CORRELATION BETWEEN MORPHO-ANATOMICAL CHARACTERS OF *CENTELLA ASIATICA* L. TO DIVERSE HABITAT CONDITIONS OF ASSAM (INDIA)

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Introduction

Centella asiatica L. belonging to the family Umbelliferae (Apiaceae) possesses medicinal value. It is a profusely branched prostrate perennial herb consisting of active principle such as vallarine, asiaticoside, sitosterol, tannin and oxy-asiaticoside. Obayed Ullah *et al.* (2009) studied the antimicrobial, cytotoxic and antioxidant activity of *C. asiatica*. Rao and Seshadri (2004) also reported the variation in chemical composition of Indian samples of *C. asiatica*. Boiteau *et al.* (1949) studied the derivatives of *Centella asiatica* used against leprosy. According to Chopra *et al.* (1956), the leaves of the species are taken as tonic for improving memory and is also used both internally and externally against syphilitic skin diseases. The water extract of whole plant of *C. asiatica* is used by traditional healer of the Haya tribes in Bakora region in Tanzania, in the management of both insulin and non-insulin dependent diabetes mellitus (Mutyabarwa *et al.*, 2006). Dev *et al.* (2009) investigated the cognitive effects of *C. asiatica* in healthy middle age female and male volunteers. In Assam this plant is found growing luxuriantly in diverse habitat conditions having diverse climatic conditions as well. The growth and development of this species are greatly influenced by its climate, soil and other factors. Depending on their habitat conditions, populations of the species growing in diverse habitat conditions show morphological and anatomical diversities. Devkota and Jha (2009) studied the variation in growth of *C. asiatica* growing in different soil composition. Since this plant is medicinally as well as economically important, the present study was made to find out morphological as well as anatomical diversities of different populations of the species growing in diverse habitats and also the physicochemical properties of soil where the species grows to show correlation between the habitat conditions and the morpho-anatomical characters of the species.

Material and Methods

Samples of the plant species selected for the study have been collected from five different localities of Assam viz. Gauhati University (G.U.) campus, Santipur (locality within Guwahati city), besides Mongaldoi, Sivasagar and Barpeta which are distantly placed from one another having the influence of diverse climatic, soil conditions.

Gauhati University campus and Santipur (locality within Guwahati city) are situated between 25.46°N-26.49° N latitude and 90.48° E - 91.50° E longitude. Climate is sub tropical with semi-dry summer and cold in winter. It has an average elevation of 55 meters above sea level. The temperature ranges from 7°C in winter to 38.5°C during summer. Maximum relative humidity varies from 70% to 78% during February to April and 79% to 89% during May to January.

Mangaldoi is located at a 20.9°N- 26.95°N latitude and 91.45°E - 92.22°E longitude. It has elevation of 150 - 250 m amsl. Climate is humid and is characterized by mild summers and winters. Relative humidity varies from 70% to 78% during February to April and 79% to 89% during May to January. The monsoon of the district commences from the end of March and intensity gradually increases till August and then declines to the minimum during November and December.

Sivasagar is situated between 94.25° to 95.25°E longitude and 21.45°N - 27.15°N latitude. It has elevation of 86.6 m amsl. Sivasagar carries a pleasant weather throughout the year. The temperature ranges from 8°C in winter to 35°C during summer. The average relative humidity of this area is 75%. The district is characterized by highly humid atmosphere with abounded rains. The regular rains of the summer generally prevent the prevalence of the hot weather. After the rainy season the cooler autumn starts from October and real cold weather prevails from the end of November and continues till the middle of February. The winter season is followed by occasional thunder storms from March to May. The temperature begins to rise from the beginning of March. In July - August, it reaches the maximum.

Barpeta lies between latitude 26.5° N -26.49° N and longitude 90.39° E - 91.17° E. The climate of Barpeta remains mild and pleasant round the year. It has elevation of 35 m amsl. Tropical monsoon climate of the district provides two distinct seasons- summer and winter. The summer season of March to May is

Table 1

Morphological characters (Mean, ±SE) of Centella asiatica of different study sites.

Site	Gauhati University	Mongaldoi	Sivasagar	Barpeta	Santipur
Length of leaf stalk (cm)	5.92 ±.59	12.3 ±1.2	5.46 ±.23	5.64 ±.26	13.6 ±1.86
Length of stolon(cm)	6.38 ±.39	7.97 ±.41	8.16±.32	8.24 ±.38	7.9 ±.56
Diameter of leaf stalk(cm)	0.9 ±.05	0.8 ±.03	0.74 ±.05	0.78 ±.03	1.81 ±.79
Leaf diameter(cm)	2.21 ±.22	4.68 ±.27	3.36 ±.26	3.8 ±.405	4.22 ±.37
Length of inflorescence (cm)	1.27 ±.4	1.6 ±.15	1.46 ±.11	1.6 ±.12	1.09 ±.07
Length of flower(mm)	2.32 ±.21	2.4 ±.21	3.4 ±.24	3 ±.24	3.4 ±.31
Breadth of flower(mm)	2.2 ±.17	2.6 ±.21	2.4 ±.24	2.4 ±.26	2.4 ±.16

Table 2

Anatomical characters (Mean, ±SE) of Centella asiatica of different study sites.

Site	Gauhati University	Mongoldoi	Sivasagar	Barpeta	Santipur
Breadth of Epidermal layer(μm)	18.2 ±3.18	18.2 ±3.18	15.6 ±2.6	15.7 ±2.6	15.6 ±2.6
Breadth of Hypodermal Layer(μm)	41.6 ±4.86	33.8 ±3.18	46.8 ±3.1	31.2 ±3.18	41.6 ±4.62
Breadth of cortex layer(μm)	88.4 ±4.86	85.8 ±3.18	97.5 ±2.16	101.4 ±3.24	91 ±4.11
No. of V.B.	6 ±0.0	6 ±0.0	6.4 ±.57	5.4 ±.68	6.4 ±.5
Length of V.B.(μm)	179.4 ±6.36	117 ±5.81	166.4 ±6.79	114.4 ±4.86	163.8 ±3.18
Breadth of V.B.(μm)	166.4 ±6.36	88.4 ±4.86	140.4 ±6.36	93.6 ±4.36	145.6 ±6.36
Area of V.B.(μm^2)	29852.16	10342.8	23362.56	10707.84	23849.28

followed by the monsoons from June to September. This is followed by cool winter season from October to February. The annual temperature is above 22°C. The average relative humidity is 80%. Mean annual rainfall ranges from 1500-2600 mm for all the sites.

The individuals of the species, collected from these localities at almost the same time, were brought to the laboratory and their complete morphological and anatomical studies were made following usual laboratory procedures. The morphological characters like length of leaf stalk, length of stolon, diameter of leaf stalk, leaf diameter, length of inflorescence, length of flower, breadth of flower were studied. Ten observations were taken for morphological studies for each parameter (Bendre and Kumar, 1999). Likewise for anatomical investigations, characters like breadth of epidermal layer, breadth of hypodermal layer, breadth of cortex layer, number of vascular bundles (V.B) per unit area, length of vascular bundles, breadth of vascular bundles were studied (Foster,1949).

The physicochemical properties of the soil of the study sites like organic matter, p^H, N, P, K, Ca, Mg and S were analyzed according to the methods of Jackson (1973) and Piper (1966).

Correlation co-efficients among different morphological and anatomical characters with different soil parameters have been calculated following the method of Pearson's coefficient of correlation (Prasad, 2001).

Results and Discussion

The morphological studies of all the individuals of the species collected from different localities reveal that the stem is prostrate, slender, creeping with long stolons and nearly glabrous or hairy on young parts. Leaves are cordate, hastate, orbicular, reniform, sub-entire or palmately lobed consisting of long petiole or stipule. Crowded leaves can be seen at nodes, consisting of very long stalks with sheathing leaf bases. Leaves are dark green in colour. However, morphological investigations show differences of the characters in the materials collected from diverse habitats. Plants collected from Mongaldoi and Santipur showed very long leaf stalks (12.3 cm, 13.6 cm respectively) whereas those from G.V. campus and Sivasagar showed short leaf stalks (5.92 cm, 5.46 cm

Table 3

Physico- chemical characters of soil samples collected from different study sites where Centella asiatica grows.

Sites	pH	%OM	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	S (Kg/ha)	Ca (Meq/100 gms soil)	Mg (Meq/100 gms soil)
Santipur	6.26	2.23(H)	1327.60(H)	34.62(M)	336.00(M)	14.0(M)	4.6	1.6
Gauhati University	6.38	.975(H)	324.24(M)	112.85(H)	362.88(H)	187.5(H)	3.8	.2
Mongaldoi	6.38	1.794(H	596.92(H)	5.13(L)	1108.8(H)	76.56(H)	1.0	.2
Barpeta	5.68	2.55(H)	493.11(M)	423.36(H)	120.96(L)	12.6(M)	.6	1.4
Sivasagar	4.34	4.77(H)	921.33(H)	56.43(H)	423.36(H)	12.5(M)	2.0	1.4

H=high, M=medium, L=low

	Low	Medium	High
Nitrogen	<272	272 -544	> 544
Phosphorous	<22.5	22.5-56.0	>56.0
Potassium	<136	136-337.5	>337.5
Sulphur	<20	20-60	>60

respectively). Likewise plants collected from Sivasagar and Barpeta showed long stolons (8.16 cm, 8.24 cm respectively) and those from G.U. campus showed short stolons (6.38 cm). Plant collected from Santipur possessed large leaf stalks (1.81 cm), where as those from Sivasagar have small leaf stalks (0.78 cm). Likewise plants collected from Mongaldoi and Santipur showed large leaves (4.68 cm, 4.22 cm respectively) whereas those from G.V. campus showed very small leaves (2.21 cm). Plants collected from Mongaldoi and Barpeta showed very long inflorescence (1.6 cm, 1.6 cm respectively) while those from G.U. campus and Sivasagar showed long inflorescence (1.27 cm, 1.46 cm respectively) and those from Santipur showed comparatively shorter inflorescence (1.09cm). (Table1).

Anatomical studies reveal that breadth of epidermal layers were thicker in the plants grown in G.U. campus (18.2 μm) and Mongaldoi (18.2 μm) than the other sites. Plants collected from Sivasagar, G.U. campus and Santipur showed very thick hypodermal layers (46.8 μm,41.6μm and 33.3μm respectively), whereas those from Mongaldoi and Barpeta showed thin hypodermal layers (33.3μm, 31.2μm respectively). Breadth of cortex layers was thicker in the plants grown in Barpeta (101.4μm) than the other sites. Number of vascular bundles per unit area higher in the plants collected from Sivasagar and Santipur (6.4, 6.4 respectively) than the other sites. Variations were also found in the size of vascular bundles in the plants of different study sites like the plants collected from G.U. campus showed very large vascular bundles (29852 μm^2), while those from Sivasagar and Santipur showed large vascular bundles (23362.56 μm^2, 23849.28μm^2 respectively) while plants grown in Mongaldoi and Barpeta showed smaller vascular bundles (10342.8μm^2, 10707.84 μm^2 respectively) (Table 2).

Results of different physicochemical properties of soils of different study sites showed that pH level was slightly acidic in nature at G.U campus (6.38) and Mongaldoi (6.38) while it is extremely acidic at Sivasagar(4.34). Organic matter concentration did not show any significant differences among the study sites. Nitrogen concentration was high at Santipur (1327.60Kg/ha), Mongaldoi (596.92Kg/ha) and Sivasagar (921.33Kg/ha), medium at G.U. campus (324.24Kg/ha) and Barpeta (493.11Kg/ha). Mongaldoi (5.13Kg/ha) showed low phosphorous concentration whereas the other sites showed high phosphorous concentration. Potassium concentration was low at Barpeta (120.95Kg/ha) whereas the other sites showed higher concentration. Concentration of sulphur is high (76.56Kg/ha) in Mongaldoi whereas it is low in other sites. Calcium level was high in the soils of Santipur (4.6Meq/100gms) while it was very low of those at Barpeta (0.6 Meq/100gms). Likewise the soils of Santipur (1.6 Meq/gms) showed high magnesium concentration whereas G.U. campus(0.2 Meq/100gms)and Mongadoi(.2 Meq/100gms) showed low concentration of Magnesium in its soils. (Table 3).

Results of correlation coefficients among different soils and morphological parameters of *C. asiatica* showed that pH levels were positively correlated with leaf diameter and magnesium levels were positively correlated with breadth of flower while phosphorous concentrations were negatively correlated with length of flower and sulphur levels were negatively correlated with stolon length at 0.05 level of significance. Likewise phosphorous levels were negatively correlated with leaf diameter and calcium concentrations were negatively correlated with inflorescence length at 0.01 level of significance (Table 4).

Results of correlation coefficients indicate that plants grown in Santipur showed short stolons which may be due to low concentration of

Table 4

Correlation coefficients among different soil and Morphological parameters of Centella asiatica.

	PH	OM	N	P	K	S	Ca	Mg	Length of stalk	Length of stolon	Diameter of stalk	Diameter of Leaf	Length of Inflorescence	Flower size (breadth)
OM	-0.209													
N	0.375	0.432												
P	-0.881	-0.203	- 0.373											
K	0.379	-0.176	-0.08	-0.469										
S	-0.475	-0.704	- 0.656	0.687	0.192									
Ca	-0.201	-0.277	0.461	0.508	-0.264	0.3								
Mg	0.156	0.638	0.684	-0.246	-0.64	- 0.851	0.077							
Length of leaf stalk	0.802	-0.314	0.577	-0.598	0.525	- 0.181	0.308	-0.031						
Length of stolon	0.567	0.654	0.475	-0.837	0.067	- 0.945*	-0.551	0.64	0.203					
Diameter of stalk	0.424	-0.204	0.768	-0.11	-0.201	- 0.222	0.765	0.414	0.693	0.001				
Diameter of Leaf	0.144	0.921*	0.471	- 0.987**	0.482	- 0.663	-0.365	0.25	0.714	0.786	0.254			
Length of Inflorescence	0.112	0.229	- 0.553	-0.422	0.333	- 0.168	- 0.988**	-0.211	-0.349	0.439	- 0.841	0.278		
Flower size (Breadth)	0.089	0.755	0.808	-0.238	-0.488	- 0.839	0.165	0.956*	0.04	0.631	0.433	0.257	-0.279	
Flower size (Length)	0.763	0.204	0.243	- 0.947*	0.704	- 0.516	-0.568	0	0.562	0.733	- 0.078	0.925*	0.526	0.054

* Significant at 0.05 level, ** Significant at 0.01 level.

Table 5

Correlation coefficients among different soil and anatomical parameters of Centella asiatica.

	PH	%OM	N	P	K	S	Ca	Mg	Breadth of epidermal layer	Breadth of hypodermal layer	Breadth of cortex layer	No. of V.B.	Length of V.B.
OM	-0.209												
N	0.375	0.432											
PH	-0.881*	-0.203	- 0.373										
K	0.379	-0.176	-0.08	-0.469									
S	-0.475	-0.704	- 0.656	0.687	0.192								
Ca	-0.201	-0.277	0.461	0.508	-0.264	0.3							
Mg	0.156	0.638	0.684	-0.246	-0.64	-0.851	0.077						
Breadth of epidermal layer	-0.1	-0.695	- 0.625	0.233	0.647	0.857	0.001	- 0.994**					
Breadth of hypodermal layer	-0.616	0.452	0.447	0.514	-0.167	0.065	0.621	0.19	-0.186				
Breadth of cortex layer	-0.283	0.452	0.08	-0.017	-0.626	-0.41	0.718	0.718	-0.788	0.091			
No. of V.B.	-0.393	0.776	0.385	0.201	0.356	0.369	-0.104	-0.104	0.102	0.856	- 0.156		
Length of V.B.	-0.677	0.429	0.256	0.772	-0.318	0.831	0.025	0.025	0	0.894*	- 0.115	0.636	
Breadth of V.B.	-0.671	-0.047	0.197	0.821	-0.397	0.859	0.016	0.016	0.014	0.822	0.133	0.518	0.989**

* Significant at 0.05 level

** Significant at 0.01 level

sulphur and can be the probable factor as reported earlier by Pandey and Sinha (1998). Breadth of flower showed positive correlation with magnesium concentration in soil. Plants collected from Mongaldoi, Sivasagar and Barpeta showed larger flowers which may be attributed to the high concentration of magnesium in the soils of those areas. The results are also su ported by the reports of Cheal and Winsor (2006) who showed that high concentration of soil magnesium increases the leaf area, length of stem and size of flowers. Diameter of leaf showed positive correlation with pH levels and negative correlation with phosphorous concentration. High pH levels favours the eathering of minerals into the release of various important ions like potassium (Singh, 1996). Plants collected from Mongaldoi and Santipur showed larger leaves which might be contributed to high soil Potassium concentration, where pH level is also high. Plants collected from Barpeta and Mongaldoi showed longer inflorescences than the other sites. This may be attributed to the low concentration of calcium (Table 4). Hewiitt (1963) reported that low concentration of calcium limits seed production but helps in the development of flower parts. As per the report of Bidwell (1974) plants grow well in soil with low concentration of calcium, if other adjustments are made in composition of the nutrient medium. This was also found to be applicable during the present investigation.

Correlation coefficients among different soils and anatomical parameters showed that magnesium concentrations were negatively correlated with breadth of epidermal layers at 0.01 level of significance (Table 5). Plants collected from G.U. campus and Mongaldoi showing thicker epidermal layers may be attributed to the lower concentration of magnesium. Lyon and Garcia (1944) found that a low concentration of magnesium increased the development of epidermal cells in tomato stem. Plants grown in Santipur and Sivasagar showed thinner epidermal layers which may be due to the high nitrogen concentration in the soils of that area. Hewitt (1963) observed that high nitrogen concentration decr ased both the mean size and the total number of epidermal cells in *Ipomoea caerulea*. Plants collected from G.U., Sivasagar and Santipur showed thicker hypodermal layers which may be due to the high concentration of calcium. Hewitt (1963) also earlier reported that increased concentration of calcium increased the thickness of hypodermal layers in tomato plants. The present investigation supports some reports put forwarded by earlier workers in connection with concentration of soil nutrients and anatomical characters of different species.

Conclusion

The investigation showed significant correlation between morpho-anatomical characters of *C. asiatica* and different habitat conditions. The results suggest that the soil with high magnesium concentration, pH level and low phosphorous and calcium concentration showed maximum growth of *C. asiatica*.

SUMMARY

Different morpho-anatomical characters of *Centella asiatica* in response to diverse habitat conditions of Assam have been reported. The climate of Assam is generally of sub-tropical type influenced by northeast monsoon, with neither too cold in the winter nor too hot in summer. Assam's soils have been classified into the following three types - red loamy, lateritic and alluvial. Site Santipur, Gauhati University campus, Barpeta and Mangaldoi are made up of alluvial soil cover, whereas Sivasagar is capped by red loamy soil. Results showed significant correlation among morpho-anatomical characters of *C. asiatica* with soil nutrients concentration. Magnesium concentration was positively correlated with flower size. High pH levels increase the leaf size by releasing important ions like potassium. Negative relationship was obtained between soil phosphorous concentration and flower size. Calcium concentration increased inflorescence size. Soil nutrients also affect some anatomical features of *C. asiatica*. High soil nitrogen concentration showed thinner epidermal layers and high soil calcium increased the thickness of hypodermal layers.

Key words: *Centella asiatica*, morpho-anatomy, habitat, soil.

असम (भारत) की विभिन्न प्राकृतावास दशाओं में मिलते *सेटेल्ला एशियाटिका* लि॰ के रचनाकारिकी-शरीर लक्षणों में सहसम्बन्ध

एस.के शर्मा व के. मजूमदार

सारांश

इस अभिपत्र में असम की विभिन्न प्राकृतावास दशाओं के प्रतिचार स्वरूप मिलते *सेण्टेल्ला एशियाटिका* के भिन्न-भिन्न रचनाकारिकी-शरीर लक्षण सूचित किए गए हैं। असम की जलवायु उत्तरपूर्वी मानसून से प्रभावित होती उपोष्ण प्रकार की है जो सर्दियों में न तो ज्यादा ठण्डी और न गर्मियों में ज्यादा गरम ही रहती है। असम की मृदाओं को निम्न तीन प्रकार से श्रेणीकृत किया गया है- लाल दुमटी, लेटराइटी (इष्टकिंजीय) और जलोढ़। शांतिपुर स्थल, गुआहाटी विश्वविद्यालय परिसर, बरपेटा ओर मंगलदोई जलोढ मृदा आवरण से बनी है जबकि शिवसागर में ऊपर लाल दुमटी मृदा चढ़ी है। परिणामों ने मृदा पोष्याहार संकेन्द्रणों की दृष्टि से

से. एशियाटिका के रचनाकारिकी शरीर लक्षणों में सार्थक (या काफी) सहसम्बन्ध रहता पाया। मैगनीशियम संकेन्द्रण फूलों के आकार से सकारात्मक सह सम्बन्ध रखते पाया गया। अधिक पी.एच. पोटाशियम जैसे आयनों को मुक्त करके पर्ण आकार भी बढ़ाते हैं। मृदा के फास्फोरस संकेन्द्रण और फूलों के आकार में नकारात्मक सहसम्बन्ध रहता देखा गया। कैल्शियम संकेन्द्रण से पुष्प विन्यास में वृद्धि हुई। मृदा के पोष्याहार *से. एसियाटिका* की कुछ शरीर विशेषताओं को भी प्रभवित करते हैं। मृदा में नाइट्रोजन का अधिक संकेन्द्रण रहने पर अधिक पतला परिवर्तन स्तर बनते दिखे तथा मृदा में कैल्शियम ज्यादा रहने पर उपत्वक स्तरों की मोटाई बढ़ गई।

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