



## Shifting phenologies: a case of *Cassia fistula* L. from Northern India

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Plant phenology represents one of the most sensitive biotic responses to climate variability and change. The phenological observations help in identifying how plant species respond to regional climate fluctuations as well as to the climatic changes (Chmielewski and Rötzer 2001). Shifts in the timing of annually recurrent biological events, including flowering, leafing and fruiting, are highly spatially and temporally specific (Fitchett and Fani 2018).

*Cassia fistula* L. a native to the Indian subcontinent and adjacent regions of Southeast Asia is commonly known as golden shower or Indian laburnum. It is a member of the subfamily, Caesalpinioideae of the legume family, Fabaceae. *Cassia fistula* is grown on road sides and avenues as an ornamental tree fully covered with pendulous inflorescence and it has several medicinal uses (Kumar *et al.* 2017). Duraipandiyani *et al.* (2012) and Al Ssadh *et al.* (2018) have demonstrated anti-cancer properties of flowers of *Cassia fistula*.

Phenological events in *Cassia fistula* L. growing at Agra, Uttar Pradesh, India were recorded on 25 marked trees growing at R. B. S. College, Agra (26° 44' N to 77° 26' E and an elevation of 171 m from sea level). Dates of leaf fall and leaf renewal, commencement of flowering, optimum and end of flowering, fruiting were recorded during 2009-2019. The data on average annual temperature in India and Agra during this period were collected from the India Meteorological Department, Ministry of Earth Sciences, Govt. of India, New Delhi (Anonymous 2019).

*Cassia fistula* is a medium sized, 15±5 m tall tree (Fig. 1a) of the subfamily, Caesalpinioideae of family Fabaceae. The leaves are 37±25 cm long and pinnate with 5±3 pairs of leaflets, each leaflet is 14±7 cm long and 6.5±2.5 cm broad (Fig. 1c). The flowers are arranged in pendulous 30±10 cm long racemes (Figs. 1b,c). Each flower is 5.5±1.5 in diameter with five yellow petals of equal size and shape (Fig. 1d). Young fruits are green (Fig. 1e) and turn dark brown on maturity (Fig. 1f) and they remain attached to tree till the trees bloom next year (Fig. 1b). Fruit is a legume, 45±15 cm long and 4±0.5 cm broad with pungent odour and contained large number of brown seeds in several compartments made by septa (Fig. 1g). The tree is pollinated by several species of bees and butterflies. The carpenter bees (*Xylocopa* sp.) are most frequent pollinator (Murali 1993). Seeds disperse with the

help of squirrels, which feed upon the fruits and disperse seeds by breaking the hard fruit wall.

During 2009-2014, leaf fall started in the second and third week of February. The trees became completely leafless in the beginning of March. The new flush of leaves appeared soon after the flowering came to an end in the month of May. Flowering started in the first week of March and the trees were in full bloom in the second week of March and remained so till the beginning of May. Flowering declined and in last week of June flowering was over. Fruiting commenced in last week of May and mature fruits remained attached to the trees till the flowering commenced in the next season (Fig. 1b). The timings of phenological events are more or less invariant between 2009 and 2014. However, after 2015, there is a shift in the timings of various phenoevents became evident. The leaf fall started in the first week of March and the trees were leafless by the end of March. Flowering was delayed and commenced in the first week of April and continued till the end July. During 2019 flowering was recorded in the second week of July (Fig. 1b), and fruiting commenced in May and mature fruits were attached to the trees till they were in full bloom.

The shifting of various phenol-events is associated with the change in the average annual temperature during this period. The meteorological data released by the Ministry of Statistics, New Delhi, shows that the average annual temperatures increased gradually during 2008-2018 (Anonymous 2019). During 2008-2014, the average annual temperature ranged between 23.23° and 25.13°C (Fig. 2). However, during 2015-2019, the annual temperature increased gradually and ranged between 24.6°C-26.2°C with an increase by 1.6°C (Fig. 2).

Similar shift of various phenological events in *Cassia fistula* trees growing in other cities of North India has also been recorded. In Jaipur (stretches across 26.9°N 75.8°E with an elevation of 431 m in Rajasthan), for last 15-20 years flowering in this tree was recorded in the first week of March. However, in 2019 flowering is delayed and floral buds emerged only in third week of April (Kumar, Personal Communication). At Pathakot (stretches across 32.266814°N 75.6°E with an elevation of 332 m in Punjab) during 2018-2020, flowering commenced in the first week of April which continued till the end of June (Vinayak, Personal



Fig. 1: *Cassia fistula* trees at Agra. a: Tree in full bloom in April, 2019, b: Tree in bloom in July, 2019 c: Flowering Tree with mature fruits in May, 2019, d: Inflorescence, e: Young fruit, f: Mature fruit, g: Dehisced fruit.

communication). Jain (Unpublished data) observed at Gwalior (stretches across 26.221521°N 78.178024°E with an elevation of 211 m in Madhya Pradesh) that the phenological events, flowering in particular shifted from the months of May-July to May-August. This was associated with the rise in temperature.

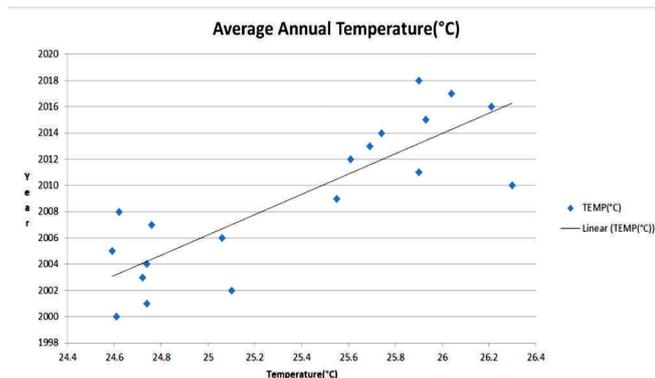


Fig. 2. Average annual temperature (°C) during 2018-2019 at Agra.

In the light of the observations recorded on phenophase and those of others presented in support, it is concluded that the shift in the timing of various phenoevents is the trees of *Cassia fistula* at Agra (India) are influenced by the change in the rise in temperature.

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