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### Flowering and Fruiting Phenology of *Caesalpinia coriaria* (Jacq.) Wild

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#### ABSTRACT

*Caesalpinia coriaria* (Jacq.) Wild is an evergreen species which have rich amount of tannins in pods, fodder and ornamental value. To understanding the floral phenology will helps us to expeditiously utilize the tree in urban landscapes, avenues and agroforestry systems. Production of superior quality seedling starts from the selection of superior trees, collection of good quality pods for which there is a need to understand the floral phenology and the harvesting index. The present investigation revealed that *C. coriaria* was starts flowering from Mid-September to October. It was observed that a mean of 41 flowers per inflorescence with pod set and having a seed set percentage around 2-4 %. The pods attains harvest maturity at 21<sup>st</sup> week after anthesis indicating a distinctive colour change from yellowish brown to darker brown colour. Seeds are orthodox in nature and has a 70% germination rate. Floral phenology will help us to understand, reproductive biology of *C. coriaria* and will help to know much more about the species.

#### 1. Introduction

*Caesalpinia coriaria* (Jacq.) Wild is a small or medium-sized leguminous evergreen tree belongs to family Fabaceae. It is commonly called Divi-Divi or American Smac. It is distributed throughout Central America and north of South America. It has been introduced in Kolkata, India during 1834 as a shade trees in urban landscapes (Chacko *et al.*, 2002). The species will enjoys in areas having annual rainfall of 600 mm to 2500 mm and mean annual temperature 15-28 °C. It is a drought resistant, wind- resistant and fairly saline tolerant. It will attains 9 m in height with a dense low spreading umbrella like crown, somewhat resemblance to babul (*Acacia nilotica*) in appearance. It has short trunk and often crooked in nature (Troup, 1921; Sasidharan and Sivaraman, 1996; Bose *et al.*, 1998). Very recently the species have very much attention due to the anti-bacterial and antioxidants properties, apart from this it have good tannins, fodder and avenue suitability (Mohana and Raveesha, 2006; Lokeswari and Sujatha, 2011; Anandhi, 2011). Due to its fodder and nitrogen fixing capacity it can be effectively included in Agroforestry system (CAB, 2005; Vera, 2006).

The fruits and seeds characteristics has been considered as an important factors in the reproductive biology of plants (Khan *et al.*, 2002). Floral phenology and reproductive biology are the base for the breeding programs and to regulate the genetic structure (Kukade and Tidke, 2013). This is the first kind of study from India, aims to investigate the floral phenology, developmental variation in fruit and seed, maturation period.

#### 2. Materials and Methods

The present study was carried out in existing *Caesalpinia coriaria* plantations of Madurai. It is located at 9°55' N latitude and 78° 56' E longitude at an altitude of 147 m above mean sea level. It enjoys the mean annual rainfall is 131.1 mm distributed over 29 rainy days with 60 % from North East monsoon and 20 % from summer showers. The temperature varies from 19-35.4° C. The study was conducted during 2012-2014. The selected trees were used for studying flower phenology, pod development, seed and seedling quality characters.

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### Floral Phenology

Five trees were selected based on the morphological characters from the plantation (Fig.1). From each tree ten inflorescences were tagged during the flower initiation and were observed up to pod maturation. In each inflorescence, number of flowers, pods, and number of seeds per inflorescence were recorded twice a day for the period of 21 weeks during maturation. Pod setting percentage and seed setting percentage were also calculated adopting the following formulae:

#### Pod to seed set percentage

$$= \frac{\text{Number of seeds in number of pods}}{\text{Total number of pods per inflorescence}} \times 100$$

#### Pod setting percentage

$$= \frac{\text{Number of pods formed}}{\text{Total number of flowers per inflorescence}} \times 100$$

### Studies on fruit and seed maturation

At peak flowering period, matured flower buds (Flowers that will open on next day) were tagged and observed at weekly intervals upto 21 weeks. At the time of maturation, from the whole plantation the fresh fruits (pods) were categorized based on the colour as light green, green, darker green, yellowish brown, darker brown. Pod colours and seed colours was identified with Royal Horticultural Society Standard Color Chart (RHS, 2001) and their code were noted down. Fruit and seeds parameters (ISTA 1999) such as pod length (cm), pod breadth (cm), seed length (cm), seed breadth (cm), seed thickness were taken using digital vernier caliper.

Pod and seed weight (g) were taken using digital balance. Seed moisture content using gravimetric method. The seeds from different maturation stages are collected and germination test was conducted to find out the germination percentage. Fifty fresh fruits (pods) from each colour category were replicated three times (AOAC, 1960).

Figure 1. *Caesalpinia coriaria* plantations



Figure 2. Maturation of fruits



### Statistical analysis

Data were statistically analysed as per Panse and Sukhathme (1985) was used to understand the level of significance (5%). Since all the experiments were laboratory basis, the experimental design adopted was completely randomized design. The percentage values were transformed to arcsine values before analysis

### 3. Results and Discussions

During the part of study, it was observed that intimation of flowering started from recorded from September-March in Bangladesh (Khatun, 2006; Bose *et al.*, 1998) but contradicting observation by Troup (1921) that flowering was from May to June. The study (Table 1.) revealed that flowering end and fruiting started from 17<sup>th</sup> week to 21<sup>st</sup> week from the start of initiation of inflorescence panicle. Inflorescence (Fig. 4) was supra-axillary to dense terminal panicles upto 4.5 cm long but shorter than the subtending leaves. It has been found that mean number of flowers per inflorescence was 41.06 ±1.82 which had ranging from 33.5 to 47.9 flowers. The pods are asymmetrical, reinforced, ovate-oblong in dark brown colour in mature pods. The mean pod per inflorescence was 1.94±0.24. It has seen that 4.08±0.56 of seeds per inflorescence.

The seed set and pot set percentage are 5.91% and 12.51% respectively. It is widely recognized that flowering period does vary with different climatic region of the world especially found in *Swietenia macrophylla* King (Singh and Kushwaha, 2006; Krisnawati, *et al.*, 2011). Variations of *C. coriaria* fruit and seed colors characters are highly significant (Table 2 and Table 3), and it was also found that as fruit colour changes (Fig. 4). From light green (144C) to dark brown color (200A). The moisture content showed an abrupt change from 35-19.3% and 39-12.3% in both fruit and seed respectively. Fruit length and breadth was highest (6.10 and 1.84cm respectively) in dark brown colour (200A) and seed length and breadth were also maximum (0.75 and 0.38cm respectively) at dark brown colour (200A).

The maximum 100 fruit and seed weight was observed in yellowish brown colour (167D) is 250.35 and 5.7g respectively, however it shrunk slightly in dark brown (200A) colour with mature advances. Maximum seed thickness in yellowish brown and dark brown colour (200A) in 0.03cm. The highest seed germination obtained during dark brown colour (200A). The yellowish brown (200A) colour fruit with high seed characteristics are coincided with seed maturation results of earlier. In *Jatropha curcas* (Sowmya *et al* 2012: Gurunathan *et al.*, 2009, Kathiravan 2004, Kaushik *et al.*, 2001) and in *Syzygium cumini* (Srimathi *et al.*, 1997) found similar variations of fruit colours indicating that it would serve as seed maturation indication index in Divi-divi.

Individual Tree	T1	T2	T3	T4	T5	Mean	CD (p=0.05)
Number of flowers in Inflorescence	43.9±3.71	43.1±3.73	47.9±3.25	36.9±3.67	33.5±4.67	41.06±1.82	2.885
Pod per inflorescence	0.78±0.28	1.10±0.31	2.00±0.30	3.20±0.65	2.50±0.60	1.94±0.24	1.08
Number of seeds per inflorescence	2.22±0.86	1.90±0.72	5.10±1.30	5.70±1.62	5.30±1.21	4.08±0.56	2.80
Pod set percentage (%)	1.81±0.65	2.77±0.90	4.45±0.87	10.77±3.20	9.32±2.28	5.91±0.96	4.465
Seed set percentage (%)	6.03±3.00	4.40±1.60	11.85±3.63	20.86±8.84	19.30±4.59	12.62±2.37	12.51

Table 1. Flowering phenology and fruit set in *Caesalpinia coriaria*

Maturation of the pods of *C. coriaria* has distinctive colour change from darker green to yellow during the maturation phase (13<sup>th</sup> to 15<sup>th</sup> week of observation) and finally turning into darker brown colour (15<sup>th</sup> to 21<sup>st</sup> week). The pods colour (Table 4.) changed from light green (144C) to green (140B) during 4<sup>th</sup> week. In 8<sup>th</sup> and 9<sup>th</sup> week green (140 B) change to darker green (143C), Yellowish brown (167D) in 14<sup>th</sup> week and dark brown (200A) in 21<sup>st</sup> week (Fig.5). The maximum pods length and breadth was 7 cm during 18 week and 2.10 cm during 19 week respectively. During 21<sup>st</sup> week, started shrinkage in size due to fruit maturation. Chacko, (2002) was reported that similar values in Kerala and also by Troup (1921). Maximum pod weight 2.53g in 18<sup>st</sup> week and started shrinking. Formation of flowers, pod and seed setting percentage are highly influenced by genetic effect and environment factors in tree species like *Pongamia pinnata*, *Bixa orellana* and many other species

(Kaye, 1999; Nelsonnavamaniraj, 2005; Dhillon *et al.*, 2009; Srimathi *et al.*, 2013). This sort of influence was recorded in different species (Gassama - Dia *et al.*, 2003, Ndoye *et al.*, 2004, Natarajan and Srimathi, 2008, Piechowski and Gottsberger, 2009, Adjaloo *et al.*, 2012; Kukade and Tidke, 2013). Examining the germination percentage at different week of study revealed that germination reached the maximum of 70 % in 21<sup>st</sup> week from flower initiation, but germination started from 16<sup>th</sup> week of development of pod. On average it took the seed to fully mature at 20<sup>nd</sup> and 21<sup>st</sup> week from anthesis *i.e.* 150 day from anthesis. Due to lack of prior studies on the seed development especially in *C. coriaria* has limited our views on comparing our studies. The colour variation have been used to determine the maturation index in Jamun, Karanj, Jatropha and many other species. (Gurunathan *et al.*, 2009; Kathiravan, 2004; Kaushik *et al.*, 2001; Srimathi *et al.*, 2001).

**Table 2.** Interaction of fruit colour and their characters

Fruit Colour/ Characteristics	Fruit length (cm)	Fruit breadth (cm)	Fruit moisture content (%)	100 Fruit weight (g)
Light green (144C)	0.73	0.195	35	36.5
Green (140B)	2.51	0.512	31.3	136.17
Darker green (143C)	4.72	1.602	30.5	180.82
Yellowish brown (167D)	6.10	1.84	25.2	250.35
Darker brown (200A)	6.73	1.98	19.3	235.7

**Table 3.** Influence of *Caesalpinia coriaria* fruit colour in seed and seedling characters

Seed / Seedling characters	100 Seed weight (g)	Seed length (cm)	Seed breadth (cm)	Seed thickness (cm)	Seed moisture content (%)	Germination (%)
Light green (144C)	3.9	0.3	0.2	Negligible	28	-
Green (140B)	5.9	0.4	0.25	0.01	24.2	-
Darker green (143C)	6	0.5	0.35	0.02	22.6	-
Yellowish brown (167D)	5.7	0.6	0.37	0.03	18.3	-
Darker brown (200A)	5.6	0.75	0.38	0.03	12.5	52.6

**Figure 3.** Stages of Inflorescence



**Figure 4.** Stages of Seed Development



**Table 4.** Studies on seed development and maturation in *Caesalpinia coriaria*

Pod Development after Anthesis (Week)	Colour of Pod	Colour code (RHS Chart, 2001)	Pod Length (cm)	Pod Breadth (cm)	Pod Weight (g)	Germination (%)
1	Light green	144C	0.5	0.15	0.23	-
2	Light green	144C	0.9	0.24	0.50	-
3	Green	140B	1.3	0.29	1.01	-
4	Green	140B	1.9	0.35	1.27	-
5	Green	140B	2.4	0.42	1.32	-
6	Green	140B	2.7	0.56	1.48	-
7	Green	140B	3.3	0.62	1.52	-
8	Green	140B	3.5	0.83	1.57	-
9	Darker green	143C	3.8	1.22	1.61	-
10	Darker green	143C	4.3	1.56	1.66	-
11	Darker green	143C	4.7	1.69	1.72	-
12	Darker green	143C	5.1	1.75	1.73	-
13	Darker green	143C	5.6	1.79	1.82	-
14	Yellowish brown	167D	5.9	1.83	1.85	-
15	Yellowish brown	167D	6.2	1.85	1.86	-
16	Dark brown	200A	6.4	1.91	1.89	-
17	Dark brown	200A	6.4	1.95	1.91	30 (17.45)
18	Dark brown	200A	7.0	2.10	2.53	45(26.73)
19	Dark brown	200A	6.9	2.10	2.25	56 (34.04)
20	Dark brown	200A	6.9	1.91	2.23	62 (38.30)
21	Dark brown	200A	6.8	1.90	2.20	70 (44.41)
Mean			4.40	1.287	1.63	7.66
SD			2.16	0.72	0.55	14.8
SED			.4709	0.16	0.12	3.23

SD- Standard Deviation; SED- Standard error of Mean



**Figure 5.** Different Stages of Maturation of Pods (Fruits)



## Conclusion

The study being first of its nature in *Caesalpinia coriaria* Wild. has evidently helped us to conclude that species produce an average 41 flowers per inflorescence with pod set and seed set percentage was around 2-4 percentage with flowering period from Mid-September to October. The collection of fruits at 21<sup>st</sup> week had maximum germination percentage indicating the pod at darker brown colour can be used as criteria for collection of seed.

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