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A Review on Phenological Study of Selected Tree Species

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ABSTRACT
Phenology is major source of information about the beginning of growing season in different climate conditions. This reference article provides a brief introduction to the discipline, relevance and significance of phenology. The central part of the article reviews phenological observation methods and multiple disciplines, including ecology, evolutionary biology and remote sensing with long-term monitoring data. Phenological study is useful to understand periodicity of the life span of plants. Phenological observations were taken for plant tree species for their phenological events, viz. leaf initiation, leaf fall, flowering and fruiting. The variations in phenophases occurs due to environmental conditions, habitat and soil availability as well as the nutrient content of the soil, which was adapted to the habitats in according to abiotic and biotic factors.

Keywords:-*Phenology, plant species, discipline, leaf fall, flowering, fruiting.*

INTRODUCTION

The term phenology was first introduced by the Belgian botanist Charles Morrenin1853. "Phenology" is derived from the Greek word "phaino" means "to show" and "logos" means"to study". Thus, the word phenology linked with dates of first occurrence of each natural events in their annual cycle. Phenology is the study of timing of seasonal biological activities [14]. The phenological studies are essential to have knowledge about ecological adaptation, interactions of individual species and also from the point of view of conservation of genetic resources [33,35]. Plant phenological data are important for better understanding of the pattern about plant growth, relationship with environment and selective pressure on flowering and fruiting behaviors of a particular region [41]. Many deciduous tree species occurred flowering in the leafless period [28]. Temperature is primary factor affecting flowering and fruiting phenology of any species. However, there are many factors responsible for flowering and fruiting, viz. humidity, rain fall and day length [21]. Phenological observations have involved recording of key events such as first leaf opening, developing bud, first flowering, full Bloom and end of bloom by continued observations. Plant developmental phases are brought about by the current anthropogenic global climate change can effect on plant productivity, inter linkage with heterotrophe organism and competition between plant species[4]. The aim of the study is to compare the phenological patterns of tree species from different regions.

MATERIALS AND METHODS

Study Area

Studies appeared that geographical elements like altitude, latitude, longitude and according to its climate condition can influence phenology at various scales. Some observations were recorded by one or more observers at one locations and others as part of phenological observations of the same species from various locations (Echereme ,C.B. *et al.*,2018). Ground computations are made by visual observation and recorded of the various phases ofthe plant's life cycle [7].

Field Study

Phenological observations were made on selected Plant species of each were marked and Observations were checked once in every 15 days. Phenological study included various stages of plant phases as Leaf Initiation (LI), Blade Open (BO), Blade close (BC), Matured Leaves (ML), Yellow Leaves (YL) and No Leaves (NIL). Flowering stage also reported into Flower Bud (FB) and Matured Flower (MF). While Fruiting stage recorded into Matured Fruit (MFR) and Dry Fruit (DFR)[18].

Data Analysis

Phenophases of plant is shown in Figure 1: (1) Vegetative (2) Reproductive and (3) Post-reproductive.

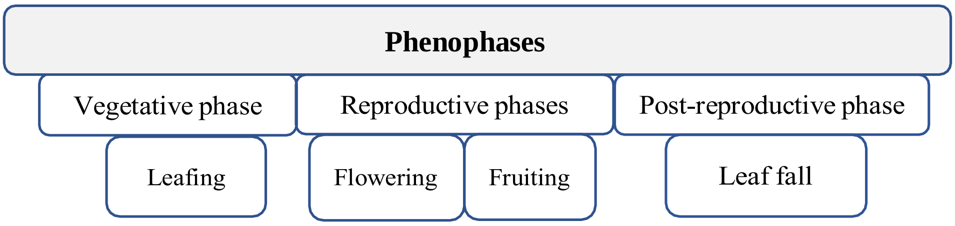

Fig.1:*-Plant phenophases*

Vegetative phase includes leafing stage and reproductive phases divides into flowering and fruiting. While post-reproductive phase includes Leaf-fall. Leaf initiation was indicated from the proposition of Leaf initiation (LI), Matured Leaves (ML) and Yellow Leaves (YL). Leaf fall is defined as 20 % (Starting of fallen leaves), 50% (Half tree become leafless), 80-100 % (No leaves (NL). Flowering stage was calculated from the parameters of Flower Bud (FB) and Mature Flower (MF). Fruiting stage was calculated from the proposition of Matured Fruit (MFR) and Dry Fruit (DFR). Variations in the time of leaf flushing, leaf fall, flowering and fruiting is shown in Table 1 below. Various phenophases were observed and recorded by initial date and last date. The census of leaf numbers was made for each individual tree at the beginning of the study [5].

Phenology involves major characters such as diameter of stem, branches per tree, leaves per Branch, flower per branch, inflorescence per branch and fruits per branch were observed at one month regular interval [22].

Photography

Photography was important in capturing traditional phenological event information, such as the first date of leaf sprouting, date of flowering and senescence [10]. In addition, the equipment is required for positive plant identification and important when germinating plant are being captured in the study area. The cameras can be set to take pictures downward from the tower, upward from the ground, horizontally or with fisheye views. International research networks such as ILTER can play an important role in standardizing phenology research protocols. Automatic repeat cameras are able to conveniently and continuously record phenology should be installed in networked sites for long-term monitoring of phenology. These cameras should be complemented by spectroradiometers to monitor to leaf- and canopy- scale to capture physiological variabilities. [34].

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The Measurement of phenology using remote sensing and camera spectro-radiometer is shown in Figure 2. The Photographs of Selected Tree Species for Phenological Study is shown in Figure [4-8].

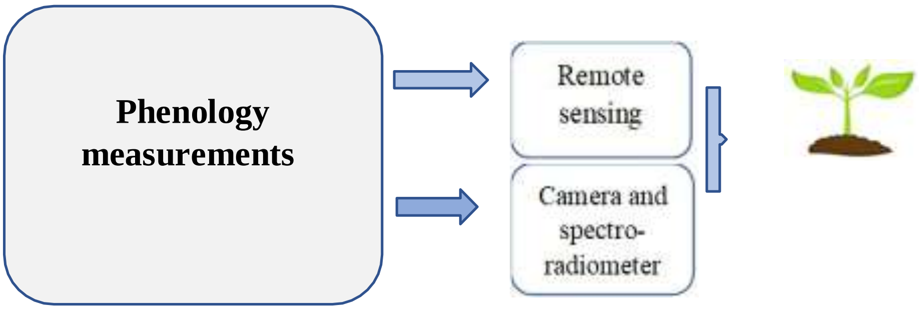

Fig.2:-*Measurement of phenology using remote sensing and camera spectro-radiometer.*

SEASONALITY AND PHENOLOGY

The seasonal changes in stem water changes in stem water status (sws) of tree, which forms link between seasonality and phenology. Sws rely on the balance between water absorption by roots and transpiration water loss from leaves, depending on tree characteristics and environmental components [28]. Leaf phenological functional types, characterized by specific combinations of phenological characters, seasonal changes in stem water status (sws), and structural properties affecting tree water relations have been recognized in dry tropical forest [2,3]. Interaction between environmental factors, e.g. Temperature [1],photoperiod [37], soil water storage, seasonal variations in rainfall [23] and organ functions (e.g, Absorption, water, sws) are responsible for a variety of phenological patterns in tropical trees [29].

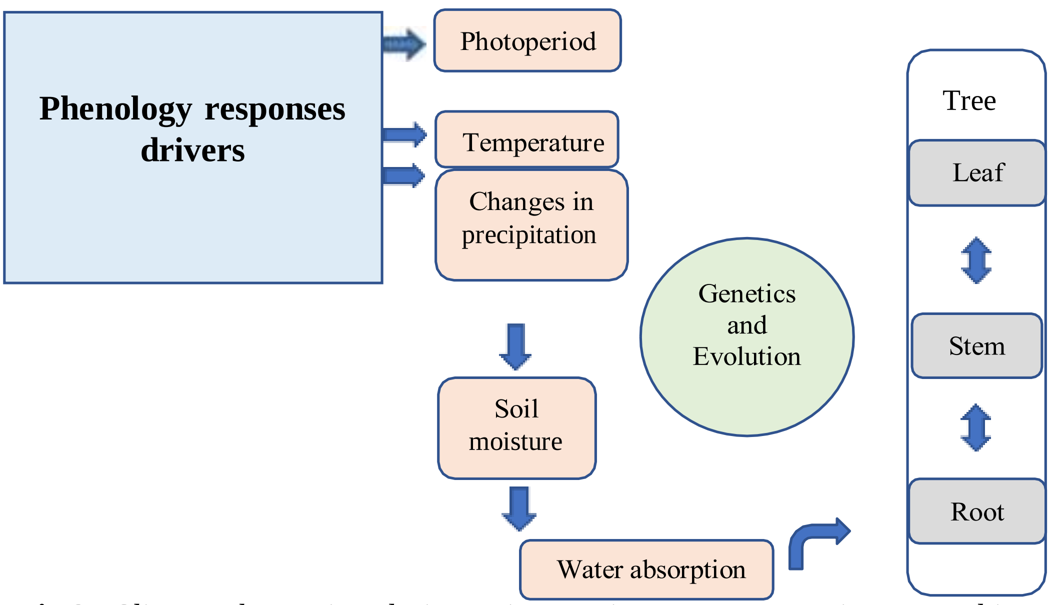

Fig.3:-*Climate change in relation to interactions amongst environmental inputs.* [2,28].

CLIMATE CHANGE IMPACTING PHENOLOGY [Figure 3]

Various species respond to climate change at different rates and to different degrees, the structure of communities and nature of species interaction must inevitably changes [12, 24, 27]. Temperature is a main driver of many developmental procedure in biology [4]. Climate change may also lead to modification in day - length for plants [36] or modifications in geographic distribution [38]. In many cases high-rise temperatures have been shown to speed up plantdevelopment [29] and lead to switch to the next stage. Phenology involves study of living organism's responses to seasonal and climatic changes of the environment over the last century, global temperature has increased by 0.7 ^{0}c as a result of rising carbon emission into the atmosphere [25]. Many studies have shown that the timing of life cycle events is able to provide a good indicator for climate change impacts [6,32].

***Table 1:**-Variations in the time of leaf flushing, leaf fall,flowering and fruiting*

Sr.No	Name OfSpecies	Leaf Flushing	Leaf fall	Flowering	Fruiting	Author
1	*Aegle marmelous* (L)correa	April	November	March	April	Rajendra Kumar& S.kalavathy (2013)[18]
2	*Azadirachta indica* A.Juss.	March, April	March April, May	March,April May	May, June, July	Singh & Kushwaha (2005)[28]
3	*Melia azedarach* L.	April,May	November	March, April, May	December, January, February	Singh & Kushwaha (2005)[29]
4	*Bauhinia purpurea* L.	-	-	October, November, December, September	January, February, March	Singh & Kushwaha (2005)[28]
5	*Millingtonia hortensis* L.*f*.	-	-	October, November	May, June	Singh & Kushwaha (2005)[29]

Photographs of Selected Tree Species for Phenological Study:

***Fig.4:**-Aegle marmelous (L)cor*rea in flowering and fruiting)

***Fig.5:**-Azadirachta indica A.Juss. in flowering*

Fig.6:-*Melia azedarach L. in flowering and fruiting*)

Fig.7:-*Bauhinia purpurea L.in flowering and fruiting*

Fig.8:-*Millingtonia hortensis L.f. in flowering)*

PLANT PHYSIOLOGICAL ATTRIBUTES

The physiological attributes and traits such as seed germination, seed viability, soil type, soil moisture and regeneration have direct effect on phenology [21].

Seed Studies

A seed, which is small in size and weight, possess an admirable programme for formationof a huge tree weighing various tonnes. In seed studies morphological characters such as colour, size, shape and structure shows in different species. The smaller and lighter seeds in drier areas [8]. In most of studied, comparision of germination and viability, viability was high as compared to germination [22]. A viable seed is a seed that can germinate under suitable conditions. There are four tests used in agriculture to find out seed viability comprising the cold test, the accelerated aging test (AA test), the conductivity test and tetrazolium test [17].

APPLICATIONS OF PHENOLOGY

Phenology study is use in easy to understand biodiversity, climate change agriculture andforestry of human health. It can also contribute to many environmental disciplines.

The Use of Phenology in Agriculture and Forestry

Phenology plays an important role due to plants and animals survive in their environment and food supply depends on the timing of phenological events. It provides valuable data for land-use designing, timing of agriculture work , forestry and domestic pest species, protection of species conservation interest [26]. Phenological data are essential for studies on breeding system, information on pollen release and its implications for humans. Knowledge of regeneration is crucial to understanding of the cause of rarity and conservation of rare plant taxa [11,16].

The Use of Phenology in Ecology

Phenology of individuals plays a major role in understanding how ecosystems are structured and how they function [9]. Because phenology is involved in nearly all ecological relationships, there is clearly potential for significant effects [13]. Phenology is a key driver in determining population dynamics, species interactions and distributions, animal movement and evolution of life histories [31,19].

The Use of Phenology in Tourism and Recreation

Tourists are interested in phenology-driven events such as spring wild flower displays, Autumn tree colour and bird watching. Many plants have specific phenoplasts (e.g, First leaf, flowering, leaf colouring, leaf falling etc.). The beauty of blooming flowers causes spring to be one of the most picturesque and pleasant seasons in which to travel.

CONCLUSION

Phenological study has been focused on the influence of various environmental factors viz, Temperature, photoperiod and moisture on phenological behaviour of plants. Phenology changes can be monitoring as how to plants response in climate change at different degrees. Phenological data helps to understanding interaction between living organisms, Strategies in agriculture and forest management, biodiversity/ecology and tourism.

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