academicJournals

Vol. 7(8), pp. 331-338, August 2013
DOI: 10.5897/AJPS12.084
ISSN 1996-0824 ©2013 Academic Journals
http://www.academicjournals.org/AJPS

African Journal of Plant Science

Full Length Research Paper

Shoot growth behaviour of selected trees and shrub species along an altitudinal gradient in Kumaun Himalaya, India

Sanjay Kumar* and Lalit M. Tewari

Department of Botany, D. S. B. Campus, Kumaun University, Nainital-263002, India.

Accepted 29 May, 2013

This paper reports on the shoot diameter and shoot elongation of common 10 trees and 9 shrubs species of 6 natural forests occurring between 350 to 2500 m in Kumaun Himalaya. The findings indicated that over 90% shoot elongation was accomplished prior to the commencement of rainy season in a majority of species. The average values of diameter increment were similar for canopy and subcanopy species and it was markedly higher for open grown deciduous species. In shrubs, it was higher for deciduous species. The relationship between the shoot length and shoot diameter in all species was positive and significant.

Key words: Kumaun Himalaya, shoot length, shoot diameter.

INTRODUCTION

Competitive advantages and limitation of plant growth under different environmental conditions are still poorly understood. It is very important to find out the phenological adaptation of the forest community as a whole, the reactions and adaptations of trees to varied environmental condition and adaptations of trees to varied environmental condition and occupancy of successional niche against the ecological background to understand the ecosystem function. The amount of growth and its seasonal variation caused by environ-mental factors have been mostly studied for temperate trees (Zimmerman and Brown, 1974; Reed, 1980; Pietarinen et al., 1982; Zobel, 1983). Temperature is the most important of the environmental factors regulating phenophases and the whole annual cycle of the plant (Hari, 1972; Anderson, 1974; Reader, 1975; Zobel, 1983). Information on shoot growth of tropical and subtropical trees is scanty. The tree and shoot growth have been mostly studied for Eastern and Kumaun Himalaya (Boojh and Ramakrishnan, 1982a, b; Ralhan, 1985; Negi, 1989).

MATERIALS AND METHODS

Site description

The study area involved six Kumaun Himalayan forest sites located between 29° 10' to 29° 40’ N and 79° 21' to 79° 43’ E at elevations ranging from 350 to 2500 m and covering the following six forest types: Tilonj-oak, Banj-oak, Oak-mixed broadleaf, Mixed broadleaf, Pine mixed with Sal and Sal (Figure 1).

Climate

Mean meteorological data for the town of Nainital, for the years 2008 to 2009 indicate that the year may be divided into three distinct seasons: rainy (mid-June to September), winter (October to March) and summer (April to mid-June). Mean monthly maximum temperatures range from 14°C in November to 30°C in May; mean monthly minimum temperatures from -2°C in January to 16°C in October and mean monthly rainfall ranges from 4 mm in December to 611 mm in August (Figure 2a). The winters are severe and frosts and are common from December to February. Mean meteorological data for sites lying outside the Nainital

*Corresponding author. E-mail: sanjay14_kumar@yahoo.in

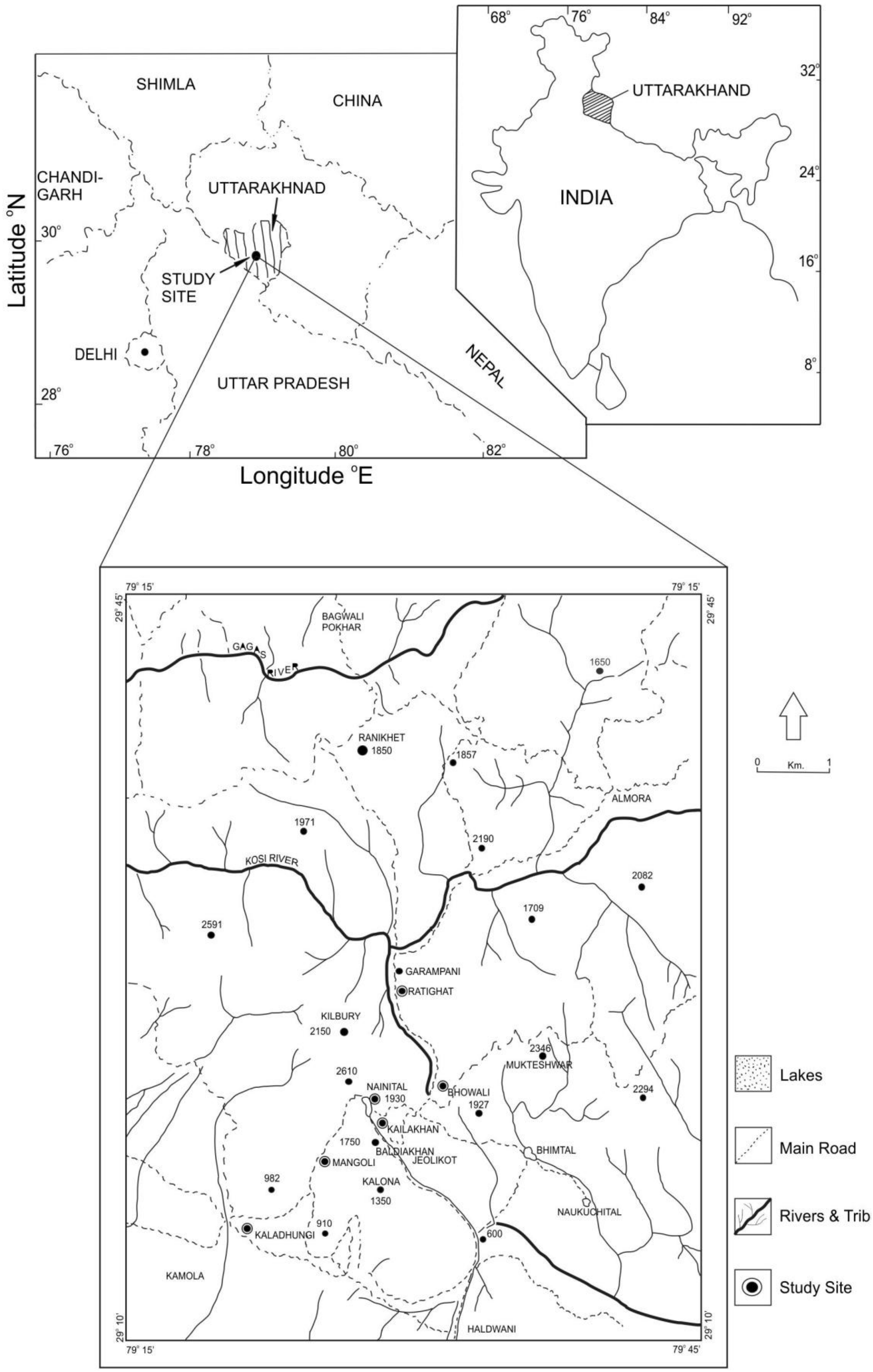

Figure 1. Location map of the study area.

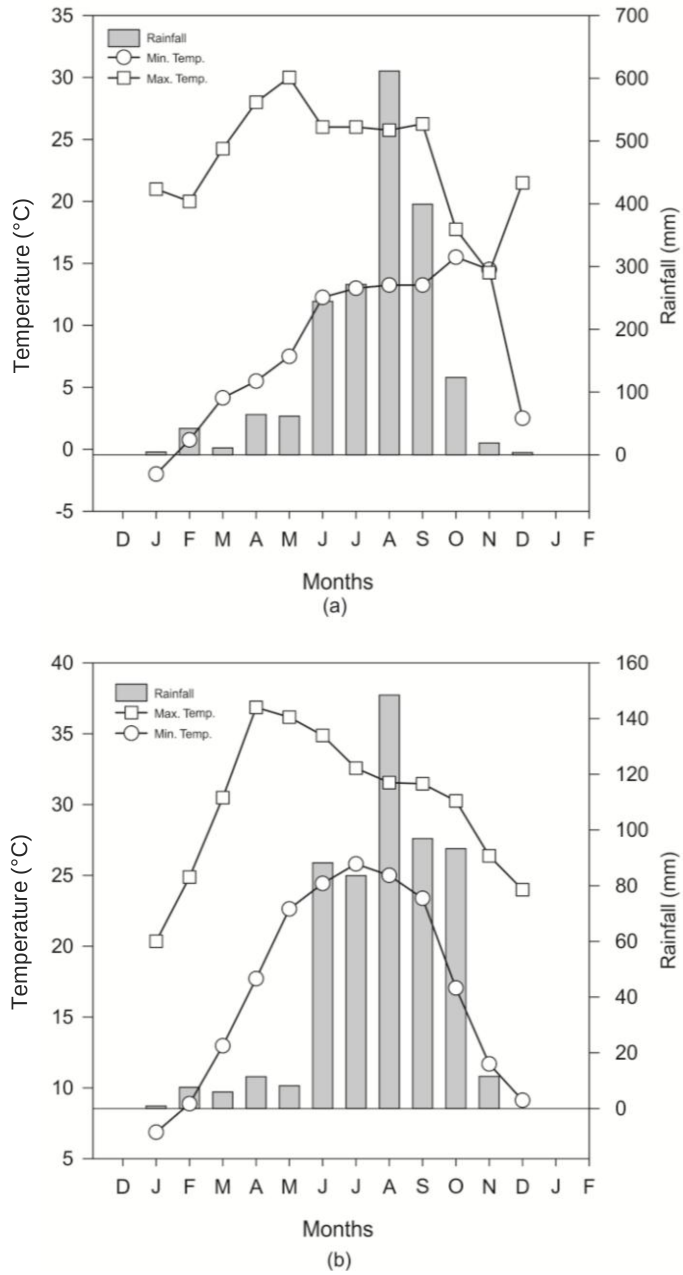

Figure 2. Mean monthly meteorological data of high altitude (ARIES) (a), and lower altitude (O/I Agrometerological observatory, Pantnagar) (b).

catchment indicate that mean monthly maximum temperatures range from 20°C in January to 36°C in May; mean monthly minimum temperatures from 7°C in January to 26°C in July and mean monthly rainfall ranges from 1 mm in January to 148 mm in August. Also, temperatures increase with decreasing elevation (Figure 2).

At each forest site, 1 ha permanent plot was established. Within 1 ha permanent plot of each of the selected forest sites, ten individuals of each of the canopy, subcanopy and shrub layer species were randomly selected for measuring seasonal shoot elongation and diameter changes. One healthy lateral branch from each stratum namely, upper, middle and lower was marked. To assess the shoot elongation, the distance from the mark to the end of the shoot was measured to the nearest millimetre approximately fortnightly starting from late winter of 2007 for a period of two years. The diameter changes for marked branches were measured by vernier calliper in two directions at right angle to one another to compensate, to extent, for any eccentricity in the shoots. The observations for diameter changes were made each month at approximately the same time of the day on each reading date to reduce effect of thermal expansion and hydration from March 2008 to August 2009. The species considered for this study are

Table 1. Site and species characteristics.

Forest type	Elevation (m)	Site	Selected Species	
			Trees	Shrubs
Tilonj-oak forest	1900-2200	Nainital	*Ilex dipyerna* Wall (subcanopy) *Acer oblongum* Wall. ex. D.C. (open-grown)	*Berberis asiatica* Roxb. ex DC. *Berberis chitria* Edwards *Myrsine africana* L. *Viburnum cotinifolium* D. Don
Banj-oak forest	1700-2000	Kailakhan	*Quercus leucotrichophora* A. Camus (canopy) *Myrica esculenta* Ham. ex D. Don (subcanopy) *Rhododendron arboreum* Smith (subcanopy)	*Daphne cannabina* Wall. *Rubus ellipticus* Smith *Debregeasia salicifolia* (D.Don) Rendle
Oak-mixed broadleaf forest	1600-1700	Bhowali	*Prunus cerasoides* D.Don (agro-forest)	*Indigofera heterantha* Wall. Ex Brandis
Mixed broadleaf forest	1000-1100	Ratighat	*Bauhinia variegata* Linn. (agro-forest)	
Pine mixed with Sal forest	900-1200	Mangoli	*Pinus roxburghii* Roxb. (canopy)	*Woodfordia fruticosa* (L.) Kurz
Sal forest	400-900	Kaladhungi	*Shorea robusta* Gaertn (canopy) *Mallotus philippinensis* (Lam.) Muell.-Arg. (subcanopy)	*Murraya paniculata* (L.) Jack.

described in Table 1.

Results

Trees

Shoot elongation

In all tree species, shoot elongation began with the increase of temperature and photoperiod (after the winter season) with the exception of *P. cerasoides* which began to produce new shoots in November when both temperature and photoperiod were declining. On an average, the canopy species of forests reflected greater amount of shoot extension than their subcanopy counterparts (19 versus 11 cm). The average amount of shoot elongation for open grown species of natural environments was 21.18 cm. This value was little less than for the agro-forest species (29.79 cm). The amount of shoot elongation ranged between 8.45 cm in *M. esculenta* (a subcanopy forest species) to 44.21 cm in *B. variegata* (an agro-forest species). The average amount of shoot elongation was markedly greater for deciduous (29.79 cm) and semi-deciduous species (20.11 cm) than for the evergreen species (14.35 cm) (Figure 3).

Shoot diameter

Of the total diameter increment, the percentage realized in one month of bud-break ranged between 62.54% in *A. oblongum* to 82.94% in *P. roxburghii*. The average value of shoot diameter was maximum (73%) for the subcanopy forest species and minimum for open grown species (63%). A value comparable to that of the subcanopy forest species was also realized by canopy species of forests (72%). The average value of shoot diameter was maximum (73%) for the subcanopy forest species and minimum for open grown species (63%). A value comparable to that of the subcanopy forest species was also realized by canopy species of forests (72%). Distribution of species in different diameter increment classes are listed as follows: 3 to 4 mm - *R. arboreum*; 4 to 5 mm - *S. robusta*, *Q. leucotrichophora*, *P. cerasoides*, *M. esculenta*; 5

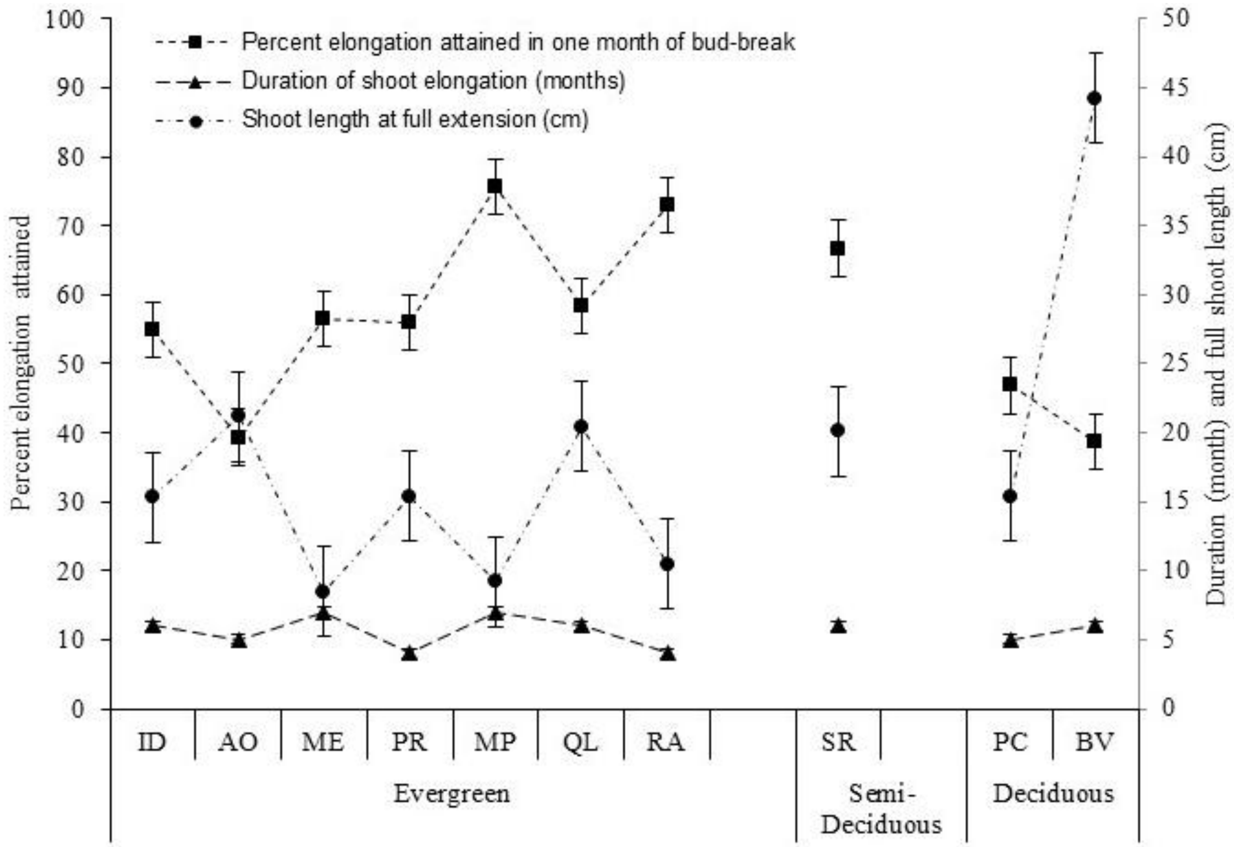

Figure 3. Periodicity and rate of shoot length growth in tree species where ID = I. *dipyrena*, AO = *A. oblongum*, ME = *M. esculenta*, PR = *P. roxburghii*, MP = *M. philippinensis*, QL = *Q. leucotrichophora*, RA = *R. arboreum*, SR = S. *robusta*, PC = *P. cerasoides*, BV = *B. variegata*.

to 6 mm - *I. dipyrena*, *A. oblongum*, *B. variegata* and *M. philippinensis*. *P. roxburghii* showed markedly high value among all the deciduous species (18.52 mm) among the evergreen species.

The average values of diameter increment were similar for canopy (4.96 mm; excluding *P. roxburghii*) and subcanopy (5.25 mm) species of natural forest community. It was markedly higher for open grown deciduous species (6.22 mm) (Figure 4).

Shrubs

Shoot elongation

The average values of diameter increment were similar for canopy (4.96 mm; excluding P. roxburghii) and sub-canopy (5.25 mm) species of natural forest community. It was markedly higher for open grown deciduous species (6.22 mm). The amount of shoot elongation ranged between ranged between 15.18 cm in *V. cotinifolium* (a deciduous species) to 25.46 cm in R. ellipticus (an evergreen species). The average amount of shoot elongation was markedly greater for evergreen species (19.33 cm) than for the deciduous species (16.75 cm). Most of the fully elongated shoots had the length between 15 to 18 cm in deciduous species and less than 21 cm length in most of the evergreen species (Figure 5).

Shoot diameter

Of the total diameter increment, the percentage realized in one month from bud-break ranged between 44.52% in *R. ellipticus* to 69.56% in *V. cotinifolium*. The average value of shoot diameter was maximum (66%) for the deciduous species and the minimum for evergreen species (58%). Distribution of species in different diameter increment classes are listed as follows: 3 - 4 mm - *M. paniculata*, *R. ellipticus*; 4 - 5 mm – *M. africana*, *B. asiatica*; 5 - 6 mm - *W. fruticosa*, *V. cotinifolium*; 6 - 7 mm *D. salicifolia* and *B. chitria* (Figure 5). The average values of diameter increment were higher for deciduous species (6.75 mm) than the evergreen species (5.08 mm) (Figure 6). The amount of shoot elongation of studied tree and shrub species was found significantly related to temperature (Figure 7a and b).

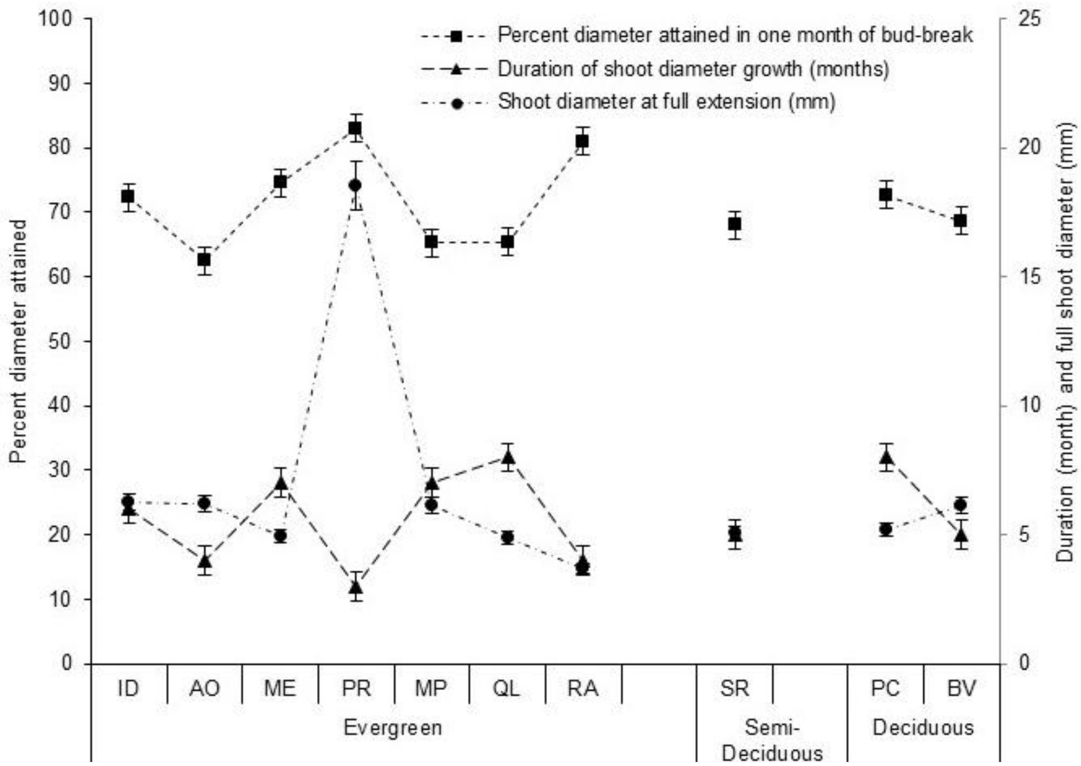

Figure 4. Periodicity and rate of shoot diameter growth in tree species where ID = *I. dipyrena*, AO = *A. oblongum*, ME = *M. esculenta*, PR = *P. roxburghii*, MP = *M. philippinensis*, QL = *Q. leucotrichophora*, RA = *R. arboreum*, SR = *S. robusta*, PC = *P. cerasoides*, BV = *B. variegata*.

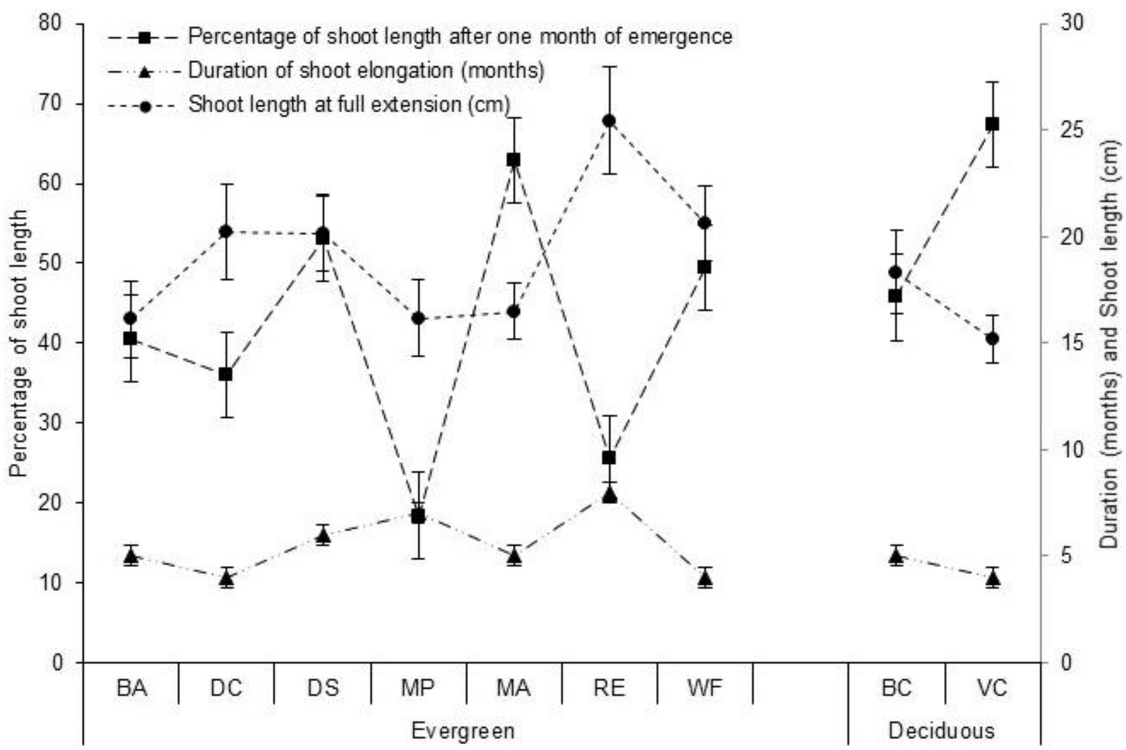

Figure 5. Periodicity and rate of shoot length growth in shrub species where BA = *B. asiatica*, DC = *D. cannabina*, DS = *D. salicifolia*, MP = *M. paniculata*, RE = *R. ellipticus*, WF = *W. fruticosa*, BC = *B. chitria*, VC = *V. cotinifolium.*

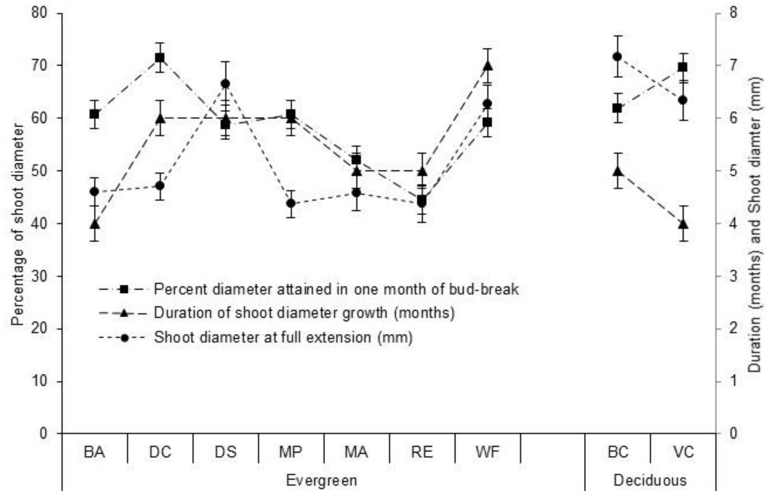

Figure 6. Periodicity and rate of shoot diameter growth in shrub species where BA = *B. asiatica*, DC = *D. cannabina*, DS = *D. salicifolia*, MP = *M. paniculata*, RE = *R. ellipticus*, WF = *W. fruticosa*, BC = *B. chitria*, VC = *V. Cotinifolium*.

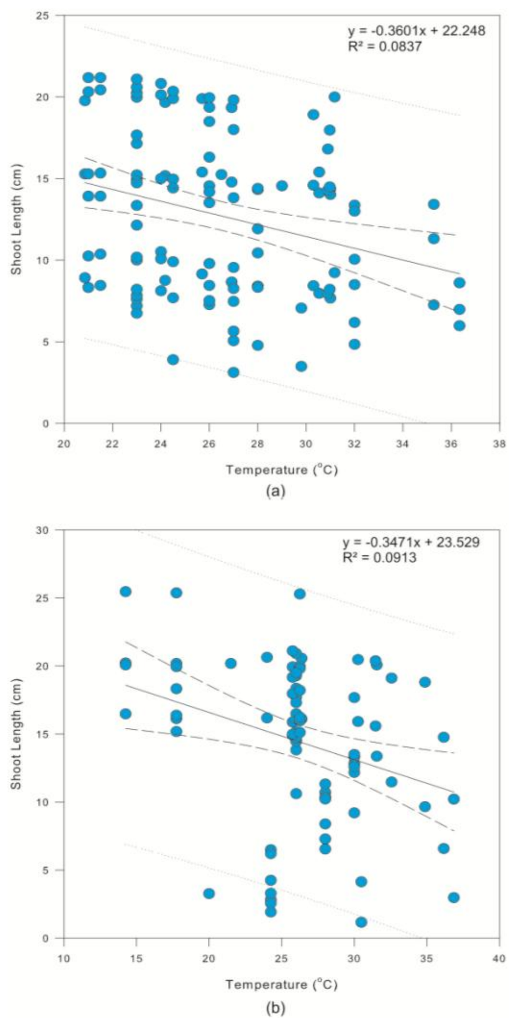

Figure 7. Relationship between temperature (°C) and shoot length growth of tree species (a) and shrub species (b).

Conclusion

Majority of the species studied followed a unimodal pattern of growth, that is, peak extension growth being in the summer season (April to June). Height growth of many temperate zone species is completed relatively early in the season and often long before the drought of mid-summer and late-summer (Kienholz, 1941; Kozlowski, 1971a).

Interestingly, in this montage region of subtropical latitudes where climate is governed by the monsoon pattern of rainfall, the late summer (July to mid-September) is wet, yet most of the shoot extension is either before the onset of wet summer season or in the middle of the wet summer season. This phenological strategy which involves maximum production of shoots and hence, the foliage prior to the onset of rainy season enable the species to utilize maximally the most favourable growth condition of rainy season (with regard to moisture and temperature). Thus, the late summer season which is wet, is responsible for a longer favourable period for plant productivity in this region, compared to that in temperate region.

REFERENCES

Anderson RC (1974). Seasonality in terrestrial primary producers. In: H. Lieth (ed.). Ecological Studies: Phenology and Seasonality Modelling. Springer-Verlag. Berlin Heidelberg. New York: pp.103-112.

Boojh R, Ramakrishnan PS (1982a). Growth strategy of trees related to successional status. I. Architecture and extension growth. For. Ecol. Mgmt. 4:359-374.

Boojh R, Ramakrishnan PS (1982b). Strategy of trees related to successional status. II. Leaf dynamics. For. Ecol. Mgmt. 4:375-386.

Hari P (1972). Physiological stage of development in biological models of growth and maturation. Ann. Bot. Fenn. 9:107-115.

Kienholz R (1941). Seasonal course of height growth in some hardwoods in connecticut. Ecol. 22:249-258.

Kozlowski TT (1971a). Growth and Development of Trees. Vol. I. Academic Press, New York.

Negi GCS (1989). Phenology & Nutrient dynamics of tree leaves in Kumaun Himalaya. Ph.D Thesis. Kumaun University, Nainital.

Pietarinen I, Kanninen M, Hari P, Kellomaki S (1982). A simulation model for daily growth of shoots, needles, and stem diameter in scots pine trees. For. Sci. 28(3):573-581.

Ralhan PK (1985). Phenology of plants in forest ecosystem of Kumaun Himalaya. Ph.D. Thesis, Kumaun University, Nainital.

Reader RJ (1975). Effect of air temperature on the flowering date of dogwood (*Cornus florida*). Can. J. 53:1523-1534.

Reed KL (1980). An ecological approach to modeling growth of forest trees. For. Sci. 26(1):33-50.

Zimmerman MH, Brown CL (1974). Tree structure and function. Springer-Verlag. Berlin Heidelberg, New York. p. 336.

Zobel DB (1983). Twig elongation patterns of *Chamaecyparis lawsoniana*. Bot. Gaz. 144(1):92-103.