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# Phenological trend of tree species at Forest Research Institute Dehradun, India

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## Abstract

*The study was primarily focused on 11 tree species which were selected as sample trees. Other trees were kept under observation for general perception. The observations were based on phenological behavior such as leaf emergence, leaf expansion, senescence, budding, ripening, etc. The results were presented in the pictorial and tabular forms. Phenological events in plants were highly affected by the seasonal climatic stress. Thus, monitoring and recording this phenological process of plants helps to know about the changing patterns of the season. The outcome of this study is expected to be relevant in the future for the comparative studies. Further, reviewing these biological events of different trees speciescan provide valuable inputs for identifying the long-term phenology trends.*

**Keywords**: Phenophases**,** tree species, temperature, development.

## Introduction

Phenology has been defined as the study of recurring biological events in plants and their timing in response to various biotic as well as abiotic forces with the interrelation among phases of the same or different species[1-2]. The different phases of the plant's life cycle which changes with time are known as phenophases. The event of a phenophase is determined by the biotic appearances of the plant species, and by native climatic characteristics[3]. It includes leaf emergence, leaf expansion, senescence, flowering, fruiting, etc. which are directly affected by temperature, rainfall and day length.

These factors change throughout the year because of seasonal variation. Phenology has been suggested as a sensitive indicator of climate change[4]. Phenological changes of the plant are the most easily noticed plastic responses to climatic change[5-7].

Many scientists who are studying phenology suggests that the timing of life phasehappening is directly influenced by seasonal climate and it also affects an organism's ability to survive, reproduce, and compete. According to Zerboni *et al*., 1991**,** the flowering period in many species is influenced by climate variations[8]. Furthermore, the phenology might be less tender to temperature, photoperiod and more tuned to seasonal shifts in precipitation which is mostly reported in tropical ecosystems[9-10].In most cases, the study shows that phenology was affected by the increasing temperature[11-12].

However, previous studies have suggested that the general phenology pattern of different phenophases at community level is limited or scarce[13-15]. An environment perturbation has been related to variations in phenophases among individuals of the same species or different species[16]. Among individuals, phenophases vary from the same or different species which have been linked to environmental perturbations. Thus, phenological studies offer evidence of what is happening now and provide relationships between biological responses and weather conditions.

## Materials and methods

**Study Area:** The study area was carried on the roadside of Forest Research Institute (Campus area), Dehra Dun. It is located between 77°52'12"E, and 30°20'40" N at an altitude of 640.08 amsl[17]. It is spread over 450 hectares in the outer Himalayas in its backdrop, which is known as the oldest institute for forestry research in entire subcontinent. It provides the habitat to the flora and fauna. Rainfall, temperature Humidity and bright sunshine (hours) data were taken from the FRI Meteorology station.

It has humid subtropical to tropical climate with heavy precipitation during May to September and received annual rainfall approximately 1898 mm. During the study period temperatures ranges up to maximum 35.13°C in May and lowest minimum temperatures range up to 3.10°C in January (Figure-2). During the study year, the relative humidity fluctuated over the year. Relative humidity was higher in December and lowest in May during the morning readings time whereas, during the day, it was highest in July and lowest in March. The average bright sunshine (hours) was reached the peak at the months of May and lowest in August (Figure-3).

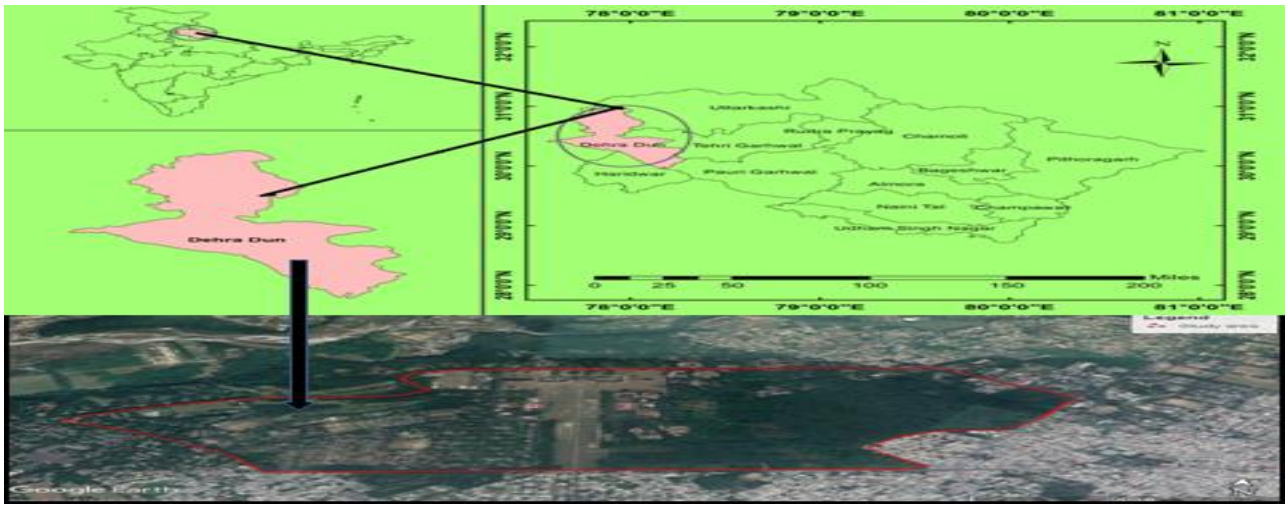


**Figure-1:** Study Area.

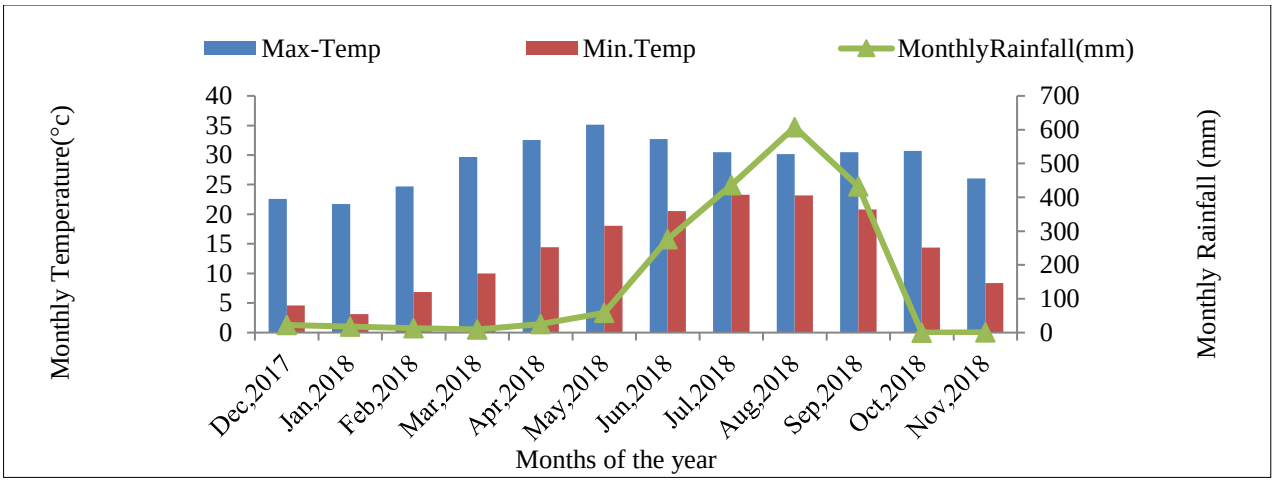


**Figure-2:** Monthly variations of temperature and rainfall during the study period.

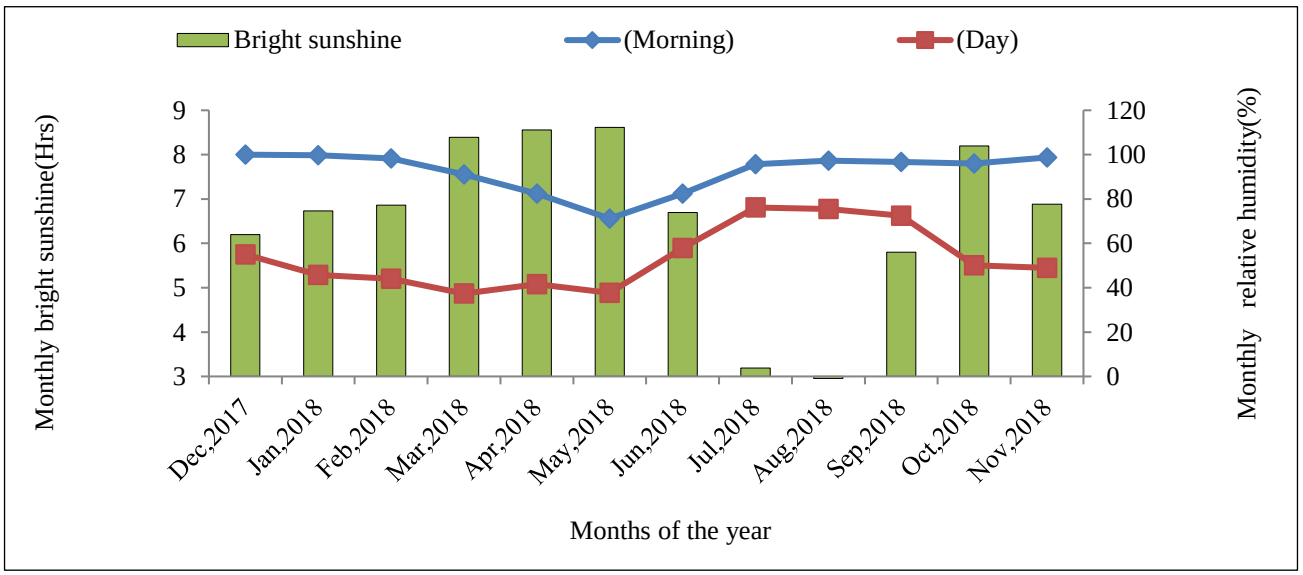


**Figure-3:** Monthly variations of relative humidity and sunshine.

**Phenology:** Phenological study was carried out along the road site inside the research institutes. Form the road site, eleven tree species were identified (Table-1) and selected for the study. Then, the phenological observation was done at 15 day's time's interval and weekly in the periods of high activity. Phenological records were kept made for different phenophases viz., leafing, leaf drop, flowering, fruiting, fruit ripening, etc. for tree species (Table-1) for a period of 12 months (December 2017 to November 2018). Other trees were kept under observation for general perception. Most of the phenophases observations were captures by mobile cameras (Samsung Galaxy J7 prime).

**Table-1:** Phenological study of tree species

| Species Name | Family | Common Names |
|---|---|---|
| *Pinusroxburghii sergeant* | Coniferae | Chir |
| *Shorearobusta* Gaertn. F. | Dipterocarpaceae | Sal |
| *Syzygiumcumini*(L.) Skeels. | Myrtaceae | Jamun |
| *Dalbergiasisso Roxb.exDc.* | Leguminosae | Shisham, Sissoo |
| *Acacia catechu Willd* | Leguminosae | Khair, cutch |
| *Litchi chinensis* | Sapindaceae | Litchi |
| *Mangiferaindica Linn.* | Anacardiaceae | Mango |
| *Jacaranda mimosaefolia D.Don* | Bignoniaceae | Mimosa-leaved Jacaranda |
| *Tectonagrandis Linn. F.* | Verbenaceae | Teak |
| *Brousonetiapapyrifera (L.)Vent.* | Moraceae | Paper-Mulberry |
| *Cassia Fistula Linn.* | Leguminosae | Amaltas |

## Results and discussion

The figure demonstrates the percentage of plant species exhibiting major events of phenophases (Figure-4). Leaf budding was noticed as first phenophases which was observed in February (36.36%), March (45.46%) and April (18.18%). In most of the tree species, phenophases activities were highly sensitive in the months (February to June). Study species shows that about 63.64% of leaf emergence and flower budding in the months of March, whereas flowering emergence showed the peak in the months of March (54.55%) and April (27.27%). Similarly, the fruiting period (Fruit emergence and fruit budding) was observed during the months of April to June. Detail Phenological events were tabulated from each sampled tree of every month as shown in Table-2.

The study was focused on understanding the phenological events in forests trees species (Figure-5). The diversity of phenophases patterns among 11 different plant species were recorded for one year (December 2017-November 2018) which included all the four seasons. The timing of leaf budding and leaf emergence was observed from February to April whereas the leaf senescence initiated after June. The peak period for flowering and leaf emergence was in March. After the flowering period, the fruit development was noted i.e. budding and fruit emergence in the months of April and May. Among all the studied species first fruit ripping took place in the month of May in *Litchi chinensis* and continued on June in *Shorearobusta*, *Mangniferaindica*, and *Syzygiumcumini*, whereas October that in *Acacia catechu and Dalbergiasisso.*

The pattern shows fruit ripening period varied from species to species. In the months of spring, the maximum activity of bud occurs in this period. The flowering which started in spring and extended to summer which coincided with the observation of Pilar and Gabriel and Kaur *et al.*[16,18]. When there was a maximum temperature, longer photoperiod (bright sunshine hours) was during the day of pre-monsoon (March, April and May) period might be probably responsible for reaching the maximum phenological responses (i.e. peak period of emergence and budding of leaf, flower and fruit observed in the species.

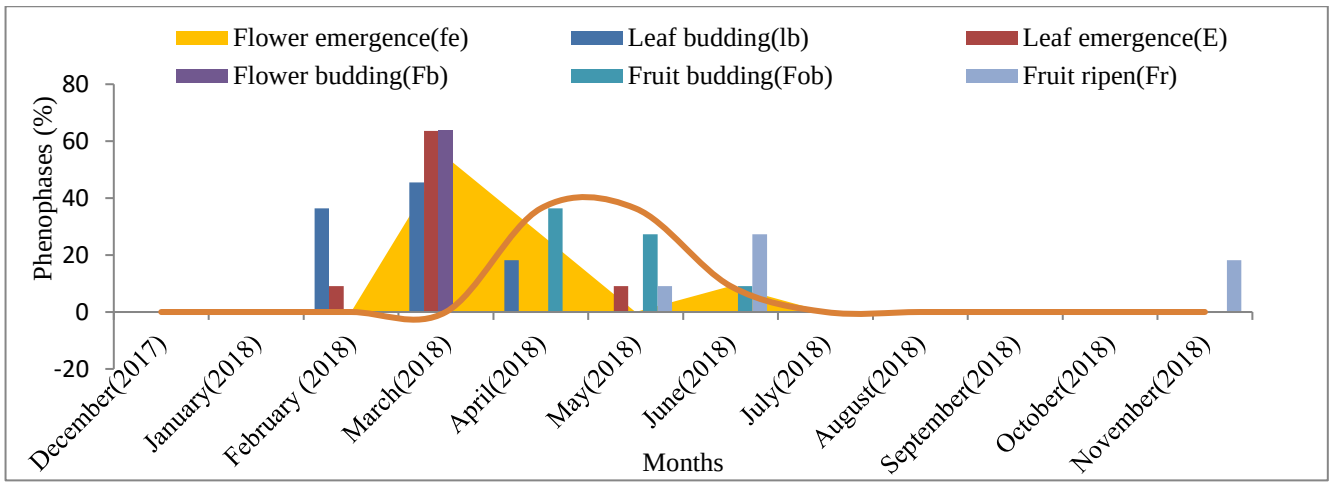


**Figure-4:** Monthly phenophases (%) of tree species.

**Table-2:** Phenological activities of the study species during each sampling date: Complete leaf fall (CL), last year leaf fall (LL), Leaf budding (Lb), leaf senescence (S), leaf emergence (E), flowering Budding (Fb), Flower emergence ( Fe), fruit budding (Fob), fruit emergence (Fo), Fruit mature (M), Last year fruit fallen (Fl), Fruit ripen (Fr), and Fruit fall down (D).

| Months | A. catechu | D. sisso | S. cumini | P. roxburghii | S. robusta | L. chinensis | T. grandis | M. indica | B. papyriFera | J. mimosaefolia | C. fistula |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. | | S | S | Fr | S | S | fr | S | S | S | |
| Jan. | S | S | S | S | S | S | - | S | S | Fr | |
| Feb. | S | Lb,E | Lb,S | S, Lb | S | S | S, D | Lb | S,LL | CL | Fl |
| March | Lb, E | FE, F, Fb | E, Fb, Fe | E, Fb, Fe | Lb, E ,Fb | Lb, E, Fb, Fe | S | E, Fb, Fe | Fb, Lb | Lb, Fl | CL |
| April | Fb, Fe | Fob, Fo,Fl | | Fob | Fe | Fob, Fo | S, Lb | Fob, Fo | Fe | Fb , Fob | Lb |
| May | Fob, Fo ,Fl | - | Fob,Fo | Fl | Fob | M, Fr | Fl, LL | | | Fe | E, Fb |
| June | M | M | M,Fr | S | M ,Fr | | E | M, Fr | Fe,M | | Fe, Fob, Fl |
| July | S | S | D | M | D | E | - | D | D | M | |
| August | S | S | S | S | - | S | Fe | S | S | | |
| Sept. | S | S | S | S | - | S | Fob | S | S | | |
| Oct. | S, Fr | Fr | S | S | - | S | | S | S | | |
| Nov. | S | S | S | S | S | S | S | S | S | S | M |

While similar conclusions that temperature is being responsible for the timing of development, timing of growth onset and senescence were observed earlier[10,19]. A similar study has been also carried out by Nanda *et al*. and Singh and Singh that temperature and light are responsible for the phenological responses[20,21]. According to Menzel *et al*. with rising temperature advancement in phenological events occurred resulting in an early flowering period in most of the species[22]. Monsoon season with the highest precipitation than other seasons witnessed the ripping of fruits in the majority of species which reduced with the onset of winter during the post-monsoon season.

Thus, the current investigation carried out in the phenological study might act baseline information for comparison carried out in recent times in the future supports the researchers. It helps the researchers to understand the change in phenological trends in the near and long-term as well with respect to change in global climate.

## Conclusion

This investigation on phenological observation on the tree species with meteorological variables helps in understanding the biological responses. The diversity of phenological pattern showing variation in timing phenophases on studied species is crucial to know the status and information about the development of trees during that year. Study shows the highest phenological responses with the peak period of emergence and budding such as leaf, flower and fruit during the pre-monsoon (March, April and May), when there were a maximum temperature and longer photoperiod. Leaf senescence rate was highest when there was low rainfall during post-monsoon and winter whereas the majority of plant species show maximum fruits ripening when the rainfall was highest (i.e. during the monsoon seasons).


M
Fob
Fe
E
LB
D
S
Pinus roxburghii
Fb
LE
Shorea robusta
M
LB
E
LE
Fb
E
Fob
Fe
Fb
LE
LE
LB
AF
Syzygium cumini
LB
Fb
Dalbergia sisso
Fr
Fob,Fo
M
Fr
S
Fe, Fob
Fo
M


Fb
LE
LB
LE
Fb
Fe
Fe
Acacia catechu
M
Litchi chinensis
Fr
FF
Fob
Fo
M
Fo
LE
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Jacaranda mimosaefolia
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FF
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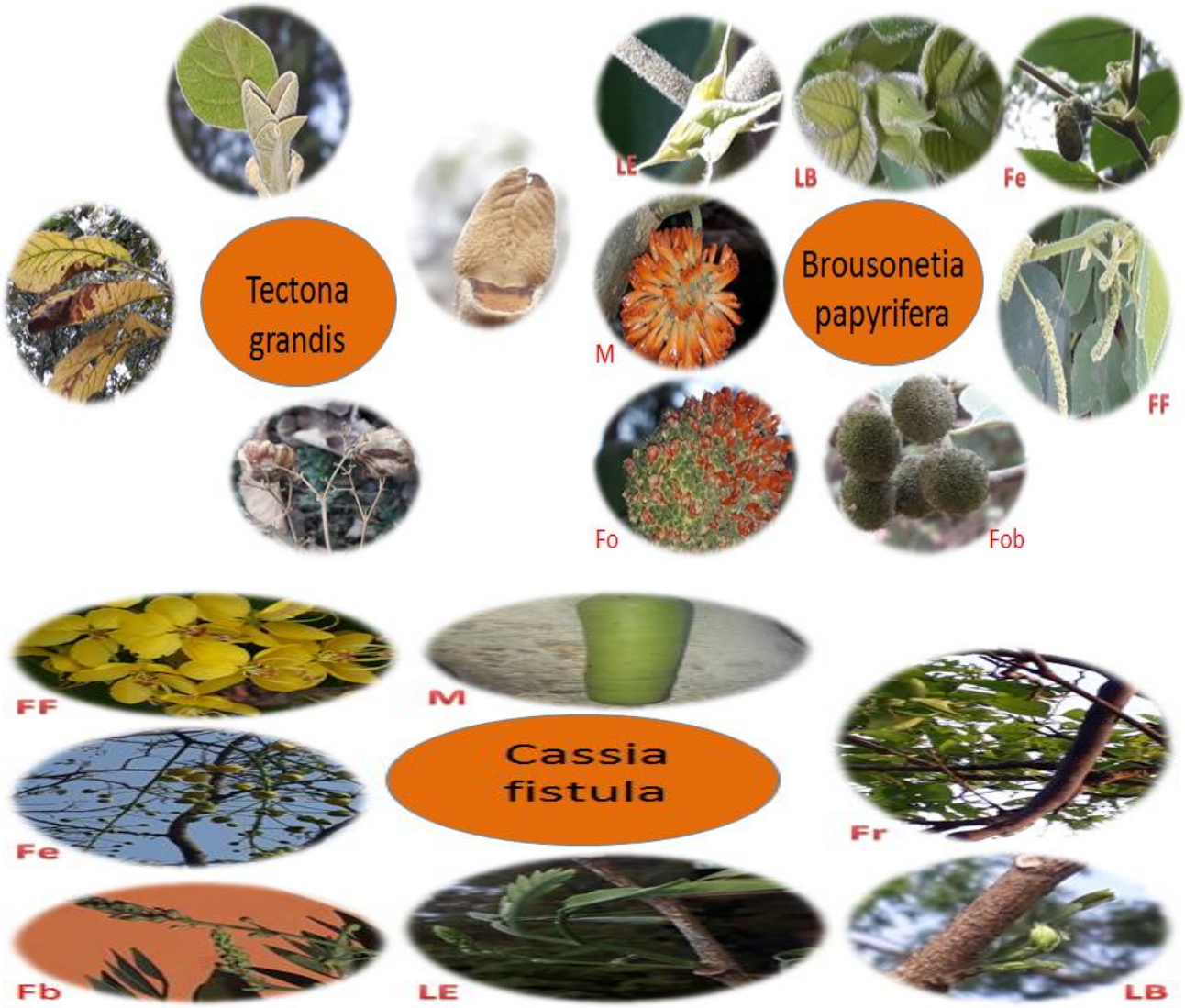


**Figure-5:** Phenological study of tree species (1-11) with different phenophases (see abbreviation on Table-2).

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