The Growth of Carnivorous Plants on an Acidified Fen Soil

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Most carnivorous plants (CPs) grow on rather acidic soils. For *Dionaea muscipula,* a soil pH range of 3.5-4.9 was found in natural sites (Roberts & Oosting, 1958). *Drosera rotundifolia,* a species with a very wide ecological amplitude, was found growing over a wide pH range of 2.9-6.5 (Adamec, unpubl.). In acidic bog and fen soils (pH 3-4.5), the molar concentration of H^+ in interstitial water is usually the highest of all soluble mineral nutrients ($NH4^+$, $H2PO4^-$, K^+, Ca^{2+}, Mg^{2+}; cf. Roberts & Oosting, 1958). Yet, the effect of soil pH on the growth of CPs has not been studied sufficiently. As shown by Rychnovska-Soudkova (1953, 1954) the effects of pH on *D. rotundifolia* growth greatly interfered with the composition of the mineral nutrient solution.

The basis for this paper was my previous finding that some CPs (*Dionaea, D. capensis* and its cultivars) grow better on a very acidic conifer leaf mould (pH 3.1-3.4) than on a less acid fen soil (pH 4.0-4.4). The aim of this study was to investigate the growth of three CP species on acidified fen soil.

Materials and methods

An acidic fen soil was used as the standard substrate (for details see Adamec et al., 1992). Its dry weight (DW, 105 °C) was 16.9 % of fresh weight (FW). pH of the soil suspension (always 0.5 g of FW of fen soil + 2.5 ml of distilled water) was 4.20 and its electrical conductivity 47-50 $\mu S.cm^{-1}$ at 21 °C. Titration of the fen soil suspension with 0.2 $mol.^{-1}$ HC1 to the pH of 3.30 revealed that such a soil acidification required 22 mmols of HCl.kg-l(FW).

Nine small uniform plants each of these species *(Dionaea muscipula, Drosera capensis cv.* White Flower, and *D. capensis cv.* Giant) were planted together on 10 December 1991, in both control (pH about 4.20) and acidified (pH theoretically 3.30) fen soil with washed sand in plastic pots (8 x 8 x 6 cm). The pots were placed in a heated greenhouse in a white plastic container (1.0 x 0.8 x 0.4 m) among pots with commercially cultivated CPs. Tap water (pH ca. 7.5, 70-80 $\mu S.cm^{-1}$) was added to the container and the water depth kept at about 2 cm. All plants were occasionally sprayed with tap water. The plants were grown in daylight at temperatures between 19-23 °C.

Initial length of the longest root was measured in all plants and initial DW (80 °C) of shoots and roots was estimated in parallel plants. The length of the longest leaf and number of living leaves were measured in all plants, beginning on 10 December 1991 and then at one-month intervals. The growth experiment was finished on 23 April 1992 after 134 days. At that time, the length of the longest root was measured in all plants again. Both shoots and roots of 9 plants of each variant were pooled together, dried and weighed. To show how the different substrates were changing in the course of time, 0.5 g (FW) of fen soil was sampled both from the top soil layer (0-3 mm) and at 30 mm in all pots after 40 days and at the end of the experiment. pH and electrical conductivity were measured in the fen soil suspensions. Electrical conductivity is a measure of the dissolved ion content in a solution.

Results and discussion

Although the initial pH of the acidified fen soil was theoretically 3.30, its actual value was 3.9 by day 40 (Table I). This was the result of probably long-term ion exchange processes in the fen soil. Yet, the pH levels differed by 0.21 to 0.41 between the control and acidified substrates. Both substrates were alkalized at about the same rate by the tap water used during cultivation. However, since the tap water was flowing from the bottom to the top of the soil where it was evaporating, the substrates were alkalized more toward the bottom. Electrical conductivity was markedly higher in the top soil layer than in the middle due to evaporation. Substrate alkalization is usually not desirable for most CPs. It may be mitigated by a higher column of substrate and by adding very soft water.

Of the three CP species, only *D. capensis cv.* White Flower produced markedly higher biomass in the acidified soil than the control plants (Table II). In *D. capensis cv.* Giant, the biomass on the acidified soil was moderately higher, but in *Dionaea* it was markedly lower than the control plants. The growth of *Dionaea* was even negative on the acidified soil when compared with its initial biomass. In all species, acidification of the fen soil affected shoot DW to a greater extent than root DW, both positively or negatively. The longest root length in all species was not significantly affected by soil acidification.

Differences in the final shoot biomass between the variants resulted from irregular growth rates of the leaves during the experiment (Figs. 1-3). In control plants, leaf growth was slow during the first 65 days. In the acidified soil, the leaves of all species were shortened (considerably in White Flower and Giant) in the first 38-65 days and the number of living leaves (except for White Flower) decreased significantly by day 38. However, leaf growth became vigorous after this early period in both cultivars of *D. capensis* on the acidified soil, whereas the growth of the control plants remained slow. Leaf number was significantly higher in the acidified plants of White Flower and Giant at the end of the experiment compared to the control plants. Therefore, after an initial decline of shoot biomass, the cultivars of *D. capensis* growing on the acidified soil were able to overcome the control plants after 134 days, due to a higher growth rate in the second half of the growth experiment. It follows from the data that this difference would increase in favour of the acidified variant over a longer time span. Growth was meagre for both *Dionaea* variants, but there was also some recovery of growth in the acidified variant by the end of the experiment (Fig. 1).

Negative leaf growth in the acidified variants during the first half of the experiment was probably due to the death of leaves which were in contact with the acidified soil. Neither a dangerous pH value nor a strongly increased content of salts occurred in the top soil (Table I). Moreover, the top soil in the acidified variant was greenish due to growth of filamentous protonemata of mosses.

The growth pattern of the CPs in this experiment was also influenced by winter irradiation, especially in *Dionaea,* which formed two types of leaves. The very low pH (3.1-3.4) of the best substrate for growing the three CP species, conifer leaf mould from wet Scotch pine forests, contributes partly to the high quality of this substrate. However, artificial substrate acidification cannot be recommended.

Table I. The mean values of pH and electrical conductivity (G; in $\mu S.cm^{-1}$) in fen soil extracts (0.5 g of wet fen soil + 2.5 ml of distilled water) Samples of the fen soil from the growth experiment were collected from both the top 3 mm of the soil layer and at 30 mm after 40 and 134 days of the experiment.

	Control fen soil				Acidified fen soil			
Date of sampling	Top soil pH	G	30-mm depth pH	G	Top soil pH	G	30-mm depth pH	G
40 days	4.21	82	4.54	63	3.92	85	4.13	67
134 days	4.43	121	4.81	53	4.22	107	4.46	58

Table II. The effect of fen soil acidification on plant growth over 134 days. C, control plants; A, acidified variants. The initial plant dry weight (DW) shown as shoot DW/root DW. 2.SEM are shown where possible.

Species and treatment	Initial plant DW (mg)	Final shoot DW (mg)	Final root DW (mg)	Initial root length (mm)	Final root length (mm)
Dionaea C	5.9/0.35	7.5	0.41	18.2±4.4	17.4±3.1
Dionaea A		5.4	0.44	21.1±3.8	23.6±3.6
White F1. C	1.2/0.23	3.7	0.76	18.8±4.9	33.8±6.2
White F1. A		6.3	1.16	24.0±6.3	40.4±12.3
Giant C	0.80/0.05	2.6	0.91	23.0±6.6	32.3±7.9
Giant A		3.1	0.91	19.3±3.0	32.3±6.4

References

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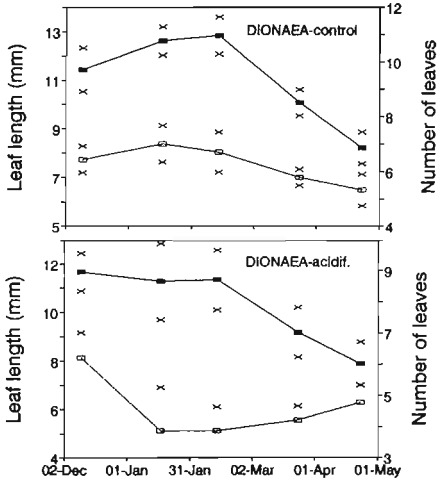

Figure 1. Longest leaf length and number of living leaves in *Dionaea musciputa* in the control and acidified fen soils over 134 days. Left axis, full symbols; right axis, empty symbols. Mean of 9 plants ±2.SEM.

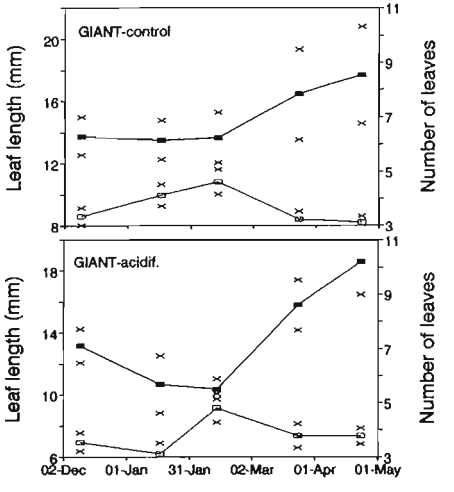

Figure 3. Growth patterns of *D. capensis cv.* Giant during the experiment. For explanation see Fig. 1.

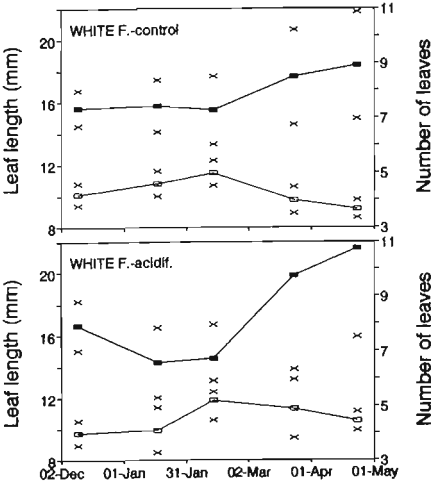

Figure 2. Growth patterns of *D. capensis cv.* White Flower during the experiment. For explanation see Fig. 1.

Thoughts, Reflections, and Upper *Nepenthes ampullaria* Pitcher

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In 1994, I decided to move my family over to Singaporeand have finally decided to share some of my thoughts. I will stick to the topic, namely that of our beloved CPs.

Approximately four years ago, a group of us CP'erphiles decided to publish a biannual CP club newsletter serving the Pacific Northwest. I was the editor, Tom Kahl, the Northwest US representative, Randy Lamb the Yukon representative, Kevin Snively the treasurer, Bob Cattermole the events co-ordinator, Don Graham, secretary, Doug Fung, Education liaison, and Lorne Dennison, B.C. representative. Ambitious as it was, we had a lot of fun and camaraderie over our common interest. We had a lot of fascinating material in our newsletter, written by many people and we managed to further the knowledge of CPs through the local media and by locating new members. It is with sincere regret that a lot of correspon-