Leaf area index and shoot densities of *Sphagnum squarrosum* Cram. Samml. and *Ceratodon purpureus* (Hedw.) Brid.

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Leaf area index in cushions of the meso-xerophytic, sciophytic, ectohydric, pleurocarpous, perennial, high altitude moss *Sphagnum squarrosum* and the xerophytic, light demanding, mixohydric, acrocarpous moss *Ceratodon purpureus* was estimated to be 58.01 cm^{-2} and 127.47 cm^{-2}, respectively. The mean number of leaves per stem were counted to be 86 and 261, respectively for the above species.

Key-words - *Sphagnum, Ceratodon*, Morphology.

INTRODUCTION

LEAF area indices are defined as the total area of living leaves within a unit area of moss cushion. In general, moss growth, shoot density and leaf area are influenced mainly by light and humidity. Competition for light between individuals might be expected, which should lead to a strong size hierarchy and a low mean shoot size at higher densities (Hoeven & During, 1997a). On the other hand, moss growth is usually considered to be water rather than light limited (Skre & Oechel, 1981; Proctor, 1982; Hoeven & During, 1997b). Like the so-called resurrection plants (Gaff, 1977), mosses are poikilohydric (Hosokawa *et al.*, 1964) that is, all metabolic processes stop when the cell dries out. Only after rehydration and a period of respiration, photosynthesis restarts (Proctor, 1982). Moss dehydration and rehydration also influence the shoot density and leaf area index.

In many bryophyte species, the sexual part of the life cycle is frequently more or less absent or not successful and clonal growth plays an important role in maintenance and spreading of shoots (During, 1990). Like in many phanerogams, clonal growth of bryophytes may lead to an increase in within clone competition involving the resources light, nutrients and water, which affect the shoot density.

Leaf area indices in mosses appear intuitively to be large, but our knowledge regarding this branch of bryology is still fragmentary. A large leaf area would seem to be an effective adaptation to the high carbon dioxide concentration close to the ground surface, especially within the moss tuft, which facilitate in a high photosynthetic rate, if light and water content does not act as limiting factor.

MATERIAL AND METHOD

Four sampling areas (each of 1 cm^2) from moss tufts were selected for each species growing naturally on uncontaminated sites of Mukteshwar (Kumaon hills), India located at 2380 msl. The number of shoots were counted for each sampling unit and number of leaves were counted from five selected shoots of each sample. The area of 10 leaves from each of these selected five shoots was estimated. Leaf area indices were then calculated by multiplying mean leaf area per shoot and mean number of shoots per cm^2 (that is expressed as leaf area per cm^2 of moss tuft). Data presented show mean values and variability for these parameters.

RESULT AND DISCUSSION

Shoot density, mean leaf area and leaf area index were found to be 68 shoots cm^{-2}, 10.02 mm^2 and 58cm^{-2} for *Sphagnum squarrosum* (Table 1) and 119 cm^{-2}, 0.44 cm^2 and 127.47 cm^{-2} for *Ceratodon purpureus* (Table 2), which represent a very high degree of species specific difference. It was also quite interesting to

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Table 1 : Shoot density and leaf area index of four clumps and five stems of *Sphagnum squarrosum*

No. of stem/ cm^2	No. of leaves per stem	Mean leaf area of 10 leaves	Leaf area on one stem	Mean leaf area per stem (mm^2)	LAI (cm^2)
	75	1.06	79.5		
	86	1.03	88.58		
64	83	1.14	94.62	85.78	54.90
	78	1.00	78.00		
	90	0.98	88.2		
	88	1.04	91.52		
	79	1.09	86.11		
61	93	0.95	88.35	88.87	54.21
	85	1.11	94.35		
	84	1.00	84.00		
	79	1.04	82.16		
	87	1.13	98.31		
78	95	0.97	92.15	82.96	64.71
	76	0.86	65.36		
	81	1.02	76.81		
	96	0.92	88.32		
	91	0.89	80.99		
68	87	1.08	93.96	85.66	58.25
	95	0.99	74.25		
	89	1.02	90.78		
67.75	85.85	1.02	83.51	85.82	58.01

Table 2 : Shoot density and leaf area index of four clumps and five stems of *Ceratodon purpureus*

No. of stem/ cm^2	No. of leaves per stem	Mean leaf area of 10 leaves	Leaf area on one stem	Mean leaf area per stem (mm^2)	LAI (cm^2)
	274	0.47	128.78		
	198	0.51	100.98		
114	327	0.49	160.23	124.40	141.40
	256	0.48	122.88		
	214	0.51	109.14		
	218	0.39	85.02		
	207	0.44	91.08		
106	224	0.50	112	98.70	104.62
	290	0.34	98.6		
	281	0.38	106.78		
	210	0.37	77.7		
	221	0.39	86.19		
150	329	0.34	111.86	98.38	147.57
	367	0.36	132.12		
	205	0.41	84.05		
	178	0.46	81.88		
	402	0.48	192.96		
107	249	0.52	129.48	108.68	116.29
	31	0.43	135.45		
	261	0.51	133.11		
119.25	26130	0.44	120.69	107.54	127.47

note that despite having a high individual leaf area value of *Sphagnum*, its leaf area index was found to be quite low.

Acrocarpous mosses have erect growing stems. Generally the top meristem ceases to function when the plant produces gametangia, and new innovations are formed basely or subapically, depending on the species (Meusel, 1935). This may result in very high shoot densities, e.g.>100 shoots cm^{-2} in *Ceratodon purpureus* (Hoeven & During, 1997b). On the other hand, in pleurocarpous mosses gametangia are produced on short lateral branches, which means that production of sporophytes does not terminate the vegetative growth of the main axis (During, 1979; Orban, 1983). In *Sphagnum*, a pleurocarpous moss, the shoot growth is upright as in acrocarpous, but sporophytes are produced on side branches so that the growth of the main axis can continue even after sexual reproduction. Thus in *Sphagnum*, sexual reproduction does not seems to play any role in alteration of shoot density, leaf area index or other growth and productivity parameters.

Data revealed that *Ceratodon* tufts had a very high leaf area index and their shoot density was also very high. High shoot density may be because of its acrocarpous nature. But mean individual leaf area of *Sphagnum* was about 2.3 times as high as that of *Ceratodon*. A red/far red ratio of the irradiant light (i.e. phytochrome effects) may also play a role in branching frequency of *Sphagnum* (Hoddinott & Bain, 1978; Brock & Bregman, 1981; Clymo & Duckett, 1986).

In *Sphagnum*, it was very interesting to note that only a few upright branches were emerging from the brown older moss parts of greater depth in the vegetation. It may be because that few dormant buds in the vegetation remain alive (Clymo & Hayward, 1982; During & Horst, 1983). A change in microclimate induces the development of new shoots from dormant buds on seemingly dead shoots (Knoop, 1984; Clymo

& Duckett, 1986; Myrmael, 1993), leading to an increase in the number of branches or new shoots. Although the exact mechanism is still to be worked out, the question remains, how are carbohydrates transported to these buds through the brown parts. The following possibilities may be enumerated:

1. The brown parts contain sufficient carbohydrate content essential for construction of a small new branch with a few leaves.
2. As the existence of plasmodesmata has been reported by Cook *et al.*, 1997, some sort of passive carbohydrate transport may also be possible to provide nutrients for construction of a new branch from brown parts.

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