

Studies on Phenological Characteristics of Different Forest Trees of South Gujarat

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ABSTRACT

Phenology has been defined as the study of the timing of recurring biological events, the causes of their timing with regard to abiotic and biotic forces and the interrelation among phases of the same or different event. The role of phenology in forest ecosystems has been discussed for several decades. Recently, understanding of tree phenology is quantitatively related to environment is even more important because of anticipated global environmental climate change. The present study describes the phenology such as leaf drop, leaf flush, vegetative growth, fruit formation and seed maturation of different tree species of South Gujarat. Random sampling of the site to assess the abundance of individuals was followed by tagging/ marking the individuals with five adult individuals (>20 cm girth over bark) was selected. Four major branches (one in each direction) were marked and observations were taken at fifteen days interval. Vegetative growth which started with leaf flushes in March to April was completed by May in 72.4 % of the species studied. For most species studied, leaf drop and simultaneous leafing occurred during warm-day period of the year. About 68.0% of species showed multiple leafing. In deciduous trees, flower (17.2 %) and fruit formation (3.4 %) occurred in March, a month earlier than evergreen trees. Fruit maturation between March and June was again ahead by one month in deciduous species. In all fifteen observations viz; leaf flush initiation, leaf flush completion, leaf fall initiation, leaf fall completion, leaf less condition, initiation of flowering, flowering (full bloom), completion of flowering, time lag between start of vegetative (first leaf flush) and reproductive (first visible flower), initiation of fruiting, time of fruit ripening, completion of fruiting, fruit fall initiation, completion of fruit fall and any pest and diseases incidence were recorded. The overall purpose of such study is to provide base line data for those working on tree improvement, silviculture and to initiate a progressive step to establish co-relation of climate change with phenograms.

Keywords: Phenophases, temperature, deciduous and evergreen.

INTRODUCTION

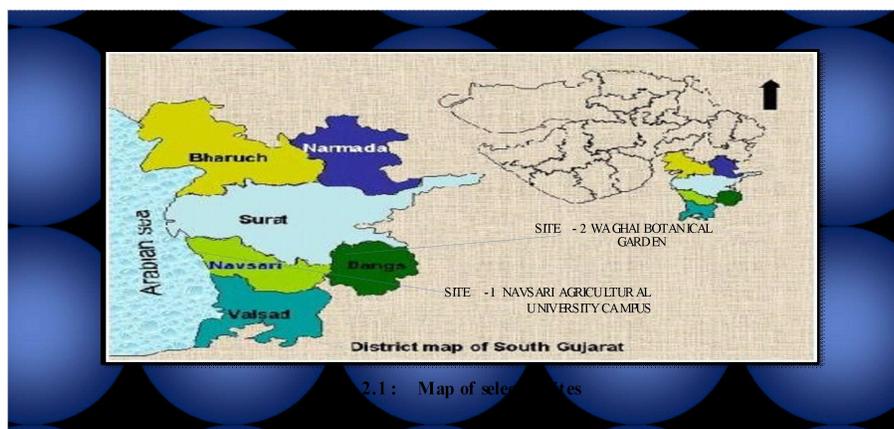
The term Phenology is derived from the Greek word "phaino", meaning to show or to appear, is the science concerned with periodic biological events in the animal and plant world as they are influenced by climate and weather. The main purpose of these studies was to compile annual "plant calendars" of leaf opening, flowering, fruiting and leaf fall together with climatological observations

"so as to show how areas differ". Phenology has been defined as the study of the timing of recurring biological events, the causes of their timing in context to changes in abiotic and biotic forces and the interrelationship among phases of the same or different events (Reichle, 1973; Leith, 1974). Vegetative and flowering phenology of trees in dry tropics is primarily affected by the periodicity of rainfall, soil water availability, duration and intensity of light, temperature and also topographical factors like elevation and altitude. Occurrence of leaf-flushing as well as flowering during summer in majority of Indian tropical trees, when drought is severe, seems to be a unique adaptation to survive under strong and adverse climate having a short growth promoting wet period and a long growth constraining dry period. The key phenological thematic areas that need research focus in the dry tropics are duration of deciduousness, timing of vegetative bud break, leaf strategy, water relations, seasonal flowering types and asynchrony. Analysis of functional types based on the duration of deciduousness and timing of bud break may enable better assessment of future climate change impact. There is a need for long-term quantitative documentation of tree Phenological patterns in India through a phenological station network in diverse climatic/vegetation/agro ecological zones.

Global climate change may force variations in timing, duration and synchronization of phenological events in tropical forests (Reich, 1995). Precise phenological information in relation to flowering and fruiting, evaluated against leafing and leafless periods, is scarce in tropical deciduous forests in India, which account for approx. 46% of the forested land in the country (Singh and Singh, 1988). So is the information on onset dates of different phenological events, duration of events and asynchrony in tropical forest trees. In these forests common tree species show a wide range of leafless periods due to differing timings of leaf fall within the annual cycle (Kushwaha and Singh, 2005). The hypothesis was tested that in tropical deciduous forest trees flowering periodicity has evolved as an adaptation to the annual leafless duration (affecting rate and period of vegetative growth) and the time required for fruit development.

MATERIALS AND METHODS

The experimental research carried out from December 2010 to November 2011. It was Simple Random Sampling design with two sites [S₁: Navsari Agricultural University Campus, Navsari (It situated at 20° 58' North latitude and 72° 54' East longitudes and at altitude of about 12 meters above the mean sea level); S₂: Waghai Botanical Garden, Waghai (It located at 20° 77' North latitude, 73°48' East longitude and about 170 meters altitude above the sea level)] in figure 2.1. The selected species such as *Tectona grandis* L. f., *Terminalia arjuna* (Roxb. ex DC.) Wight. & Arn, *Acacia auriculiformis* A. Cunn. Ex Benth. and *Azadirachta indica* A. Juss. Five adult individuals (>30 cm GBH and >6m height) of each of the species were marked. On each marked individual, four major branches (one in each direction) were selected, and on each branch four twigs (currently growing shoots of last-order branches) were marked with tags.



The year is divisible into three seasons: summer (February to May), monsoon (June to September) and winter (October to January).

Observations were made during the interval between two sampling dates (usually 30 days). In a selected tree species a particular Phenophases began before, or continued beyond, the date of the first/last record by a one-half sampling interval. For example, in this study the flowering period for each species was calculated from 15 days before the date on which the event was recorded for the first time in any individual to 15 days after the date on which the event was recorded the last time amongst individuals. Fruiting period of a species was the duration (days) from the first fruit formation to the last amongst its individuals. In the same way, the fruit-fall period of a species represented the time duration from the first fruit fall amongst individuals to the last. For each individual of a species flowering, fruiting and fruitfall durations were calculated from 15 days before the date on which the event was recorded for the first time to 15 days after the date on which the event was recorded for the last time.

RESULT AND DISCUSSION

1. *Tectona grandis*

A. Phenological behavior of *Tectona grandis* at Navsari Agricultural University Campus Longest phenophase observed was fruiting initiation to ripening/maturation lasting for 184 days, whereas the shortest phenophase was leaf less period, existed only for 31 days (Table-3.1). Leaf fall initiation started in the third week of December and extended up to second week of March. The maximum leaf fall occurred between month of January and February (third week of January to second week February). Leaf fall period continued for 89 days, and the peak leaf fall was observed for 31 days (Fig-3.1). Total leaf less condition occurred only for one month (March). Leaf flush initiation started in the first week of April and continued end of May.

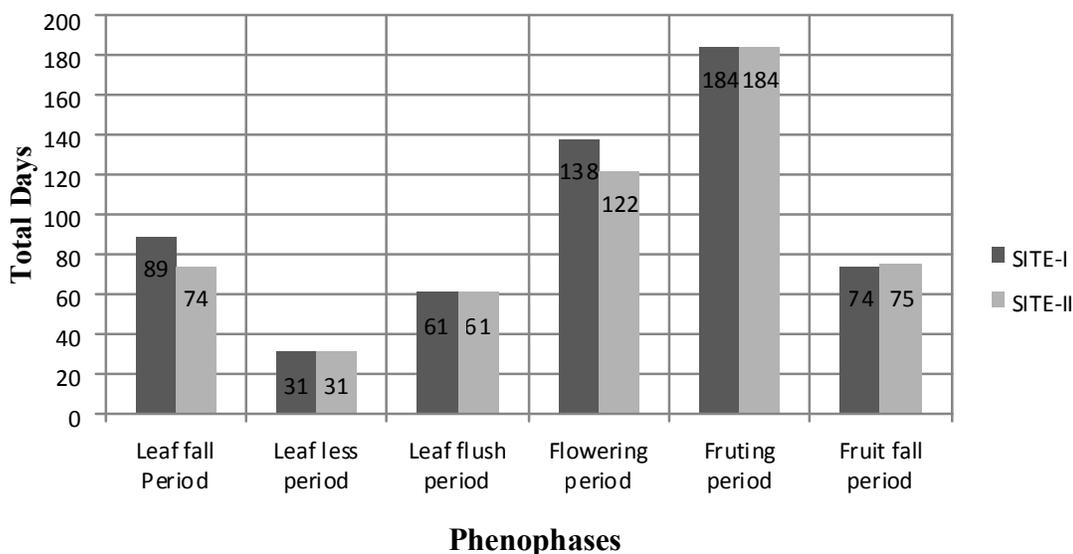
The peak in the leaf flush was set in the third week of April till second week of May (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 30 days on all tagged branches (Fig-3.1). Flowering was the second longest phenophase after fruiting, extending up to

138 days. Flowering initiation started from third week of May and ended in the last week of September. The full bloom commenced from first week of July till last week of August. *Tectona grandis* was in full bloom only for 62 days, out of total 138 days of flowering phenophase (Fig-3.1).

Table-3.1 Period of various Phenophases (in days) - *Tectona grandis*

Phenophase	Total Days	
	SITE-1	SITE-2
Leaf Fall period (Initiation to completion)	89 Days	74 Days
Leaf less period	31 Days	31 Days
Leaf-Flush period (Initiation to completion)	61 Days	61 Days
Flowering period (Initiation to completion)	138 Days	122 Days
Fruiting period (Initiation to Fruit ripening)	184 Days	184 Days
Fruit fall period (Initiation to completion)	74 Days	75 Days

Fig-3.1 Period of various phenophases (in days)- *Tectona grandis*



Fruiting observed for 184 days, from initiation to ripening of fruits occurred between first week of July and last week of December. Fruit ripening initiated from third week of October and continued last week of December. Out of 184 days of fruiting period, fruit initiation lasted for 107 days and ripening of fruit lasted for 77 days (Fig-3.1). Fruit fall period started from first week of January and completed in the second week of March. The peak in the fruit fall was set from first week of February to second week of March. Fruit fall period was observed for 74 days. (Table 3.1)

B. Phenological behavior of *Tectona grandis* at Waghai botanical garden

Longest phenophase observed was fruiting initiation to ripening/maturation lasting for 184 days, whereas the shortest phenophase was leaf less period, existed only for 31 days (Table-3.1). Leaf fall initiation started in the first week of January and extended upto second week of March. The maximum leaf fall occurred between month of February (1 Month). Leaf fall period continued for 74 days, and the peak leaf fall was observed for 28 days (Fig-3.1). Total leaf less condition occurred only for one month (Third week of March to second week of April). Leaf flush initiation started in the third week of April and continued second week of June. The peak in the leaf flush was observed throughout the month of May (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 31 days on all tagged branches (Fig-3.1). Flowering was the second longest phenophase after fruiting, extending upto 122 days. Flowering initiation started from first week of June with first shower of rain and ended in the last week of September. The full bloom commenced from first week of July till second week of September. *Tectona grandis* was in full bloom only for 77 days, out of total 122 days of flowering phenophase (Fig-3.1). Fruiting observed for 184 days, from initiation to ripening of fruits occurred between third week of July and first week of January. Fruit ripening initiated from first week of November and continued second week of January. Out of 184 days of fruiting period, fruit initiation lasted for 108 days and ripening of fruit lasted for 76 days (Fig-3.1). Fruit fall period started from third week of January and was completed in the last week of March. The peak in the fruit fall phenophase was set from first week of February to second week of March. There was no fruit fall observed immediately after ripening 15 days interval prevailed between fruit ripening and fruit fall. Fruit fall period was observed for 75 days (Table 3.1).

The patterns of leaf fall in both site studied is similar to the pattern observed in dry deciduous forest of Sagar (M.P) by Bhatnagar (1968), Joseph (1977) and Tripathi (1987). Alike present study, they have also observed two major period of leaf fall viz., winter leaf fall period and summer leaf fall period. Various workers investigated factors having impact on leaf fall has been related to water stress (Whitmore, 1975). Gupta and Rout (1992) suggested that the leaf fall in different species could be attributed to differing physiological response to water stress and leaf longevity as the leaves of *Lannea coromandelica* Merr. Fell by the middle of winter reason. According to Brasell *et al.* (1980) the seasonal pattern of litter fall is determined by leaf senescence and abscission, leaf longevity, period of water stress and intensity of rain.

2. *Terminalia arjuna*

A. Phenological behavior of *Terminalia arjuna* at Navsari Agricultural University

Longest phenophase observed was fruiting initiation to ripening/maturation

lasting for 245 days, whereas the shortest phenophase was leaf less period, existed only for 16 days (Table-3.2). Leaf fall initiation started in the third week of December and extended upto second week of March. The maximum leaf fall occurred between Month of third week of January and second week of March. Leaf fall period continued for 89 days, and the peak leaf fall was observed for 59 days (Fig-3.2). Total leaf less condition occurred only for 16 days (Last two week of March). Leaf flush initiation started in the first week of April and continued last week of May. The peak in the leaf flush was set in the third week of April till second week of May (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 30 days on all tagged branches (Fig-3.2). Leaf initiation peak in May, may be attributed to hot month of the year before rains. Leaf production towards the end of the dry season and before rains has also been observed in tree species by several workers (Frankie *et al.* 1974; Kikim and Yadava 2001; Shukla and Ramakrishnan 1982; Sundriyal 1990).

Flowering initiation started from third week of May and ended in the last week of July. The full bloom commenced from first week of June till second week of July. *Terminalia arjuna* was in full bloom only for 45 days, out of total 77 days of flowering phenophase (Fig-3.2). Fruiting observed for 245 days, from initiation to ripening of fruits occurred between first week of June and last week of January. Fruit ripening initiated from first week of November and continued last week of January. Out of 245 days of fruiting period, fruit initiation lasted for 153 days and ripening of fruit lasted for 92 days respectively (Fig-3.2). Fruit fall period initiated from first week of January and was completed in the last week of April. The peak in the fruit fall phenophase was recorded from first week of February to last week of March. Fruit fall period was observed for 120 days (Table 3.2).

Table-3.2 Period of various Phenophases (in days) - *Terminalia arjuna*

Phenophase	Total Days	
	SITE-1	SITE-2
Leaf Fall period (Initiation to Completion)	89 Days	74 Days
Leaf less period	16 Days	31 Days
Leaf-Flush period (Initiation to Completion)	61 Days	61 Days
Flowering period (Initiation to Completion)	77 Days	76 Days
Fruiting period (Initiation to Fruit ripening)	245 Days	230 Days
Fruit fall period (Initiation to Completion)	120 Days	90 Days

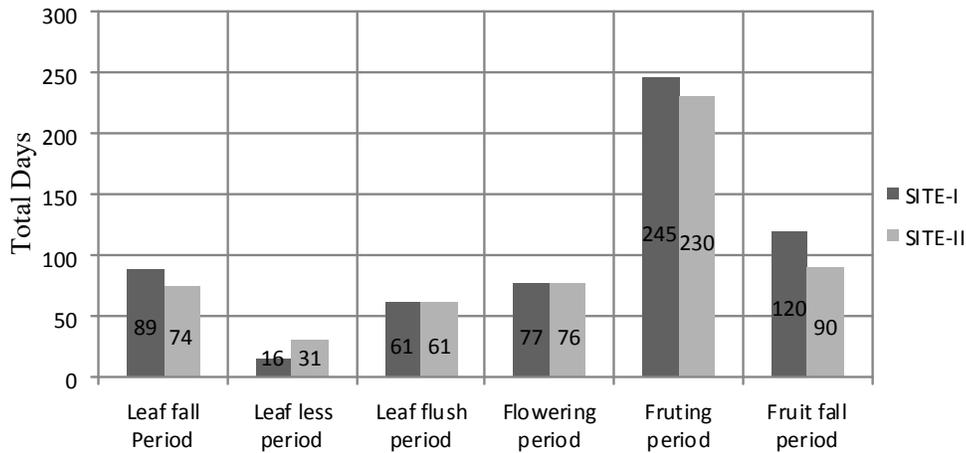
B. Phenological behavior of *Terminalia arjuna* at Waghai botanical garden

Longest phenophase observed was fruiting initiation to ripening/maturation

lasting for 230 days, whereas the shortest phenophase was leaf less period, existed only for 31 days (Table-3.2). Leaf fall initiation started in the first week of January and extended up to second week of March. The maximum leaf fall occurred between month of February and March (first week of February to second week of March). Leaf fall period continued for 74 days, and the peak leaf fall was observed for 43 days (Fig-3.2). Total leaf less condition occurred only for 31 days (Third week of March to second week of April). Leaf flush initiation started in the third week of April and continued second week of June. The peak in the leaf flush was observed throughout the month of May (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 31 days on all tagged branches (Fig-3.2). Flowering initiation started from first week of June and ended in the second week of August.

The full bloom commenced from third week of June till last week of July. *Terminalia arjuna* was in full bloom only for 46 days, out of total 76 days of flowering phenophase (Fig-3.2).

Fig-3.2 Period of various phenophases (in days)- *Terminalia arjuna*



Phenophases

Fruiting observed for 230 days, from initiation to ripening of fruits occurred between first week of July and second week of February. Fruit ripening initiated from first week of December and continued second week of February. Out of 230 days of fruiting period, fruit initiation lasted for 153 days and ripening of fruit lasted for 77 days (Fig-3.2). Fruit fall period started from third week of January and was completed in the second week of April. The peak in the fruit fall phenophase was set from third week of February to last week of March. Fruit fall period was observed for 90 days (Table 3.2).

III. *Acacia auriculiformis*

A. Phenological behavior of *Acacia auriculiformis* at Navsari Agricultural University Campus

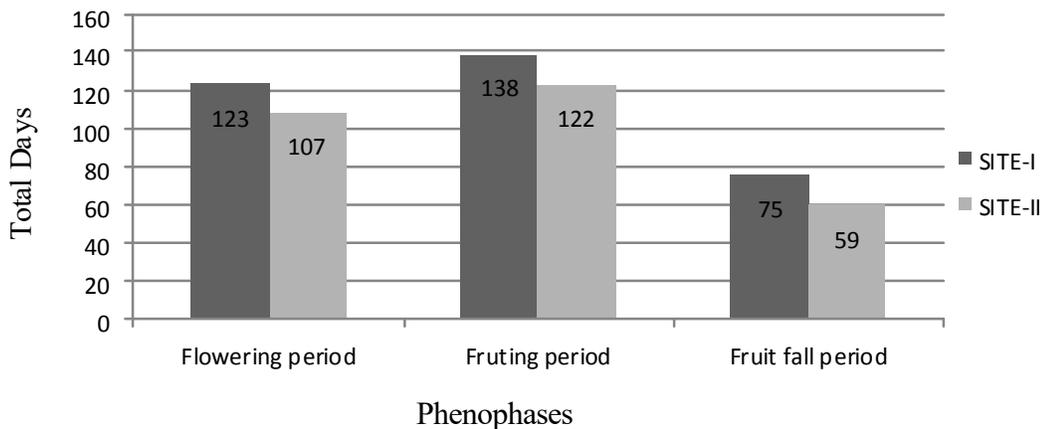
Longest phenophase observed was fruiting initiation to ripening/maturation

lasting for 138 days, whereas the shortest phenophase was fruit fall period, existed only for 75 days (Table-3.3). Flowering was the second longest phenophase after fruiting, extending upto 123 days. Flowering initiation started from third week of July and ended in the second week of November. The full bloom commenced from first week of September till second week of October. *Acacia auriculiformis* was in full bloom only for 45 days, out of total 123 days of flowering phenophase (Fig-3.3). Fruiting observed for 138 days, from initiation to ripening of fruits occurred between third week of August and last week of December. Fruit ripening initiated from third week of October and continued last week of December. Out of 138 days of fruiting period, fruit initiation lasted for 61 days and ripening of fruit lasted for 77 days (Fig-3.3).

Table-3.3 Period of various Phenophases (in days)-*Acacia auriculiformis*

Phenophase	Total Days	
	SITE-1	SITE-2
Flowering period (Initiation to Completion)	123 Days	107 Days
Fruiting period (Initiation to Fruit ripening)	138 Days	122 Days
Fruit fall period (Initiation to Completion)	75 Days	59 Days

Fig- 3.3 Period of various phenophases (in days)-*Acacia auriculiformis*



Fruit fall period started from third week of December and was completed in the last week of

February. The peak in the fruit fall phenophase was set from first week of January to second week of February. Fruit fall period was observed for 75 days. (Table 3.3)

B. Phenological behavior of *Acacia auriculiformis* at Waghai Botanical Garden Longest phenophase observed was fruiting initiation to ripening/maturation lasting for 122 days, whereas the shortest phenophase was fruit fall period, existed only for 59 days (Table-3.3). Flowering was the second longest phenophase after fruiting, extending upto 107 days. Flowering initiation started from first week of August and ended in the second week of November. The full bloom commenced from third week of September till last week of October. *Acacia auriculiformis* was in full bloom only for 45 days, out of total 107 days of flowering phenophase (Fig-3.3). Fruiting observed for 122 days, from initiation to ripening of fruits occurred between first week of September and last week of December. Fruit ripening initiated from first week of November and continued last week of December. Out of 122 days of fruiting period, fruit initiation lasted for 61 days and ripening of fruit lasted for 61 days (Fig-3.3). Fruit fall period started from first week of January and was completed in the last week of February. The peak in the fruit fall phenophase was set from third week of January to second week of February. Fruit fall period was observed for 59 days (Table 3.3).

4. *Azadirachta indica*

A. Phenological behavior of *Azadirachta indica* at Navsari Agricultural University Campus

Longest phenophase observed was leaf fall initiation to completion lasting for

90 days, whereas the shortest phenophase was leaf less period, existed only for 15 days (Table-3.4). Leaf fall initiation started in the first week of December and extended upto last week of February. The maximum leaf fall occurred between month of January and February (first week of January to second week of February). Leaf fall period continued for 90 days, and the peak in the leaf fall observed for 46 days (Fig-3.4). Total leaf less condition occurred only for 15 days (First two week of March). Leaf flush initiation started in the third week of March and continued second week of May. The peak in the leaf flush was observed throughout the month of April (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 30 days on all tagged branches (Fig-3.4). Flowering initiation started from first week of April and ended in the last week of May. The full bloom commenced from third week of April till second week of May. *Azadirachta indica* was in full bloom only for 30 days, out of total 61 days of flowering phenophase (Fig-3.4). Fruiting observed for 76 days, from initiation to ripening of fruits occurred between first week of May and second week of July. Ripening of fruit was initiated from first week of June and continued second week of July. Out of 76 days of fruiting period, fruit initiation lasted for 31 days and ripening of fruit lasted for 45 days (Fig-3.4). Fruit fall period started from first week of July and was completed in the second week of August. The peak in the fruit fall phenophase was set from third week of July to second week of August. Fruit fall period was observed for 46 days (Table 3.4).

B. Phenological behavior of *Azadirachta indica* at Waghai Botanical Garden

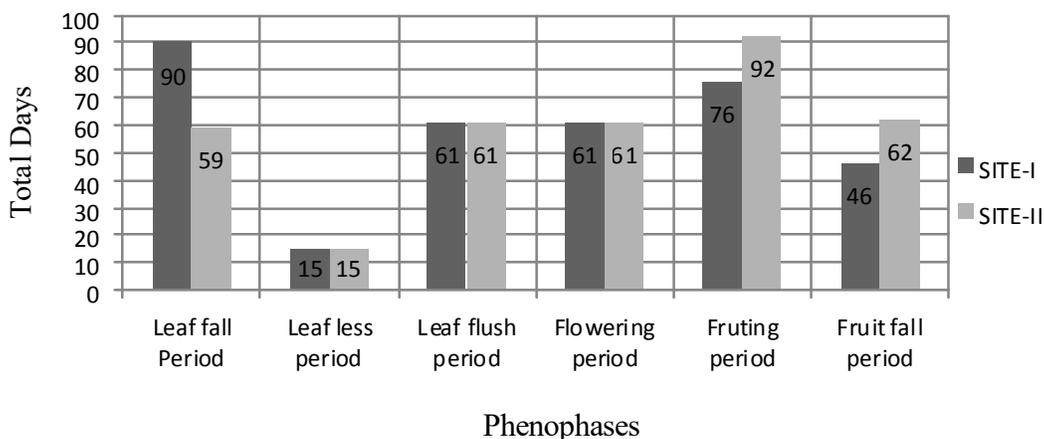
Longest phenophase observed was fruiting initiation to ripening/maturation

lasting for 92 days, whereas the shortest phenophase was leaf less period, existed only for 15 days (Table-3.4). Leaf fall initiation started in the first week of January and extended upto last week of February. The maximum leaf fall occurred in month of January to February (third week of January to second week of February). Leaf fall period continued for 59 days, and the peak leaf fall was observed for 31 days (Fig-3.4). Total leaf less condition occurred only for 15 days (First two week of March).

Table-3.4 Period of various Phenophases (in days) - *Azadirachta indica*

Phenop hase	Total Days	
	SITE-1	SITE-2
Leaf Fall period (Initiation to Completion)	90 Days	59 Days
Leaf less period	15 Days	15 Days
Leaf-Flush period (Initiation to Completion)	61 Days	61 Days
Flowering period (Initiation to Completion)	61 Days	61 Days
Fruiting period (Initiation to Fruit ripening)	76 Days	92 Days
Fruit fall period (Initiation to Completion)	46 Days	62 Days

Fig- 3.4 Period of various phenophases (in days)- *Azadirachta indica*



Leaf flush initiation started in the third week of March and continued second week of May. The peak in the leaf flush was observed throughout the month of April (1 Month). Out of 61 days of total leaf flush duration, peak leaf flush was observed for 30 days on all tagged branches (Fig-3.4). Flowering initiation started from first week of April and ended in the last week of May. The full bloom commenced from third week of April till second week of May. *Azadirachta indica* was in full bloom only for 30 days, out of total 61 days of flowering phenophase (Fig-3.4). Fruiting observed for 92 days, from initiation to ripening of fruits occurred between first week of May and last week of July. Fruit ripening initiated from third week of June and continued last week of July. Out of 92 days of fruiting period, fruit initiation lasted for 46 days and ripening of fruit lasted for 46 days (Fig-3.4). Fruit fall period started from first week of July and was completed in the last week of August. The peak in the fruit fall phenophase was set from third week of July to last week of August. Fruit fall period was observed for 62 days (Table 3.4).

CONCLUSION

The present investigation on Studies on Phenological Events of Some Agroforestry Tree Species was carried out to get an insight into the phenological behaviour of tree species under South Gujarat conditions (Heavy rainfall zone) in context to climatic data, synchronization and asynchronization among species and between the individuals. The wide diversity of seasonal flowering time and fruiting duration, with linkages to leafing and leafless durations, observed in selected tree species suggest a variety of reproductive and survival strategies evolved under a monsoonal bio climate in India. The drought stress is not only reflected in terms of the leafless period, but is also evident from greater seasonal separation between leafing and flowering. Flowering time and time lag between the onset of leafing and flowering affect the degree of separation of resource use for vegetative and reproductive events within tree species. In tropical deciduous tree species flowering periodicity has evolved as an adaptation to annual leafless duration (affecting rate and period of vegetative growth) and time required for fruit development. Predominance of summer flowering in association with summer leaf flushing seems to be a unique adaptation to survive under a seasonal climate. Since environmental characteristics affect flowering and fruiting either directly (e.g. through conditions in the habitat) or indirectly (e.g. through the leafless period), probable global climatic change will have serious implications on future reproductive success of dry-tropical trees.

This study was carried out with a hope that it will prove an important baseline data for tree improvement and management programmes. More research on this aspect will not only lead us to till up the lacunae in phenological patterns of species, but will also the inter-relationship between vegetative and reproductive Phenophases. The study will also enrich our knowledge of understanding forest dynamics and more precisely the natural associations of one species to another.

REFERENCES

Articles

*Brasell, H. M.; Unwin, G. L. and Stoker, G. C. (1980). The quality, temporal distribution and mineral element content of litter in two sites in tropical Australia. *J.Ecol.*, **68** : 101-157.

*Frankie, G. W.; Baker, H. G. and Opler, P. A. (1974). Comparative phenological studies of trees in tropical wet and dry forests in the low lands of Costa Rica. *Journal of Ecology*, **62**: 881-919.

Kikim, A. and Yadava, P. S. (2001). Phenology of tree species in subtropical forests of Manipur in North Eastern India. *Tropical Ecology*, **42**:269-276.

Kushwaha, C. P. and Singh, K. P. (2005) Diversity of leaf phenology in a tropical deciduous forest in India. *Journal of Tropical Ecology*, **21**: 47–56.

Leith, H. (1974). *Phenology and Seasonality Modeling*-Springer, NY. (New York. USA)

Reich, P. B. (1995). Phenology of tropical forests: patterns, causes, and consequences. *Canadian Journal of Botany*, **73**: 164–174.

Reichle, D. G. (1973). *Analysis of Temperate Forest Ecosystems*. Springer, NY.

Singh K. P, Singh J. S. (1988). Certain structural and functional aspects of dry tropical forest and savanna. *International Journal of Ecology and Environmental Sciences*, **14**: 31–45.

*Shukla, R. P. and Ramakrishnan, P. S. (1982). Phenology of trees in a sub-tropical humid forest in North - Eastern India. *Vegetatio*, **49**: 103 -109.

*Sundriyal, R. C. (1990). Phenology of some temperate woody species of the Garhwal Himalaya. *International Journal of Ecology and Environmental Sciences*, **6**: 107-117.

Tripathi, J. P. (1987). A Note on phenological observations on *Anogeissus Pendula* Edgew. *Indian forester*, **104**: 587-588.

Thesis

*Bhatnagar, S. (1968). Ecological studies of forests of Sagar with special reference to litter and ground flora. Ph.D. Thesis, Sagar University

*Joseph, R. N. (1977). An ecological study of organic layer of some forests of Sagar. Ph.D. Thesis, Sagar University, Sagar.

Books

*Whitmore, T. C. (1975). *Tropical rain forests of the Far East*. Oxford university press, London.

*Gupta, S. R. and Rout, S. K. (1992). Litter dynamics and nutrient turnover in a mixed deciduous forest. In: *tropical Ecosystem: Ecology and management*. Wiley eastern limited, New Delhi. pp. 443-459.

