



# Phenological Responses of *Crataegus songarica* K Koch. to Climate Variation in the Kashmir Himalayas: Insights from Two Consecutive Years

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**Abstract:** This study investigated the influence of temperature on the phenology of Hawthorn, *Crataegus songarica* K Koch. during 2021 and 2022. The phenological events consisting of bud set, bud bursting, leafing, flowering, fruit initiation, fruit fall, leaf tint and leaf fall, were observed during first year the bud set began in the third week of February, followed by bud bursting in the fourth week of March and in first week of April the leaves were fully open. Flowering started in the fourth week of April and continued until the fourth week of May, with the peak in second week of May. Fruit initiation was observed in the fourth week of July, while fruit fall started in the second week of September and lasted until the third week of October. Leaf tint was observed during the third week of September and leaf fall commenced in the fourth week of September, continuing until the first week of November. Investigations revealed that the entire phenophase cycle of *Crataegus songarica* lasted 9 months and 3 weeks. The observations indicated the early emergence of phenological events by 1 week in 2022 due to the higher temperature as compared to 2021. The entire phenophase cycle of *Crataegus songarica* in 2022 lasted 9 months and 3 weeks. By comparing these data of 2021 and 2022, can conclude the variations in the phenological patterns of *Crataegus songarica* and better understand the impact of environmental factors on its life cycle.

**Keywords:** *Crataegus songarica*, Phenology, Temperature impact, Environmental factors, Climate change

The genus *Crataegus*, commonly known as hawthorn, comprises of a diverse array of species distributed throughout Asia, Europe and North America (Alirezalu et al., 2018). Among these species, *Crataegus songarica*, commonly, holds particular significance due to wide adoptability (Haq 2012, Rafeeq et al., 2023). It is a shrubby tree reaching heights of 4-5 meters with distinctive bark and foliage characteristics, occupies diverse habitats across Afghanistan, Iran, northern India, northern Pakistan and neighboring regions (Zaurov et al., 2012). In India, grow in temperate Himalayas of Kashmir and Himachal Pradesh, particularly in river valleys and ravine slopes at altitudes of 1800-3000 meters above sea level (Rafeeq et al., 2022). Phenology, the study of cyclic life events in plants and their correlation with seasonal and climatic variations, offers insights into the impacts of climate change (Chhetri et al., 2020). With global temperatures on the rise, understanding phenological shifts becomes imperative. Plant phenology, influenced by environmental factors, serves as a sensitive indicator of ecosystem responses to climate change (Kushwaha et al., 2011). The effects of temperature on the

timing of phenological events, which hold implications for species distribution and ecosystem dynamics need special attention (Marques et al., 2004). Given the significance of phenological research in relation with altering temperature, this study focuses on investigating the phenology of *Crataegus songarica* in the Kashmir Himalayas. The aim is to assess impact of temperature variations on key phenological events.

## MATERIAL AND METHODS

**Study area:** Phenological studies of *Crataegus songarica* were conducted at Malhar, Ganderbal of Sindh Forest Division, to document the phenological events of the species and generating baseline data for further research. The study site, located at an altitude of 1850 m with geographic coordinates 34.33° N and 74.46° E, provided an ideal environment for observing the growth phases of *Crataegus songarica*.

**Data collection:** It was carried out using a systematic sampling approach. A total of 5 trees were randomly selected within the study site, and from each tree, 4 branches were

chosen for observation. This sampling strategy ensured a representative sample of the population. Observations were conducted at weekly intervals, starting from February. This frequent sampling allowed for the accurate tracking of phenological events over time. Descriptive statistics and phenological indices were employed to interpret the data and identify any significant patterns or trends in the phenological cycle of *Crataegus songarica*. To capture the various stages of growth and development, a comprehensive set of parameters, including bud set, bud burst/break, leaf initiation/flush, flowering, fruit formation, fruit/seed fall, leaf tint, leaf fall and fruit fall was recorded

### RESULTS AND DISCUSSION

The bud set occurred in the third week of February, followed by bud bursting in the fourth week of March, 2021. By the first week of April, the leaves were fully open, and flowering commenced in the fourth week of April, lasting until the fourth week of May, with the peak occurring in the second week of May. Fruiting initiation was observed in the fourth week of July, while fruit fall started in the second week of September and lasted until the third week of October. Leaf tint appeared in the third week of September, and leaf fall began in the fourth week of September, continuing until the first week of November. The entire phenophase cycle of *Crataegus songarica* in 2021 lasted 9 months and 3 weeks. The observations from 2022 indicate that bud set began in the second week of February, followed by bud bursting in the third week of March. By the fourth week of March, the leaves were fully open, and flowering commenced in the third week of April, lasting until the third week of May, with the peak occurring in the first week of May. Fruiting initiation was observed in the third week of July, while fruit fall started in the

first week of September and lasted until the third week of October. Leaf tint appeared in the second week of September and leaf fall began in the third week of September, continuing until the fourth week of October. The entire phenophase cycle of *Crataegus songarica* in 2022 lasted 9 months and 3 weeks. By comparing these two years, understand the impact of temperature on variations in the phenological patterns of *Crataegus songarica* (Table 1, Fig. 2).

Temperature is a critical environmental variable that significantly influences tree phenology by regulating the timing of phenophases such as bud burst, leaf emergence, flowering, fruiting, leaf senescence, and leaf fall (Parmesan 2007). These phenological changes are closely linked to ecosystem functioning and the adaptation of species to their environments. Several studies have demonstrated that temperature variations can cause shifts in phenological events, leading to ecological and evolutionary implications (Parmesan 2007, Cleland et al., 2007). The findings corroborate these observations, as we documented an early emergence of phenological events in *Crataegus songarica* in 2022 compared to 2021. This shift is likely attributable to elevated temperatures during the phenologically active periods. Such early occurrences can have cascading effects on ecological interactions, such as pollination dynamics, seed dispersal and competition for resources among co-occurring species (Walther et al., 2002). The early emergence of phenophases in *Crataegus songarica* highlights the species sensitivity to temperature changes, which could have broader implications for its ecological fitness and distribution. Warmer temperatures may enhance or disrupt phenological synchrony with other organisms, such as pollinators or seed dispersers. Long-term monitoring and modeling are crucial to understanding how temperature-

**Table 1.** Phenophases of *Crataegus songarica* in Kashmir Himalayas

Phenological characteristic		Year 2021	Year 2022
Bud set		February (3 <sup>rd</sup> week)	February (2 <sup>nd</sup> week)
Bud burst/ break		March (4 <sup>th</sup> week)	March (3 <sup>rd</sup> week)
Leaf initiation/flush		April (1 <sup>st</sup> week)	March (4 <sup>th</sup> week)
Flowering	Initiation	April (4 <sup>th</sup> week)	April (3 <sup>rd</sup> week)
	Peak	May (2 <sup>nd</sup> week)	May (1 <sup>st</sup> week)
	Completion	May (4 <sup>th</sup> week)	May (3 <sup>rd</sup> week)
Fruit Formation/Seed set		July (4 <sup>th</sup> week)	July (3 <sup>rd</sup> week)
Fruit/seed fall	Initiation	September (2 <sup>nd</sup> week)	September (1 <sup>st</sup> week)
	Completion	October (3 <sup>rd</sup> week)	October (3 <sup>rd</sup> week)
Leaf tint		September (3 <sup>rd</sup> week)	September (2 <sup>nd</sup> week)
Leaf fall	Initiation	September (4 <sup>th</sup> week)	September (3 <sup>rd</sup> week)
	Completion	November (1 <sup>st</sup> week)	October (4 <sup>th</sup> week)

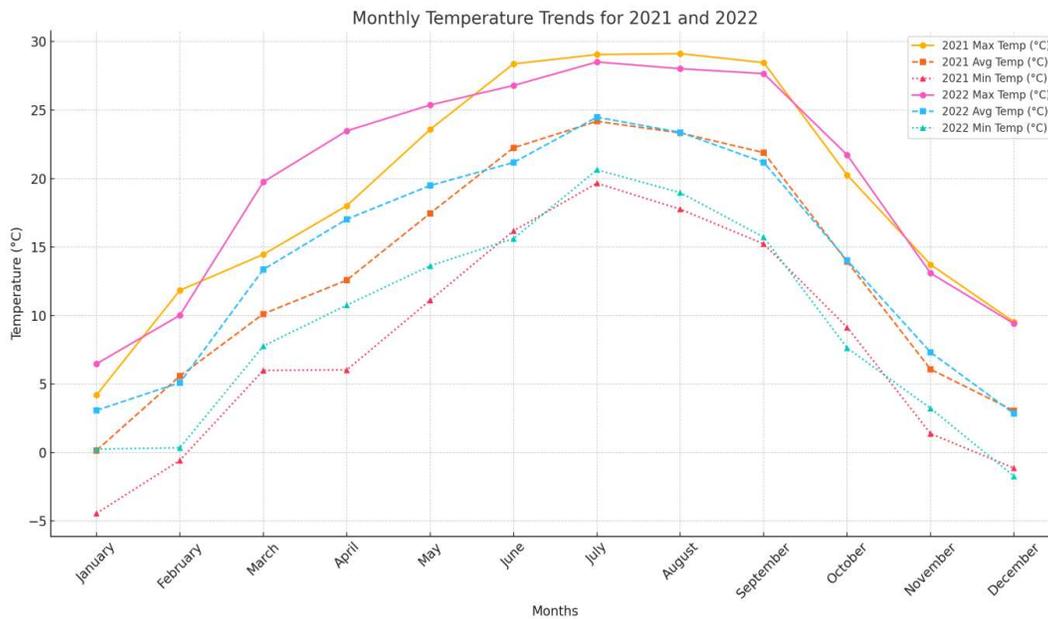


Fig. 1. Monthly average temperature of study area

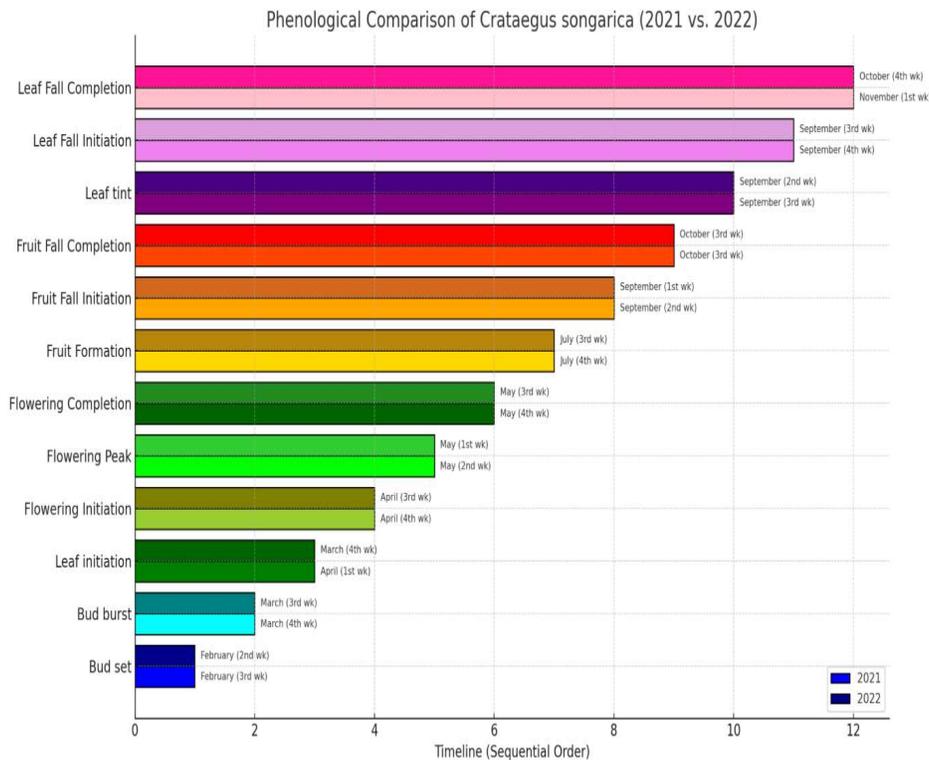


Fig. 2. Phenological comparison of *Crataegus songarica* 2021 vs. 2022

driven phenological shifts which may impact species survival, forest productivity, and ecosystem resilience (Cleland et al., 2007). Several researchers have also conducted studies on tree phenology with similar trend (Kumar et al., 2009, Mir et al., 2016, Singh and Negi 2018).

**CONCLUSION**

This study on phenology of Hawthorn across two consecutive years offers valuable insights into the influence of temperature on its life cycle. The observed phenological events, from bud set to leaf fall, revealed a consistent pattern



**Plate I.** Phenophases of *Crataegus songarica*

across both years, with early occurrence of events in 2022 by one week, attributed to higher temperatures. This advancement underscores the sensitivity of *Crataegus songarica* to environmental changes, particularly temperature variations..

#### **AUTHORS CONTRIBUTION**

JR, KNQ, PAK, JAM and AS conducted conceptualized the study and conducted Phenological data collection and analysis. IAP, TM, MIJ, OAY and SF contributed in ecological interpretation and manuscript development and refinement.

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