops erect trichomes acting as pollen. Wilcock and Neiland (2002) reported that pollination failure is associated with pollen if it is delivered to a stigma too little, too much, too late, too mixed in composition or too poor in quality.

Pollen grains are monad, tricolporate, prolate and exine sculpture reticulate (Fig. 2). The polar length (P) was higher in *S. sesban* (87.61±5.52 µm) followed by, *S. cannabina* (86.40±2.56 µm), *S. bispinosa* (83.50±4.23 µm) and the lowest in *S. sesban* ratoon (75.46±3.21 µm) (Table 4). Moreover, equatorial diameter (E) was the highest in *S. cannabina* (55.03±4.74 µm) followed by *S. sesban* (53.48±3.59 µm), *S. bispinosa* (46.21±4.86 µm) and. *S. sesban* ratoon (43.41±3.21 µm). The highest P:E ratio was found in *S. bispinosa* (1.81) and the lowest in *S. cannabina* (1.57). The thickest exine was found in *S. bispinosa* (2.47±0.47 µm) followed by *S. sesban* ratoon (2.39±0.45 µm), *S. sesban* (1.61±0.25 µm), and *S. cannabina* (1.16±0.21 µm). On the other hand, longest colpus observed in *S. cannabina* (69.59±3.88 µm) followed by *S. sesban* (69.16±3.97 µm), *S. bispinosa* (61.92±5.90 µm) and *S. sesban* ratoon (59.34±3.98 µm) (Table 4). The variation in P, E, exine thickness and colpus length of pollen grains may be due to genetic effect of *Sesbania* species. Bhattacharya *et al*. (2015) reported that the value of P was 20-40 µm, E 12.50-22.50 µm, exine thickness 1.25-2.50 µm, length of colpus 17.50-37.50 µm and P:E 1.71 in *S. grandiflora*.

The number of pods/raceme was higher in *S. bispinosa* (2.61±0.50) followed by *S. cannabina* (2.14±0.38), *S. sesban* (2.10±0.44) and *S. sesban* ratoon (1.75±0.36). The highest pod length (21.35±0.59 cm) was found in *S. sesban* and the lowest in *S. cannabina* (17.79±1.19 cm) (Table 5). The maximum number of seeds/pod contained in *S. sesban* ratoon (36.90±2.24) and minimum in *S. bispinosa* (29.44±2.45). Higher seed length was found in *S. bispinosa* (3.83±0.11 mm) and the lowest in *S. sesban* (3.70±0.22 mm). The widest seed was observed in *S. sesban* ratoon (2.64±0.29 mm) and the narrowest in *S. cannabina* (2.21±0.12 mm) (Table 5). The highest pod setting was found in *S. cannabina* (50.35%) and followed by *S. bispinosa* (44.31%), *S. sesban* (24.85%) and *S. sesban* ratoon (21.68%). There may be a huge scope for further research to improve the pod setting (%) of *Sesbania*. Kaur (2015) reported that different soluble nutrients application could retention the number of flowers and increased pod setting percentage, number of seeds/pod and seed weight. Furthermore, nutrients application can increase phloem area of pedicel and ultimately reduced the flower abscission and improved the crop yield of pigeon pea. Rao and Damodaram (1972) reported that the ratoon crop produce more biomass, however, less seed production than the original crop. On the other hand, highest seed setting was observed in *S. bispinosa* (91.06%) and followed by *S. sesban* (88.92%) *S. sesban* ratoon (87.86%), and *S. cannabina* (87.78%). Burd (1994) suggests that inadequate pollen receipt is a primary cause of low fecundity rates and pollen leads to increased fruit set more often than increased seed set within fruits. The 1000-seed weight was heavier in *S. sesban* (20.03±2.06 g) and lower in *S. cannabina* (16.28±2.20 g) (Table 5). Pod setting (%) and seed setting (%) may differ due to the genetic effect of the species and the environmental effect as well. Morandi *et al*. (1988) reported that soybean pod initiation, abscission as well as seed number and filling are affected by environment or different physiological causes. Singh *et al*. (2014) stated that fruit and seed setting percentage of *Sida cordifolia* are affected by temperature and relative humidity in different flowering period. They further mentioned that on relation to lack of the efficient pollination and the incidence of sterile pollens, the plant showed the lowest fruit or seed set. *de* Souza *et al*. (2016) observed that pollinators increased fruit set in *S. virgata* and reproduction and fruit establishment success of this species in dry season.

A dichotomous key was made for identification of these *Sesbania* species –

1a. 8 or more flowers per inflorescence, flower length larger than 3.0 cm, pod diameter larger than 0.40 cm ———— *S. sesban*

1b. 6 or less flowers per inflorescence, flower length 2.1 cm or less, pod diameter smaller than 0.30 cm ———— 2

2a. 5–6 flowers per inflorescence, P: E 1.81, exine thickness 2.47 µm ———— *S. bispinosa*

2b. 4–5 flowers per inflorescence, P: E 1.57, exine thickness 1.16 µm ———— *S. cannabina*

Conclusion

The quantitative descriptors *viz*. flower, wing, keel length, keel width, stamen and carpel length, P: E along with qualitative descriptors *viz*. flower color, spots on standard, color and shape of seeds, would be helpful for effective and identification of *Sesbania* species *viz*. *S. bispinosa*, *S. cannabina* and *S. sesban*, in the field. The floral parts of *S. sesban* plant were comparatively larger than those of *S. bispinosa* and *S. cannabina* plants. New descriptors in the floral and reproductive features may help pertinent for convenient field

Table 5. Variation in pod and seed morphological features of *Sesbania* species showing mean value and standard deviation.

Species	Pod						Seed			1000-Seed weight (g)
	No./ Inflorescence	Set (%)	Length (cm)	Diameter (cm)	Ovule (no.)	Seeds (no.)	Set (%)	Length (mm)	Width (mm)	
S. bispinosa	2.61±0.50	44.31	20.31±1.18	0.29±0.02	32.33±3.11	29.44±2.45	91.06	3.83±0.11	2.26±0.13	16.58±1.33
S. cannabina	2.14±0.38	50.35	17.79±1.19	0.28±0.02	33.60±5.10	29.49±2.22	87.78	3.80±0.07	2.21±0.12	16.28±2.20
S. sesban	2.10±0.44	24.85	21.35±0.59	0.44±0.03	37.92±3.75	33.72±2.88	88.92	3.70±0.22	2.60±0.23	20.03±2.06
S. sesban ratoon	1.75±0.36	21.68	20.67±3.86	0.39±0.07	42.00±4.22	36.90±2.24	87.86	3.74±0.14	2.64±0.29	19.40±2.78

identification of *Sesbania* species. A dichotomous key was made for these *Sesbania* species.

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REFERENCES :

Ahmed, Z.U., Hassan, M.A., Begum, Z.N.T., Khondker, M., Kabir, S.M.H., Ahmad, M. and Ahmed, A.T.A. 2009. *Encyclopedia of Flora and Fauna of Bangladesh, Vol. 8.* Angiosperms: Dicotyledons (Fabaceae–Lythraceae). Asiatic Society of Bangladesh, Dhaka. pp. 1-474.

Bhattacharya, P., Biswas, S. and Pal, J.K. 2015. Palyno-taxonomic study of some plant taxa of Fabaceae from Arambagh region of Hooghly district, West Bengal, eastern India. *Bioscience Discovery,* **6**: 27-34.

Bonde, E.K. 2008. Effects of gibberellic acid on growth and parthenocarpy in the dwarf telephone pea. *Physiologia Plantarum,* **19**: 356-364.

Burd, M. 1994. Bateman's principle and plant reproduction: the role of pollen limitation in fruit and seed set. *Botanical Revolution,* **60**: 83-139.

Chanda, S.C., Islam, M.M., Sagar, A. and Sarwar, A.K.M. Golam. 2017. *Sesbania*: Reproductive Morphology. *Abs. 4th Int. Symp. Minor Fruits, Medicinal and Aromatic Plants,* Pasighat (Arunachal), India, 5–6 December, 2017. p: 97.

Chanda, S.C., Prodhan, A.K.M.A. and Sarwar, A.K.M. Golam. 2018. Morphological descriptors of seed and seedling for identification of *dhaincha* (*Sesbania* spp.) accessions. *Bangladesh Journal of Botany,* **47**: 237-46.

de Melo, P.A.F.R., Silva, K.B., Alves, E.U., *de* Medeiros, R.L.S., *dos* Anjos, Neto, A.P., Pinto, K.M.S., *de* Sousa, L.W. and Matos, V.P. 2016. Morphological analysis of fruits, seeds and seedling germination *Acacia farnesiana* (L.) Willd. *African Journal of Agricultural Research,***11**: 2913-19.

de Souza, V.C., *de* Andrade, L.A. and Quirino, G.M. 2016. Floral biology of *Sesbania virgata*: an invasive species in the Agreste of Paraiba, northeastern Brazil. *Rodriguesia,* **67**: 871-78.

Erdtman, G. 1952. *Pollen Morphology and Plant Taxonomy – Angiosperm* (An Introduction to Palynology). Almigvist and Wiksell, Stockholm.

Evans, D.O. 1990. What is *Sesbania*? Botany, taxonomy, plant geography and natural history of the perennial members of the genus. In: Macklin, B. and Evans, D.O. (eds). *Perennial Sesbania species in Agroforestry Systems.* Proc Works., Nairobi, Kenya. March 27-31, 1989. Nitrog Fix Tree Assoc Waimanalo, Hawaii, USA. pp: 5-19.

Fakir, M.S.A., Rahman, M.M., Hasan, M.M., Moonmoon, S. and Rahman, M.M. 2018. Flower morphology and fruit maturity of four minor fruits (*Diospyros peregrina*, *D. discolor, Muntingia calabura* and *Careya arborea*) of Tropics and subtropics. *International Journal of Minor Fruits, Medicinal and Aromatic Plants,* **4**(2): 18-27.

Girma, G.M. 1999. The breeding system of *Sesbania sesban* (L.) Merr. (Leguminosae). *Master of Science in Biology Thesis, Addis Ababa University*. pp. 1-104.

Heering, J.H. 1994. The reproductive biology of three perennial *Sesbania* species (Leguminosae). *Euphytica,* **74**: 143-48.

Heering, J.H., Nokoe, S. and Jemal, M. 1996. The classification of a *Sesbania sesban* (ssp. *sesban*) collection. I. Morphological attributes and their taxonomic significance. *Tropical Grassland,* **30**: 206-14.

Jahan, S., Sarwar, A.K.M. Golam and Fakir, M.S.A. 2013. Phenology, floral morphology and seed yield in *Indigofera tinctoria* L. and *I. suffruticosa* Mill. *Bangladesh Journal of Botany* **42**: 231-37.

Joshi-Saha, A. and Gopalakrishna, T. 2007. Agromorphological and molecular variability in the genus *Sesbania*. *Genetic Resources and Crop Evolution,* **54**: 1727-36.

Kaur, G. 2015. Physiological and anatomical basis of flower drop in pigeon pea (*Cajanus cajan* L.) in response to foliar application of mineral nutrients. *PhD Dissertation, Punjab Agricultural University,* Ludhiana. pp. 1-145.

Lavin, M. and Delgado, A. 1990. Pollen brush of Papilionoideae (Leguminosae): morphological variation and systematic utility. *American Journal of Botany,* **77**:1294-1312.

Morandi, E.N., Casano, L.M. and Reggiardo, L.M. 1988. Post-flowering photoperiodic effect on reproductive efficiency and seed growth in soybean. *Field Crops Research,* **18**: 227-241.

Ndoye, L., Tomekpe, K. and Dreyfus, B. 1990. *Sesbania* and *Rhizobium* symbiosis: nodulation and nitrogen fixation. In: Macklin, B. and Evans, D.O. (eds). *Perennial Sesbania species in Agroforestry Systems.* Proc Works., Nairobi, Kenya. March 27-31, 1989. Nitrog Fix Tree Assoc Waimanalo, Hawaii, USA. pp: 31-38.

Nico, M., Mantese, A., Miralles, D.J. and Kantolic, A.G. 2016. Soybean fruit development and set at the node level under combined photoperiod and radiation conditions. *Journal of Experimental Botany,* **67**: 365-77.

Punt, W., Hoen, P.P., Blackmore, S., Nilsson, S. and Le Thomas, A. 2007. Glossary of pollen and spore terminology. *Review of Palaeobotany and Palynology,* **143**: 1-81.

Rao, D. and Damodaram, G. 1972. Preliminary studies on ratooning in sorghum varieties and hybrids. *Madras Agricultural Journal,* **59**:301-03.

Sarkar, M., Sutradhar, S., Sarwar, A.K.M. Golam, Uddin, M.N., Chanda, S.C. and Jahan, M.S. 2017. Variation of chemical characteristics and pulp ability of *dhaincha* (*Sesbania bispinosa*) on location. *Journal of Bioresources and Bioproducts,* **2**: 24-29.

Sarwar, A.K.M. Golam, Islam, A. and Jahan, S. 2015. Characterization of *dhaincha* accessions based on morphological descriptors and biomass production. *Journal of Bangladesh Agricultural University,* **13**: 55-60.

Singh, D.K., Agnihotri, R.K., Chauhan, S., Ganie, S.A., Singh, G. and Sharma, R. 2014. Effect of environmental changes on phenology and reproductive biology of *Sida cordifolia* with special reference to the temperature and relative humidity. *International Journal of Plant and Soil Science,* **3**: 372-79.

Srivastava, N. and Kumar, G. 2014. Morphotaxonomy and phenology of three different accessions of *Sesbania cannabina* Poir. *International Research Journal of Biological Sciences,* **3**: 70-72.

Veasey, E.A., Schammass, E.A., Vencovsky, R., Martins, P.S. and Bandel, G. 2001. Germplasm characterization of *Sesbania* accessions based on multivariate analysis. *Genetic Resources and Crop Evolution,* **48**: 79-90.

Wilcock, C.C. and *Neiland,* M.R.M. *2002*. Pollination failure in plants: why it happens and when it matters. *Trends in Plant Science,* **7**: 270-77.