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PHENOLOGY AND REPRODUCTIVE BEHAVIOUR OF TWO PERENNIAL GRASSES UNDER BURNT AND UNBURNT CONDITIONS AT PAURI GARHWAL, UTTARAKHAND INDIA

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Abstract

The objective deals with the phenological and reproductive observations of two members of Poaceae *Arundinella nepalensis* Trinius and *Imperata cylindrica* L. The investigations were made in the burnt protected site (BPS) and unburnt protected site (UPS) forest grazingland of Pauri Garhwal dominated by *Pinus roxburghii*. The phenological behaviour was studied on 6 point scale events: germination, vegetative growth, flowering, fruiting, seed maturation and senescence of the individual and an attempt have been carried out to analyze different phases monthly. The average plant height for *Arundinella nepalensis* was maximum (97.71±2.1) on BPS in contrast to the UPS (92.42±1.1). Plant height for *Imperata cylindrica* was also maximum (44.28±4.7) on BPS in compare to UPS (40.28±2.7). With respect to the reproductive phase, the proportion (%) of the flowering clump with flowering culms (CF) for *Arundinella nepalensis* was 31 % on BPS, 25% on UPS and for *Imperata cylindrica* CF was 71% on BPS, 68% on UPS. The reproductive phase was represented during peak growing rainy season and persistent up to winter season and again enhanced vegetative growth after resprouting during the summer season. The gradation appears to be peculiarity extended on the unburnt site and the phase initiation found comparatively prompt on the burnt site.

Key words: Phenological behaviour, reproductive phase, flowering clump

Introduction

Plants perform different vegetative and reproductive capacities during the time so as to stay within their environments. Plant phenology assumes an important part in the dynamics of plant communities (Paritsis *et al.,* 2006) and involves the observation, recording and elucidation of the timing of their life history events (Fenner, 1998). A formative relationship relating vegetative and flowering phenology entail with the intention of we cannot infer a particular trait allied with phenology as the conclusion of range pressures acting exclusively on one aspect of phenology (Diggle, 1999). Herbaceous vegetation characterizes a key component in sub-temperate forests and *Pinus roxburghii* (Chir Pine) being a chief conifer in the Himalayas, bears an open canopy harboured more herbaceous biomass. The seasonal timing of flower assembly is a vital event in the life cycle of angiosperms (Rathcke and Lacey, 1985). A perennial species may be an indication for a wide-ranging flowering pattern inclined by growth situation, competition, and consumer pressures across seasons (Inouye *et al.,* 2002). The temperature, photoperiod and rainfall are the ambient variables and are the most important for persuading phenological events in plant development (Hamann, 2004). This study of the timing of drifting biological activities of plants is very imperative to know about plant's continued existence and its reproductive success. Reproductive phase is relied upon to oscillate spatially with environmental circumstances that amend microclimate, specifically temperature (Spano *et al.,* 1999). Prescribed fire is an imperative managing and reinstatement action in an assortment of environment worldwide, particularly in ecosystems that are fire reliant and that have experienced frequent fire repression (Szeicz and MacDonald, 1991; Wolf, 2004). In any case, the influence of local ecological drivers such as the biochemical concerto of soil, as well as usual or human-induced disturbances such as forest fires and destruction of habitats, in regulating phenology are still scantily understood (Cardoso *et al.,* 2012; Hagen *et al.,* 2012). Flowering is a standout amongst the most noteworthy phenological period to assess the affectability to climatic

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fluctuation (Sola and Ehrlen, 2007). The phenological pattern of different species in a community differs from each other. As a result in pursuance of structural and functional characteristics of ground vegetation comprehension of various phenophases of individual species is insistent to understand diverse multifaceted nature of the system. Thus the hypothesis was to examine due to fire, flowering will prompt earlier in contrast to the unburnt site and vegetative phenology will be greater on burnt site than the unburnt one.

Materials and methods

Study area

Geographically, the Garhwal Himalaya is one of the hot spots of biodiversity situated in the Western part of Central Himalaya. Uttrakhand Himalaya, a part of Indian Himalaya region is tranquil of two divisions called Garhwal and Kumaon Himalaya. The Garhwal Himalaya lies between the latitudes 29°26' to 31°28' N and longitudes 77°49' to 80°60' E with a total geographical area of 3000 km2 exhibiting submontane to alpine climates with distinct characteristics of the specific vegetation types. To document phenological diversity two permanent plots were marked one at Dandapani and other at Mandakhal (1850-2000masl) at Pauri (fig. 1) and observations were taken every month. Forest areas are categorized by two stratums, a woody layer dominated by *Pinus roxburghii* Sargent*,* in alliance with other woody species and a herbaceous stratum correspond to largely by species of Asteraceae, Cyperaceae and Poaceae. The topography is irregular with various uplands and depressions. The steepness is moderate to high in general. The area enjoys sub-tropical to a temperate climate with cool winter and pleasant summer.

Methodology

Several quadrats were fixed at the beginning and all the species from each quadrat were contemplated for six phenophases: germination, vegetative growth, flowering, fruiting, seed maturation and senescence of the individuals (Singh and Yadava, 1974). The germination stage includes seedlings up to 0.2cm high in monocots and intermediate stage between germination and floral initiation was considered as a vegetative stage (V). Blooming period is referred as a flowering stage (Fl). The developing seed stages were considered as a fruiting stage (Fr) followed by seed maturation stage (S) and finally senescence stage (Sn) representing the death of above ground plant parts. In case of grasses, an erect tiller was synonymous with the plant.

Results and discussion

The two plants into consideration *Arundinella nepalensis* and *Imperata cylindrica* both are perennials with life form cryptophyte (Cr) and Hemicryptophyte (He), respectively. The observations taken were qualitative, *i.e.* only presence and absence of the phenological phase were enlisted. The perception of blooming and fruiting occasions for the species sampled in every single one of the sub-areas empowered the examination of their reproductive phenology at the community level. It was feasible to find species flowering, fruiting, budding and shedding leaves throughout data collecting due to the diversified nature of grasses and results showed interesting comparisons for the same species on BPS and UPS. It was bring into being that phenological patterns alter due to soaring surface temperature, which has lead to a reallocate in phenological performance of plant species on BPS site. The germination of *Arundinella nepalensis* corresponds with winter and spring season while in case of Imperata cylindrica the germination corresponds with the summer season. In both the species flowering commence at the end of August and fruiting was also seen in between August and September, a similar result was also observed from the Garhwal Himalayas (Agrawal, 1990) and (Ragusa-Netto and Silva, 2007) from dry forests of western Brazil USA. This provides insight that reproductive phase corresponded to the rainy season and continued till winter season and again enhanced vegetative growth after resprouting during the summer season. The accelerated development on BPS was probably due to the increased and the consequential higher temperature isolation during the part of growing season

Table 1: Phenological Phases of *Arundinella nepalensis* and *Imperata cylindrica*

Species	LF	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Arundinella nepalensis Trinius	Cr	S, Sn, G	Sn, G, V	V	V	V	V	V	V	V, Fl	V, Fl	Fl, Fr	Fl, Fr, S
		(Fr, S)	(S, Sn, G)	(Sn, G, V)	(G, V)	(V)	(V)	(V)	(V)	(V)	(V, Fl)	(Fl, Fr)	(Fl, Fr, S)
Imperta cylindnica L.	He	S, Sn	Sn,V	Sn,V	Sn	Sn	G,V	G,V	G,V, Fl	V, Fl, Fr	V, Fl, Fr, S	Fl, Fr, S	Fr, S, Sn
		(Fr, S, Sn)	(S, Sn)	(S, Sn)	(Sn,V)	(Sn)	Sn	(Sn)	(G,V)	(G,V)	(V, Fl)	(Fl, Fr)	(Fl, Fr, S, Sn)

Table 2: Plant height, Leaf length, Leaf width and Reproductive events of *Arundinella nepalensis* Trinius and *Imperata cylindrica*

Name of the Species	Plant Height	Leaf Length	Leaf Width	Spike Length	Proportion of Clumps with Flowering culms (CF)	No. of Flowering per clump (FC)
Arundinella nepalensis Trinius	97.71±2.1 (92.42±1.1)	43.42±3.7 (36.42±1.7)	0.4±0.3 (0.3±0.1)	31.1±3.9 (28.1±3.4)	31 (25)	18 (15)
Imperta cylindnica L.	44.28±4.7 (40.28±2.7)	29.14±2.1 (22.14±2.0)	1±0.1 (0.7±0.1)	29.2±2.3 (23.2±2.2)	71 (68)	20 (18)

(Leith, 1974). During the study period, the research sites experienced soaring soil and atmospheric temperatures in the rainy season than the mean annual respective temperatures. Earlier similar prevalent assessments were also made by (Lechowicz, 1984; McGee, 1986). Fire similarly influenced the phenology of the two grass species contemplated which was similar to the findings of (White *et al.,* 1991) carried out in Pine forests of USA. Fruiting is less affected by fire as compared with the results of (Paritsis *et al.,* 2006) that ecological indications have fewer influence on fruiting commencement than on flowering onset. We suggest that the substantial increase in flowering after burning. Amplified flowering subsequent to fire has been observed in many species of grasses (Poaceae) and other monocotyledons (Gill 1981; Sapsis 1990). The effect of fire in the increased soil temperature results in prior emergence and earlier flowering (Kucera and Ehrenreich, 1962). The intended timing of fire has been used effectively in grassland restoration, although primarily where invasive species flowered in a diverse season than the native commune, so that fire can be premeditated to correspond with the vegetative and early reproductive growth of the invasive species, while most native species are at an arrest/ dormant (DiTomaso *et al.,* 2006). Though our study shows relatively shift of phenophases on burnt and unburnt sites. However shift in phenophases of *Imperata cylindrica* was comparatively more and diminish active states suggests eradication of this weed for future planning strategies. Likewise, the "ideal" instant of a growing season burn (*i.e.* the timing with the intention of effect of majority damage to the invasive species and the slightest damage to the native flora) is expected to change from year to year, and may eliminate some years completely, depending on precipitation patterns and temperature drifts (Ruckman *et al*., 2012). Our results unified that *Arundinella nepalensis* due to its fire resistant nature showed prolonged active phases while as *Imperata cylindrica* showed expedite active phases. Hence interesting fact, in this case, is that *Imperata cylindrica* stand in as a weed in some cases and can be inundated by the effect of fire.

Both the two species the maximum of spike length, Proportion of Clumps with Flowering culms (CF) and Number of Flowering per clump (FC) on BPS than UPS. Spike length for *Arundinella nepalensis* on BPS was (31.1±3.9) and on UPS (28.1±3.4). The value of CF and FC for *Arundinella nepalensis* on BPS was 31% and 18 respectively while on UPS CF and FC was 25% and 15. Spike length for *Imperata cylindrica* was comparatively less than *Arundinella nepalensis* but shows the same trend on BPS (29.2±2.3) and UPS (23.2±2.2). In case of *Imperata cylindrica* L. on BPS CF was 71% and FC while on UPS CF was 68% and FC was 18. In our study clumps mostly emerged in

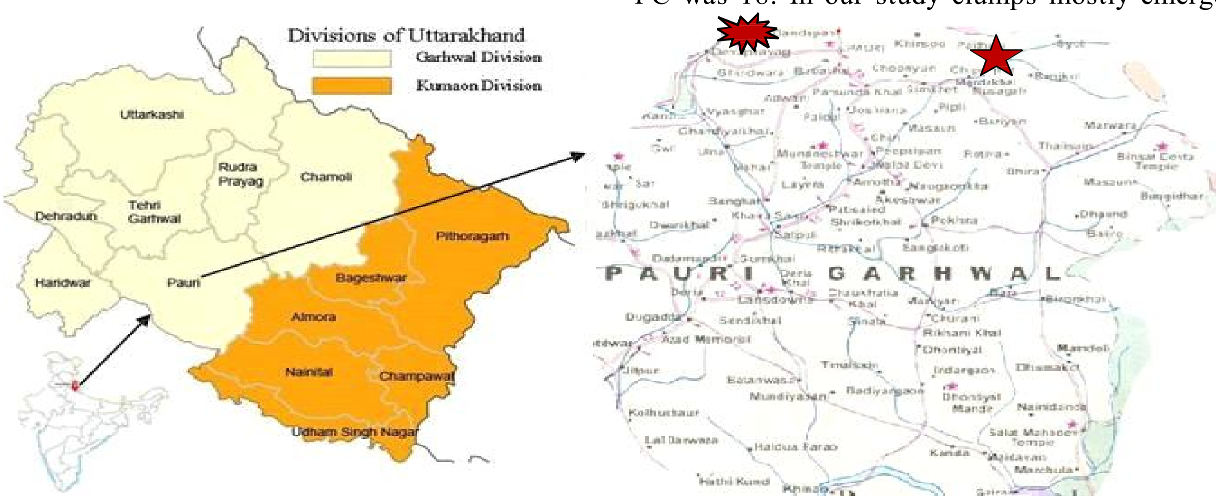


Fig. 1: Location of study area

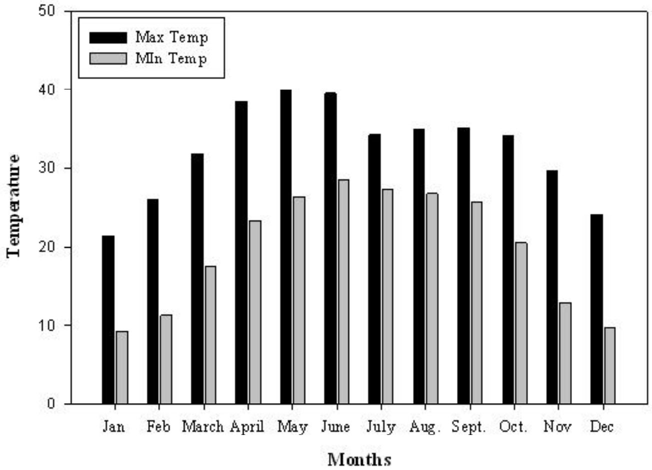
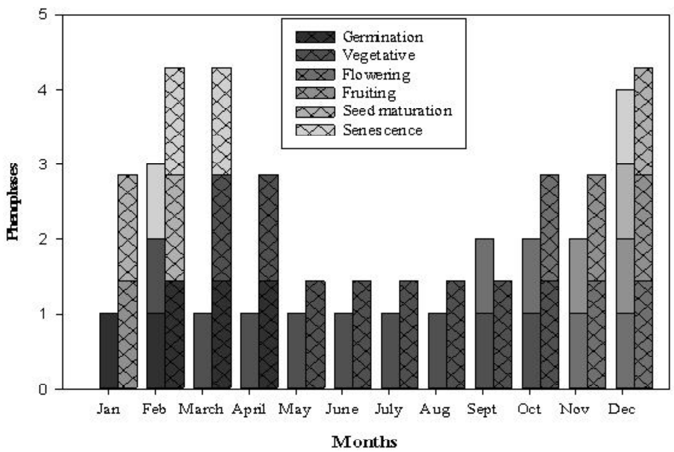


Fig. 2: Temperature recorded during study period (Maximum and Minimum)

Phenology studies, therefore, signify an essential step for construct the association among studies in fundamental and applied ecology. An enlarge in the recurrence of observation would be enthralling to improve our comprehension of conceivable variety in the beginning date and the length of the phenophases affected by fire (Alvarado *et al.,* 2014). To test if sporadic a longer-term study is needed, but present reproductive success among community rather explains the variable flowering phenology. The alternation in the phenology has prompted to the peculiar type of vegetation and phenological behaviour of different species in a community varies from each other. Plant phenophases at one area can anticipate harvest times for plants at another location and can provide better management in convention to the future climate.



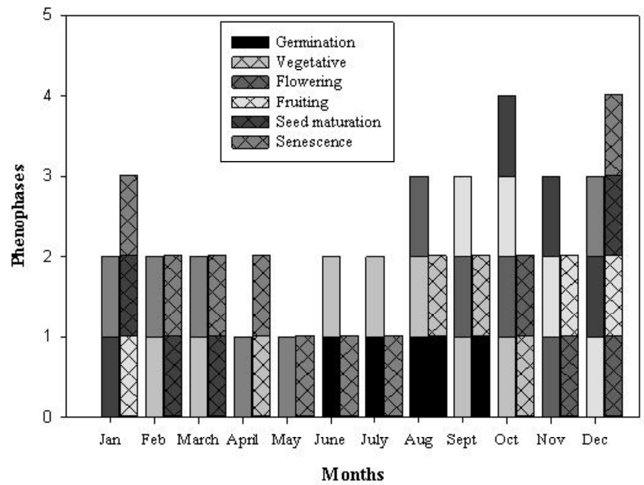


Fig 3 and 4: Graphs showing phenophases of *Arundinella nepalensis* and *Imperata cylindrica*.

between vegetative and blooming period during the rainy season, the same pattern of flowering clumps oscillation were also observed by (Ramanayake and Yakandawala, 1998) in *Dendrocalamus giganteus* Wall. ex Munro. Current records of CF and FC are mainly constrained in Bamboo species (Bhattacharya *et al.,* 2006; Franklin and Hogarth, 2008), interpretation and composing is yet to research for other species. The maximum temperature during study period was recorded as 39.54°C in June and minimum was recorded in December (9.8°C) represented in fig. 2. The phenological phases of both species are shown in table 1 and graphically represented in fig. (3 and 4) while as reproductive patterns of both species are shown in table 2:

Conclusion

Phenology is sensitive to climatic change or microclimate. Therefore, fire can fortify flowering and fruiting increment fruit product creation or potentially quicken the phenological sequence by shifting the beginning date of blooming/fruiting (Paritsis *et al.,* 2006).

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