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Effect of nutrient application on some central Himalayan species from a successional gradient

K. BARGALI and S. P. SINGH
Department of Botany, Kumaun University, Nainital 263002, India

Abstract. In present study effect of nutrient application have been observed on some early and late successional species of Central Himalaya. For this, seedlings of three early and three late successional species were raised in polythene bags containing 3:1 mixture of sand and soil. After establishment, seedlings were kept under six nutrient levels. In general, maximum production levels were greater for early successional species than they were in late successional species. Root:shoot ratio were greater for late successional species while leaf weight ratios were greater for early successional species. With increasing nutrient availability, root:shoot ratio decreased and leaf weight ratio increased.

Key words: Root:shoot ratio, *Fraxinus micrantha*, *Pinus roxburghii*, *Quercus leucotrichophora*, *Q. floribunda*.

Introduction

Grime (1977) has given evidence for the existence of three primary strategies in plants viz., competitive strategies, stress tolerant strategy and ruderal strategies. Significance of these strategies was also analysed in view of the successional courses that occur in different environments. Parameters such as growth rate, dry matter allocation to leaf and reproductive structures, root shoot ratio, leaf weight ratio under different enviromental conditions and response breadth on different environmental gradients have been used to idenfity these strategies (Grime 1977; Zangerl and Bazzaz 1983; Rao and Singh 1989). In Grime's (1977) frame work of plant strategies it is implied that the various species assigned to one category would respond in similar fashions to various forms of stress. For example, the stress-tolerant species would show limited changes in morphology in response to stress caused by shade, or nutrient-deficiency or moisture stress.

The objectives of this study were firstly to provide date on the effect of nutrient on some Central Himalayan tree seedlings which have developed in environments characterised by frequent and unpredictable disturbances (Singh and Singh 1992). A secondary objective was to test whether or not a species tolerant of one kind of the stress (e.g. deficiency in soil moisture or shade) responds in a fashion similar to that suggested for stress tolerant species Grime (1977) when subjected to stress caused by another factor. This is the nutrient stress in present study.

Materials and Methods

All the six species (*Acer oblongum* Wall. Ex D.C., *Fraxinus micrantha* Lingelsh, *Pinus roxburghii* Sarg., *Quercus leucotrichophora* A Camus, *Q. floribunda* Lindl. and *Aesculus indica* Calebr.) selected for the study are native to Kumaun Himalaya and commonly occur around 2,000 m (Campion and Seth 1968; Rao and Singh 1989). The climate is characterised by a mean annual temperature of about 15˚C and an annual rainfall of about 2400 mm of which nearly three-fourth occurs from the end of June to the end of September. The forest soils are generally rich in nutrients. The soil organic C, total N, available P and exchangeable Ca range between 0.88-5.04%, 0.07-0.38%, 0.004-0.009% and 8.62-15.92%, respectively (Singh and Singh 1992). The primary productivity in forests generally ranges ranges between 12.6 to 27.6 + ha yr in forest communities (Singh and Singh 1992). In view of the framework of basic plant strategies provided by Grime (1977), on the basis of successional status and performance along moisture and shade gradient Rao and Singh (1989) categorised these species into three category viz. 1. Late successional (*Q. leucotrichophora*, *Q. floribanda* and *A. indica*), 2. Early successional stress-intolerant(SI) (*A. oblongum* and *F. micrantha*), 3. Early successional stress-tolerant(ST) (*P.roxburghii*).

Soil used in this experiment was collected from a nearby *Q. leucotrichophora* forests to a depth of 15 cm. Soil was air dried and sieved through wire mesh size 1 x 1 mm to remove plant parts and gravel. After sieving this soil have 0.38% N, 0.10% P and 0.113% K. Soil was then mixed with washed fine commercial sand (with indetectable nutrients) in 1:3 ratio, and filled in polyethylene bags (2 kg per bag). Seedlings of all the species were raised from the seeds collected from the current year seed crop. After establishment two seedling per bag were maintained and subjected to six nutrient levels by adding 0, 144, 264, 384, 504 and 624 mg 20:20:20 NPK fertilizer per kg of soil. Plats were watered regularly. This experiment was carried out in a glass house where the mean minimum and the mean maximum temperature were 5˚C (December-January) and 36˚C (June), respectively during the study period. As many as 12 bags each containing two seedlings were placed under each nutrient level.

Height of seedlings from the ground level to terminal bud or shoot apex was measured at bimonthly intervals and measurements of 24 plants were averaget for each treatment. The dry weight of seedlings were estimated by harvesting 8 plants at an interval of 8 months from each of the treatment for each species and values were averaged. The different plant parts (root, stem and leaves) were dried at 60˚C in an oven for 48 hours and weighed. Leaf weight ratios were calculated on the basis of all the leaves produced during the study period including leaf shed.

Measure of response breadth was calculated using Levins Niche Breadth Metric (1968).

$$B = \frac{1}{S}$$

$$B = (Pi^2)S$$
$$I = 1$$

Where, Pi is proportion of seedling dry weight response in state i and S is the total number of states (treatments). The resulting measure B was a scale from 0 to 1, with 1 being the widest breadth.

Relative height and relative dry weight for a given species were calculated by dividing the values at lowest nutrient level by those in highest nutrient level.

Results and Discussion

Height growth and dry mass yield

Height growth (considering the maximum amount the values in different nutrient levels) of early successional stress-intolerant (SI) was higher than the late successional and early successional stress tolerant (ST) species. This is in conformity with Grime (1977) and Rao and Singh (1989). The height growth of the late successionals was similar to that of the early successional (ST) species (Table 1). However, dry mass of early successional ST species was higher than the late successional species as well as early successional SI species (Table 1). This is inconsistent with the trend towards the decrease in net primary production (Odum 1969) and lower net photosynthetic rates (Bazzaz 1979) as succession proceeds. In each species, dry mass increased with increasing nutrient level (Fig. 1). This indicates that the nutrient addition favoured dry mass production in seedlings. Relative height and dry mass indicate that increase in height as well as dry mass was greater for early successional species than late successional species (Table 1).

Response breadths

Response breadths of species on the nutrient gradient were wide in terms of height growth than in termsof dry mass (Table 1). The adverse effect of low nutrient as indicated by the relative height growth (height in lowest nutrient level divided by height in highest nutrient level) was lowest on late successional species and severe on early successional- SI. The early successional ST occupied an intermediate position from this standpoint (Table 1). A similar trend was found for the relative performances in terms of total seedling dry mass. However, response breadths were generally wider for early successional species than for late successional species (Table 1). This is in corformity with the findings of Paris and Bazzaz (1982 a,b), Rao and Singh (1989), Bardali (1992), which indicate relatively narrow response breadths for late successional species than for the early successional ones.

Height : stem dry weight ratio

The height:stem dry weight ratio for all species decreased with increasing nutrient level (Table 2). This indicates that addition of nutrient favoured dry mass production more than height increment. Early successional stress intolerant SI species showed maximum height:stem dry weight ratio followed by late successional species (Table 1). The early successional stress tolerant species showed minimum height:weight ratio (Table 1). However, relative stem height:weight ratio were almost similar for all the three categories (Table 1).

Parameter	Late successional	Early successional	
		Stress-int.	Stress-tol.
Heigh (cm)	42.61 ±3.86	49.26 ±5.15	44.12 ±4.05
Dry weigh (g)	15.05 ±0.73	15.16 ±0.67	15.82 ±0.82
Leaf weigh ratio (LWR)	0.375 ±0.05	0.521 ±0.02	0.515 ±0.02
Root : Shoot ratio	1.385 ±0.14	0.520 ±0.01	0.612 ±0.04
Stem heigh/stem dry weigh (cm/g)	3.566 ±0.18	4.14 ±0.55	3.20 ±0.01
Relative heigh	0.438 ±0.01	0.421 ±0.02	0.385 ±0.01
Relative dry weight	0.349 ±0.03	0.330 ±0.01	0.335 ±0.01
Relative leaf weight ratio	0.619 ±0.02	0.651 ±0.03	0.792 ±0.01
Relative root : shoot ratio	1.967 ±0.28	1.498 ±0.04	1.691 ±0.01
Relative stem height/stem dry weight	1.266 ±0.09	1.277 ±0.04	1.149 ±0.02
Response breadth for height	0.924 ±0.03	0.924 ±0.02	0.891 ±0.00
Response breadth for dry weight	0.844 ±0.02	0.867 ±0.02	0.853 ±0.01

Table 1. Average values of certain parameters for different categories of species in relation to nutrient effect. Values for height, dry weight, leaf weight ratio, root:shoot ratio and stem height per unit stem dry weight represent the average of the maximum values obtained among the different nutrient levels. Relative values are the values in lowest nutrient level divided by those in highest nutrient level.

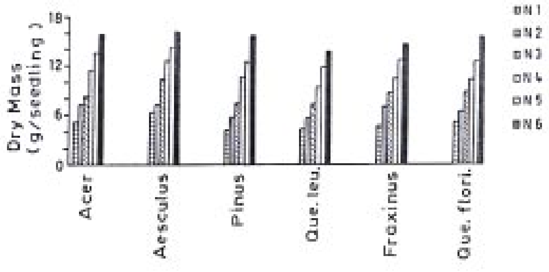

Fig. 1. Dry mass of seedlings (g/seedling) as affected by nutrient addition (nutrient level increases from N1 to N6 nutrient level).

Leaf weight ratio and Root : Shoot ratio

The higher leaf weight ratios (LWR) (0.312-0.541) and lower root:shoot ratios (0.343-0.612) for early successional species than late successional species (Table 2) were consistent with earlier findings (Abrahamson 1979; Rao and Singh 1989; Bargali 1992, 1993). The early successional species with small seeds are known to have higher LWR than large seed bearing late successional species (Rao 1988; Bardali and Singh 1995). Late successional competitive species are known to have higher root:shoot ratios (Ricklefs 1980; Rao and Singh 1989) and early successional tree species displayed a ruderal character. With increased nutrient availability, the leaf weight ratio increased while the root : shoot ratio decreased (Table 2). These results support the general hypothesis proposed by Davidson (1969 a,b), that photosynthate is partitioned to roots in inverse proportion to their functional activity, thus providing a balance the work done by roots and by leaves.

In general, the results of present study are in conformity to previously established successional trends (Bargali 1992; Bargali and Singh 1995, 1996). Maximum production levels were greater in early successional species than they were in late successional species. However, as the seedlings of a species may show adaptations to a wider range of environments, thereby exhibiting mixture of attributes given to more than one primary strategies. For example, some of the late successional species showed ruderal strategies (wider response breadth on the nutrient gradient) in addition to competitive strategies and early successional species showed competitive strategies (reduction in root : shoot ratio in nutrient-rich condition) in addition to tolerant strategies. These results suggest that response of species assigned to one category can change in response to nutrient availability.

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Species	Leaf weight ratio (in dry weight terms)						Root:shoot ratio (in dry weight terms)						Stem height per unit stem dry weight (cm.g^{-1})					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Late successional																		
Q. leucotrichoph.	0.22	0.23	0.25	0.27	0.32	0.34	1.67	1.26	1.11	0.87	0.73	0.69	3.88	3.19	2.80	2.61	2.56	2.80
Q. floribunda	0.21	0.22	0.23	0.25	0.26	0.32	1.23	1.03	0.99	0.90	0.88	0.84	3.55	3.14	2.57	2.74	2.83	2.68
A. indica	0.27	0.33	0.39	0.41	0.41	0.47	1.26	1.05	0.93	0.88	0.72	0.63	3.27	3.85	3.08	3.33	3.24	2.99
Early successional-SI																		
A. oblongum	0.37	0.38	0.41	0.42	0.43	0.54	0.53	0.47	0.47	0.40	0.38	0.34	4.69	4.29	4.64	3.94	3.78	3.56
F. micrantha	0.31	0.33	0.37	0.41	0.46	0.50	0.52	0.49	0.43	0.44	0.38	0.35	3.60	2.86	2.64	2.91	3.01	2.91
Early successional-ST																		
P. roxburghii	0.41	0.42	0.43	0.48	0.50	0.52	0.61	0.58	0.51	0.43	0.40	0.36	3.20	3.33	3.01	2.68	3.02	2.79

Table 2. Average ratio among certain plant components of the species on the nutrient gradient. Nutrient level increase from 1 to 6.

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