Phenological Studies of Critically Endangered High Value Medicinal Herbs: *Picrorhiza kurroa* and *Saussurea costus* Insub-Alpine Regions of Garhwal Hiamalya, Uttarakh and India

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Key words: Phenology, leaf fall, leaf flush, flowering, fruiting, Garhwal Himalaya

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Abstract: The study of various periodic behaviours of plant species or the phenology has great significance because it not only provides knowledge about the plant growth pattern but also provides the inferences on the effect of environment and selective pressure on flowering and fruiting behaviour. In this study,an attempt has been made to record such data regarding periods of leaf fall, leaf flushing, flowering, fruiting and all. This was done for a period of two years for two species viz. *Picrorhiza kurroa* and *Saussurea costus* of course which were somehow having medicinal properties and it was carried out in the VCGS UUHF Bharsar district of Pauri, Uttarakhand. In the study the leaf fall peak period was found in last part of December, leaf flushing peak period in the month of march where as flowering and fruiting activity peak period was found during the month of May-June and July-August, respectively. So, this type of study will be helpful to give inferences in future whether the of climate change are giving pressure on the periodic behaviour of plant species. Changed phenological behaviour of plant species indicates the losing of plant diversity of the district in a critical level.

INTRODUCTION

In nature it is often seen that each species has a definite period, month, season in a year during which its seeds germinate, seedlings grow or show maximum vegetative growth, leaves fall (if it is deciduous), flushing of new leaves, flowering and then fruiting. The study of all these periodic behaviour of a species is called its phenology. In the life cycle of a plant each and every stage is greatly influenced by a number of environmental factors. The different stages of the plant species remain completely embedded in an environmental complex. It is very interesting to note that being fixed at a particular place, the requirement of germination, growth, flowering, fruiting, leaf fall etc of the species are met with at the same place but of course in different times of the year. There is a synchronization of phenological behaviour of the species

and the various factors of the environment that plants are spoken of biological clocks. This is mostly regulated by external signals from the environment. But the interactions of each and every species are different at different stages of their life cycle. Thus, plant phenological study has great significance because it not only provides knowledge about the plant growth pattern but it also provides the idea on the effect of environment and selective pressure on flowering and fruiting behavior (Zhang *et al*., 2006).

About *Picrorhiza kurroa:* *Picrorhiza kurroa* Royle ex Benth. (Family: Scrophulariaceae) native to Western Himalayan region, between 3000-5000 m elevation is valued as hepato-protective, antiperiodic, cholagouge and stomachic, antiamoebic, anti-oxidant expectorant etc. (Singh and Kushwaha, 2005). The rhizome of *Picrorhiza* has been traditionally used to treat worms, constipation, low fever, scorpion sting, asthma and ailments affecting the liver. *Picrorhiza kurroa* also known as kutki is found in the North-Western Himalayan region from Kashmir to Kumaun and Garhwal regions in India.

Kutkin is the active principal of *Picrorhiza kurroa* and is comprised of kutkoside and the iridoid glycoside picrosides I-III. Other identified active constituents are apocynin, drosin and nine cucurbitacin glycosides (Stuppner, 1990). Apocynin is a catechol that has been shown to inhibit neutrophil oxidative burst in addition to being a powerful anti-inflammatory agent while the curcubitacins have been shownto be highly cytotoxic and possess antitumor effects (Simons *et al*., 1990).

About *Saussurea costus*: *Saussurea costus* (family: Asteraceae) is an erect, robust, pubescent, perennial herb, with a stout simple stem 1-2 m high. Leaves membranous, scaberulous above, glabrate beneath, auricled at base, irregularly toothed; basal ones very large, 0.50-1.25 m long with a long winged petiole; upper leaves smaller, subsessile or shortly petioled; two small lobes at the base of these leaves almost clasping the stem. Flower heads stalkless, bluish-purple to almost black, hard, rounded, 2.4-3.9 cm across, often 2-5 clustered together in the axils of leaves or terminal. Involucral bracts many, ovate-lanceolate, long pointed, purple, rigid, hairless. Receptacle bristles very long. Corolla about 2 cm long, tubular, blue-purple or almost black. Anther tails fimbriate. Achenes curved compressed *ca.* 8 mm long, tip narrowed with one rib on each face. Pappus brown, double feathery. Roots are stout, dark brown or grey, up to 40 cm long (Hajra *et al*., 1995). Upadhyay *et al*. (1993) have described the macro and microscopical characters of the roots of *Saussurea costus* while Saklani *et al*. (2000) have reported its achene morphology. Several workers (Gupta, 1964; Hajra, 1988; Hajra *et al*., 1995; Chaudhary and Rao, 2000) have significantly contributed towards the morphological characterization of the genus *Saussurea*in India, including *Saussurea costus*. Macromorphological parameters like habit, size of plants, size and shape of leaves and capitula and the nature of phyllaries in *Saussurea costus* have been described by all the above workers.

In the Indian systems of medicine *Saussurea costus* is used either as a single drug or in combination with other drugs. Its roots are used mainly as an antispasmodic in asthma, cough and also in treatment of cholera, chronic skin diseases and rheumatism. Its different preparations are also used by Ayurvedic physicians for the treatment of various ailments like cough and cold, quartan malaria, leprosy, persistant hiccups, rheumatism, hair-wash, stomachache, toothache, typhoid fever, etc. It is an important medicine for gout, erysipelas and promotes spermatogenesis. *Saussurea costus* has been used by different people and ethnic tribes of the Northern parts of India for the treatment of various ailments. The root is also used in Tibetan medicine where it is considered to have an acrid, sweet and bitter taste with a neutral potency. Several traditional Tibetan formulae that are used for chronic inflammation of the lungs, cough, chest congestion Hippophae 5 and Eliminator of Lung Inflammation contain *Saussurea* as one of the important ingredients.

MATERIALS AND METHODS

Study area: In general, the climate of the Bharsar represents mild summer, higher precipitation and prolonged cold winter season. The climatic factors such as precipitation, temperature, relative humidity and wind, in association with elevation, slope aspects, drainage, vegetation, etc. are responsible for the micro-climate of this area. Generally, days of Bharsar are fairly warm followed by cool nights. The area receives adequate sunshine hours whereas the growing period is shorter due to long winter. The area also receives heavy precipitation during monsoon and occasional snow fall during winter season. The mean monthly weather data for one year between is presented in Fig. 1.

The phenological study was carried out for two species of medicinal plants of the VCSG UUHF MAP field. Observation was made on leaf fall, leaf flushing, flowering and fruiting at one month of interval from January 2012-December 2014.

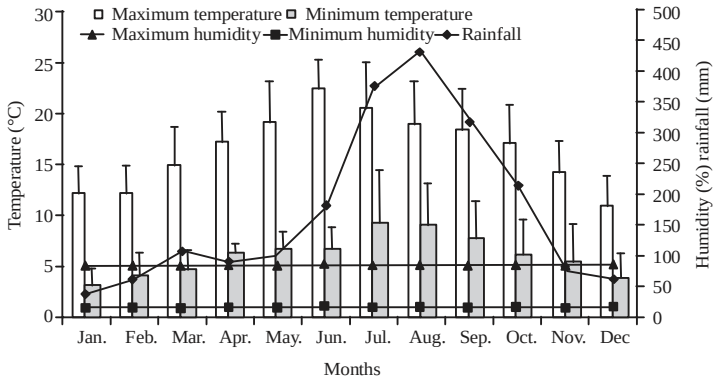

Fig. 1: Meteorological data of the study area

RESULTS AND DISCUSSION

After observation a record of time period of leaf fall, leaf flushing, flowering and fruiting were done for the species of medicinal plants in a tabular form for a period of three years. Then the data were analyzed from which some important inferences were made.

Seed germination and Vegetative phage: Seed germination started in both species in the 25 days after seed sowing in polyhouse and open condition.

Leaf fall and leaf flushing activity: The leaves of the plant are flat, oval and sharply serrated. After the data analysis it was found that leaf fall initiation was a periodic activity of the species. Both the species leaf fall started in the month of November/December with a peak in the last part of January (30%) to first part of February (50%). After shedding of older leaves new leaf initiation starts in the species, the time period of this activity seen to be different in different species. But it can be said that new leaf formation started in majority of species in the month of February (25%) continued upto May (30%) with a peak in the month of March (50%) that is before the outset of monsoon. Among forty species 75% showed brief leaf flushing activity where as only about 25% exhibited extended leaf activation.

Flowering activity: The flowers which appear March through May, are white or pale purple and borne on a tall spike in *Picrorhiza*. In *Saussurea costus* flowering start in the month of March to April. Flowering continued in other species throughout the year. However, peak period of flowering can be distinguished for the species in the month of July-August even other plants species associated with these two species like Mention may be made of the species like *Hemiphragma heterophyllum*, *Potentilla fulgens, Swertia angustifolia Salvia nubicola, Fragaria nubicola* exhibite *Geranium wallichianum* and *Polygonum ampliaxicaule* all these exhibited flower initiation in response to increasing length to photoperiod.

Table 1: Calendar for reproductive phase in *P. kurroa*

Stages	Time period (days)	Month (weeks)	Temperature (°C) (under polyhouse)
Young inflorescence	12-15	February (2nd)	26-30
Inflorescence with slightly opened buds	8-10	February (4th)	26-30
Inflorescence with half opened floral buds	16-20	March (3rd)	28-30
Inflorescence with fully opened flowers	10-16	April (1st)	28-33
Immature green pods	8-10	April (2nd)	28-33
Mature pods	15-20	April (4th)	28-33
Close up of mature pod	20-25	May (3rd)	34-36
Pod ready to dehisce	7-10	June (1st)	34-36
Fully mature dry pod	7-10	June (2nd)	34-36
Seed	-	-	-
Germination (35%)	20-25	Culture lab conditions	25±2
Days from bud formation to seed set	120 days approximately		

Fruiting activity: After flowering both the species start fruiting. The peak period of maturation of fruit was May-Juneof majority of the species concerned. In the month of May-June most of the species showed fruiting activity which is found to be followed by the month of climax of flowering which was in the month of April-May (Table 1 and 2).

Due to various anthropogenic activities the flora of this district are often disturbed. The problem of infiltration is a well known fact which is responsible for rapid degradation of forest land and this is particularly true in the hill districts of Uttarakhand. Thus while studying on the phenology of the medicinal plant species the forest flora of the district is seen to be disturbed or depleted to a considerable extend. Besides both of the species are in the study area which are enlisted in red data book as critically endangered.

Plant density value of any species provides the numerical strength of species in an area. It provides an

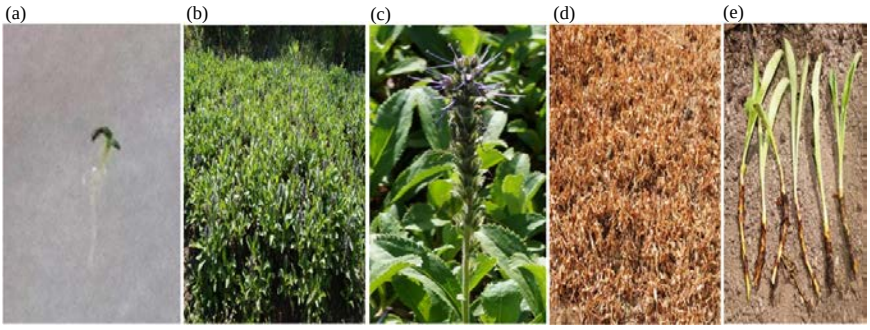

Fig. 2(a-e): *Picrorhiza kurroa*: Different phenol phage, (a) Germinated seed, (b) Vegetative growth, (c) Floral part (d) Dormancy stage and (e) Young seedling

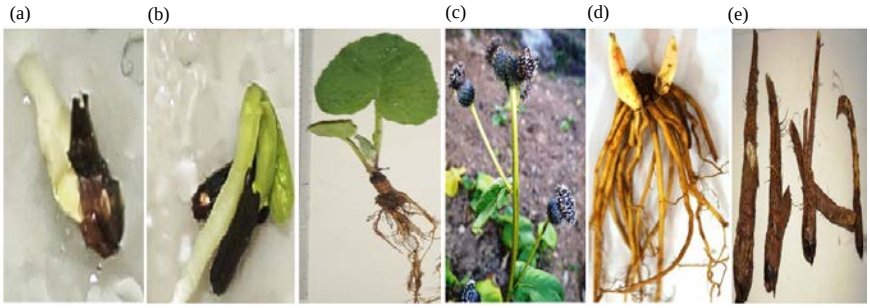

Fig. 3(a-e): *Saussuria costus*: Different phenophage, (a) Germinated seed (b) Vegetative growth (c) Floral part (d) Second year root and (e) economic part

Table 2: Calendar for reproductive phase in *Saussurea costus*

Stages	Time period (days)	Month (weeks)	Temperature (°C) (poly house condition)
Young inflorescence	25-35	May (1st)	
Inflorescence with slightly opened buds	15-20	May (3rd)	
Inflorescence with half opened floral buds	10-15	June (1st)	
Inflorescence with fully opened flowers	15-20	June (2nd)	
Immature green pods	5-10		
Mature pods	10-15		
Close up of mature pod	15-20		
Pod ready to dehisce	20-25		
Fully mature dry pod	25	July	
Seed	10-20	July	
Germination (%)	45-60	August	
Days from bud formation to seed set	120		

idea of competition between individuals of the species. The higher is the density, the more is the competition stress between the individuals of the species that is reflected in poor growth and lower reproductive capacity of the individuals of the species. The density of species in community varies in time and space, and is influenced by various environmental characteristics. On the basis of density of the species associated with two species are *Poa annua*r epresents maximum density followed *Crepis japonica* and *Hemiphragma heterophyllum* in the study period while the *Veronia cinerea* and *Viola biflora*s howed the least density in the study area (Bisht, 2005). Some other species are *Potentilla cuneata*, *Stellaria decumbens*, S*alvia hians* associated with the *Picrorrhiza kurroa*. Phenological variation attributed to varied environmental conditions (Temperature, humidity, rainfall, light etc.) among the domestication sites (Butola and Malik, 2012). Along altitudinal difference, the temperature is a major factor which is the main determinant of phonological plant development (Worral, 1993) (Fig. 2 and 3).

The phenology and growth of the plants changes with the increase in altitude due to alteration in assimilate investment patterns and metabolism, thereby affecting their growth (Korner and Renhard, 1987). Low temperature and high light intensity at higher altitudes are responsible for small height of plants besides having small leaves with thicker lamina. It has also been reported that alpine plant species have lower shoot mass ratio and higher root mass ratio than low land species (Woodward 1986) but the extent the to which shoot and root mass ratios effected the growth rate of alpine plants needs to be determined. Low temperature at high altitudes also results in low growth rate in alpine plants species by reducing rate of nitrogen mineralization in soil and uptake of nitrate by plants (Bowman *et al*., 1995; Seastedt and Vaccaro,

2018). Leaf area, respiration rate, photosynthesis per unit leaf mass and carbohydrate level play an important role in maintaining growth of many plant species (Pandey *et al*., 2008).

Often it is seen that there is a delay in flowering and fruiting of some medicinal plant species of the study area due to habitat disturbance. This leads to lowering the rate of seed viability so lesser germination in nature. If it goes on continuously there will be disturbance in phenological cycle of increased number of species day by day for which there is definite possibility of inclusion of more and more medicinal and other plant species in the red data book list so, people should be conscious enough about the plant resources of the district and important must be given to protect and coverage the plant resources anduse them in a judicious manner, so that, we do not exhaust them (Bisht, 2015). We can plant such medicinal plants inour home garden as required and we should use the resources in such a way that we can always save enough of these for our future generation. Through, such type of work of the paper on the condition of the flora of this vulnerable district we can know what actually happening to the biodiversity in the finest or accurate level. Works on micro level should not be continued to research level or scientific community but we should make it open to the public about the position, situation of vegetation and terrible effect of loss of biodiversity and all. Every step should be taken to conserve the medicinal or other plant diversity of the regions which is already in a critical level that can be justified by observing the present percentage of forest inclusion of species in red data book or changed phenological behaviour of the plant species.

CONCLUSION

It is a fact that not only this region but most of the immigrant predominant districts recorded very low percentages of the forest land due to decrease of forest besides loss of biodiversity there is increase there is increase in temperature, decrease in rainfall reliability, run off of fertile soil, silt ration for which again the water holding capacity which is a common phenomenon of the whole of the state Uttarakhand.

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