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PLANT PHYSIOLOGY

Phenological Behaviour and Reproductive Biology of *Ailanthus excelsa* Roxb.

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ABSTRACT

Studies on reproductive biology of Mahaneem (*Ailanthus excelsa*) indicated that mild defoliation started in mid of March and continued up to end of February, majority being from May 13-28. Leaf promodial started appearing after all the leaves had shed off. Within a week of new foliage appearance, the panicle with small protruding buds appeared. The floral buds took 9-13 days to come to bloom. More than 80 per cent floral buds opened between 0800-0900 h. The number of days required from panicle initiation to fruit maturity ranged from 132-140. Fruit set under open-pollination was higher as compared to the fruit set in self-pollinated and a highly significant difference in growth characters of self versus open pollinated progenies formed a strong evidence for xenogamous behavior of mahaneem.

Highlights

- The number of days required from panicle initiation to fruit maturity ranged from 132-140.
- Fruit set under open-pollination was higher as compared to the fruit set in self-pollinated and a highly significant difference in growth characters of self -versus open pollinated progenies formed a strong evidence for xenogamous behavior of mahaneem.

Keywords: Breeding system, mahaneem, polliation, phenology and reproductive biology

Ailanthus excelsa Roxb. commonly known as 'Ardu' or 'Mahaneem' is a fast growing tree and is extensively cultivated in many parts of India. Mahaneem plantation on community land, farm boundary, road avenues and in agroforestry system helped in maintaining the ecosystem by slowing down the variations in climatic parameters due to climate change. Foliage of mahaneem is used by small ruminants to meet the green fodder requirement during lean period and it is also sold in the market to earn some income to meet the farmer's expenditure to sustain their livelihood in harsh climate.

It has been found to be a suitable species for planting in dry areas with annual rainfall of about 250 - 300 mm. It can grow on a variety of soils but thrives best on porous sandy loams. The tree can be seen growing upto an elevation of 900 metres (Orwa *et al.* 2009). Mahaneem is a large deciduous tree of upto 24 m height with a straight cylindrical bole. Bark is light grey and smooth in young trees with large leaf-scars, rough, granular and grayish brown in older trees. Leaves are pinnately compound, upto 90 cm long with 8-14 pairs of leaflets. Flowers small, yellowish in panicles and fruits are single seeded samara (Kirtikar and Basu 1995).

Its wood is very light, soft and perishable. The timber is used for packing cases, fishing floats, boats, spear sheaths, sword handles, toys and drums. The bark is bitter, astringent, anthelmintic and it is used in diseases like dysentery, bronchitis, asthma, dyspepsia and ear ache (Lavhale and Mishra 2007), antifertility (Dhanashekaran *et al.* 1993 and Ravichandran *et al.* 2007) insect feeding, antifungal, antimicrobial, antibacterial, hypoglycemic, hepatoprotective, antiproliferative

(Tripathi and Jain 1993 and Joshi *et al.* 2003). The pulp is obtained from debarked wood is used in paper industry. The leaves are rated as highly palatable and protein rich nutritious fodder for sheep and goats and are said to augment milk production (Jat *et al*. 2011).

Such a species with multifarious uses has gained only limited research attention especially with inference to tree improvement. It holds good potential for various industrial utilities and also amenable for agroforestry and farm forestry. In literature, unavailability of reports related to phenology and breeding system which is the prerequisite for tree improvement programme of this versatile tree species necessitated the present study to collect information on reproductive biology and breeding behaviour of *A.excelsa* for subsequent application in its genetic improvement programme.

MATERIALS AND METHODS

Experimental Site and Environment

Present investigation on the phenology and reproductive biology and breeding system was carried out in the research farm of CCS Haryana Agricultural University, Hisar (20° 10′ N lat., 75° 46′ E long., alt. 215 m msl), situated in the arid region of North-Western India. The climate is sub-tropical monsoonic with an average annual rainfall of 350-400 mm, 70-80 per cent of which occurs during July to September.

Experimental Material and Observations

The Mahaneem trees growing at the campus of CCS HAU, Hisar formed the basic material for the studies on phenology and reproductive biology and breeding system (Table 1). The visual observations were made throughout the year at 15 days interval for broad phenological changes. However, from bud primordial initiation to pod setting, observations were recorded daily on ten trees selected randomly and five twigs on different positions (lower, middle and upper portion of crown) on these trees were taken for observations. The observations were also recorded on inflorescence and floral bud development, anthesis time and peak period of flowering and stigma receptivity period. Pollen viability was studied with 1% acetocarmine solution as per the method of Marutani *et al.* (1993). Mature anthers were crushed and pollen grains were mixed thoroughly with the acetocarmine stain to determine number of viable pollens. To determine pollen fertility, darkly stained pollen grains were recorded as fertile and viable, and unstained or very lightly stained ones were considered as sterile or non-viable. Pollen fertility was calculated by dividing the number of viable pollen grains by the total number of grains counted in the field of view and averaging them. Pollen viability was expressed as percentage pollen fertility. Breeding behaviour was examined by covering the inflorescence with muslin cloth bags before opening of floral buds. Already opened and very small flower buds were removed before bagging. Approximately an equal number of buds were kept open in close vicinity of the so covered branches. Reproductive capacity was examined from the percentage of fruit setting in marked inflorescences.

Table 1: Morphological characters of trees used in phenology and reproductive biological study

Tree No.	Total height (m)	GBH (cm)	Clear bole height (m)	Canopy height (m)	Approximate Age (yrs)	Crown Spread (m)	
						EW	NS
1	17.2	162	2.5	16.4	9	11	14.1
2	18.1	146	3.3	14.8	9	12.2	11.3
3	14.7	126	3.2	11.2	8	13.4	9.3
4	16.6	132	4.1	12	8	11.8	12.3
5	13.8	122	2.9	10.6	7	13.6	10.2
6	15.6	128	3.9	11.8	8	9.6	9.4
7	13.4	112	3.6	8.9	7	10.2	7.6
8	12.8	102	3.5	8.8	6	9.7	10.2
9	16.8	125	4.2	11.9	8	7.5	6.8
10	11.8	98	3.8	7.6	6	7.8	9.2

RESULTS AND DISCUSSION

The critical observations on leaf fall pattern in mahaneem indicated that mild defoliation started in mid of March and continued up to end of May. However, in young seedlings in nursery sever leaf fall was noticed during first week of March. In majority of trees, the leaves turned to yellowish brown colour during the first week of March followed by light to moderate defoliation. However, rigorous leaf fall was observed in May and bulk of defoliation occurred from May 13-28. There was complete defoliation before the initiation of new vegetative growth and the new leaves started coming up after all the leaves had shed off. At the terminal end of the branches, the initiation of leaf primordial was noticed during second to third week of January in different selected trees. After 3-4 days of leaf bud emergence, new leaves light green in colour arose and within one week these new leaves turned into dark green colour. The leaves attained their full size in about three weeks. Within a week of leaf primordial emergence, panicle initiation started during second fortnight of January and continued throughout January in the randomly selected trees (Table 2).

Observations on flowering habit indicated that bud begins to appear as small protruding structures with the commencement of new leaves. Inflorescence was a cymose panicle which is often axillary. Maximum well developed buds were observed on all the trees from February 8- February 20. The floral buds started to open during last week of February. The flowering pattern was asynchronous i.e. new flowers were developing at different times on the same tree. The trees were in full bloom during first fortnight of March. Peak period of flowering varied from 9-13 days. Flowering gets completed by March end. On all the marked trees, natural pod setting was noticed during last week of March. There were minor variations for these observations among different plants during the same season. It appears that microclimatic changes and genetic makeup of

Table 2: Phenological data on flowering, pod setting and maturity in *Ailanthus excelsa*

Tree No.	Date of panicle initiation	Commence-ment of flowering	Peak period of flowering	Cessation of flowering	Duration of peak period of flowering (days)	Duration of flowering (days)	Date of pod initiation	Date of pod maturity	Duration of pod maturity	Duration of panicle initiation to pod maturity
1	24-Jan	26-Feb	2 March - 13 March	16-Mar	12	19	25-Mar	2-Jun	70	132
2	21-Jan	23-Feb	1 March - 12 March	17-Mar	12	24	29-Mar	3-Jun	67	136
3	20-Jan	26-Feb	4 March - 12 March	16-Mar	9	19	26-Mar	30-May	66	133
4	19-Jan	22-Feb	29 Feb - 12 March	18-Mar	13	26	27-Mar	5-Jun	71	140
5	24-Jan	28-Feb	2 March - 14 March	22-Mar	13	23	1-Apr	2-Jun	63	132
6	26-Jan	27-Feb	3 March - 13 March	17-Mar	11	19	28-Mar	7-Jun	72	135
7	21-Jan	21-Feb	1 March - 11 March	20-Mar	11	29	27-Mar	31-May	66	133
8	23-Jan	22-Feb	2 March - 13 March	21-Mar	12	29	29-Mar	7-Jun	71	138
9	20-Jan	27-Feb	4 March - 16 March	19-Mar	13	21	28-Mar	9-Jun	74	136
10	25-Jan	28-Feb	3 March - 12 March	19-Mar	10	20	30-Mar	7-Jun	70	133
Range	**19 Jan – 26 Jan**	**21 Feb - 28 Feb**	**29 Feb - 16 March**	**16 March- 22 March**	**9.0-13**	**19-29**	**25 March - 1 April**	**30 May – 9 June**	**63 - 74**	**132 - 140**

plants caused such variations. Similar observation was also observed by Dhillon *et al.* (2004) in neem (*Azadirachta indica)* and Sen and Batra (2011) in *Melia azedarach.*

On the basis of size, shape and colour etc. of the flower buds, the development was divisible into five stages (Table 3). The number of stages is variable for different species. Johar *et al.* (2015) suggested five stages in *Melia composita* while Dhillon *et al*. (2004) delineated five stages in *Azadirachta indica*. Knowledge of initiation and development of floral buds, floral morphology, anthesis, anther dehiscence, stigma receptivity, events in fertilization, fruit and seed set and their development are pre-requisite for advance breeding programmes. Among them, floral morphology, anthesis, anther dehiscence and stigma receptivity are more important as these are directly linked with the breeding behaviour of the species.

Flower opening start between 0600-0700 h and the maximum flowering, ranging from 85.71 to 92.85 per cent (Table 4) was recorded between 0800-0900 h. Such observations have also been recorded by Chauhan and Singh (2001) in *Terminalia arjuna.* Maximum buds opened up to 1000 h, however, anthesis continued till noon hours. The dehiscence of anther started at about 0830 h and continued up to 1130 h with maximum frequency between 0900-0950 h. Earlier, Gupta *et al.* (2003) observed similar observations in *Azadirachta indica* while working on the similar aspects.

The data on pollen morphology and stainability are presented in Table 5. Pollens were round in shape. Pollen stainability in 1 per cent acetocarmine ranged from 85.58 to 91.49 per cent. The shiny surface of the stigma was taken as measure of receptivity. It was observed that the receptivity started half hour before flower opening and remained receptive upto 24 hours after flower opening.

The average pod setting of 12.60 per cent was recorded under open pollination which ranged from 8.51 to 19.05 per cent on different trees. By using paired 't' test, it was clear from Table 6 that average pod setting under selfing and open pollination differ significantly even at 5 per cent level of significance. Therefore, the results of present study indicate that mahaneem is capable of producing pod through geitonogamy and xenogamy. Such type of breeding system represents facultative xenogamy.

Table 3: Time of flower opening in *Ailanthus excelsa*

Date of observation	No. of buds observed	Per cent flower opened between				
		6 -7 AM	7 – 8 AM	8 – 9 AM	9 – 10 AM	10 – 11 AM
11/3/2015	45	0.15	30.12	85.71	1.85	—
12/3/2015	52	—	34.65	89.16	1.05	0.98
13/3/2015	61	—	42.06	92.06	0.78	—
14/3/2015	50	1.84	40.84	92.75	0.63	—
15/3/2015	48	—	35.64	86.82	1.84	0.59
16/3/2015	59	1.45	42.23	92.85	0.95	1.94

(-) No flower opening

Table 4: Pollen stainability in *Ailanthus excelsa*

Date of observation	Total pollen (No.)	Stainable pollens (No.)	Non-stainable pollens (No.)	Pollen stainability (%)
8/3/2015	120	109	11	90.83
9/3/2015	104	89	15	85.58
10/3/2015	152	132	20	86.84
11/3/2015	94	86	8	91.49
12/3/2015	124	111	13	89.52
Range				85.58 - 91.49
Mean				88.85

CONCLUSION

The results indicate that mahaneem is capable of producing pod through geitonogamy and xenogamy. Such type of breeding breeding system represents facultative xenogamy in mahaneem. Therefore, the elite genotypes/accessions of this species can be multiplied either by seed or vegetative means to get the quality planting material for different afforestation programmes.

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