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# Studies on Phenology and Reproductive Biology of Khejri [*Prosopis cineraria* (L.) Druce]

Preeti Singh, K.S. Bangarwa, R.S. Dhillon

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## ABSTRACT

**Background:** Khejri [*Prosopis cineraria* (L.) Druce] belongs to the family Leguminosae and subfamily Mimosoideae. The rural communities encourage the growth of Khejri in their agricultural fields as it improves grain yield and storage biomass production. It is the true multipurpose species and also called as 'Golden Tree of Desert', 'Kalpvriksha' of the desert, 'King of desert', 'Love Tree', and 'Pride of the Desert'. For any tree improvement programme, knowledge of phenology and breeding system is pre-requisite, which also helps in understanding the evolutionary dynamics of a species. The range of genetic variability is controlled by reproductive system, which in turn controls the adaptive change. Pollination mechanisms affect seed set, fertility, gene flow, breeding systems, hybridization and genetic constitutions of tree populations.

**Methods:** In this investigation during 2014-15, ten trees of [*Prosopis cineraria* (L.) Druce] growing at the research area of Forestry Department of CCS Haryana Agricultural University, Hisar were randomly selected and phenological observations were made on the selected trees at different phenophases. Through selfing, breeding behaviour was examined, by covering the inflorescence with muslin cloth bags before opening. Approximately, an equal number of buds were kept open in close vicinity of the covered branch. Reproductive capacity was estimated from the percentage of fruit setting in marked inflorescence.

**Result:** In present study of *Prosopis cineraria*, the average fruit set under self-pollination was nil whereas it was 2.03 per cent in open natural pollination. This study confirms previous studies that *Prosopis cineraria* is a cross-pollinated species.


**Key words:** Khejri, Pollination, *Prosopis cineraria*, Reproductive biology.

## INTRODUCTION

The trees of *Prosopis* spp. are remarkably found growing in poor soil conditions and require relatively low moisture for survival (NAS, 1979). It holds an important place in the desert ecosystem (Jatasra and Paroda, 1981; Shankarnarayan *et al*., 1987). The tree is known locally as Jandi or Khejri (India), Jand (Pakistan) and Ghaf (Arabic). Its synonym is *Prosopis spicigera*. It belongs to the family Leguminosae and subfamily Mimosoideae. It is distributed mainly in dry regions of Southwest Asia and Africa (Khatri *et al*., 2010). In the most important areas of *Prosopis cineraria* distribution, the climate is dry to arid and rainfall shows considerable variation 100 to 600 mm annually with long dry season. It is seen at its best on alluvial soils consisting of various mixtures of sand and clay. The rural communities encourage the growth of Khejri in their agricultural fields, pastures and village community lands. Through experience, farmers have realized its usefulness and learnt that it does not adversely affect crop yields; instead, it improves grain yield and storage biomass production (Kaul, 1967). It is being regarded as 'King of desert', 'Golden Tree of Desert', 'Love Tree' and 'Pride of the Desert', because every plant part of this versatile tree is utilized. This tree is so important in arid region that their number forms the major criterion for the value of land (Singh *et al*., 1998). It is the true multipurpose species and often referred to in ancient literature as the 'Kalpvriksha' of the desert (Mahoney, 1990).

It provides fuelwood, fodder, small timber, medicines, gum and tannins and also helps in improving the soil fertility and sand dune stabilization (Singh *et al*., 1998). This tree species is much valued as fodder tree. The fodder from its leaves, commonly known as loong is very nutritious, protein rich (12-18% crude protein) and palatable to the animals (Bhandari *et al*., 1979; Bohra and Gosh, 1980). The wood is suitable for interior construction work such as column of huts, roofs, doors, windows *etc*. Wood is also used for agricultural hand tools. 40-70 kg fuel wood per tree can be obtained from 20$^{th}$ to 30$^{th}$ year of age group plant (Mann and Saxena, 1980). The unripe pods are used as a feed supplement (Brown, 1992), while mature pods are fed to livestock. Its pods contain 9-4 per cent crude protein and 6-16 percent sugar. The bark is used in the cure of rheumatism and scorpion bite. It is a tree with great potential for agroforestry systems as it is highly compatible with

Department of Forestry, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.

**Corresponding Author:** Preeti Singh, Department of Forestry, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India. Email: preetiarad919@gmail.com

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agricultural crops (Puri *et al*., 1994) due to its deep root system, monolayer canopy, nitrogen fixing ability and high efficiency of recharging the soil with organic matter (Toky and Bisht, 1992). Its branches are slender, glabrous and armed with somewhat compressed, straight and scattered prickles of 3-4 cm length. Flower is in the form of axillary spikes with the length of 7-11 cm, either solitary or in terminal panicles. Flower posses yellow corolla, attracting large number of insects including large number of *Apis florea* and numerous other wild bees in the month of December and April (Gorain *et al*., 2012).

For any tree improvement programme, knowledge of phenology and breeding system is pre-requisite, which also helps in understanding the evolutionary dynamics of a species. The range of genetic variability is controlled by reproductive system, which in turn controls the adaptive change (Simmonds, 1962). Pollination mechanisms affect seed set, fertility, gene flow, breeding systems, hybridization and genetic constitutions of tree populations (Bangarwa, 1996).

## MATERIALS AND METHODS

The investigation on the phenology, floral biology and breeding system were carried out during 2014-15 on ten randomly selected trees of *Prosopis cineraria* (L.) Druce (Table 1) growing at the research area of Forestry Department 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 subtropical monsoonic with an average annual rainfall of 350-400 mm, 70-80 per cent of which occurs during July to September. The phenological observations were made on the selected trees at different phenophases observations were recorded on development and type of inflorescence, flower development, peak period of flowering, breeding behaviour and fruit set. Several inflorescences on different trees were observed for flower initiation, flower opening time, stigma receptivity period, peak period of flowering and flower cessation. To observe the time of anthesis, three randomly selected branches on three trees were tagged during April 2015 and the numbers of buds opening at different hours of day were noted from 0600 h to 1500 h. For observing the time of flower opening, fully mature buds on the selected branches, which were likely to open the following morning, were tagged in the afternoon of the same day and the immature buds on the same branches were removed. Beginning at 0600 h, the number of fully open flowers was noted at one hour interval upto 1500 h and after that next observation was taken at 0600 h on next day. All the opened flowers after each interval were plucked to avoid the possibility of recounting. The pollen morphology and viability study was done by mounting pollens in 1 per cent acetocarmine stain. For pollen stainability, pollen from freshly opened flower of a randomly selected tree was dusted on a clean slide and 1-2 drops of acetocarmine solution were added to the pollen mass. The slides were then left for 10-15 minutes to allow the pollen to take the stain. The deeply stained normal looking grains were recorded as stainable, which are usually considered viable. Unstained pollen grains were recorded as non-viable. The observations were repeated for five days.

## RESULTS AND DISCUSSION

The critical observations on leaf fall pattern in *Prosopis cineraria* indicated that defoliation started during the month of November and continued till end of January. The new leaves started appearing in late February. 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. Panicle initiation was started in the first week of March in the randomly selected trees and continued till 2nd of April (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 raceme panicle, which was often axillary. Maximum well developed buds were observed on all the

**Table 1:** Morphological characters of trees used in phenology and reproductive biology.

| Tree No. | Total height (m) | gbh (cm) | Clear bole height (m) | Canopy height (m) | Approximate Age (yrs) | Crown spread (m) | |
|---|---|---|---|---|---|---|---|
| | | | | | | E-W | N-S |
| 1 | 8.6 | 115 | 3.0 | 5.4 | 20 | 10 | 9 |
| 2 | 9.2 | 108 | 3.8 | 5.2 | 20 | 6 | 5 |
| 3 | 6.8 | 88 | 1.8 | 5.0 | 16 | 5 | 7 |
| 4 | 5.7 | 63 | 1.3 | 4.2 | 16 | 2 | 5 |
| 5 | 7.7 | 92 | 2.4 | 5.2 | 15 | 7 | 9 |
| 6 | 8.2 | 99 | 1.8 | 6.3 | 20 | 8 | 6 |
| 7 | 10.0 | 109 | 4.0 | 5.8 | 21 | 8 | 10 |
| 8 | 8.4 | 96 | 2.8 | 5.4 | 20 | 6 | 7 |
| 9 | 9.6 | 106 | 3.9 | 5.6 | 21 | 9 | 7 |
| 10 | 7.8 | 94 | 2.6 | 5.1 | 15 | 6 | 8 |
| Range | 5.7- 10 | 63-115 | 1.3-4 | 4.2- 5.6 | 15- 21 | 2- 10 | 2- 10 |
| Mean | 8.2 | 97 | 2.7 | 5.3 | 18.4 | 6.7 | 7.3 |

selected trees from April 7 to April 23. The floral buds started to open from first week of April to third week of April. The flowering pattern was asynchronous *i.e.* new flowers were developing at different times on the same tree. The trees were in full bloom from second week of April to third week of May. Peak period of flowering varied from 13 to 24 days. Flowering gets completed by first week of June. Duration of flowering varied from 27 to 49 days. On all the marked trees, natural fruit setting was noticed during April end. There were minor variations for these observations among different plants during the same season. It appears that microclimatic changes and genetic makeup of plants caused such variations. Earlier, Dhillon *et al. (2003) in Prosopis cineraria,* Dhillon *et al.* (2004) in *Azadirachta indica,* Dhillon *et al.,* (2009) in Karanj (*Pongamia pinnta*) and Puttaswamy *et al.* (2012) in *Jatropha curcas* conducted similar studies on this aspect. The results of present study and earlier reports suggested to complete the task of reproductive biology before initiation of tree breeding programme in a particular tree species.

The period of pod development and maturity ranged from 28 to 46 days (Table 2). The pod maturity was observed from May 23 to June 4. Duration of panicle initiation to pod maturity varied from 56 to 93 days on the randomly selected trees.

The observations regarding the time of flower opening were recorded from 0600-1500 h at one hour interval. The data are summarized in Table 3. Flower opening started between 0600-0630 h and maximum flowering, ranging from 84.38 to 93.82 per cent was recorded between 0800-0900 h. Maximum buds opened up to 1100 h, however anthesis continued till noon hours. Such observations have also been reported by Chauhan and Singh (2001) in *Terminalia arjuna* and Jose and Pandurangan (2012) in *Ochreinauclea missionis.*

The data of observations on pollen morphology and stainability are presented in Table 4. Pollens were round in shape. It was observed from the data that pollen viability in 0.1 per cent acetocarmine ranged from 86.21 to 94.00 per cent.

The shiny stigma was considered receptive. It was found that the stigma receptivity occurred between 0800 to 1100 h. It was further confirmed through the visits of honey bees (*Apis cerana indica* and *A. dorsata*), wasps (*Polister spp.*) and lady bird beetle (*Coccinella septempunctata*) during 0800 to 1100 h. The best way to find out the nature of pollination in a species is to examine fruit/ seed setting under self pollination vis-a-vis natural open pollination. In present study of *Prosopis cineraria*, the average fruit set under self pollination was nil whereas it was 2.03 per cent in open natural pollination. No fruit setting in self pollination suggested self incompatibility in *Prosopis cineraria* (Table 5). In *Tectona grandis* the extent of self incompatibility varied from 96-100 percent (Bryndum and Hedgeart, 1969). The results of present study suggested the cross pollinating nature in *Prosopis cineraria*.

**Table 2:** Phenological data on flowering and fruiting in Prosopis cineraria during 2015.

| Tree No. | Date of panicle initiation | Commencement of flowering | Peak period of flowering | Cessation of flowering (days) | Duration of peak period | Duration of flowering (days) | Date of first pod formation | Date of first pod maturity | Duration of pod maturity | Duration of panicle to pod initiation maturity |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mar. 13 | Apr. 10 | Apr.23-May 16 | May-24 | 24 | 45 | Apr. 19 | Jun. 3 | 46 | 83 |
| 2 | Mar. 4 | Apr. 8 | Apr.17-May 10 | May-26 | 24 | 49 | Apr. 27 | Jun. 4 | 39 | 93 |
| 3 | Mar. 24 | Apr. 10 | Apr 19-May 4 | May-17 | 16 | 38 | Apr. 21 | May-27 | 37 | 65 |
| 4 | Mar. 18 | Apr. 11 | Apr.23-May 5 | May-16 | 13 | 36 | Apr. 23 | May-25 | 33 | 68 |
| 5 | Apr. 2 | Apr. 20 | Apr.29-May 13 | May-19 | 15 | 30 | Apr. 22 | May-27 | 36 | 56 |
| 6 | Mar. 20 | Apr.7 | Apr.18-May 1 | May-10 | 13 | 34 | Apr. 28 | May-28 | 31 | 59 |
| 7 | Mar. 29 | Apr. 18 | Apr.24-May 10 | May-24 | 16 | 37 | Apr. 25 | Jun. 1 | 38 | 64 |
| 8 | Mar. 10 | Apr. 17 | Apr.24-May 10 | Jun. 3 | 16 | 48 | Apr. 24 | Jun. 6 | 44 | 89 |
| 9 | Mar. 31 | Apr. 23 | Apr.29-May14 | May-19 | 15 | 27 | Apr. 30 | May-27 | 28 | 58 |
| 10 | Mar. 22 | Apr. 20 | Apr.25-May16 | May-27 | 21 | 38 | Apr. 18 | May-23 | 36 | 63 |
| Range | Mar.4 - Apr. 2 | Apr.18 - Apr. 23 | Apr.17-May16 | May10-June 3 | 13- 24 | 27- 49 | Apr.18-Apr. 30 | May23-Jun. 4 | 28-46 | 56-93 |

**Table 3:** Time of flower opening in *Prosopis cineraria.*

| Date of observation | No. of buds observed | Per cent flower opened | | | | | |
|---|---|---|---|---|---|---|---|
| | | 6-7 a.m. | 7-8 a.m. | 8-9 a.m. | 9-10 a.m. | 10-11 a.m. | 11-12 Noon |
| 20/4/2015 | 320 | 65.31 | 78.75 | 84.38 | 13.44 | 1.88 | - |
| 21/4/2015 | 306 | 73.86 | 83.00 | 91.38 | 10.13 | 1.96 | 0.98 |
| 22/4/2015 | 210 | 67.62 | 78.57 | 85.71 | 9.52 | 0.79 | - |
| 23/4/2015 | 252 | 71.83 | 85.32 | 93.82 | 9.92 | - | 0.40 |
| 24/4/2015 | 114 | 71.92 | 84.21 | 92.05 | 6.14 | - | - |
| 25/4/2015 | 142 | 71.83 | 80.99 | 86.06 | 4.23 | 0.70 | 0.70 |

(-) No flower opening.

**Table 4:** Pollen stainability in *Prosopis cineraria.*

| Date of observation | Total pollens (No.) | Stainable pollens (No.) | Non-stainable pollens (No.) | Pollen viability (%) |
|---|---|---|---|---|
| 08/05/2015 | 100 | 94 | 6 | 94 |
| 09/05/2015 | 87 | 75 | 12 | 86.21 |
| 10/05/2015 | 85 | 76 | 9 | 89.41 |
| 11/05/2015 | 162 | 150 | 12 | 92.59 |
| 12/05/2015 | 96 | 84 | 12 | 87.5 |
| Mean | | | | 89.94 |

**Table 5:** Fruit setting percentage under controlled (self) and open pollination in *Prosopis cineraria.*

| Tree No. | No. of floral buds | | No. of fruit setting under | | Fruit setting percentage | |
|---|---|---|---|---|---|---|
| | Open pollination | Self pollination | Open pollination | Self pollination | Open pollination | Self pollination |
| 1 | 2726 | 3720 | 40 | Nil | 1.47 | Nil |
| 2 | 575 | 469 | 12 | Nil | 2.09 | Nil |
| 3 | 1022 | 737 | 22 | Nil | 2.15 | Nil |
| 4 | 1284 | 953 | 28 | Nil | 2.18 | Nil |
| 5 | 1162 | 878 | 23 | Nil | 1.98 | Nil |
| 6 | 1152 | 977 | 21 | Nil | 1.82 | Nil |
| 7 | 1049 | 949 | 24 | Nil | 2.29 | Nil |
| 8 | 2340 | 2150 | 48 | Nil | 2.05 | Nil |
| 9 | 1059 | 971 | 23 | Nil | 2.17 | Nil |
| 10 | 2124 | 1768 | 45 | Nil | 2.12 | Nil |
| Mean | | | | | 2.03 | |

## CONCLUSION

This study confirms previous studies that *Prosopis cineraria* is a cross pollinated species. In present study of *Prosopis cineraria*, the average fruit set under self pollination was nil whereas it was 2.03 per cent in open natural pollination.

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