

# Assess the Leaf Phenological Characters of Main Tree Species in Urban Forests of Smart City Srinagar

## Abstract

Study was carried out to determine the phenological characteristics of prominent tree species in the urban forests of Srinagar city in India from 2023 to 2024 at three sites viz, Shalimar Bagh, Botanical Garden and Iqbal Park. Phenophases of five deciduous species namely *Platanus orientalis*, *Salix babylonica*, *Salix alba*, *Juglans regia* and *Ginkgo biloba* were recorded in all the seasons at all the three sites following the Observational and Herbarium approaches. All the phenophases, including bud burst, leafing, flowering, fruiting and defoliation were observed to occur earlier in 2024 than 2023. Leafing phenology of species was concentrated from the first week of March to the first week of April, whereas defoliation phenology was concentrated from the final week of September to the first week of December. Maximum variation was seen in vegetative bud initiation which was approximately one-two months earlier for all the species, followed by the leafing phenology, flowering phenology and defoliation phenology of *Platanus orientalis* which was 16 days, 10-20 days and 8 days earlier respectively. Minimum variation was seen in the leafing, flowering and defoliation phenology of *Juglans regia* which was 3 days, 4 days and on time respectively. The earliest bud break was observed in *Salix alba* from the first week of March at all the three sites and this species recorded the longest growing period from the first week of March to first week of December whereas *Ginkgo biloba* being the last one to start its bud break.

**Keywords:** Phenology, Changes, Defoliation, Urban, Tree species, Urban forests, Srinagar city

## 1.

## INTRODUCTION

Events in phenology occur at varying times. According to Miller and Primack (2008), spring time plant activities including bud burst and flowering are happening substantially earlier. These changes reflect changes on

the weather and more of these studies have demonstrated how rising temperatures affect the timing or length of phenological occurrences. However, the ways in which various ecological situations are responded to by different species vary and variations have been studied, for instance in terms of functional features and environment-specific responses (Inouye, 2008). Plants adapt their phenological traits to the seasonality of their surroundings. Such plant activity, which is so closely synchronized with local temperature changes and timing, offers one of the strongest indications yet that species and ecosystems are being impacted by global climate change. Globally, it has been seen that spring time plant flowering is occurring earlier than usual. The earlier spring greening up of the land surface shown in satellite photographs has also encouraged this. Recent changes in the timing of bud bursting, flowering, fruiting, leaf-out, or senescence are indicative of a shift in tree phenology (Farooq and Meraj, 2016).

Major phenological events, such as the widely reported spring advancement and autumn postponement (Gill *et al.*, 2015; Jeong *et al.*, 2011; Menzel *et al.*, 2006; Piao *et al.*, 2006); and phenological mismatches across trophic levels (Renner and Zohner, 2018; Tylianakis *et al.*, 2008) have all been significantly impacted by climate change. According to Suttle *et al.*, 2007 and Yang and Rudolf (2010), such severe phenology shifts caused by climate change can have a considerable impact on community structures and ecosystem services. The current rise in plant activity and carbon uptake is primarily due to warming-induced changes in phenology (Piao *et al.*, 2017). By altering the flow of water and energy between terrestrial ecosystems and the atmosphere, changes in plant phenology may also have an impact on climate (Penuelas *et al.*, 2009; Richardson *et al.*, 2013). In order to better understand and predict the interactions between ecosystems and the climate system, it is therefore imperative to have better knowledge of phenology changes, their primary drivers, and ecological implications (Piao *et al.*, 2019).

## **2. STUDY AREA**

The observation sites were located in the Srinagar city at an elevation of 1,585m. [S1: Shalimar Bagh (34.1495° N, 74.8729° E)]; [S2: Botanical Garden (34.083656° N, 74.797371° E)]; [S3: Iqbal Park (34.0646° N, 74.8054° E)]. The district has total area of 294 sq. kms. The outer boundary of the Srinagar city is roughly 109.43 kms along. It is the 31<sup>th</sup> most populous city in India, and second largest metropolitan area in the Himalayas. These areas show warm temperate climate. The annual average temperature is 2.5° C (winter) and 23.8° C (summer). The average annual rainfall is 650 mm.

### **2.1. MATERIALS AND METHODS**

The climate of the study location is defined by four distinct seasons: a chilly spring (March to May), a warm summer (June to August), a pleasant Autumn (September to November) and a severe winter (December to February). Maximum precipitation is received from December to April in the form of snow and rain. The plants at these sites are mostly deciduous broadleaves trees for which leafing finishes by April to May and the Autumn senescence starts in September. Phenophases of five deciduous species namely: *Platanus orientalis*, *Salix babylonica*, *Salix alba*, *Juglans regia* and *Ginkgo biloba* were recorded on weekly basis (reproductive phenophases) and at an interval of 10-15 days (vegetative phenophases during the year 2023 and 2024 respectively).

## **3. RESULTS AND DISCUSSION**

The data presented in **Table 1 & 2** summarizes vegetative and reproductive phenophases of all the selected species. Phenological data of selected tree species was recorded on weekly basis during the reproductive phase as these are one of the sensitive phases while as other phenophases were observed almost after every 10-15 days. These observations were recorded from three distant sites while as *Juglans regia* was recorded only from Site I. Bud initiation typically occurs in response to seasonal changes, particularly during the late winters to early spring period. bud initiation was first observed in species like *Ginkgo biloba* at Site II, followed by *Platanus orientalis*, *Salix babylonica* and *Salix alba* at Site III, and *Juglans regia* at Site I. Bud initiation was seen one month early in 2024 than 2023 for all the species as per metrological data, 2024 was much hotter than 2023. El Kayal *et al.*, 2011 found that after growth cessation, bud growth and induction of dormancy continues over several weeks, and these processes are primarily controlled by temperature and bud size is a function of the number of primordia contained therein. The timing and duration of leaf initiation significantly affect a plant's overall health and ecological fitness. leaf initiation was first observed in *Salix alba* and *Salix babylonica* in the first ten days of March, followed by *Platanus orientalis* in the second ten days of March. It was 4-5 days early as compared to year 2023. Leaf initiation was observed in the first ten days of April for *Juglans regia* at Site I, followed by *Ginkgo biloba* at Site II respectively. Around 60% of the tree species end their leafing in the second to third ten days of March. *Juglans regia* and *Ginkgo biloba* end their leafing processes by the second ten days in April, which is 20-30 days later than the other species. Fu *et al.*, 2019 found that while temperature is a primary driver for leaf-out, daylength also plays a crucial role in ensuring that temperate deciduous trees initiate leaf growth at optimal times, potentially mitigating some effects of temperature variations. Qaisar *et al.*, 2020 also found that the bud break of *Salix alba*, *Platanus orientalis* was observed from 20<sup>th</sup> February and 30<sup>th</sup> March under Shalimar conditions respectively. Flowering phenology marks as the starting point of plant reproductive growth and an important phase of general phenology and is the core attribute of plants that allows them to cope with environmental changes and progeny reproduction. Flowering was first observed for *Salix alba* followed by *Salix babylonica*, *Platanus orientalis*, *Ginkgo biloba* and *Juglans regia* and later on full bloom also followed the same trend as it was first observed in *Salix alba* at Site II and immediately followed by *Salix babylonica* at Site II in the second ten days of March, then by *Platanus orientalis* at Site III in the last ten days of March, *Ginkgo biloba* at Site II in the first ten days of April, and finally by *Juglans regia* at Site I in the first ten days of April respectively. In some species flowering starts prior to leafing and thus eventually blooms first. Qaiser *et al.*, 2020 found that the flowering of *Platanus orientalis*, *Salix alba* starts in the last ten days of March and second ten days of February respectively. Wagay *et al.*, 2024, while investigating the floral biology of *Platanus orientalis* found that the male inflorescences also known as catkins often emerge earlier than female inflorescence. Damialis *et al.*, 2011 observed that the male catkins of *P. orientalis* started to develop in the early spring, usually in late March or early April. According to Geissler *et al.*, 2023 plants flowered 2.26 days earlier per 1° C increase in spring onset average temperatures and 2.93 days earlier per 1° C increase in spring onset average temperatures. Fruit set, an important phenophase in plants life cycle where a fertilized flower begins to develop into a young fruit. As *Salix alba* and *Salix babylonica* fruits are very minute, so we were not able to identify them. Other than these species, *Juglans regia* was the first species to set its fruit in the last ten days of May at Site I, followed by *Ginkgo biloba* in the last ten days at Site II, and finally by *Platanus orientalis* in the second ten days of June at Site III respectively. Salama *et al.*, 2021 reported that climate change is generally a great challenge for temperate fruit tree production. Leaf senescence patterns highlight the intricate relationship between trees and their changing environment, providing insights into

how ongoing climate changes impacts the tree species. leaf senescence was first observed in *Juglans regia* at Site I from second ten days of September, followed by *Platanus orientalis* from second ten days of September, *Salix babylonica* and *Salix alba* from the last ten days of September at Site III and by *Ginkgo biloba* from the first ten days of October at Site II respectively. Leaf senescence was observed early in the year 2024 compared to 2023. This shift was due to climate warming and because of the early leafing in the spring 2024 compared to 2023. Ferguson *et al.*, 1990; Scheurwater *et al.*, 2000; Haba *et al.*, 2014 also found that the warmer conditions can result in earlier leaf senescence and flower fall. Leaf abscission, the natural detachment of leaves is typically in response to environmental changes and is crucial for the tree's survival and adaptation. leaf abscission was early in the 2024 compared to 2023. It was early by about 4-6 days for each species in the year 2024. This shift was due to warming temperature in 2024 which caused early leaf senescence and eventually early leaf fall for the species. Leaf fall was first observed for *Platanus orientalis* at Site III from the last ten days of September, followed by *Juglans regia* at Site I from the first ten days of October, then by *Salix babylonica* and *Salix alba* at Site III from the first ten days of October and finally by *Ginkgo biloba* at Site II from the first ten days of November. Around 60% of the tree species end their defoliation in the third ten days of November. However, different tree species varies greatly in defoliation end time. For example, to the second ten days in November *Platanus orientalis* have finished their defoliation and in the third ten days *Juglans regia*, *Salix babylonica* have finished their defoliation. The last defoliating species including *Salix alba* and *Ginkgo biloba* end their defoliation processes by the first ten days in December, which is 10-20 days later than the earliest ones. Leaf lifespan is one of the most important phenophase of a species. For early leafing species, it would be longer and consequently have advantage on carbon accumulation compared with later defoliation. The data from our study reveals that the leaf lifespan was maximum of 37 weeks for *Salix alba* at Site I, followed by 35 weeks for *Salix babylonica*, 33 weeks for *Platanus orientalis* at Site II, 32 weeks for *Ginkgo biloba* at Site II and finally of 31 weeks for *Juglans regia* at Site I respectively. This phenophase was almost of same order to that of year 2023 with 2024 having some 5-6 days more than 2023 for almost all observed species.

### **3.1. The relationship between beginning and Ending time of leaf emergence**

Leaf initiation is crucial for plant growth and development, as leaves play key role in photosynthesis, gas exchange, and transpiration. The data from (Fig. 1) reveals that leaf initiation was first observed in *Salix alba* and *Salix babylonica* in the first ten days of March, followed by *Platanus orientalis* in the second ten days of March. Leaf initiation was observed in the first ten days of April for *Juglans regia* at Site I, followed by *Ginkgo biloba* at Site II respectively. Around 60% of the tree species end their leafing in the second to third ten days of March. However, different tree species varies greatly in leafing end time. Fig.1 also reveals that earlier the beginning time of leaf emergence, earlier would be its ending time of leaf emergence and as the temperature increases leaf emergence increases until it becomes threshold temperature for a species. For example, to the second ten days in March *Salix babylonica* and *Salix alba* have finished their leafing and in the third ten days *Platanus orientalis* have finished their leafing while many tree species had not yet begun to leaf.

### **3.2. The relationship between beginning and Ending time of leaf abscission**

The leaf abscission data was monitored for the year 2023-2024 and it was observed that leaf abscission was early in the 2024 compared to 2023. It was early by about 4-6 days for each species in the year 2024. This

shift was due to warming temperature in 2024 which caused early leaf senescence and eventually early leaf fall for the species. Leaf fall was first observed for *Platanus orientalis* at Site III from the last ten days of September, followed by *Juglans regia* at Site I from the first ten days of October, then by *Salix babylonica* and *Salix alba* at Site III from the first ten days of October and finally by *Ginkgo biloba* at Site II from the first ten days of November.

Analysis of the defoliating phenology of prominent tree species in Srinagar's urban forest Fig. 2 shows that the species-specific timing differences in leaf abscission, emphasizing the effect of climatic conditions on phenological responses in the region. As the temperature decreases leaf defoliation process increases and earlier the beginning time of leaf defoliation, earlier the ending time of leaf defoliation. Around 60% of the tree species end their defoliation in the third ten days of November. However, different tree species varies greatly in defoliation end time. For example, to the second ten days in November *Platanus orientalis* have finished their defoliation and in the third ten days *Juglans regia*, *Salix babylonica* have finished their defoliation. The latest defoliating species including *Salix alba* and *Ginkgo biloba* end their defoliation processes by the first ten days in December, which is 10-20 days later than the earliest ones

### **3.3. The relationship between leaf lifespan and leaf phenology**

The prominent tree species in Srinagar's urban forest show an average leaf lifespan of 236 days. The leaf lifespan of all the observed 5 species exceeds 200 days (Table 1). *Salix alba* shows the longest leaf lifespan of 249 days, while as *Juglans regia* has the shortest leaf lifespan of 223 days. Analysis of the relationship between leaf lifespan and leaf phenology reveals that (Fig 3), leaf lifespan is negatively correlated with beginning time, ending time, duration and timing of leaf emergence, which suggests that earlier initiation of a phenophase results in a longer duration. This implies that trees initiating growth phases earlier benefit from prolonged activity, potentially due to favourable climatic conditions. Moreover, leaf lifespan is positively correlated with ending time of leaf abscission and timing of leaf abscission which indicated that the prolongation of leaf retention phases is critical for maximizing photosynthetic output.

S. no	Tree species	Budding		Leafing			Flowering			Fruiting	Leaf senescence	Leaf fall			Leaf life span
		V. bud	R. bud	B. T	E. T	D	B. T	E. T	D			B. T	E. T	D	
1	<i>Platanus orientalis</i>	9(I)	9(I)	3(II)	3(IV)	11-15 days	3(II)	3(III)	10-12 days	6(II)	9(II)	9(IV)	11(III)	55-60 Days	235 days
2	<i>Salix babylonica</i>	9(I)	9(I)	3(II)	3(III)	10-13 days	3(I)	3(III)	8-12 days	–	9(IV)	10(I)	11(IV)	52-58 days	243 days
3	<i>Salix alba</i>	9(I)	9(I)	3(I)	3(III)	10-15 days	3(I)	3(II)	8-12 days	–	9(IV)	10(I)	12(I)	50-60 days	249 days
4	<i>Juglans regia</i>	9(I)	9(I)	4(II)	4(III)	10-14 days	4(I)	4(III)	10-12 days	5(III)	9(II)	10(I)	11(IV)	50-58 Days	223 days
5	<i>Ginkgo biloba</i>	8(IV)	8(IV)	4(I)	4(III)	10-15 days	3(IV)	4(II)	10-12 days	5(IV)	10(I)	10(IV)	12(I)	32-37 days	226 days

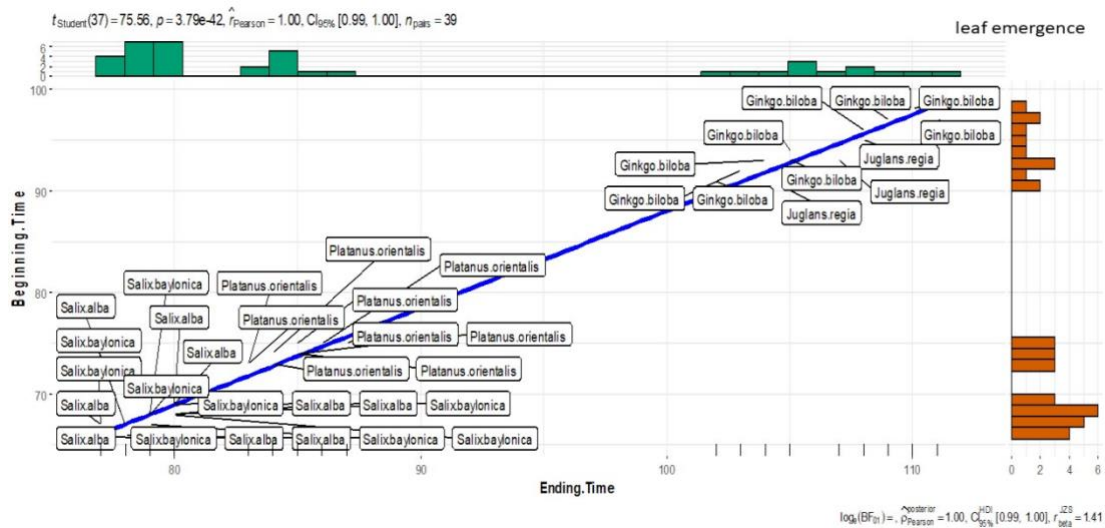
**Table 1: Phenophases of different species (2023- 2024)**

**V. bud-** Vegetative bud; **R. bud-** Reproductive bud; **B. T-** Beginning time; **E. T-** Ending time; **D-** Duration

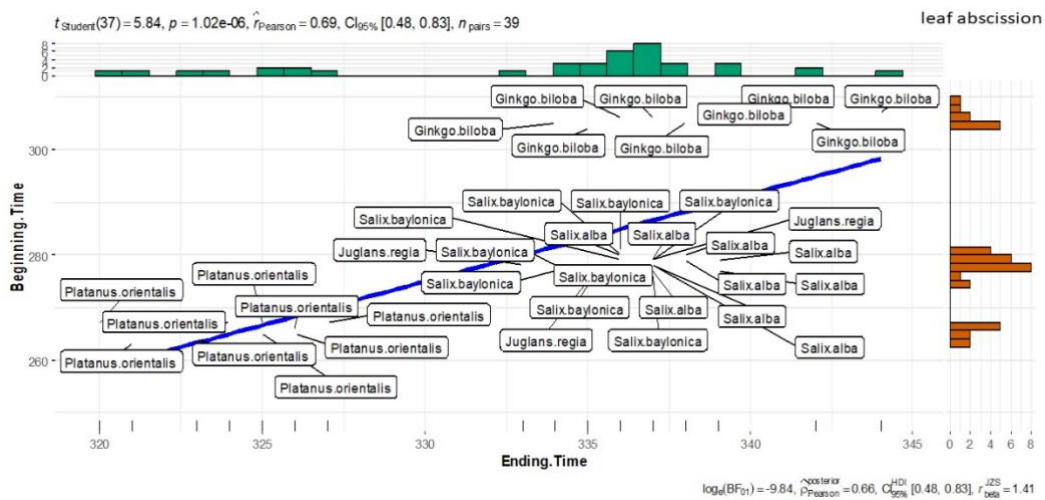
\*Arabic numbers represent months and roman numbers within parenthesis represent week.

**Table 2:** Leaf phenological characters of prominent tree species in urban forests of Srinagar (2023-24)

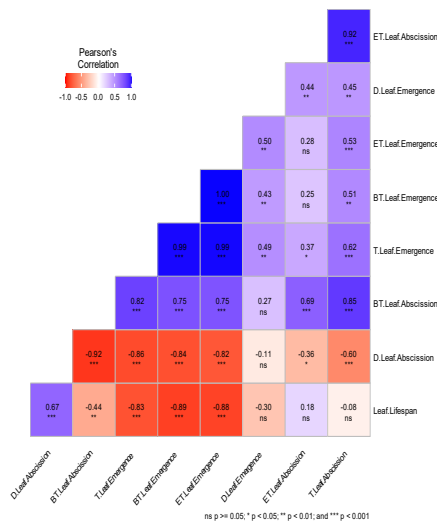
S.no	Species	Beginning time of leaf emergence	Ending time of leaf emergence	Duration of leaf emergence	Beginning time of leaf abscission	Ending time of leaf abscission	Duration of leaf abscission	Timing of leaf emergence	Timing of leaf abscission	Leaf lifespan
1	<i>Platanus orientalis</i>	74±0.86	84.66±1.32	10.66±0.70	265.66±1.50	324.11±2.36	58.44±2.40	77.11±1.26	312.22±2.94	235.11±2.75
2	<i>Salix babylonica</i>	67.55±1.22	78.77±1.20	11.22±0.66	278±2.121	335.66±1.11	57.66±2.12	74.11±0.92	320.88±2.08	246.77±2.16
3	<i>Salix alba</i>	67.33±1.22	78.66±1.32	11.33±0.70	278.55±1.13	337.55±1.01	59±1.65	74.44±1.13	324.66±1.58	250.22±1.92
4	<i>Juglans regia</i>	92.66±2.51	106.66±1.52	14±1.00	277.33±2.08	335±2.00	57.66±2.51	99.66±2.51	322.66±2.51	223±4.35
5	<i>Ginkgo biloba</i>	94.55±2.50	106.33±3.24	11.77±0.97	305.77±1.48	338.55±3.46	32.77±2.86	101.88±2.93	329.88±2.66	228±1.58



**Fig. 1: Beginning and Ending time of leaf emergence**



**Fig. 2: Beginning and Ending time of leaf abscission**



**Fig. 3: Correlation analysis of leaf phenological characters of prominent tree species in urban forests of Srinagar (Relationship between leaf lifespan and leaf phenology).**

**B-T= Beginning time; E-T= Ending time; T= Timing (at 50%); D= Duration**

## CONCLUSIONS

Each of the species under study viz *Platanus orientalis*, *Salix babylonica*, *Salix alba*, *Juglans regia*, and *Ginkgo biloba* exhibited unique phenological patterns, going through discrete stages of budburst, leaf unfolding, branching, and senescence. In the setting of an urban forest, these phenological data demonstrate the impact of environmental conditions and species-specific characteristics on leaf development and lifecycle stages. The blooming trend of species is in line with the leafing trend; when temperatures rise, flowering begins in species. The air temperature and leaf phenology are significantly correlated. As temperatures rise, *Juglans regia* and *Ginkgo biloba* bloom later, while *Salix alba* and *Salix babylonica* bloom first, followed by *Platanus orientalis*. When compared to species that defoliate later, early leafing species would have a longer lifespan and, as a result, have an advantage in terms of carbon accumulation.

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