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PHENOLOGY OF SOME SELECTED FLOWERING PLANTS OF DHAKA UNIVERSITY CAMPUS IN RELATION TO CLIMATIC VARIABLES

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Abstract

This study dealt with the phenological activities like leaf flushing, leaf maturation, leaf fall, flower bud formation, flower bud maturation, flower fall, fruit initiation, fruit color changing and fruit ripening for some plants of Curzon Hall Campus, University of Dhaka in 2019 and 2020. The seasonal cycle of plants however is influenced to the greatest extent by temperature, humidity and the concentration of CO_2. Forty individuals were studied from 20 species. These 20 species belong to twelve families. Among these 20 species, 5 species are evergreen and 15 species are deciduous, and 7 species are short trees and 13 species are trees. Variation in some individual plants were observed which belong to the same species and they are close to each other, e.g. in different individuals of *Couroupita guianensis* Aubl., *Mesua nagassarium* (Burm. f.) Kosterm. leafing, flowering, fruiting times were different. Some plants shed their leaves in frequent season. The temperature, humidity and concentration of CO_2 beside trees were also recorded. Temperature was highest in the month of July and lowest in the month of December. Humidity was also highest in the month of July but lowest in the month of February. The concentration of CO_2 was highest in the month of August and lowest in the month of January. The temperature, humidity and CO_2 concentration varied from 20.1 - 41.8°C, 37.0 - 88.0%, 435.0 - 713.0 ppm, respectively. From the study, it was found that temperature, humidity and concentration of CO_2 are important factors for phenological changes.

Introduction

Modern phenology is the study of the timing of recurring biological events in the plant world, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species are of great importance (Lieth 1974). Leaf unfolding, flowering, fruit ripening, color changing and leaf fall are some important phenomena of plants to record. Climate change refers to long term shifts in temperatures and weather patterns. Abiotic environmental conditions such as rain, change in temperature, presence or absence of pollinators, competitors and herbivores have been shown to play a significant role in timing of various phenological events (Thompson and Willson 1979, Stiles 1980).

Phenological studies are also important in understanding species interrelations and their interaction with the environment. Variations in phenophases among individuals of the same species or different species have been linked to environmental perturbations (Suresh and Sukumar 2011). Enhancement of plant growth and yield in elevated atmospheric CO_2 concentration is well documented (Kimball 1983, Idso and Idso 1994, Curtis and Wang 1998). Several studies have also shown that elevated CO_2 affects the growth rhythm of forest trees by altering the timing of bud burst and growth cessation (Cannell and Smith 1986, Murray *et. al.* 1994, Ceulemans *et al.* 1995). Although there have been many studies on the effects of elevated CO_2 on growth (Norby and O'Neill 1986, Bazzaz and Williams 1991, Miao *et al*. 1992, Murray *et. al.* 1996, Tissue *et al.* 1997) and phenology (Murray *et al.* 1994, Ceulemans *et al.* 1995) of tree species, there have been few investigations of the effects of CO_2 on crown structure (Chen *et al*. 1997, Rey and Jarvis 1997).

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The research work dealt with phenological observations of twenty plant species growing in different sites of Curzon Hall campus, University of Dhaka over two years from 2019 and 2020. The study aims to observe phenological activities of the selected plants and how plant phenology changes from one season to another season. The study also dealt with the relationship of plant phenology with the different climatic variables.

Material and Methods

Curzon Hall premises of University of Dhaka is located in the midst of Dhaka Metropolis. It lies between 23.727389˚ N north latitude and 90.401902˚ E east longitude (Fig. 1). Total area of Curzon Hall is about 9 acres with tropical deciduous and evergreen type of natural and planted vegetation. The climate of Curzon Hall is tropical with heavy rainfall and bright sunshine in the monsoon and warm for the greater part of the year. The winter months from November to March are however most likely cool and pleasant. Dhaka has a distinct monsoonal season with an annual average temperature of 25℃ and monthly means varying between 18℃ in January and 29℃ in August (Weatherbase: Historical Weather for Dhaka, Bangladesh). Figure 1 shows the location of Curzon Hall on the map of Dhaka. The whole area of Curzon Hall was surveyed and some tree species were selected for data collection. Forty individuals representing twenty plant species were selected and tagged (Table 1). Data was collected from July 2019 to March 2020. Data was recorded in every fifteen days at around 9 am to 12 noon to record presence or absence of different

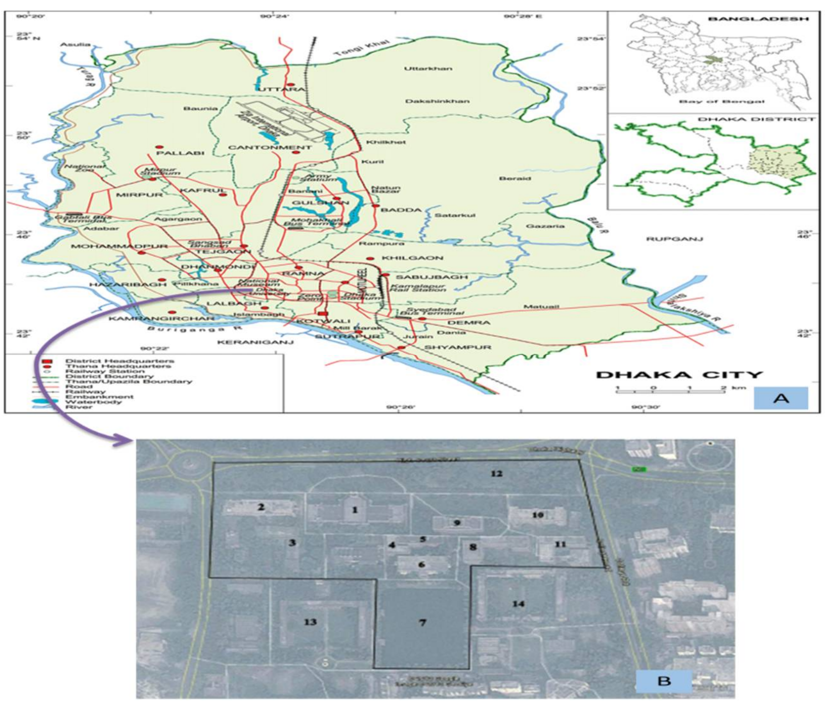


Fig. 1. Location and administrative map of Dhaka city (A). Map of Curzon Hall premises, numbers showing the major structures of the area, black line depicting the boundary of the study area. Here 1. Curzon Hall, Department of (2. Applied Physics, 3. Geology, 4. Fisheries, 5. Applied Chemistry, 6. Zoology), 7. Pond, Department of (8. Botany and the adjacent area for Conservation of Medicinal plants, 9. Chemistry, 10. Biochemistry and Molecular Biology, 11. Soil, Water and Environment), 12. Botanical Garden, 13. and 14. Dormitories of University of Dhaka (B) (Source: Google Earth).

phenological events or phenophases like leaf initiation (LI), leaf color (LC), leaf fall (LF), flower bud initiation (FBI) flower bud maturation (FBM), flower fall (FF), fruit initiation (FI), fruit color changing (FCC), fruit ripening (FR). Temperature and relative humidity were also recorded. For the record of the temperature and relative humidity, thermometer and hygrometer were used. Temperature was recorded inside the canopy of the tree.

Table 1. List of plant species, their family, habit and leaf habit.

Sl. No.	Species	Abbreviation	Family	Habit	Leaf habit
1	*Polyalthia longifolia* (Sonn.) Thw.	Plo	Annonaceae	T	E
2	*Mesua nagassarium* (Burm. f.) Kosterm.	Mna	Calophyllaceae	T	E
3	*Michelia champaca* L.	Mch	Magnoliaceae	T	E
4	*Plumeria obtusa* L.	Pob	Apocynaceae	ST	E
5	P. *acuminata* Ait.	Pac	Apocynaceae	ST	E
6	P. *filifolia* Griseb.	Pfi	Apocynaceae	ST	D
7	*Millettia ovalifolia* Kurz.	Mov	Fabaceae	T	D
8	*Cassia fistula* L.	Cfi	Fabaceae	ST	D
9	*Holarrhena antidysenterica* Wall. *ex* Decne.	Han	Apocynaceae	ST	D
10	*Swietenia mahagoni* Jacq.	Sma	Meliaceae	T	D
11	*Bauhinia purpurea* L.	Bpu	Fabaceae	ST	E
12	*Peltophorum pterocarpum* Roxb.	Ppt	Fabaceae	T	E
13	*Magnolia grandiflora* L.	Mgr	Magnoliaceae	ST	E
14	*Couroupita guianensis* Aubl.	Cgu	Lecythidaceae	T	D
15	*Gliricidia maculata* H. B. & K.	Gma	Fabaceae	T	D
16	*Butea monosperma* (Lamk.) Taub.	Bmo	Fabaceae	T	D
17	*Terminalia catappa* L.	Tca	Combretaceae	T	D
18	*Hydnocarpus kurzii* (King) Warb.	Hku	Achariaceae	T	D
19	*Sterculia foetida* L.	Sfe	Sterculiaceae	T	D
20	*Adansonia digitata* L.	Adi	Malvaceae	T	D

T, ST, E and D represent tree, short tree, evergreen and deciduous, respectively.

Furthermore, concentration of CO_2 was also recorded. For the recording of concentration of $CO_{2,}$ "Air CO_2ntrol 3000" meter was used. Photograph was also taken for all individual species and the changes were recorded in photography. Photograph was taken by the camera which model is "Nikon COOLPIX S9700."

Result and Discussion

The phenology of plant communities can be studied by dealing with particular life-history stages separately such as leafing, leaf fall, flowering, fruiting, seed dispersal and germination. The results of 20 plant species taken all together showing timing of different phenophases (LI, LM, LF, FBI, FBM, FF, FI, FCC, FR) are shown in Fig. 2. This figure reveals that leafing, flowering, fruiting showed almost a similar trend during the study period within each phenophase. Leaf formation showed a peak in the month of July when the temperature was maximum. Another peak of leaf initiation found in the month of August when the concentration of CO_2 was high (Table 2). In some plants leaf initiation also found in the months of October, November, February and

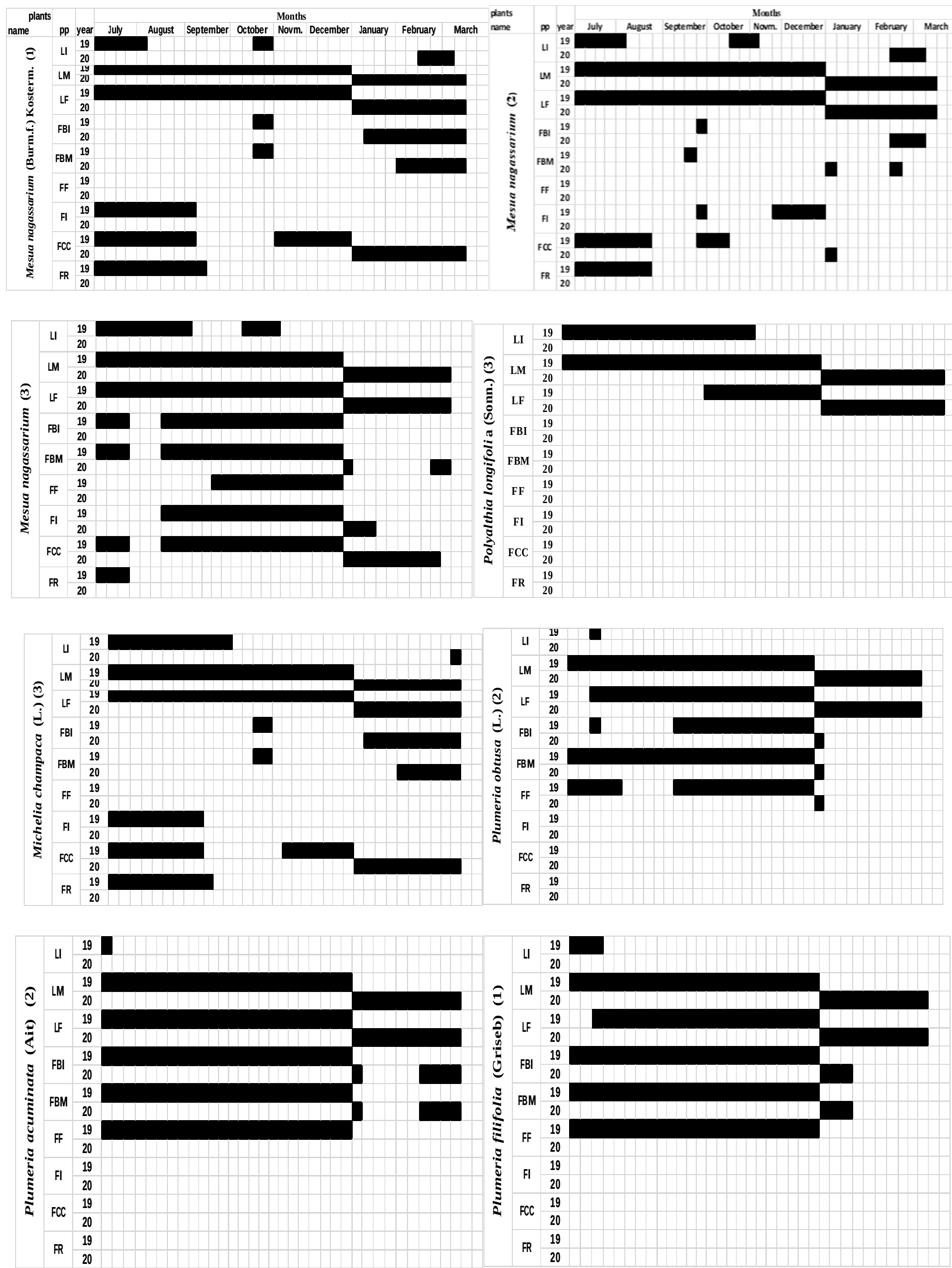
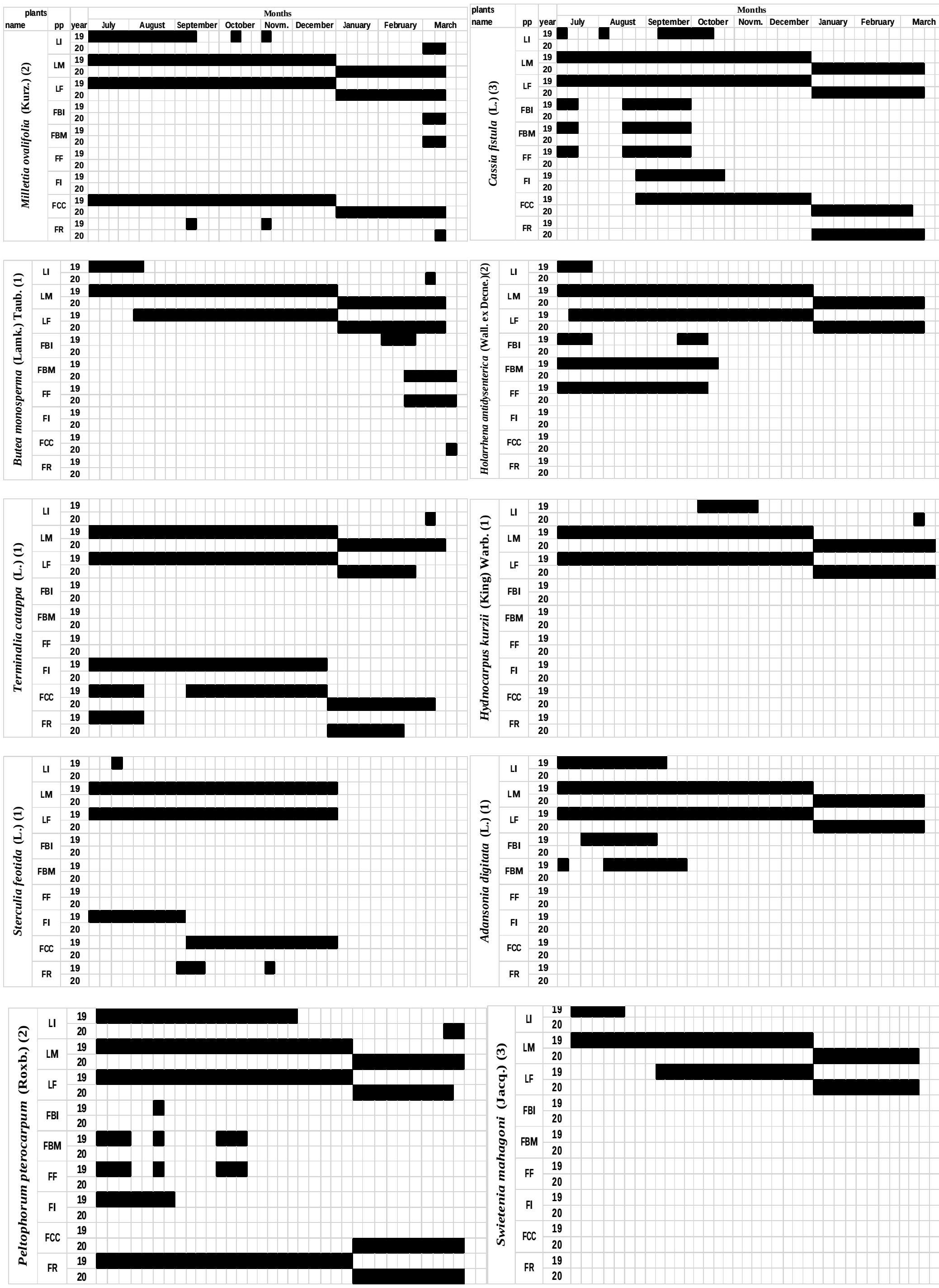
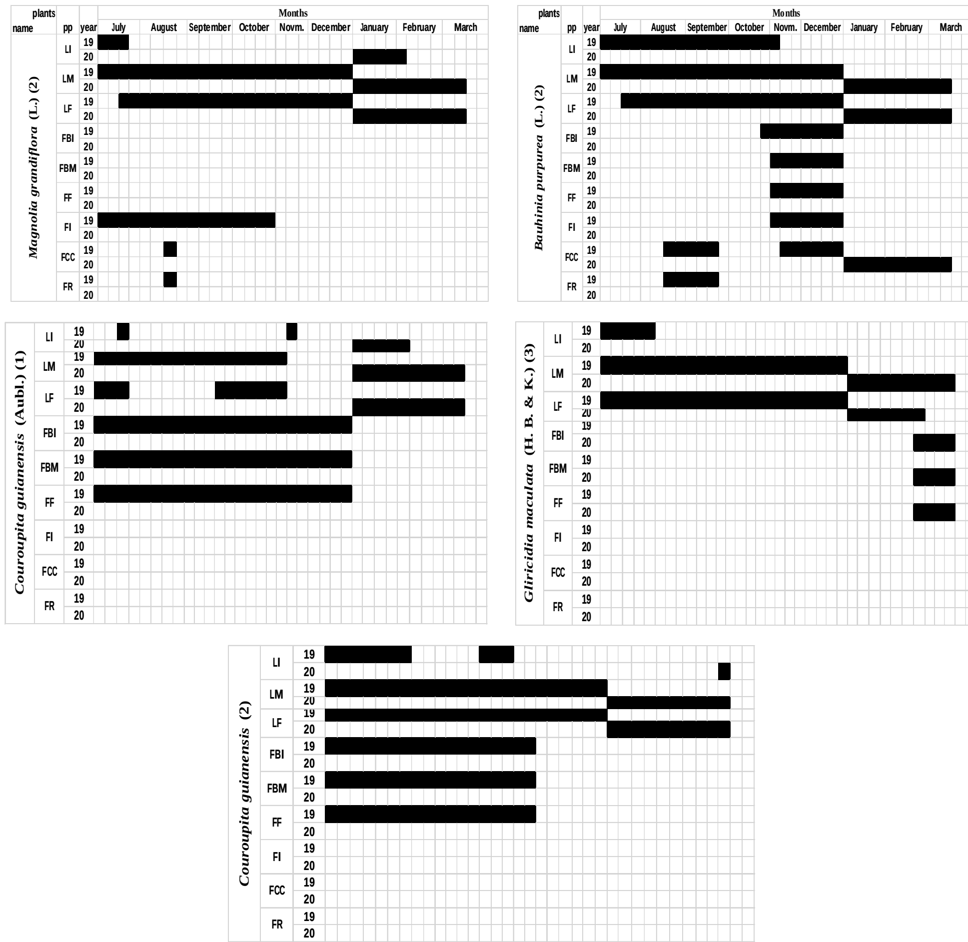


Fig 2. Phenological diagrams of twenty plant species. The dark colored bars indicate the whole period of appearance of different phenophases (pp) (full forms of abbreviated words have been explained in the text). Numbers in parenthesis beside the species names are the individual number of the respective studied species. (Fig. 2. Contd.)

(Fig. 2. Contd.)


plants name
pp
year
Months
July
August
September
October
Novm.
December
January
February
March
LI
LM
LF
FBI
FBM
FF
FI
FCC
FR
19
20
Milletia ovalifolia (Kurz.) (2)
Cassia fistula (L.) (3)
Butea monosperma (Lamk.) Taub. (1)
Holarrhena antidysenterica (Wall. ex Decne.)(2)
Terminalia catappa (L.) (1)
Hydnocarpus kurzii (King) Warb. (1)
Sterculia feotida (L.) (1)
Adansonia digitata (L.) (1)
Peltophorum pterocarpum (Roxb.) (2)
Swietenia mahagoni (Jacq.) (3)

(Fig. 2. Contd.)



March. On the other hand, in December when the temperature was low no leaf initiation was found in most of the plant (Fig. 2, Table 2). In the month of February, fewer leaf initiation found in the study period. Flower was also bloomed when the temperature was high in most plant species.

In most of the plants, flowering occurred in the month of July. Flower also occurred in the month of September, October, January, February and March. In low temperature and humidity some plants like *Butea monosperma* and *Gliricidia maculata* bloom their flower (Fig. 2, Table 2). Fruiting were found all the year round in some plants. Fruiting was observed mostly in the month of July, August, September, December, January and March. No fruit was found in *Polyalthia longifolia, Plumeria obtusa, P. acuminata, P. filifolia, Holarrhena antidysenterica, Couroupita guianensis, Gliricidia maculata, Hydnocarpus kurzii* and *Adansonia digitata* during the study period.

Figure 2 showed phenological patterns of individual plant species. For each plant species, the whole period of appearance of different phenophases-like leaf initiation, flowering and fruiting have been indicated for the study period. The study revealed high phonological diversity for different phenophases studied among twenty plant species. However, for individuals of the same species, some differences in the appearance of different phenophases were observed. Flowering rarely found in the plant of *Adansonia digitata*. In the present study, it was found that there were many differences in the two individual plants of *C. guianensis*. In this species, leaf initiation occurred in the mid of July, end of November, January and beginning of February in the first individual plant, but in the second individual it was occurred in the month July, August, October and mid of March. In the first individual plant, few mature leaves were found in the month of July, no mature leaf found in ending of November and except that mature leaves were found rest of the month. The plant species showed two times leaf falls in a year.

The study revealed high phenological diversity for the three phenological patterns (leaf, flowers and fruits) among twenty plant species growing under similar environmental condition in the study area. Some studies have demonstrated an association of an advancement in flowering date with climate change. A number of other studies have shown an advancement of phenological events as a result of increase in temperature (Parmesan and Yohe 2003, Menzel *et al.* 2006, Piao *et al.* 2006, Julien and Sobrino 2009). With the increase in temperature, most of the species showed earlier flowering time period (Menzel *et al.* 2006).

It is suggested that temperature related air humidity might be the main trigger of the development of trees. Other workers (Do *et al.* 2005, Jochner *et al.* 2013) found an influence of air humidity on phenology in tropical environments.

Table 2. Monthly temperature, relative humidity and concentration of CO_2 in Curzon Hall campus during the study period.

Year	Months	Temperature (°C)			Relative humidity (%)			Concentration of CO_2 (ppm)		
		Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
2019	July	30.2	41.8	36.0	54.0	88.0	71.0	580.0	639.0	609.5
	August	30.5	41.0	35.8	55.0	81.0	68.0	589.0	713.0	651.0
	September	32.0	40.2	36.1	62.0	77.0	69.5	561.0	710.0	635.5
	October	30.0	36.0	33.0	62.0	74.0	68.0	447.0	526.0	486.5
	November	28.0	35.5	31.8	55.0	67.0	61.0	456.0	553.0	504.5
	December	20.1	35.0	27.6	47.0	79.0	63.0	443.0	530.0	486.5
2020	January	25.5	34.0	29.8	48.0	71.0	59.5	435.0	510.0	472.5
	February	25.0	30.0	27.5	37.0	66.0	51.5	547.0	579.0	563.0
	March	30.0	35.5	32.8	42.0	55.0	48.5	571.0	626.0	598.5

Min. and Max. represent minimum and maximum.

The present study revealed high phenological diversity for ten different phenophases among 20 plant species. This study would be of great help in knowing the timing of different phenophases of the studied plants. This study also provides important insights into the biology of the plants concerned and reveal phenological pattern of surveyed species and would also be of great help for comparison over long duration of time in relation to climate changes. From the present study, we can conclude that atmospheric temperature, relative humidity and concentration of CO_2 are important factors for plant phenological changes.

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