Ecol. Env. & Cons. 6 (2) : 2000; pp. (143-146)

Response of Juvenile Plants of *Myriophyllum Elatinoides* Gaudich. To shade in Experimental Culture

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ABSTRACT

Myriophyllum elatinoides is an aquatic submersed plant with erratic distribution in the irrigation systems of southern Argentina. The species usually occurs in channel sites with high light availability, suggesting a low tolerance to the reduced light conditions caused by water turbidity or shading. The aim of the present work was to study the response of this species to shading in experimental culture. Buds contained in 400 cm^3 pots were introduced in tanks with water (150 l; 12 plants/tank), under artificial light supply (113.86 $\mu E\ m^{-2}\ s^{-1}$ just below water surface; 16/8 plants/tank). Shade treatments were assayed by installing a geotextile material just over the tanks. Treatments were: high shade (86% reduction in PAR radiation), low shade (41% reduction) and full light, resulting a complete randomised design with three replicates. At 35 days, significant reductions were observed at both shade levels for stem length, plant total length, number of branches per plant, below and above ground plant weight. At the end of the experiment (78 days), the percentages of reduction varied between 70 and 97% for all the measured parameters. The effect of treatments on plant chlorophyll a and b and total chlorophyll is discussed. Results showed that shade stress produced in *M. elatinoides* none of the typically-observed morphological responses of most of submersed plants to shade, but clear deleterous effect at both shade levels.

Key words : *Haloragaceae*, Myriophyllum elatinoides, M. quitense, *Gambarusa, Shade stress.*

Introduction

Myriophyllum elatinoides Gaudich. (=*M. quitense* H.B.K., Orchard, 1981), commonly known in Argentina as gambarusa, is a perennial herbaceous submersed macrophyte. It has a wide distribution in freshwater bodies of South America, from where is native (Orchard, 1981; Boelcke, 1992), being a common component of the aquatic flora of lakes, ponds, streams and irrigation systems. Since the '90's this species has been found in two irrigation systems located in southern Argentina, known as Valle Inferior del Rio Negro (VIRN, 40° 48' S; 63° 05' W) and Valle Inferior del Rio Colorado (VIRC; 39° 10' S; 62° 55' W). Its profuse growth, specially in the VIRN system causes serious troubles with the utilization and management of water for irrigation purposes.

In macrophyte-dominated freshwater bodies, light is a key factor that affects the distribution of the supersede species (Barko *et al.*, 1986 and references submersed therein). Studies on the effects of shade on the growth of aquatic macrophytes have shown that most species are, in different degrees, shade-tolerant (Barko and Smart, 1981; Goldsborough and Kepm, 1988; Vermaat and Hootsmans, 1994; Abernethy *et al.*, 1996). An exception to this phenomenon may be, for example, *Potamogeton polygonifolius*, a "sun" species that is normally found in shallow and clear waters (Spence and Chrystal, 1970).

Although the effects of light attenuance have been reported for *M. spicatum* (Barko and Smart, 1981; Smith *et al.*, 1991; Abernethy *et al.*, 1996), experimental data on the tolerance of *M. elatinoides* to low light are not available. Observations made in artificial channels of the VIRN and VIRC systems, indicated that the species occurs in shallow sites characterised by low water turbidity, sometimes forming monospecific stands. On this basis, we hipothetised that

M. elatinoides is a shade-intolerant species, that do not acclimate to the low water light levels typical of the artificial channels of the VIRC and VIRN systems.

The aim of the present study was to determine, under standardised experimental laboratory conditions, the response of *M. elatinoides* to decreased light intensity.

Materials and Methods

Two cm length shoots of *M. elatinoides* were planted in 400 cm^3 pots (1 plant/pot), filled with a rooting medium constituted by enriched soil (8-10% organic matter; C/N relationship; 19/1). To prevent problems of algal contamination, the soil was covered with a layer of washed sand (Smart and Barko, 1984). The pots were introduced in 12 aerated 150 1 black polypropilene tanks (12 plants/tank), filled with tap water. Light was daily provided during 16 h by a panel of 34 fluorescent tubes (1.20 m length; 40 W) supplemented with 100-W incandescent bulbs. Light intensity, measured using a LI-COR 192SB underwater quantum sensor, was 113.86 μE m^{-2} s^{-1} (photosynthetically-active radiation PAR) just below water surface. Water temperature was 22°C (± 2°C) during the experiment.

Six days after planting, when plants had 5-7 cm height, experiment started by placing a geotextile material just above the shade treatment tanks. Treatments were: unshaded (full light), low (41% reduction in PAR at water surface) and high shade (86% reduction). A complete random design was used, resulting a replication (tanks) of n = 4.

At 6, 35 and 78 days post-planting, measurements were performed of plant morphological trails. The number of pots removed from each tank was two at the first two sampling dates and four at day 78 (end of experiment). Measurements of plants harvested from each tank were averaged to obtain the true replication value.

Morphological traits measured were: main stem length (SLEN), total plant length (TLEN, stem plus branches length); number of branches per plant (BRAN); and dry weight per stems (WST), leaves (WLE) and roots (WRO). Dry weight was determined on oven-dried (78°C; 48 hs) material. At the end of the experiment, chlorophyll a (Chl. a) and b (Chl. b) contents were also determined in four plants per tank, following Wintermans and De Mots (1965).

Prior to statistical analysis, data were checked for normality and homoscedasticity, by using MINITAB Release 8.3 (1994) and Bartlett's test (Snedecor and Cochran, 1980), respectively. When data were not normal or variances were not homogeneous, $\log_{10}$ transformation gave improvement. Analysis was performed using one-way ANOVA ($p \leq 0.05$) at each sampling date, and the significance of the differences between mean values was tested by means of SNK test ($p \leq 0.05$).

Results and Discussion

Light attenuation causes a deleterous effect on juvenile plants of *M. elatinoides* at both shade levels assayed, as indicated by the strong decrease in all morphological parameters measured in shaded when compared to unshaded plants (Fig. 1).

The stem length ratio (ratio between SLEN at shade and full light) was 0.71 and 0.72 for low and high treatments, respectively, at 35 days, and 0.31 and 0.24 for low and high, respectively, at 78 days. Shade stress caused also an important reduction in BRAN, which ranged between 84% for low and 93% for high shade at 35 days. At the end of the experiment, only under full light plants were profusely branched, whereas in the shade treatments only the main stem with two-three weak branches remained in the plants. These results showed the lack of an extensive shoot elongation and an associated canopy formation at water surface as a consequence of the reduction in light irradiance contarily to the response that has been widely reported for most aquatic macrophytes under laboratory and field conditions (Barko and Smart, 1981; Goldsborough and Kemp, 1988; Van Wijk *et al.*, 1988; Abernethy *et al.*, 1996; Sabbatini and Murphy, 1996; Vermaat and Hootsmans, 1994).

Plant biomass was also affected by shade, with reductions in total plant weight that varied between 83 (low) and 91% (high) at 35 days, and between 96% (low) and 94% (high) at the end of the experiment (Fig. 1). At 35 days, the reductions observed in the above ground weight (stem plus leaves) resulted from significant reductions in WST (84% reduction in low and 91% in high, with respect to full light) and WLE (81% and 95% reduction for low and high, respectively). These two parameters (WST and WSL) were not measured at the end of the experiment due to the high degree of deterioration of the plants.

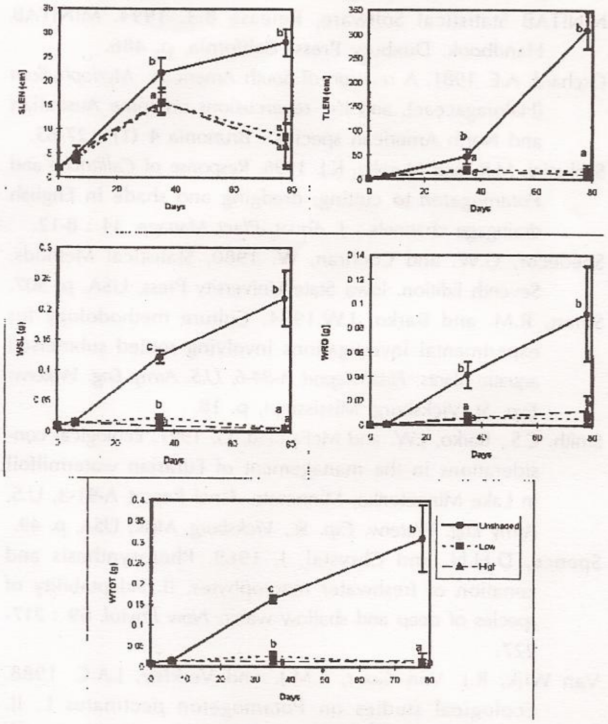

Fig. 1. Main stem length (SLEN), total length (TLEN), above-ground dry weight (WSL), below-ground dry weight (WRO) and total dry weight (WTOT) of plants during the experiment, for the control (unshaded) and shade treatments (low: 41 % reduction in PAR with respect to unshaded; high : 86% reduction in PAR). Mean values (n = 4) and ± standard deviation bars are drawn. Different letters indicate significant differences between treatments at each sampling data (SNK test; $p \leq 0.05$). Absence of letters indicate that differences were not significant.

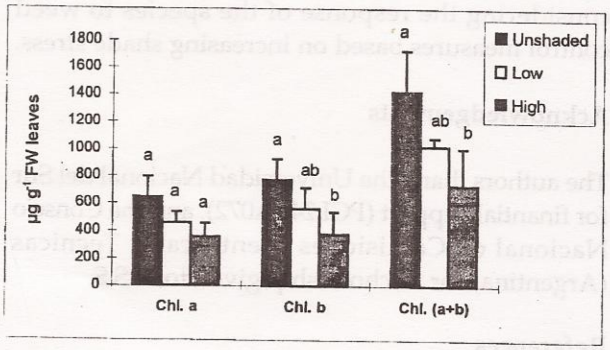

Fig. 2. Plant content of chlorophyll a (Chl. a), b (Chl. b) and total chorophyll [Chl. (a+b)] (μg g^{-1} fresh weight leaves) at the end of the experiment. Mean values (n = 4) and + standard deviation bars are drawn for the control (unshaded) and shade treatments (low: 41% reduction in PAR with respect to unshaded; high 86% reduction in PAR). Significant differences between treatments (SNK; $p < 0.05$) are indicated by different letters.

Plant content of chlorophyll a and b and total chlorophyll [Chl. (a + b)] at the end of the experiment is shown in Fig. 2. An extensive literature exists on acclimation and/or adaptation of chlorophyll contents to changing light climates (see for example Björkman (1981) and Jeffrey (1981) for a review on terrestrial and aquatic environments, respectively). Unlike most submersed macrophytes, total chlorophyll content decreased with decreasing irradiances in the present study (Fig. 2). A similar response was reported by Spence and Chrystal (1970) for the shade-intolerant *Potamogeton polygonifolius*, when subjected to shade conditions. Another reported shade-induced change in plants is the increase in Chl. b content, resulting a growing Chl. a: b ratio as light irradiances decrease. In the present study, no systematic tendence was found for this ratio, being in average 1.05 ± 1.04 for the three treatments.

The distribution of individual macrophyte species is largely dependent upon their specific breadth of adaptability to the environment, among other considerations as for example herbivory and disturbance (Barko and Smart, 1981). Some submersed plants are able to extend into light reduced environments through various mechanisms of acclimation and adaptation involving changes at both cellular and whole-plant levels (Goldsborough and Kemp, 1988). Although those mechanisms varieties from one species to another within a rather wide range of responses, there are some basic features that all shade-tolerant species develop following irradiance reduction, such as stem elongation concentration of canopy near water surface, or increasing in total chlorophyll content. In our study, shade stress produced none of the tipically-observed morphological responses of submersed plants to shade.

The results reported in the present work are of great interest since they show the importance of light in controlling the distribution of *M. elatinoides* in freshwater bodies. They are relevant when considering the response of the species to weed control measures based on increasing shade stress.

Acknowledgements

The authors thank the Universidad Nacional del Sur for finantial support (PGI 24/A072), and the Consejo Nacional de Comisiones Cientificas y Tecnicas (Argentina) for a scholarship given to N.S.S.

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