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Effects of Different Light Levels on the Growth Traits and Yield of *Centella asiatica*

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Abstract: The growth patterns and yield of *Centella asiatica* plant under four different levels of shading 0% (full sunlight), 30, 50 and 70% of solar radiation interception were investigated.The plantlets were grown in earthen pots containing soil, sand and vermicompost (1:2:1) and submitted to different levels of shading andof solar radiation and full sunlight, as control. The results suggested that plants submitted to 30% shading showed higher plant biomass. However, the plantlets root system showed higher dry biomass under full sunlight. This information is helpful in planning cultivation of the plant.

Key words: *Centella asiatica* · Light intensity · Growth traits · Plasticity

INTRODUCTION

Light is one of the most important environmental factors affecting plant survival, growth, reproduction and distribution. Light intensity affects photosynthesis and which in turn, is related to the accumulation of organic matter and biomass. Moreover, to sustain higher photosynthetic capacity or survival, plants modify their morphology and biomass allocation at different light conditions [1]. For example, plants grown at low light intensities have higher specific leaf areas (SLA) and leaf area ratios (LAR) and lower biomass and root shoot ratios (R/S) [2, 3]. Different species, however, respond differently to light intensity. Light-demanding species are more flexible in both morphology and biomass allocation in response to light change than shade tolerant species [4, 5]. Ryser and Eek [6] suggested the adaptive phenotypic plasticity differences among species may contribute to their different abilities to occupy variable and diverse habitats in the nature. Thus, studies on the plasticity responses of plant species to light environments will contribute to our understanding of the ecological mechanism of plant distribution and assist in the development of conservation approaches to important plant species.

Centella asiatica (L) Urban is a perennial herb of the family Apiaceae. It is found throughout India and Nepal in moist places up to an altitude of 2200m (tropical to subtropical region) and also on moist stone wall or other rocky sunny areas. It is a clonal plant colonising early in the abandoned jhum (slash and burn agriculture) [7]. Observation of natural populations of *Centella asiatica* indicated extensive variation in its growth and reproductive traits. andAlthough an important traditional medicinal plant in Nepal [8]. no work on the effect of light intensities has been carried out on *Centella asiatica* plant. Therefore, the present research work has been undertaken to study the effect of light intensity on dry matter production, growth traits and chlorophyll content of *C. asiatica*. The objectives were to compare the effects of light intensity on the plant biomass, biomass allocation and morphological characters, to analyze the relative importance of these characters in response to light intensity and to find suitable light condition for cultivation purpose.

MATERIALS AND METHODS

Plants and Treatments: A pot culture experiment in a completely randomized design was established in the Botanical Garden, Central Department of Botany (CDB), Tribhuvan University, Kirtipur Kathmandu, (85°17.32'E Long and27°40.20'N Lat ,1350m asl), Nepal. Several plant cuttings of randomly sampled individual plants of *C. asiatica* were collected from same population from garden of CDB, TU, Kathmandu. The cuttings of plantlets were more or less uniform size containing four leaved condition; they were planted in earthen shallow pots filled with a mixture of field soil, sand and vermicompost(1:2:1) in green house. Altogether 160 plants; forty plants for

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each treatment were planted separately for experiment. Planting was done in October 2007. After two weeks they were then transferred to three distinct shading levels (30, 50 and 70%) and full sunlight as control. The light was controlled by different layers of nylon-net shade placed 2 m above ground. The plantlets were irrigated at regular periods depending on the weather and soil moisture status. Each treatment was repeated twice.

Measurements and Calculation: Data on yield and morphological traits were recorded in April 2008. All plants per replication were used for the observations. Sixteen quantitative traits pertaining to plant morphology and yield were measured. Ninety mature leaves per treatment were measured for petiole length (PL) and specific leaf area (SLA). Petiole length, length and width of leaves were measured in fresh leaves. Then these leaves were oven dried (60°C, 48 h) and mass of each leaf was weighed in electric balance (0.001g). Length and width of leaves were measured and multiplied by conversion factor following Zobel *et al.* [9] for determination of leaf area. SLA was calculated as the ratio of leaf area and dry mass.

Leaf nitrogen (N) content was determined by modified micro Kjeldahl method following the procedure described by Horneck and Miller [10]. Leaf N content was determined in twenty samples from each treatment. Chlorophyll a, Chlorophyll b and total chlorophyll content was determined following the method of Arnon [11] in five samples from each replication.

Number of nodes (NND) occurring along each primary branch were noted. Internodal lengths (IND) were also measured on primary branches arising from mature rosettes. The number of leaves (NLN) and primary branches (NBN) arising from it was also scored. Inflorescences were measured for flower pedicel length (FPL) and total number of flowers per mature rosette. Dry mass of individual plant per replication was obtained after harvest. R/S ratio was calculated by dividing root mass with shoot ass.

RESULTS

Growth and Morphological Characters: All the measured traits of leaves varied significantly with light intensity (Table1). Among the leaf traits, the extent of variation was the highest in specific leaf area (CV=124, Table 1). Average number of leaves was 18.62 per ramet. There was significant difference in leaf number among the treatments with the highest number of leaves in plants grown in 30% shade (Table 1). Petiole length ranged from 2.4 cm at full sunlight to 4.63 cm at 70% shading. All treatments differed significantly (p< 0.001) in petiole length. Regarding the internode length, it was significantly longer (p< 0.001) in plants grown at 70% shading (Table1). Specific leaf area ranged from 195.16 cm^2/g at full sunlight to 1536.2 cm^2/g at 70% shading (average 892.86 cm^2/g). The difference in specific leaf area (SLA) among the treatments was significant (p=0.002) (Table 1). Regarding leaf chlorophyll concentration, an increment in these photoreceptors was observed with the increase of shading (Fig. 1), reaching the highest values in plants cultivated under 70% shading. There was significant difference (p=0.001) in leaf N concentration ranging from 1.73% at full light to 2.66% at 70% shading (Table 1). Number of primary branches per ram*et al*so differed significantly (p<0.001) among treatments, a higher number being in treatment with 30% shading (Table 1). The number of flower per ramet ranged from 17.85 in plants grown in full sunlight to 0.94 in plants grown in 70 % shading condition.

Table 1: Growth traits and yield of *Centella asiatica* in different light conditions .For each parameter significant difference between mean among the sites are indicated by different letters (Duncan homogeneity test, α = 0.05). F and P values were obtained by one way analysis of variance (ANOVA).

Attributes[a]	Full light	30%Shade	50% Shade	70% Shade	Mean	CV (×100%)	F value	P value[b]
No. of leaves$	20.26±9.6a	22.65±3.82b	16.6±8.41ab	12.57±4.64a	18.02±7.5	0.45	4.456	0.006
SLA(cm^2/g)*	195.16±30.29a	967.93±1092b	873.2±954.71b	1536.2±1.46b	892.86±1114.7	1.24	5.429	0.002
Petiole length (cm)*	2.47±0.6b	2.55±0.51a	4.55±0.91a	4.63±0.77b	3.55±1.26	0.35	54.173	0.000
Leaf N (%) #	1.73±0.23a	2.38±0.5b	1.81±0.28a	2.66±0.22c	2.14±0.5	0.23.	35.311	0.000
Number of branch$	3.78±2.37b	5.55±1.46c	3.55±2.06b	2±0.66a	3.74±2.14	0.57	13.218	0.000
Number of nodes$	2.84±1.06b	7.62±0.805c	3.2±0.95b	2±0.66a	3.95±2.37	0.6	160.182	0.000
Length of internode(cm) $	0.87±0.44a	4.92±0.69b	4.93±0.68b	5.1±0.84b	3.93±1.92	0.48	182.726	0.000
Peduncle length(cm) $	0.11±0.26a	0.59±0.06b	0.58±0.068b	2c	0.83±0.72	0.86	689.267	0.000
Number of flower per node$	17.85±11.52c	10.65±11.28b	9.63±9.77b	0.94±2.24a	9.88±11.14	1.12	10.220	0.000

[a] Sample size(n) for each treatment: *n=90 ;$=40 and# n=20;b Bold number indicates significant difference among the mean, ± Standard deviation, CV= Coefficient of Variance

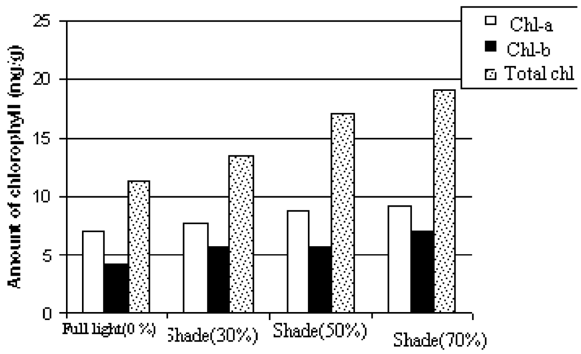

Fig. 1: Mean values of chlorophyll concentration of *Centella asiatica* submitted to different levels of shading

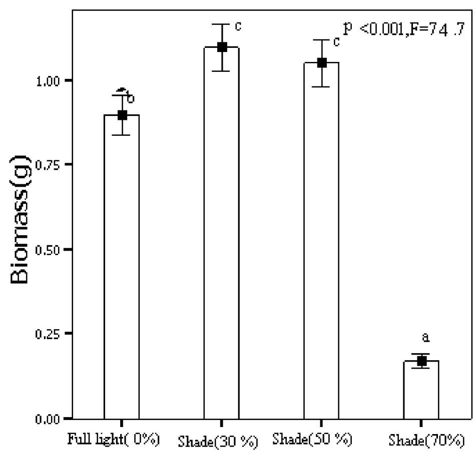

Fig. 2: Mean values of Biomass of individual plant of *Centella asiatica* submitted to different levels of shading (Means followed by the same letter do not differ by the Duncan Test at 5%)

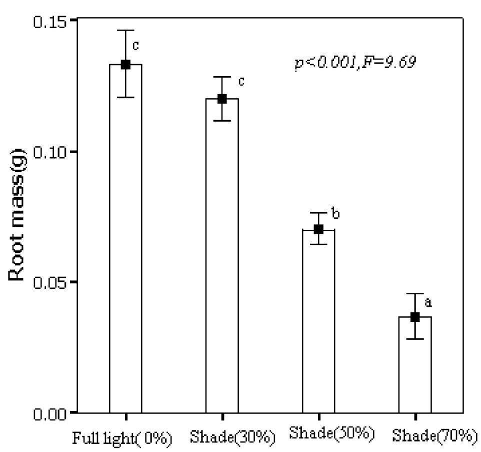

Fig. 3: Mean values of root mass of *Centella asiatica* submitted to different levels of shading (Means followed by the same letter do not differ by the Duncan Test at 5%)

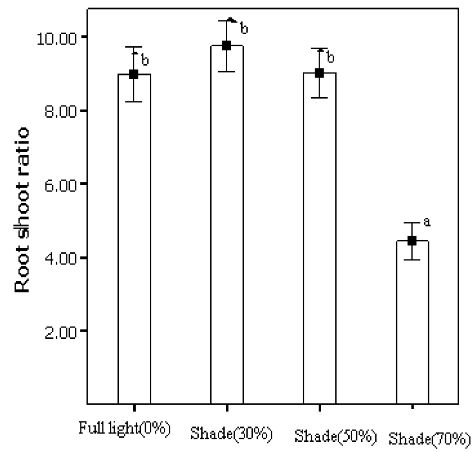

Fig. 4: Mean values of root / shoot ratio of *Centella asiatica* submitted to different levels of shading (Means followed by the same letter do not differ by the Duncan Test at 5%)

Biomass Allocation and R/s Ratio: There was significant effect of light intensity on biomass allocation of *C. asiatica* plant. It was significantly higher in partially shade (30% shade) than in other treatment (Fig.2, $p<0.001$). Less shaded plants tended to concentrate the dry weight in roots in relation to more shaded plants (Fig. 3). The R/S ratio of the *Centella asiatica* plant was significantly affected by light intensity as it was highest in full light (Fig. 4, $p<0.001$).

DISCUSSION

Growth and Morphological Characters: Light intensity had significant influence on growth and morphological characters. The number of leaves under full sunlight was, on average twice that of shaded plants (Table 1). Some other tropical species showed the similar response, as in *C.asiatica*, which increased twice the number of leaves growing in gaps when compared to shade grown plants [12].

The shaded plants (50% to 70%) produced larger leaves, longer petiole and internode length, in order to capture more light, probably because of a shade-avoidance mechanism [13] which resulted in decreasing the flower buds, showing that plants grown in lower light conditions tended more on vegetative part growth like leaf area, petiole length and internode length rather than reproductive growth [14].

The significantly lower specific leaf area in high light *C.asiatica* suggests leaf anatomical differences brought about by low quantum flux density [15] and reflects a strategy to increase this species competitive ability under low light through an increase in leaf area. The highest values for SLA in more shaded treatment could be due to the increase in leaf area and a reduction in thickness caused by shading. andLeaves in the sun are usually thicker than those growing in the shade [16]. An increase in SLA is a common response observed in plants under low light conditions [17-19] and is usually associated with extra layers of mesophyll cells [20].

Leaf chlorophyll was found to increasing with increasing of shading (Fig. 1), up to 70%. Leaf chlorophyll levels are controlled by light [21]. In elevated radiation intensities, chlorophyll molecules are susceptible to photo oxidation and the equilibrium is reached in lower radiation levels [22]. This was the reason for having higher chlorophyll levels in shaded leaves than leaves grown under full sunlight. Similar results were obtained by Alvarenga *et al* [23], in seedlings of *Guarea guidonia*.There was significant positive correlation (r^2=0.325, p=0.003) of leaf N with SLA. It was the reason for having high nitrogen content in plants grown in more shaded site. This response followed the same pattern reported by other studies with tropical species [20].

Biomass Allocation and R/s Ratio: In the present study, at plantlets grown under full sunlight compared with those grown under shading, a higher increase in root dry weight was verified in relation to the aerial part (Fig. 4). A reduction in specific leaf area and higher translocation of photoassimilates to roots (Fig. 3 and 4; Table 1) were observed. Young plants of *Garcinia mangostana* showed a similar behaviour, reduced leaf area and higher dry weight translocation to root system under decreasing shading conditions [24]. As suggested elsewhere [20], the lowest allocation to roots under low light conditions is known to be maximized in sun-loving plants and probably reflects a response to attributes that improve carbon gain under reduced irradiance such as an increase in SLA, or that reflects a light seeking strategy such as an increase in petiole length and internode length. A common response to shade reported in many studies is a reduced allocation to roots [20, 25, 26].

CONCLUSION

There was significant variation in many vegetative growth traits and yield of *C. asiatica* along different levels of light intensity. The results also suggest that *Centella asiatica* plant showed a better development when exposed to shading of 30%. This information can be used in planning cultivation of the plant.

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REFERENCES

1. Den, Dubbleden, K. and M.J. Oosterbeek, 1995. The availability of external support affects allocation and morphology in herbaceous climbing plants. Functional. Ecol., 9: 628-634.
2. Semb, K., 1996. Growth characteristics of spring barley and selected weeds. I. Effect of irradiance in growth chambers. Weed. Res., 36: 339-352.
3. Lentz1, K.A. and D.F. Cipollini, 1998: Effect of light and simulated herbivory on growth of endangered northeastern bulrush, *Scirpus ancistrochaetus* Schuyler. Plant. Ecol., 139: 125-131.
4. Lortie, C.J. and L.W. Aarssen, 1996. The specialization hypothesis for phenotypic plasticity in plants. International J. Plant. Sci., 157: 484-487.
5. Valladares, F., S.J. Wright, E. Lasso, K. Kitajima and R.W. Pearcy, 2000. Plastic phenotypic response to light of 16 congeneric shrubs from a Panamanian rainforest. Ecol., 81: 1925-1936.
6. Ryser, P. and L. Eek, 2000. Consequences of phenotypic plasticity vs. interspecific differences in leaf and root traits for acquisition of aboveground and belowground resources. American J. Botany, 87: 402-411.
7. Wankar and R.S. Tripathi,1993: Population dynamics of *Centella asiatica* (Linn.) Urb., a clonal herbaceous perennial, in '*jhum*' fallows of two different ages. Tropical. Ecolo., 34: 35-43.
8. Devkota, A. and P.K. Jha, 2008. Biology and medicinal characteristics of *Centella asiatica.* pp: 68-80 In P.K. Jha, S.B Karmacharya. M.K. Chettri, C.B. Thapa and B.B. Shrestha, (eds.). Medicinal Plants in Nepal: An Anthology of Contemporary Research.)Ecological Society (ECOS): Kathmandu.
9. Zobel, D.B., P.K. Jha, M.J. Behan and U.K.R. Yadav, 1987. A Practical Manual for Ecology. Ratna Book Distributor, Kathmandu.
10. Horneck, D.A. and R.O. Miller, 1988. Determination of total nitrogen in plant tissue. pp: 75-83. In: Hand Book of Reference Methods for Plant Analysis. TP Kalra (ed.) CRC Press, USA.
11. Arnon, D.I., 1949. Copper enzymes in isolated chloroplasts, polyphenol oxidase in *Beta vulgaris* L Plant. Physiol., 24: 1-15.

12. Pooter, H. and Y. Hayashida-Oliver, 2000. Effects of seasonal drought on gap and understory seedlings in a Bolivian moist forest. J. Tropical. Ecol., 16: 481-98.
13. Ballaré, C.L., 1999. Keeping up with the neighbours: phytochrome sensing and other signalling mechanisms. Trends in Plant. Sci., 4: 97-102.
14. Evans, G.C., 1972. The Quantitative Analysis of Plant Growth: Blackwell Scientific Publication. Oxford, UK.
15. Lambers, H. and H. Poorter, 1992. Inherent variation in growth rate between higher plants: a search for physiological causes and ecological consequences. Advances in Ecological. Res., 23: 187-261.
16. Nobel, P.S., 1983: Biophysical Plant Physiology and Ecology. W.H. Freeman and Company (Ed.), New York.
17. George, S. and R.V. Nair, 1990. Effect of shading on leaf development and chlorophyll content in groundnut (*Arachis hypogea* L.). Legume Res., 13: 130-132.
18. Buisson, D. and D.W. Lee, 1993: The developmental responses of papaya leaves to simulated canopy shade. American J. Botany, 80: 947-952.
19. Stoneman, G.L. and B. Dell, 1993. Growth of *Eucalyptus marginata* (Jarrah) seedlings in a greenhouse in response to shade and soil temperature. Tree. Physiol., 13: 239-252.
20. Thompson, W.A., P.E. Kriedemann and I.E. Craig, 1992. Photosynthetic response to light and nutrients in sun-tolerant and shade-tolerant rainforest trees. I. Growth, leaf anatomy and nutrient content. Australian J. Plant. Physiol., 19: 1-18.
21. Kramer, P.J. and T. Koslowski, 1979. Physiology of Wood Plants. Academic Press, New York.
22. Alvarenga A.A., E.M. Castro, E. Lima and M.M. Magalhães, 2003. Effects of different light levels on the initial growth and photosynthesis of *Croton urucurana* Baill in Southeastern Brazil. Rev. Árvore, 27(1): 53-57.
23. Alvarenga, A., E.A. Castro, M.L. Gavilanes, A.F. Blank and A.A. Camolesi, 1998. Desenvolvimento de mudas de Guarea [*Guarea guidonea* (L.) Sleumer], Daphene, 8(3): 22-26.
24. Wiebel, J., E.K. Chacko, W.J.S. Downton and P. Lüdders, 1994. Influence of irradiance on photosynthesis, morphology and growth of mangosteen (*Garcinia mangostana* L.) Seedlings. Tree. Physiol., 14(3): 263-274.
25. Zollinger, R.K. and J.J. Kells, 1991. Effect of soil pH, soil water, light intensity and temperature on perennial sowthistle (*Sonchus arvensis* L.). Weed Sci., 39: 376-384.
26. Messier, C., 1992. Effects of neutral shade and growing media on growth biomass allocation and competitive ability of *Gaultheria shallon*. Canadian J. Botany, 70: 2271-2276.