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RESEARCH ARTICLE

Reproductive biology of *Acacia senegal* (L.) Willd.

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Abstract

The pollen morphological characters of seven accessions of the *Acacia senegal* (Mimosoideae) representing 456 plants were investigated for reproductive capacity. The different palynological parameters that have taxonomic significance were: Number of floral buds per inflorescence, Inflorescence length (cm), Pollen fertility percentage and Reproductive capacity recorded. This is a cross-pollinated plant, where the pollination process is being done by insect in mostly day time. The flower of this plant gives odor to attract the insects and the concentration of flower is very high during the season. *A. senegal* has a high degree of self-incompatibility which was also responsible for low fruit set ratio. It shows very low fruit set ratio which was less than one percent.

Introduction

Acacia senegal (L.) Willd. Leguminous tree, subfamily Mimosaceae is an important multipurpose tree of desert. *Acacia* is abundant in savannas and arid regions of India, Australia, Africa and America. Many species of *Acacias* are exceedingly robust and grow under the most severe conditions. Fabaceae or Leguminosae is a large and economically important family of flowering plant. It is commonly known as legume family, pea family, bean family and pulse family. Fabaceae is third largest family of flowering plants behind Orchidaceae and Asteraceae, with 730 genera and over 19400 species according to Royal Botanical Gardens and *Acacia* with 900 species.

Tree grows up to 8 m in height, with umbrella-shaped or flat or rounded crown (Maundu et al., 1999). It is based chiefly on characteristics of the seed and seedlings, absence of stipular spines (but prickles present) and pollen characteristic. It is very branched with many upright twigs (Von Maydell, J.H. 1990). Selection of the best seed sources of *A. senegal* for given region is necessary for maximum productivity in plantation forestry and agro forestry systems (Subramanium et al., 1992). Tree breeder wants to explore the naturally occurring variability which permits tree breeder to make rapid genetic advance.

The diversity of environmental conditions, especially moisture, under which *A. senegal* occurs naturally, suggests that there is a great genetic variability among the populations of the species (Brenan, 1983). Species with wide geographic ranges like *A. senegal* always develop locally adopted plant populations and show variation for morphological expressions (Elberse et al. 2003). The morphological variability signifies the adaption of the species to the environment and it may be genetically determined or environmentally induced.

Recently scientists have shown an increasing interest on the reproductive biology of tropical trees such as *Leucaena* (Brewbaker, 1983), the genus *Acacia* (Tybirk, 1989; Tybirk, 1992; Buitlaar, 1993; Diallo, 1997), *Saba senegalensis* (Traoré, unpubished), and the monospecific genus *Faidherbia albida* (Gassama-Dia et al, 2003). Regarding *B. aegyptica*, some preliminary studies on seed pre-germination treatment and vegetative propagation were mentioned by El Nour et al. (1991). This paper presents results on the flowering, pollination and reproductive capacity in *A. senegal*.

Materials and Methods

Seeds of six exotic collections and one indigenous, as detailed in Table I, procured from CIFT Nogent Sur Marne Cedex (France) in 1988, were shown into polythene bags containing a mixture of sand, clay and manure in ratio of 2:1:1 in last week of March, 1988. The plants were transplanted to the field in third week of July, 1988 in a randomized complete block design with four blocks at Central Research Farm of CAZRI, Jodhpur. The climate of this area is typically arid, characterized by exceptionally hot dry summers, sub-humid monsoons and cold dry winters. The soil is sandy loam (camborthid) with ph 8.1 and low nutrient level with 0.23% organic carbon, 0.03% nitrogen and 0.02% phosphorus (Dhir, 1984). Each plot consisted of three rows of six plants for five provenances and two rows of six plants for Sudan and Rajasthan origin each at 3 m spacing. Data on all the surviving plants in December of 2007 and 2008 were recorded for pollen fertility anthers before dehiscence were collected during the flowering time August-September in 2008 from each tree.

For reproductive capacity, ten inflorescences on each tree were tagged, their lengths were measured and number of flowers on each inflorescence was counted. The number of fruit found on each inflorescence were collected and counted to estimate the reproductive capacity

$$\text{Reproductive Capacity (\%)} = \frac{\text{No. of pods formed}}{\text{Total no. of flowers}} \times 100$$

For pollen fertility, anthers before dehiscence in August 2008 from each individual tree were collected and crushed with the help of glass rod in the presence of acetocarmine on a glass slide. Then the slide was warmed for 10 to 15 seconds using sprit lamp and pollen bags were again pressed with clean glass rod. The slide was covered with a cover slip, examined under microscope to count the pollen grains which had colour with red dye (viable pollen grains) and the others which could not get the colour (non-viable pollen grains). Pollen fertilizing percent was calculated.

$$\text{Pollen fertility \%} = \frac{\text{Pollen grains got colour}}{\text{Pollen grain got colour} + \text{Pollen grains which could not get the colour}}$$

Results and Discussion

Abundant flowers are produced almost every year but only a few of them set into pods. The desert trees are mostly cross-pollinated in nature and if pollination is there due to some factors then also cross-pollination are dominant over self. Jindal et al. (1985) studied the breeding system of Rohida and reported that the flower buds developed during November to January fell before and after their opening a few of them developed after February set fruit. Fruit set varied from 0.64 % for selfing to 3.94 % for cross-pollinated indicating the presence of self compatibility in the species. The range of genetic variability is controlled by reproductive system which in turn controls the adaptive change (Simmonds, 1962). Neem (*Azardirachta indica* A. Juss) flowering was maximum during April and flowers of March-April drop without fruit formation. Reproductive capacity was low (Jindal et al., 1992-94). Tybrik (1989) reported that *A. nilotica* is a cross-pollinated species and chances of inbreeding are less.

Insects are the main vectors of pollination (Coetzee, 1955) and also birds, which are attracted to the extra floral nectories. The flower shed their pollen between 7:30 and 12:00 hours in Kenya for *A. nilotica* (Tybrik, 1989) and average pollen production is 1.1 million grains per inflorescence. In case of *Salvadora persica* flowering starts in November and maximum during December. Flower of November, December, January and February fall without fertilization. Very few flowers in March set into fruit. Reproductive capacity per inflorescence very low causing the poor fruit set and the fruit set was 17.2 % in selfing and 54.4 % in sibbing in the flowers during March (Jindal et al., 1997).

Number of floral buds inflorescence, inflorescence length, pollen fertility percent and reproductive capacity are given in Table II and III. The mean number of floral buds per inflorescence was 95.7 and it was maximum 107 in Provenance (P)-7 followed by 103 in P-3 and 98.5 in P-5. The number of floral buds per inflorescence varied from 40.8 on an individual tree in P-1 to 136 in P-7. Mean inflorescence length was 6.19 cm showing that there are about 15 floral buds per cm of inflorescence length. Pollen fertility was 84.2 % and it ranged between 81.2 % in P-4 and 87.9 % in P-6. There was not much change from provenance to provenance, but considering the individual trees 97.4 % pollen fertility was recorded in P-6. Reproductive capacity were maximum in the accession Rajasthan followed by Sudan and minimum in EC87/7497. Pollen fertility percent were maximum in the accession Sudan (97.4 %) and minimum in EC87/7493 (70.0 %). The mean numbers of floral buds per inflorescence were highest in accession Rajasthan (136) and minimum in EC87/7500 (36.4). Mean of inflorescence length were maximum in accession Rajasthan (13.1 cm) and minimum in EC87/7490 (2.01 cm).

Percent reproductive capacity is the number of fruit formed out of 100 flowers. Mean reproductive capacity was 0.088 showing that only 88 flowers out of one lakh set into fruits. And there is large variation in reproductive capacity from provenance to provenance and it varied from 0.045 % for P-3 to 0.166 % for P-1. But Tandon et al.

(2001) reported 0.36 % fruit set which is about more than 4 times of our studies showing that this variation may be due to the studies conducted in different environment. The insufficient pollination may be the main cause of low fruit set. The mass of fragrant flowers attracts many insects during bright sun in the month of September when the monsoon is withdrawn. Parihar and Singh (1998) reported 15 species of insects visit the flowers. Flowers emit a mild fragrance and produce a minute quantity of nectar. The stigma is wet non-papillate, cup-shaped and generally accommodates one polyad with 16 pollen grains. The style is solid. The mass effect created by the brush type of blossoms attracts a wide variety of insects of which the giant Asian honey bee, *Apis dorsatal* is the effective pollinator (Tandon et al., 2001). The variation in reproductive capacity among the provenance may be due to the number of pollen grains and the fragrance of the flowers. The seed yield per pod yield is directly related to the visits, population and dynamics of pollinators, which are influenced by the humidity, temperature and range during the preceding year also.

Tables

Table I. Source of seed of *Acacia senegal* planted at CAZRI in 1988

Provenance (P)	Accession	Origin	Longitude	Latitude	Altitude (m)	Precipitation (mm)
1	EC87/7490	Niger	8°00'E	16°00'N	-	150
2	EC87/7493	Mali	11°35'W	14°57'N	100	560
3	EC87/7497	Mali	10°22'W	14°37'N	150	650
4	EC87/7499	Mali	7°10'W	15°08'N	270	450
5	EC87/7500	Senegal	14°49'W	15°40'N	60	400
6	Sudan	Sudan	-	-	-	-
7	Rajasthan	Rajasthan	73°08'W	26°18'N	241	371

Table II. Mean, SD and range of number of floral buds per inflorescence length in different provenances

	Number of floral buds per inflorescence				Inflorescence length (cm)			
Provenance (P)	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
1	85.7	30.94	40.8	124	4.85	1.84	2.01	7.27
2	89.3	24.12	44.1	117	5.19	2.15	2.26	9.42
3	103	19.62	73.4	114	5.08	0.87	4.40	6.29
4	94.7	32.83	42.2	125	4.46	1.94	2.59	7.65
5	98.5	25.86	36.4	115	6.29	1.89	2.12	8.72
6	94.1	19.34	65.1	130	6.89	1.36	4.65	8.72
7	107	28.87	53.3	136	8.60	1.90	6.46	13.1
Grand	95.7	25.85	36.4	136	6.19	2.19	2.01	13.1

Table III. Mean, SD and range of pollen fertility and reproductive capacity in different provenances

	Pollen fertility %				Reproductive capacity			
Provenance (P)	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
1	83.1	5.63	73.2	90.7	0.166	0.117	0	0.280
2	82.9	5.21	70.0	89.8	0.073	0.087	0	0.227
3	84.5	4.88	80.5	91.5	0.045	0.052	0	0.091
4	81.2	6.98	70.1	91.0	0.069	0.093	0	0.248
5	83.3	4.96	76.8	91.0	0.074	0.112	0	0.285
6	87.9	5.69	76.1	97.4	0.099	0.106	0	0.314
7	83.8	4.27	76.5	90.8	0.084	0.093	0	0.322
Grand	84.2	5.63	70.0	97.4	0.088	0.101	0	0.322

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