

ECOLOGICAL IMPLICATION OF PLANT TRAITS, STRATEGIES AND COMPETITIVE ABILITIES OF HERBS

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Abstract. Natural selection generally favors plants whose forms and physiology tends to maximize their net rate of growth, because plant uses resource to reproduce and compete for additional space. Above ground characteristics of a plant often greatly affect its competitive abilities and population dynamics rather than below ground because drymass of a plant depends on leaf strategy, where as root in the top soil is responsible for exploitation, competition through depletion of a common pool of resources so fine roots are also important. The use of root/shoot ratios to describe allocation of dry weight to structures for capturing soil resources and light is limited due to other functions of the root and shoot such as storage and support. Dry matter allocation, specific leaf area, root length and different ratios were determined for 17 herb species by extraction of soil cores from an intact forest. Interspecific values of RLA were considered. It has been hypothesized that the co-variation among species in leaf trait and other morphological adaptations particularly leaf and growth rate reflects a set of mutually supporting traits that interact to determine plant identity in similar climatic conditions.

Keywords: *Herbs, above ground characteristics, dry matter allocation, SLA, RLA, root length, root: shoot ratio*

Introduction

The recognitions in ecology of the significance of individual species level of reduction or what species do in ecosystem is important [21]. Although, It is well recognized that plant species differ in taxonomic status and ecological strategy [7, 17]. The presence of a plant species in a forest community is determined by many ecological traits of the target species, as well as those of surrounding species as its competitors [19] because of species interacts with both its biotic and abiotic environments [35, 36]. Both biotic and physical factors determine the growth of plant species in any habitat and the composition of plant communities. The relative importance of these two categories of factors may vary with the successional position of the community and the time scale in which it is considered. Perhaps so the fundamental niche of a species in the contribution and resources allow the species to maintain viable population [4]. Parrish and Bazzaz (1982) [26] also have observed that physical factors such as disturbance, creates, have shaped the niches of early successional species, and biotic factors, including competition have relatively more impact on the evolution of niches of successional species.

Earlier, Hall (1974) [11] stated that the growth of plants in a multi-specific community is typically influenced in some or all stages of development by biological and physical processes which are frequently due to competition, which results in physical effects. Variation in relative competitive abilities among environments has been proposed to control the species composition of plant communities. Since the relative performance of different species in any given interaction in a given environment is governed to a large degree by plant traits [6, 16], a logical extension of the comparative approach is the utilization of plant traits across several species for predicting species performance [34]. A major spectrum of variation runs between species with traits that favor nutrient conservation and those with traits that allow rapid short term growth [39]. Wilson and Tilman, (1995) [38] stated that within any given habitat, species with a range of leaf traits may coexist.

Few experimental studies have succeeded in partitioning the effects of roots and shoot competition in an intact sward [8]. However, Tilman (1988) [32] assumed that the competition intensity is unaffected by plant productivity though the ratio of above ground to belowground varies and further he stated that root/ shoot ratio may be used to quality allocation to structure for capturing light and soil resources, but this does not focus the other functions of both the root and shoot such as storage and support system. Much attention has been directed towards the edaphical nature of energy allocation pattern in plant under various environmental studies. The distribution of biomass among the vegetative parts is also subject to variation [1] suggested that the pattern of allocation will depend on the nature of the living factor.

The purpose of the present study was to investigate through using a range of 17 herbaceous plant species of several ecophysiological traits measured for each of the species, the degree to which the various types of interactions outlined above were related to particular traits, and which combinations of traits may have potential for preceding outcomes of interactions involving plant species and the ultimate goal was to investigate the range values of root length/ leaf area ratios for number of representative species growing at study site.

Materials and methods

Study site

The samples were taken from the evergreen oak (*Quercus leucotrichophora*) forest at 2200m altitude with 29° 23' N latitude and 79° 26' -79° 27' E longitude with south facing slope.

Oak forest soil is residual brown earth with acidic pH-6, 4.5% carbon, 0.5% nitrogen content and 56-79% water holding capacity The annual rainfall is 248 cm of which 75% occur in rainy season, Mean daily temperature ranges from 7.8 to 21.20°C (Poonam Mehrotra, 1998).

Herb species were selected for the detailed study on the basis of their high density (> 4.0 plants/ m²) at the site (Poonam Mehrotra 1988), following Misra (1968). Plant species characteristics were sampled during the first week of October (peak of growing season) and ten individuals were randomly sampled for each species. The plants were carefully excavated from the surroundings and separated into different components viz., belowground, main root, fine roots, stem, leaves, and fruit / flower. Each component was dried at 800°C until constant weight and weighed.

The categorization of forms in different growth forms, except fern and sedge, species were categorized into different growth forms following Givnish (1987); Poonam Mehrotra (1998) [13, 28]. The categorization was based on the appearance of aerial stem, presence of branching, lateral branching and foliar arrangement on supporting systems—1.- Erect form: Attains peak growth after summer. Here the plant has scattered leaves along a vertical, indeterminate axis and finally have a multilayered crown. 2.- Basal form: These plants have very short aerial shoot; leaves emerge near the ground level with well developed petioles. 3.- Arching form: This growth form differs from erect ones in having a long arching stem and is present generally at hill slopes with acute slope angle. 4.- Sprawling mat: these are characterized by small leaves placed in close proximity to the ground surface. 5.- Umbrella forms: Species arrange thin foliage in a variety of umbrella like structures including branching and lateral branching. 6.- Special umbrella form; this is slightly different to that of umbrella growth form. In them, an umbrella is formed by compound leaves which are directly attached to with the stem through minute petioles.

Results

Seventeen herb species at the site were studied. *Artemisia nilagirica* var. *septentrionalis* (Clarke) (Pamp.), *Arisaema concinnum* (Schott), *Gerbera gossypina* (Royle) (G. Beauv.), *Onychium cryptogrammoides* (Wall. ex Hope), *Anemone vitifolia* (Buch.-Ham) (DC.), *Calamintha umbrosa* (Linn.), *Carex cruciata* (Wahlenb), *Thalictrum foliolosum* (DC.), *Cnicus argyranthus* (Clarke), *Geranium wallichianum* (D.Don), *Strobilanthus alatus* (Muell.-Arg.), *Sonchus asper* (Garsault), *Valeriana wallichii*. (DC.), *Ainsliaea aptera* (D.C.), *Roscoea procera* (Wall.), *Hedychium spicatum* (Smith) and *Aralia cachemrica* (Decne).

These herb species showed a wide range of taxonomic placements as well (Table 1) i.e. from primary family Ranunculaceae to Asteraceae an advanced family in dicots and Aracaceae and Zingiberaceae in monocots. These species varied in leaf longevity i.e., *Arisaema*, *Roscoea* were among the deciduous habit and others like *Aralia*, *Artemisia*, *Cnicus* *Strobilanthus*, *Gerbera*, *Sonchus*, *Valeriana* approaching towards the evergreen habit (leaf life span <310 days) [28]. These seventeen herbs belonged to different growth forms. (Table1). Four herbs belonged to erect form, seven to basal, and two to umbrella one each to arching, special umbrella, sedge and fern growth forms respectively.

Percent allocation of drymass in different components

Givnish, (1987) stated that the allocation of dry mass of a plant depends on leaves strategy because leaf provide outstanding opportunities for competitive studies and their extraordinary variation in form, physiology and phenology have implications for not only carbon exchange but also water loss, allocation to above vs. below ground tissues, interactions with competitors and whole plant growth.

It had been observed that herbs which like shady places differed from the others in having a greater proportion of their dry weight (above 60%) in above ground parts. i.e., *Arisaema*, *Calamintha* *Strobilanthus*, *Roscoea*, *Geranium* with the exception of *Hedychium* and *Onychium* (Fig.1). These two were rhizomatous plants and differed

Table 1. Characteristics of the seventeen herb species.

S.N.	Species	Family	Growth form
1	Artemisia vulgaris	Compositae	Erect
2	Anemone vitifolia	Ranunculaceae	Erect
3	Calamintha umbrosa	Labiatae	Small erect
4	Roscoea procera	Zingiberaceae	Erect
5	Geranium wallichianum	Geraniaceae	Basal
6	Ainslaea aptera	Compositae	Basal
7	Gerbera gossypina	Compositae	Basal
8	Sonchus asper	Compositae	Basal
9	Valeriana wallichianum	Valaerianaceae	Basal
10	Cnicus argyranthus	Compositae	Basal erect
11	Thalictrum foliolosum	Ranunculaceae	Umbrella
12	Strobilanthus alatus	Acanthaceae	Umbrella
13	Arisaema cancinnum	Araceae	Special umbrella
14	Aralia cachemirica	Araliaceae	Sprawling-mat
15	Hedychium spicatum	Zingiberaceae	Arching
16	Carex cruciata	Cyperaceae	Grass
17	Onychium contiguum	Polypodiaceae	Fern

Table 2. Values of fine root length, BGR (Belowground ratio), RLA (ratio of fine root length to leaf area) and Fine root weight. Values in parentheses indicate standard error (\pm).

S.N.	Species	Fine root length (cm)	BGR (g/g)	RLA (cm/m ²)
1	Artemisia	7.14 \pm 0.315	0.38	0.030
2	Anemone	22.44 \pm 1.7	0.39	0.404
3	Calamintha	19.16 \pm 1.324	0.265	2.514
4	Roscoea	15.06 \pm 0.735	0.379	14.678
5	Geranium	9.532 \pm 0.542	0.281	0.549
6	Ainslaea	11.9 \pm 0.314	0.462	1.226
7	Gerbera	11.42 \pm 0.99	0.438	0.293
8	Sonchus	8.94 \pm 0.635	0.211	0.262
9	Valeriana	17.1 \pm 2.531	0.48	0.289
10	Cnicus	24 \pm 1.619	0.498	0.216
11	Thalictrum	4.13 \pm 10.334	0.51	3.473
12	Strobilanthus	22.32 \pm 1.262	0.203	0.416
13	Arisaema	5.84 \pm 0.816	0.17	0.260
14	Aralia	6.88 \pm 0.428	0.57	0.356
15	Hedychium	18.7 \pm 1.333	0.73	0.0486
16	Carex	12.61 \pm 0.76	0.552	0.101
17	Onychium	7.21 \pm 0.475	0.628	0.097

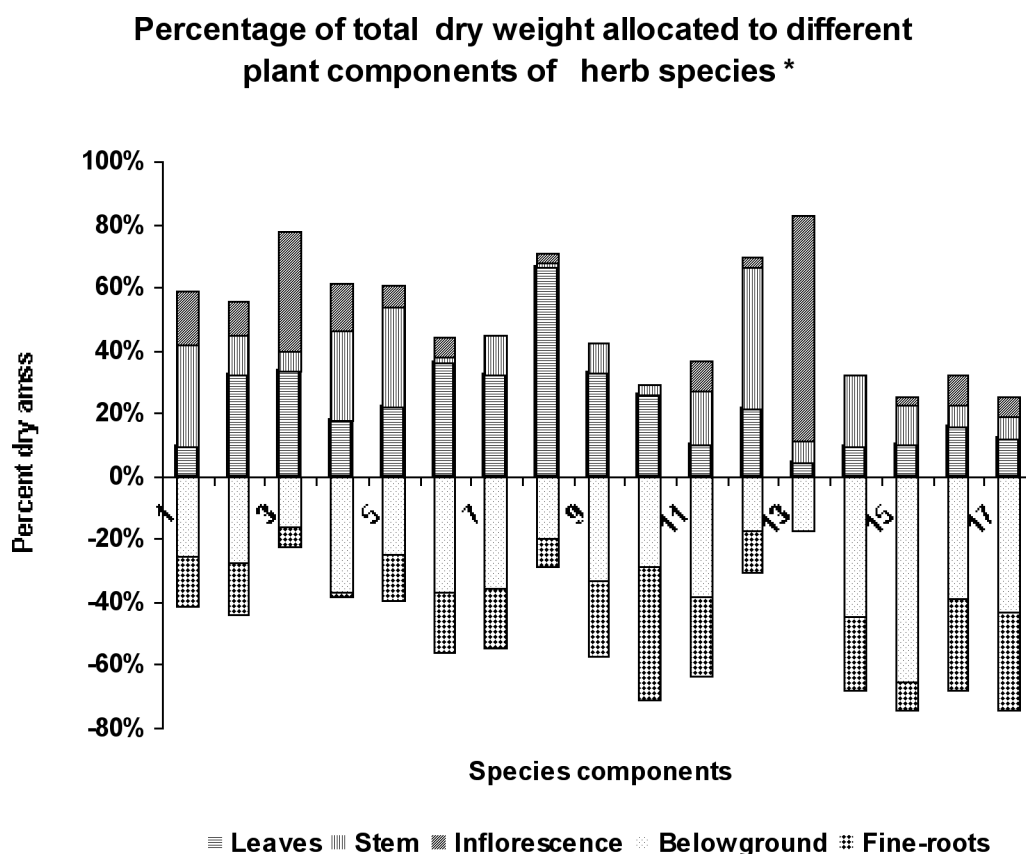


Figure 1*: Species: 1 *Artemisia*, 2 *Anemone*, 3 *Calamintha*, 4 *Roscoea*, 5 *Geranium*, 6 *Ainslaea*, 7 *Gerbera*, 8 *Sonchus*, 9 *Valeriana*, 10 *Cnicus*, 11 *Thalictrum*, 12 *Strobilanthus*, 13 *Arisaema*, 14 *Aralia*, 15 *Hedychium*, 16 *Carex*, 17 *Onychium*.

from the others allocating greater proportion of their dry weight to below ground part (more than 55% of dry mass). *Thalictrum*, *Carex* and *Onychium* had well-developed absorptive system and allocated a significant dry mass to fine roots. The allocation of drymass to different above ground parts are shown in Fig. 1. The percent of drymass allocation to above-ground vegetative components ranged from 11 (*Hedychium*) to 73% (*Sonchus*) for leaves and from 1 (*Sonchus*) to 52% (*Strobilanthus*) for stem.

Among the growth forms erect, basal, umbrella forms had greater investment to the above parts significantly to the photosynthetic component (leaf) except special umbrella (*Arisaema*) which allocated its >70% dry matter to its reproductive efforts. The reproductive efforts of species ranged from 3 (*Hedychium*) to 72% (*Arisaema*).

The maximum drymass allocation for leaves of *Sonchus* might be due to its basal habit having very low plant heights, to harvest more filter light for its survival through spreading its leaves. Whereas *Hedychium*, having well developed long massive stem by which it kept high leaf height, did not face any competition for light. So it allocated minimum drymass to its photosynthetic component as compared to supporting system.

Dry matter partitioning within root system

In general, the main root systems were thick with few, sparsely branched thin lateral/vertical secondary roots. Tables 2 and 3 show characteristic of the root system of dif-

ferent herb species. All 17 herbs differed in below ground system having tap root /adventitious /tuber / rhizome. Table 2 and 3 shows that, the main root in some species had greater mass accumulation for storage function than in the fine roots (absorption). The percent of allocation of dry mass in secondary roots ranged from 0.07 (Arisaema) to 74% (Cnicus).

Fine root length ranged from 4.13 (Thalictrum) to 22.44 cm (Anemone) (Table 2). The growth of secondary roots totally depends on habitat conditions. Generally the harsh or low water potential promotes a minimum growth of secondary roots. This trend is just opposite to present study. It might be due to that the roots of herbaceous plants generally go 25-30 cm deep except xerophytes and they want to utilize every drop of natural water. So they tend to increase the surface area of below ground system for the absorption of more water and due to this, plants growing at low water potential site show a significant growth of secondary roots.

Arisaema likes mesic as well as filter light area. So in this area soil moisture content in microclimate always remains more than enough. Hence plants never feel scarcity of water.

Exchange surface: mass

This gives thee explanation for the ratio of investment in structure for light capture for photosynthesis and the absorption of soil resources by a plant. This ratio can be measured by specific leaf area and specific root length. These express the size of exchange surface (leaf surface) attained by investment of unit dry weight [24]. Values of SLA are shown in Table 4 and specific root length of fine root length for all plants is given in Table 3. Among the species SRL (fine roots) ranged from 0.243 cm/mg (Cnicus) to 0.255 cm/mg (Roscoea). The low value of SRL for fine roots suggests low surface area and limited investment of dry matter. Cnicus showed the lowest SRL, which is a primary successional species and representative of harsh degraded site, their root length became more than their accumulation of mass. To tolerate the adverse conditions, their storage system becomes more massive than the absorptive system. Like, in case of Roscoea, which prefers mesic conditions, where soil moisture content is not a limiting factor. So in these species belowground absorptive component was well developed and the number of fine roots as well as their length became reduced. Similar observation has been seen in the example of other plants which like mesic conditions, such as Calamintha, Geranium and Valeriana.

The specific leaf area denotes the dry mass cm² in photosynthetic tissue. It is reciprocal to species leaf mass, which is directly correlated with leaf longevity of herb plants [27]. In the study, this trend was reverse to earlier reports, in which the plants growing at harsh site had more SLM than SLA.

In general, mesic conditions favor the low investment to leaf thickness of a plant because they devoid of external growth, hair, spines, a layer of fibers etc. These morphological adaptations may promote large SLA but low SLM in a plant. The plant with long leaf longevity, growing at harsh soil conditions (low water potential) allocate dry-mass to their photosynthetic system as well as supporting organs. Across species maximum SLA were represented for Artemisia (697.369 cm²/g) and minimum for Ainslaea (8.09 cm²/g) (Table 4).

The maximum SLA of Artemisia showed also its low investment of dry mass to photosynthetic components and tended to increase number and area. Whereas Ainslaea had small surface area, which might be due to that this species has two times flowerings, which are in

Table 3. Characteristics of the root system for the herb species. Main root dry wt., Fine root weight and SRL (specific root length) of herbs and values in parentheses indicate standard error (\pm).

S.N.	Species	Type of root system	Main root dry wt (gm/plant)	Fine root weight (gm/plant)	SRL (cm/mg)
1	Artemisia	Tap root	10.82 \pm 0.227	17.323 \pm 0.154	0.007
2	Anemone	Rhizome	8.526 \pm 1.34	17.519 \pm 0.926	0.019
3	Calamintha	Rhizome	5.272 \pm 0.042	3.088 \pm 0.471	0.126
4	Roscoea	Rhizome	13.85 \pm 1.196	0.046 \pm 0.005	0.255
5	Geranium	Tap root	1.885 \pm 1.34	2.72 \pm 0.356	0.177
6	Ainslaea	Tuber	22.02 \pm 1.596	11.6 \pm 0.635	0.029
7	Gerbera	Rhizome	9.982 \pm 0.593	11.612 \pm 0.29	0.010
8	Sonchus	Tuber	5.437 \pm 0.572	4.886 \pm 0.735	0.016
9	Valeriana	Rhizome	5.3882 \pm 0.766	9.12 \pm 1.38	0.074
10	Cnicus	Taproot	28.008 \pm 6.18	228.17 \pm 3.076	0.243
11	Thalictrum	Taproot	7.514 \pm .234	15.43 \pm 1.085	0.003
12	Strobilanthus	Taproot	6.151 \pm 2.10	39.511 \pm 3.647	0.005
13	Arisaema	Tuber	31.324 \pm 0.89	0.129 \pm 0.005	0.146
14	Aralia	Tap root	12.58 \pm 1.019	14.746 \pm 1.595	0.013
15	Hedychium	Rhizome	223.82 \pm 6.108	34.841 \pm 2.035	0.004
16	Carex	Taproot	8.882 \pm 0.351	24.768 \pm 0.377	0.055
17	Onychium	Rhizome	12.229 \pm 0.74	29.728 \pm 0.943	2.04

winter and second during cold early spring [28]. So perhaps it required a significant amount of organic mass in photosynthetic component for its extra reproductive efforts.

The low values of SRL for coarse root of a plant may reflect the role of these roots as storage organs. The ratio of fine root length to leaf area of plant will be influenced by the characteristics of the plant and its environment.

Root length: leaf area

The leaf area together with pigment concentration plays a key role in ecosystem functioning. Gholze et al., (1982) [11] suggested that leaf area is of great importance to model ecophysiological process and growth efficiency, and leaf enlargement is highly sensitive to water stress. It is one of the first growth processes to be affected by a decrease in leaf water potential [18].

RLA is influenced by the changes of condition. In winter the ratio becomes infinite because due to the above ground shoots die back completely. The ratio of fine root length to leaf area of plant will be influenced by the characteristics of the plant, its environment and the characteristics of site i.e., fertility and moisture content and longevity of the plant both significantly effect the RLA of plants.

Across, species RLA ranged 0.03 (Artemisia) to 2.514 cm/cm² (Calamintha)(Table 2). Calamintha is a short herb which generally prefers shady places, whereas Artemisia is a primary successional species growing at open eroded-xeric sites but the leaf area (per leaf) was higher in Artemisia than Calamintha. This result did not follows the thumb rule of Cowling and Cambell (1980), Anderson (1961) and Givnish (1984) [2, 9, 12], where they stated that the effective leaf size increased with shade as well as along

Table 4. Characteristics of total dry weight, TLA (total leaf area/plant), LAR (leaf area Ratio), SLA (specific leaf area), and LWR (leaf weight ratio) of seventeen herb species. Values in parentheses indicate standard error (\pm).

S.N.	Species	Total dry weight (gm/plant)	TLA (cm ²)	LAR (cm ² /gm)	SLA (cm ² /gm)	LWR (gm/gm)
1	Artemisia	74.49 \pm 2.4	7506.4 \pm 1755.0	100.700	697.360	0.144
2	Anemone	69.123 \pm 5.8	817.0 \pm 71.8	11.819	44.138	0.267
3	Calamintha	31.895 \pm 2.8	147.84 \pm 14.4	4.635	8.297	0.558
4	Roscoea	38.06 \pm 4.5	554.4 \pm 45.6	14.560	14.560	0.187
5	Geranium	6.554 \pm 1.3	1294.0 \pm 66.3	78.969	216.270	0.365
6	Ainslaea	93.282 \pm 7.5	347.68 \pm 333.8	3.727	8.090	0.458
7	Gerbera	48.524 \pm 1.7	1377.0 \pm 148.6	28.377	72.360	0.392
8	Sonchus	49.854 \pm 4.7	638 \pm 36.8	12.797	17.620	0.726
9	Valeriana	30.515 \pm 3.8	918.86 \pm 61.7	30.110	74.720	0.402
10	Cnicus	633.415 \pm 12.6	7649.3 \pm 663.6	12.066	265.160	0.045
11	Thalictrum	45.433 \pm 4.6	439.54 \pm 335.8	9.674	76.040	0.127
12	Strobilanthus	190.20 \pm 12.2	5030 \pm 283.7	26.430	108.200	0.245
13	Arisaema	179.29 \pm 5.6	382.06 \pm 23.9	2.130	50.934	0.040
14	Hedera	46.711 \pm 4.1	516.26 \pm 51.7	10.990	90.930	0.122
15	Hedychium	354.17 \pm 14.7	2744.1 \pm 156.1	7.747	70.590	0.109
16	Carex	60.881 \pm 3.7	4105 \pm 365.9	67.426	310.900	0.216
17	Onychium	65.26 \pm 2.7	1578.26 \pm 149.3	24.190	140.530	0.172

increasing soil fertility, and decreased with irradiance and disturbance.

The RLA differences are expected to be particularly higher for with low height [22]. The lowest values of RLA were found in species found in disturbed fertile soils whilst the highest values were at infertile soils [23]. Grazing is another factor, which greatly influences leaf area. In general, low altitude species had RLA values in the range of 240-500m/m², whilst high altitude species had values in the range of 1000-2000m/m².

Poorfer and Remkes 1990 [29] investigated the early growth of seedlings of 24 species grown on solution-culture of optimal nutrient supply. Negative relation between growth rates vs. RLA can be observed, since grasses had values of RLA in the range of 3000-10,000m/m², forbs had values in the range of 1000-4000m/m².

Korner and Renhardal (1987) [20] used the ratio of root length to leaf area (RLA) to express the relative sizes of structures. Interspecific plasticity in RLA has been shown for a number of grass species grown under high nutrient concentrations having a lower value of RLA by Boot and Mensink (1991) [3] and concluded that species characteristic on infertile soils exhibit greater plasticity in RLA than on fertile soil. They reported a negative correlation between RLA and nutrient availability.

Discussion

Natural selection would generally favor plants whose form and physiology tend to maximize their net rate of growth because such plants use resources with which to reproduce and compete for additional space [25].

The forbs, which all have rosette form, showed little investment in stems [24] because species have a rosette of more or less horizontal wide leaves and are effective in casting shade. They also stated that graminoides show low percent allocation to belowground structure and no obvious differentiation of tissues for storage and differ from the forbs in having a greater proportion of their dry weight in above ground parts. Species with massive belowground parts – nutrients stored in the root system – may provide greater part of energy for aboveground productivity [23].

Among the growth forms, the observation for different parameters showed that at erect forms, photosynthetic as well as absorptive systems were well developed i.e. they showed maximum value for leaf area ratio, specific leaf area, ratio of fine root length to leaf area and specific root length. They had relatively large sizes of above and below ground exchange surface, and this feature made them well adapted for any situation.

The short plants like basal forms as rosette, faced extreme hot and cold condition as compared to other. During hot weather, they tolerate high temperatures and evaporation by keeping leaves overlapped, and in winter – with leaves just above soil surface – they can maintain optimum temperature for their physiological activities.

The maximum drymass allocation for leaves of *Sonchus* might be due to its basal habit having a very low plant height, so, by spreading its leaves, it tries to harvest more filter light for survival. In addition, their absorptive system was also well developed, compared to others to tolerate the extreme situations of environment.

In arching form, which prefers well developed soil profile with mesic conditions – but they may occur between boulders under filter light conditions – their below ground rhizomatous system was well developed, they accumulated more than 70% of their energy in it. However, they also can be found in dim/ filter light. So light factor can be a competitive factor for them, but their arching, long, supporting system helps during adverse light /conditions. So these plants do not face any danger for their existence and used only 5-10% of their energy for reproduction. They occur generally under canopy between boulders but on mesic soils. So they do not face any harsh condition during their life cycle, so they invest much of their energy to storage system rather than other systems. Thus, they allocated only 9-10% of drymass to their reproductive systems.

The well branched plants of umbrella forms inhabited shady places mostly under canopy area where they have almost optimal water potential conditions of soil. They spend much of their energy to their supporting system for intercepting every ray of light. These preferred dim light, well developed soil profile with mesic conditions. So they develop well-branched supporting system to use every ray of light in deep forests. In special umbrella form, the pattern of the allocation of dry mass to reproductive components showed the highest reproductive efforts (*Arisaema*), living on mesic soil and under dense canopy. This helps the plant to avoid harsh, unfavorably extreme conditions, since its very short aboveground life span ends before extreme cold could weather commences. So both biotic and physical factors determine the growth of plant species in any habitat and composition of plant communities. The relative importance of these two categories of factors may vary with the successional position of the community and the time scale in which it is considered. It is assumed that physical factors, such as disturbance, have shaped the niches of early successional species, while biotic factors, including competition have had relatively more impact on the evolution of niches of successional species. Tilman and

Downing, (1994) [33] state that annuals should have lower competitive effect than perennial

The above ground characteristics of species often greatly affect their habitat tolerance, competitive abilities, and population dynamics. The morphology of underground structures also has important ecological consequences [3] because species with massive belowground parts – nutrients stored in the root system – may provide greater part of energy needed for aboveground productivity but Reynolds and Dantonio (1996) [30] disagree with this, because they indicate that most of the above ground and below ground plant traits are not closely related to competitive ability. Wilson and Tilman (1995) [93] stated that root/shoot ratios do not vary significantly with habitat but do vary among species. Givnish (1987) [13] already declared that the dry allocation mass of a plant depends on leaf strategy because leaf is a central array of the plant, which outstanding opportunities for competitive studies and implications for competition.

Tilman (1987) [31] stated that water is essential for plant growth and higher level of soil water generally supports higher plant biomass and leaf area. The effect of water on competition for light differs from the effect of soil nutrients such as Nitrogen, because increased water availability, increases shade tolerance, thus allows the survival of plants in the under storey. In addition to the above-mentioned, he also stated that because of inherent physiological differences between species, the ranking of growth rates among a group of species depends on the relative abundance of different resources. Such a growth rate advantage may or may not result in long-term dominance by a particular species, depending on its other life history characteristics and the frequency and type of disturbances in that environment. So it is clear that shoot length may not be so important in situations where the interaction of nutrient availability and soil moisture content have great importance in determining species abundance. This study is also consistent with Grime and Curtis (1976) [15].

Wardle et al., (1998) suggested that individual plant species effects are important determinants of ecosystem properties since these effects may override the importance of abiotic factors. He also provided evidence for the existence of strong linkages between plant ecophysiological traits, biotic interactions involving plants and ecosystem-level properties and processes. The ability to predict the outcome of competition by investigating the relationship between traits and competition ability has long been an objective for ecologists (Grace, 1990) [14]. So while considering plant traits, the different competitive mechanisms of leaves and fine roots must be considered. Leaves act not just as photosynthesis organs, but also as a part of the plant weaponry against their neighbors, denying them access to light. Roots in the topsoil, on the other hand, engage in exploitation competition through depletion of a common pool of resources.

We hypothesize that co-variation among species in leaf area, SLM, and other morphological adaptations particularly in leaf and growth rate reflects a set of mutually supporting traits that interact to determine plant behaviour and production in similar atmospheric conditions.

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