



## Phenodynamics of Twenty Multipurpose Tree Species (MPTS) of Kashmir under Shalimar conditions

**K.N. Qaisar, Vaishnu Dutt\*, P.A. Khan, S.N. Zaffar, J.A. Mugloo and Immad A. Shah**

Faculty of Forestry, SKUAST- Kashmir, Benhama-Watlar, Ganderbal J&K-191201 India

\*Email: [vaishnudutt@gmail.com](mailto:vaishnudutt@gmail.com)

DOI: 10.5958/2455-7129.2020.00017.5 **ABSTRACT**

### Key Words:

Phenology, phenodynamics, multipurpose tree species (MPTS), Kashmir

Study was carried out to determine the phenological behaviour of important multipurpose trees in the Shalimar conditions of Kashmir, India. The study was conducted for the phenodynamics of 20 multipurpose tree species (MPTS) of Kashmir under Shalimar conditions during 2010-2011. Phenophases of twenty MPTS namely *Populus deltoides*, *P. alba*, *P. nigra*, *P. balsemifera*, *Salix alba*, *S. caprea*, *Albizia julibrissin*, *Quercus robur*, *Fraxinus floribunda*, *Morus alba*, *Ailanthus altissima*, *Aesculus indica*, *Castanea sativa*, *Celtis australis*, *Gleditsia tricanthos*, *Melia azedarach*, *Paulownia fortunei*, *Ulmus villosa*, *Platanus orientalis* and *Robinia pseudoacacia* were recorded. Leaf fall of the majority of the species was concentrated from September 20<sup>th</sup> to 20<sup>th</sup> November, whereas the leaf flushing and flowering period of the majority of the species occurred between 10<sup>th</sup> January to 20<sup>th</sup> May. Seed formation was concentrated between March 10<sup>th</sup> to May 30<sup>th</sup> with few species fruiting throughout the year. The earliest bud break was observed in *Salix caprea*, the ornamental species of willow, i.e., from 10<sup>th</sup> January among all the tree species. This species recorded longest growing period from 10<sup>th</sup> January to November 20<sup>th</sup> followed by *Melia azedarach* and shortest growing period was recorded in *Fraxinus floribunda* from 20<sup>th</sup> March to 20<sup>th</sup> October.

### INTRODUCTION

The passing of the seasons is one of the most familiar phenomena on earth. For

example, in the onset of spring in temperate climates, as winter ends, our surroundings burst with new life- forest canopies fill with

vibrant greens, and wild flowers and their insect pollinators appear in rapid succession across hillsides, road sides, lake margins and fields. Similarly, as autumn approaches, the deciduous forest canopy progresses towards a colourful demise, birds navigate their return to southern wintering grounds, and many plants ripen their last fruits before the onset of winter. Whether we live in urban or rural environments, there are constant reminders of the changing of the seasons. Scientists refer to the study of the timing of seasonal biological activities as phenology. This term was first introduced in 1853 by the Belgian botanist Charles Morren and is derived from the Greek words *phaino*, meaning “to appear, to come into view” and *logos*, meaning “to study”. Phenology is the science that measures the timing of life cycle events for plants, animals, and microbes, and detects how the environment influences the timing of those events. In the case of flowering plants, these life cycle events, or phenophases, include leaf budburst, first flower, last flower, first ripe fruit, and leaf shedding *etc.* Phenophases commonly observed in animals include molting, mating, egg-laying or birthing, fledging, emergence from hibernation, and migration. Thus, phenologists record the dates that these events occur, and they study how environmental conditions such as temperature and precipitation affect their timing. The way in which the entire sequence of phenophases occurs throughout the year is called the “phenodynamics” and each distinguishable phase within the life cycle of a species is called a “Phenophase”. Generally phenology involves the study of the response of living organisms to seasonal and climatic changes of the environment in which they live. Plants are adapted to the annual seasonal atmosphere changes. It is important to keep track of cyclical events such as appearance of buds, leaves, first bloom, pollination and fertilization and dispersal of seeds from year to year and determine how they relate to the weather patterns. For plants, seasonal timing of such events can be critical to survival and reproduction. There

is global consensus that climate is changing mainly due to the anthropogenic emissions of green house gases (IPCC, 2007). In 1992, United Nations Framework Convention on Climate Change (UNFCCC) defined climate change as “a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” In 2001, the Intergovernmental panel on Climate Change (IPCC) which is the major scientific body associated with climate change at the international level, defined it as “any change in climate over time, whether due to natural variability or as a result of human activity. The climate change has the impact on phenology of different plants and animals. So the study was undertaken for the phenodynamics of 20 multipurpose tree species (MPTs) of Kashmir.

## MATERIALS AND METHODS

The study was carried out at Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir (J&K) at 34°12'N and 74°46'E with an elevation of 1600m above mean sea level. The study area is characterized by temperate climate experiencing four distinct seasons: a severe winter (December to February), a cold spring (March to May), a mild summer (June to August) and a pleasant autumn (September to November). The site falls in a mid to high altitude area characterized by hot summer and very cold winter. The average precipitation is 690 mm most of which is received from December to April in the form of snow and rains. The minimum temperature ranged from -3.98 to 16.61°C and maximum temperature from 6.89 to 30.57 °C and the average maximum relative humidity from 73.27 to 93.97 percent, whereas the mean minimum relative humidity ranged from 44.03 to 71.00 percent during the study period. The study was conducted for the phenodynamics of 20 multipurpose tree species (MPTs) of Kashmir under Shalimar

conditions. Phenophases of twenty MPTs namely *Populus deltoides*, *P. alba*, *P. nigra*, *P. balsemifera*, *Salix alba*, *S. caprea*, *Albizia julibrissin*, *Quercus robur*, *Fraxinus floribunda*, *Morus alba*, *Ailanthus altissima*, *Aesculus indica*, *Castanea sativa*, *Celtis australis*, *Gleditsia tricanthos*, *Melia azaderach*, *Paulownia fortunei*, *Ulmus*

*villosa*, *Platanus orientalis* and *Robinia pseudoacacia* were recorded at an interval of ten days throughout the year.

## RESULTS AND DISCUSSIONS

The phenology of these MPTs is discussed species wise (Table 1).

**Table 1:** Phenophases of MPTs under Shalimar conditions (2010-2011)

S.N.	Tree Species Phenophases	Bud break	Flowering	Seed	Leaf Senesc ence (Yellowi ng)	Dorma ncy	Growing period
1.	<i>Populus deltoides</i>	Mar.20	Mar.20	Apr.10 - June 10	Sept.30	Nov.20	Mar.20- Nov.20
2.	<i>P.alba</i>	Jan.20	Jan.20- Mar.20	-	Sept.20	Oct.20	Jan.20- Oct.20
3.	<i>P. nigra</i>	Mar.20	Mar.20	Apr.10-May 30	Sept.30	Nov.20	Mar.20- Nov. 20
4.	<i>P. balsemifera</i>	Feb.10	Feb10- Mar.30	Mar.10-Mar 30	Sept.20	Nov.10	Feb.10- Nov.10
5.	<i>Salix alba</i>	Feb.20	Feb.20-Apr. 10	-	Sept.20	Nov.10	Feb.20- Nov.10
6.	<i>S caprea</i>	Jan.10	Jan.10 - Apr.10	-	Oct.10	Nov.20	Jan.10- Nov.20
7.	<i>Albizia julibrissin</i>	Mar.20	May20- Aug.20	Aug.30-Whole year	Sept.30	Nov.10	Mar.20- Nov.10
8.	<i>Quercus robur</i>	Mar.30	Apr.20-May 20	May.30-Oct.30	Sept.20	Nov.20	Mar.30- Nov.20
9.	<i>Fraxinus floribunda</i>	Mar.20	Mar.30- Apr.10	Apr.20- Whole year	Sept.10	Oct. 20	Mar.20- Oct.20
10.	<i>Morus alba</i>	Mar.20	Mar.20- Apr.10	Apr. 20-June 10	Sept.20	Nov.10	Mar.20- Nov.10
11.	<i>Ailanthus altissima</i>	Mar.20	Apr.20	June 20- Whole year	Sept.20	Oct.30	Mar.20- Oct.30
12.	<i>Aesculus indica</i>	Mar.20	Mar.30-10 June	June 22-Oct 30	Oct.20	Nov.10	Mar.20- Nov.10
13.	<i>Castanea sativa</i>	Mar.30	Apr.30- Sept.10	Sept.20-Oct 10	Oct.10	Nov.20	Mar.30- Nov. 20
14.	<i>Celtis australis</i>	Mar.20	Mar.30	Apr10-Nov 10	Oct.10	Nov.10	Mar.20- Nov.10
15.	<i>Gleditsia tricanthos</i>	Mar.30	Apr. 10- May 20	May30- Whole year	Sept.30	Nov.20	Mar.30- Nov.20
16.	<i>Melia azaderach</i>	Mar.30	Apr.10- June20	June 30- Whole year	Oct.30	Dec.20	Mar.30- Dec.20
17.	<i>Paulownia fortunei</i>	Mar.20	Jan10- May.20	May.30- Whole year	Sept.20	Nov.20	Mar.20- Nov.20
18.	<i>Ulmus villosa</i>	Feb.20	Feb.20-Mar. 10	Mar20-Mar.30	Sept.30	Nov.20	Feb.20- Nov.20
19.	<i>Platanus orientalis</i>	Mar.30	Mar.30	Apr.10- Whole year	Sept.20	Nov. 20	Mar.30- Nov.20
20.	<i>Robinia pseudoacacia</i>	Mar.20	Apr.10- May10	May.20- Whole year	Sept.20	Nov.20	Mar.20- Nov.20

**Poplar**

Poplars locally called as “Fras” have important contribution to the landscape and economy of Kashmir and poplar wood is used for making packing case, plywood/veneer making, interior wood work, beams, poles and fuel wood. Poplars are grown in agrisilviculture systems and on the field boundary. The Poplars are dioecious *i.e.* male and female sexes are on separate trees. These are wind pollinated and fruit ripe from ending April to early June and mature female forms of poplars produce seeds with their cottony appendages and dispersal of seed with cottony tufts is far and wide, so these trees are also known as Cottonwoods or Aspens. These cottony tufts cause visual disturbances, respiratory disorders, allergies and irritation of eyes. Poplars belonging to family of *Salicaceae* are extremely light demanding. The Poplars growing in the valley are mostly exotic.

Species like *Populus alba* (white poplar), *Populus deltoides* (Rousee Fras), *Populus nigra* (Black poplar) and *Populus balsemifera* (Balsam poplar), *Populus ciliata* (Jungli Fras) are present in the valley. Four species were selected for phenology study.

**i. *Populus deltoides*:** Commonly this species is known as Eastern cottonwood poplar, locally known as Punjabi Frass or Russi Frass. This species is widely planted by farmers as boundary plantation or Block plantation.

*Phenology:* In *Populus deltoides*, the bud break was observed from March 20<sup>th</sup>. The cottony seed dispersal was observed from 10<sup>th</sup> April to 10<sup>th</sup> June in female clones present at the site. Leaf senescence (yellowing) started from September 30<sup>th</sup> and on 20<sup>th</sup> November the dormancy was observed. The growing period was observed from March 20<sup>th</sup> to November 20<sup>th</sup>.



Phenophases of *Populus deltoides*

ii. ***Populus alba*:** This species is commonly known as White Poplar and locally known as Dudh frass. Isolated trees are found in Kashmir.

*Phenology :* In this species, the bud break was observed from January 20. Then flowering was observed from 20<sup>th</sup> January to

20<sup>th</sup> March. No seed formation was observed in trees at Shalimar Leaf senescence (yellowing) started from September 20<sup>th</sup> and on 20<sup>th</sup> October the dormancy was observed. The growing period was observed from January 20<sup>th</sup> to October 20<sup>th</sup>.



Phenophases of *Populus alba*

**iii. *Populus nigra*:** This species is commonly known as Black Poplar and locally known as Pahari frass.

*Phenology:* In *Populus nigra* trees, the bud break was observed from 20<sup>th</sup> March. The growing period was observed from March

20<sup>th</sup> to November 20<sup>th</sup>. The flowering was observed from 20<sup>th</sup> March and seed formation was observed up to 30<sup>th</sup> May. Leaf senescence (yellowing) started from September 30<sup>th</sup> and on 20<sup>th</sup> November the dormancy was observed.



Phenophases of *Populus nigra*

**iv. *Populus balsemifera*:** This species is commonly/locally known as Balsam Poplar, this species is not very common in Kashmir.

*Phenology:* In trees of this species, the bud break was observed from 10<sup>th</sup> February. The flowering was observed from 10<sup>th</sup>

February to 30<sup>th</sup> March and seed formation was observed up to 30<sup>th</sup> May. Leaf senescence (yellowing) started from September 20<sup>th</sup> and on 10<sup>th</sup> November the complete dormancy was observed. The growing period was observed from 10<sup>th</sup> February to November 10<sup>th</sup>.



Phenophases of *Populus balsemifera*

**v. *Salix alba*:** This species is commonly known as English Willow and locally known as Bote Veer.

*Phenology:* In *Salix alba*, commonly known as Kashmir willow, the bud break was observed from 20<sup>th</sup> February. The flowering was observed from 20<sup>th</sup> February to 10<sup>th</sup> April. Leaf senescence (yellowing) started from September 20<sup>th</sup> and on 10<sup>th</sup> November the complete dormancy was observed. The growing period was observed from 20<sup>th</sup> February to November 10<sup>th</sup>.

**vi. *Salix caprea*:** This species is commonly known as Goat Willow and locally known as Bed mushk.

*Phenology:* In *Salix caprea*, the earliest budbreak was observed i.e. from 10<sup>th</sup> January among all the tree species. The flowering was observed from 10<sup>th</sup> January to 10<sup>th</sup> April. Leaf senescence (yellowing) started from October 10<sup>th</sup> and on 20<sup>th</sup> November the completed dormancy was observed. It recorded longest growing period from 10<sup>th</sup> January to November 20<sup>th</sup>.

Phenophases of *Salix alba*Phenophases of *Salix caprea*

**vii. *Albizia julibrissin*:** This species is commonly known as Persian Silk tree and locally known as Albizia.

**Phenology:** In this species, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 20<sup>th</sup> May to 20<sup>th</sup> August. Pod formation started from 30<sup>th</sup> August and

after maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 30<sup>th</sup> and on 10<sup>th</sup> November the complete dormancy was observed. The growing period was observed from 20<sup>th</sup> March to November 10<sup>th</sup>.

Phenophases of *Albizia julibrissin*

**viii. *Quercus robur*:** This species is commonly known as English Oak, Pedunculate Oak, (Kashmiri as Palaekul) belongs to family Fagaceae. It is a large broadleaved deciduous tree with a very spreading crown, a short sturdy trunk and deeply fissured grey brown bark.

**Phenology:** In Shalimar, bud break was observed from 30<sup>th</sup> March. The flowering was observed from 20<sup>th</sup> April to 20<sup>th</sup> May. Acorn formation started from 30<sup>th</sup> May and after maturation, the seeds were present on trees up to 30<sup>th</sup> October. Leaf senescence (yellowing) started from September 20<sup>th</sup> and on 20<sup>th</sup> November the complete dormancy was observed. The growing period was observed from 30<sup>th</sup> March to November 20<sup>th</sup>.

Phenophases of *Quercus robur*

**ix. *Fraxinus floribunda*:** This species is commonly known as Himalayan Ash and locally known as Hom.

**Phenology:** In *Fraxinus floribunda*, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 30<sup>th</sup> March to 10<sup>th</sup> April. Pod formation started from 20<sup>th</sup>

April and after maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 10<sup>th</sup> and leaf shedding was observed on 20<sup>th</sup> October. The shortest growing period was recorded in *Fraxinus floribunda* from March 20<sup>th</sup> to October 20<sup>th</sup>.

Phenophases of *Fraxinus floribunda*

**x. *Morus alba*:** This species is commonly known as White Mulberry and locally known as Safed Tul.

**Phenology :** The bud break was observed in *Morus alba* from 20<sup>th</sup> March. The flowering was observed from 20<sup>th</sup> March to 10<sup>th</sup> April. Fruit development started from 20<sup>th</sup> May

and full ripened fruits remained up to 10<sup>th</sup> June. Leaf senescence (yellowing) started from September 10<sup>th</sup> and leaf shedding was observed up to 10<sup>th</sup> November. The growing period was observed from 20<sup>th</sup> March to November 10<sup>th</sup>.

Phenophases of *Morus alba*

**xi. *Ailanthus altissima*:** This species is commonly known as Tree of Heaven and locally known as Ailanthus.

*Phenology:* In this species, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 20<sup>th</sup> April. Pod formation started from 20<sup>th</sup> June and after

maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 20<sup>th</sup> and leaf shedding was observed up to 30<sup>th</sup> October. The growing period was observed from 20<sup>th</sup> March to October 30<sup>th</sup>.



Phenophases of *Ailanthus altissima*

**xii. *Aesculus indica*:** This species is commonly known as Indian Horse Chestnut and locally known as Handoon.

*Phenology:* In *Aesculus indica* trees, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 30<sup>th</sup> March to 10<sup>th</sup> June. Fruit formation started

from 20<sup>th</sup> June and after maturation remained on trees up to 30<sup>th</sup> October. Leaf senescence (yellowing) started from October 20<sup>th</sup> and leaf shedding was observed up to 10<sup>th</sup> November. The growing period was observed from 20<sup>th</sup> March to 10<sup>th</sup> November.



Phenophases of *Aesculus indica*

**xiii. *Castanea sativa*:** This species is commonly known as Sweet Chestnut and locally known As Gour.

*Phenology:* Bud break was observed from 30<sup>th</sup> March. The flowering was observed from 30<sup>th</sup> April to 10<sup>th</sup> September. Fruit

development started from 20<sup>th</sup> September and after maturation remained on trees up to 10<sup>th</sup> October. Leaf senescence (yellowing) started from October 10<sup>th</sup> and leaf shedding was observed up to 20<sup>th</sup> November. The growing period was observed from 30<sup>th</sup> March to 20<sup>th</sup> November.



Phenophases of *Castanea sativa*

**xiv. *Celtis australis*:** Commonly known as khirak and locally known as Brimij belongs to the family Ulmaceae. It grows in the Western Himalayas in Jammu and Kashmir, Himachal Pradesh and Uttarakhand, over a fairly wide altitudinal range of 500 to 2500 m.

**Phenology:** In this species, bud break was observed from 20<sup>th</sup> March. The flowers were appeared from 30<sup>th</sup> March to 10<sup>th</sup> April. The

fruits developed rapidly after flowering and attained full size by June –July, remained green till October and started turning yellow. The fruits ripped up to 10<sup>th</sup> November. The leaves appeared in last week of March and first week April. Leaf senescence (yellowing) started from October 10<sup>th</sup> and old leaves were shed up to 10<sup>th</sup> November. The growing period was observed from 20<sup>th</sup> March to November 10<sup>th</sup>.

Phenophases of *Celtis australis*

**xv. *Gleditsia tricanthos*:** This species is commonly/locally known as Honey locust.

**Phenology:** In *Gleditsia tricanthos* species, bud break was observed from 30<sup>th</sup> March. The flowering was observed from 10<sup>th</sup> April to 20<sup>th</sup> May. Pod formation started from 30<sup>th</sup> May and after maturation remained on

trees up to next season. Leaf senescence (yellowing) started from September 30<sup>th</sup> and leaf shedding was observed up to 20<sup>th</sup> November. The growing period was observed from 10<sup>th</sup> March to November 20<sup>th</sup>.

Phenophases of *Gleditsia tricanthos*

**xvi. *Melia azaderach*:** This species is locally known as Derk.

*Phenology:* The bud break was observed in *Melia azaderach* from 30<sup>th</sup> March. The flowers were appeared from 10<sup>th</sup> April to 20<sup>th</sup> June. The fruits developed rapidly after flowering and attained full size by July-August, remained green till October and

started turning yellow. Fruits after maturation remained on trees up to next season. The leaves appeared in first week of April. Leaf senescence (yellowing) started from October 30<sup>th</sup> and old leaves were shed up to 20<sup>th</sup> December. The growing period was observed from 30<sup>th</sup> March to 20<sup>th</sup> December.



Phenophases of *Melia azaderach*

**xvii. *Paulownia fortunei*:** This species is native to china commonly known as Paulownia.

*Phenology :* In this species, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 30<sup>th</sup> March to 20<sup>th</sup> May. Seed formation started from 30<sup>th</sup> May and

after maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 20<sup>th</sup> and leaf shedding was observed up to 20<sup>th</sup> November. The growing period was observed from 20<sup>th</sup> March to November 20<sup>th</sup>.



Phenophases of *Paulownia fortunei*

**xviii. *Ulmus villosa*:** Commonly known as Elm belongs to the family Meliaceae can be an alternative to the problems of timber and fuelwood. It grows in the Western Himalayas in Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

*Phenology :* The earliest bud break was observed in *Ulmus villosa* from 20<sup>th</sup> February. The flowering commenced

from 20<sup>th</sup> February to the 10<sup>th</sup> March. The seeds developed rapidly after flowering and attained maturation up to 30<sup>th</sup> March. Leaf senescence (yellowing) started from September 30<sup>th</sup> and old leaves were shed up to 20<sup>th</sup> November. The growing period was observed from 20<sup>th</sup> February to 20<sup>th</sup> November.

Phenophases of *Ulmus villosa*

**xix. *Platanus orientalis*:** This species is commonly known as Chinara and locally known as Boin.

**Phenology:** In this species, bud break was observed from 30<sup>th</sup> March. The flowering was observed from 30<sup>th</sup> March. Seed formation started from 10<sup>th</sup> April and after

maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 20<sup>th</sup> and leaf shedding was observed up to 20<sup>th</sup> November. The growing period was observed from 30<sup>th</sup> March to November 20<sup>th</sup>.

Phenophases of *Platanus orientalis*

**xx. *Robinia pseudoacacia*:** This species is commonly known as black locust and locally known as Kikar belongs to the family Leguminaceae.

**Phenology:** In *Robinia pseudoacacia* trees, bud break was observed from 20<sup>th</sup> March. The flowering was observed from 10<sup>th</sup> April

to 10<sup>th</sup> May. Pod formation started from 20<sup>th</sup> May and after maturation remained on trees up to next season. Leaf senescence (yellowing) started from September 20<sup>th</sup> and leaf shedding was observed up to 20<sup>th</sup> November.

Phenophases of *Robinia pseudoacacia*

From the table 1 it is inferred that the timing of leaf fall of the majority of the species was concentrated from September 20<sup>th</sup> to 20<sup>th</sup> November, whereas the leaf flushing and flowering period of the majority of the species occurred between 10<sup>th</sup> January to 20<sup>th</sup> May. Seed formation of most of the studied species was concentrated between March 10<sup>th</sup> to May 30<sup>th</sup> with few species fruiting throughout the year. The earliest bud break was observed in *Salix caprea*, the ornamental species of willow, i.e. from 10<sup>th</sup> January among all the tree species. This species recorded longest growing period from 10<sup>th</sup> January to November 20<sup>th</sup> followed by *Melia azedarach* and shortest growing period was recorded in *Fraxinus floribunda* from 20<sup>th</sup> March to 20<sup>th</sup> October .

Phenology offers evidence of climate change happening now help in assessment of the significant effect on plants in future. Phenological parameters such as appearances of leaf primordial, leaf fall, timing of opening of flowers period of maximum bloom etc. are the authentic data to study the effect of climate change on phenology (Khanduri et al. 2008). In India, Thakur and Kaur (2000) studied the phenology of twelve multi-purposes agroforestry tree species. In extension of this study, Thakur et al. (2008) has reported significant shift (advancement) in the phenophases of 10 MPTs of Solan region of Himachal Pradesh. Increase in monthly temperature above the normal has advanced leaf emergence and flower initiation phases. The climate change has prolonged the growth period of 10 out of 11 multipurpose tree species ranging between 31 and 46 days within eight years. Choudhary et al. (2011) studied the Phenological behaviour and reproductive biology of nine important fast growing *Salix* species. *Salix tetrasperma*, *S. jessonensis*, *S. gracilistyla* and *S. acmophylla* were among early flowering species, whereas *S. udensis* flowered in staggered manner from last week of January to last week of March. Das and Das (2013) reported that meteorological factors such as rainfall and temperature were found to be positively

correlated and evidently triggers for phenophases of some species and were also found to influence the shifts in phenological behaviour of a majority of the species.

The phenological changes have been studied by many scientists at global level like 0.2-0.6 days /decade earlier flowering in Hungary (Walkovsky 1998); Earlier flowering by about 0.5-1.2 days/decade in Wisconsin (Bradley et al. 1990); 1.7 days/decade leaf unfolding and 1.4 days /decade delayed leaf colouring and leaf fall in Europe (Menzel and Fabian 1999); 1.7 days/decade earlier flowering and leaf unfolding in USA (Schwartz and Reiter, 2000); 2.7 days/decade earlier flowering in Canada (Beaubien and Freeland 2000); 1.7 days/decade earlier flowering & leaf unfolding and 1.2 days /decade delayed leaf colouring and leaf fall (Menzel 2000); 2.7 days/decade earlier leaf unfolding and 0.8 days /decade delayed leaf colouring and leaf fall in Europe (Chmielewski and Ratzer 2001); Advance flowering by 4.5 days during the past decade compared to the previous four decades in England (Fitter and Fitter 2002); 0.8 days/decade earlier leaf unfolding and 1.7 days /decade delayed leaf fall in Japan (Matsumoto et al. 2003); Earlier flowering occurring 21 days/decade (Keatley et al. 2004) and Phenological growing season extended by 14 days/decade in China (Xiaoqiu 2004). It has been observed that in certain plant species leaf unfolding in spring has advanced by up to six days. Whereas, the autumn leaf colouring is delayed by 4-8 days (Menzel and Fabian 1999). Abu-Asab et al (2001) have studied changes in first flowering times of over 100 plant species representing 44 families of angiosperms for 29 years (1970- 99) in Washington , D.C. they observed that most of the trees now flower 3-5 days earlier than they did some years ago.

## CONCLUSIONS

The present study provides useful insight into the phenological behaviour of multipurpose trees in the Kashmir region. The timing of leaf fall of the majority of the species was concentrated from September

20<sup>th</sup> to 20<sup>th</sup> November, whereas the leaf flushing and flowering period of the majority of the species occurred between 10<sup>th</sup> January to 20<sup>th</sup> May. Seed formation of most of the studied species was concentrated between March 10<sup>th</sup> to May 30<sup>th</sup> with few species fruiting throughout the year. The earliest bud break was observed in *Salix caprea*, the ornamental species of willow, i.e. from 10<sup>th</sup> January among all the tree species. This species recorded longest growing period from 10<sup>th</sup> January to November 20<sup>th</sup> followed by *Melia azedarach* and shortest growing period was recorded in *Fraxinus floribunda* from 20<sup>th</sup> March to 20<sup>th</sup> October. On the basis of the present study it can be concluded that the plant species of the temperate region of Kashmir exhibit variable phenological behaviour as adaptive responses to abiotic factors such as local climatic variables. The importance of the present study provides important information on the phenological response of multipurpose trees which can be implemented in further understanding and strengthening and can be useful in future selection of species for incorporation into Agroforestry and other forestry practices.

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