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Growth of Hygrophila and Hydrilla in Flowing Water[1]

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ABSTRACT

The growth of hydrilla and hygrophila increased when grown in flowing water. Flow rates or turn over times of 1 to 5 hours produced a 3 to 5 fold increase in growth of hygrophila whereas growth of hydrilla increased 2 fold in the flow rates (turnover time) of 2 and 5 hours. In general, hygrophila growth responded more dramatically to increased flow rates, however at the same time hydrilla was spreading and began to compete with hygrophila.

Key words: competition, biomass, turnover, selective control, chemical control, exotic plants, canals.

INTRODUCTION

Hygrophila (*Hygrophila polysperma* (Nees) T. Anderson) is an exotic plant in Florida apparently introduced by aquarium plant growers around 1950 (Innes 1947, McLane 1969). In the last five years, extensive growth of hygrophila have been found at various locations and have begun to cause serious weed problems, most notably in canals in South Florida (Vandiver 1980). It has been shown that hygrophila has high potential growth characteristics which include a low light saturation and compensation point (Spencer and Bowes 1984). Hence, hygrophila is able to fix CO_2 at light levels where many other submersed aquatic plants show net CO_2 loss through respiratory processes. Additionally, hygrophila tolerates high light levels and forms shoots and leaves above the water surface thus intercepting maximum solar radiation. Considering the profuse vegetative reproduction by fragmentation and the lack of seasonality in biomass, it becomes clear that hygrophila has certain advantages over other plants, however, Spencer and Bowes (1984) have shown that hygrophila, at least under experimental conditions, is not able to compete with hydrilla (*Hydrilla verticillata* (L.F.) Royle) in static water.

Hydrilla is considered the most abundant and problematic submersed aquatic weed throughout Florida (Haller 1976). The competitive success of hydrilla results from several well-established combined factors including the tremendous potential of vegetative reproduction (Haller 1976) and a low light saturation and compensation point (Van *et al.* 1976). Although hygrophila does not appear to effectively compete with hydrilla under experimental static conditions, it has competed successfully with hydrilla in naturally flowing water conditions, particularly in South Florida irrigation and drainage canals where it is becoming problematic. Due to the inconsistencies noted above in the growth of hydrophila and hydrilla, this study was designed to evaluate the impact of water flow rate on the growth of these two plants, and compare competition between them.

MATERIAL AND METHODS

The experiment was conducted in twelve 700-liter circular, plastic lined steel tanks. The tank bottoms were covered with a layer of soil, 5 cm thick, and filled with approximately 0.45 m (approximately 500 liters) of water. The soil used, was a mixture of two parts cow manure (analysis reported 0.5, 0.5 and 0.5% NPK, respectively) and one part builders sand. The soil surface was covered with a thin layer of builders sand to stabilize planted apical sections and to prevent turbidity. The water source for the experiment was recycled pond water from a nearby filter channel used in fish culture. Analysis of essential nutrients found in the pond water was completed according to standard methods of analysis. The bottom of each tank was divided into three equal areas (0.25 m^2 each) and was planted with 3 × 84 apical sections (25 cm long) of either hygrophila, hydrilla, or an equal mixture of both species planted alternately. The hygrophila was collected in Boggy Creek in Central Florida and hydrilla from a fishpond in the Austin Cary Forest, in Gainesville.

The flow rates were maintained at 0-l/min, 1.8-l/min, 5.3-l/min and 8.7-l/min, each in three replicate tanks. These flow rates provide an approximate turnover time of 0, 5, 2 and 1 hours, respectively. The water in the tanks with zero flow (static) was aerated and changed weekly.

The mean length of the plants was recorded weekly by measuring at random the length of 10 plants in each of the three planted areas of the tanks. In the area planted with both hygrophila and hydrilla, the length of 10 hygrophila and 10 hydrilla plants was measured. After 6 weeks the plants were harvested, cleaned and dry weight determinations were made of the standing crop. For each tank the dry weight of hygrophila and hydrilla was determined separately for the three areas.

After completion of analysis of variance ($p < 0.05$), means were compared for significance with Duncan's Multiple Range Test. Values with a column in the tables followed by the same letter are not significantly different at the 5% level.

RESULTS AND DISCUSSION

The results of the dry weight determinations are presented in Table 1. Six weeks after the start of the experiment it was evident that both species produced more biomass when grown in flowing water. Hydrilla produced

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TABLE 1. THE STANDING CROP BIOMASS (g) OF PLANTS HARVESTED FROM THE 3 AREAS IN THE EXPERIMENTAL TANKS WITH VARIOUS FLOW RATES. EACH VALUE IS THE MEAN OF 3 REPLICATIONS.

	100% hydrilla	100% hygrophila		50% hydrilla	50% hygrophila
Water flow	hydrilla	hygrophila	hydrilla[1]	hydrilla	hygrophila
Static	47.2B	3.5B	3.9A	25.0A	1.6B
Low	43.6B	14.0A	0.9B	22.0A	6.8A
Medium	74.6A	17.1A	5.9A	44.5A	7.8A
High	75.0A	17.2A	6.1A	43.6A	7.8A

[1]In all treatments, all replications, hydrilla invaded the area initially planted with only hygrophila.

TABLE 2. RELATIVE AMOUNT (IN %) OF THE TOTAL BIOMASS OF HYGROPHILA AND HYDRILLA IN THE DIFFERENT AREAS BASED ON THE TOTAL MASS OF EACH SPECIES IN THE TANKS.

		Area planted		
Waterflow	Species	100% hygrophila	100% hydrilla	50% hydrilla: 50% hygrophila
Static	hygrophila	69	0	31
	hydrilla	5	62	33
Low	hygrophila	68	0	32
	hydrilla	4	60	36
Medium	hygrophila	68	0	32
	hydrilla	5	60	35
High	hygrophila	68	0	32
	hydrilla	1	66	33

the greatest biomass in the medium and high flow rates whereas hygrophila grew equally well at all flow rates studied. Under all flow conditions, the mean biomass of hygrophila was approximately 5 times greater than in static water and the growth of hydrilla at medium and high flow rates was approximately 2 × that of static and low flow rate water. The mean biomass of hydrilla in area 50% hydrilla: 50% hygrophila didn't have significantly different values under the various flow conditions.

The only significant treatment difference of mean shoot length resulting from flow rates was noted for hygrophila (low, medium and high flow) in which case all flow rates resulted in increased shoot length (data not shown). The increased biomass of hydrilla in the higher flow rates was due to increased numbers of shoots, not increased shoot lengths. The impact of flow on the growth of hygrophila includes, besides an increase in biomass and longer shoots, the forming of more emersed leaves and a healthier appearance of the plants. During the experimental period it was noticed that the hygrophila plants grown in static water had a pale light green color in contrast to plants grown in flowing water which had a dark green to brownish color and were more robust.

The total phosphate and total nitrogen analyses of the water didn't result in differences between the four flowrates. The total phosphate concentration was about 0.02 mg/l and the total nitrogen concentration ranged from about 0.35 to 0.50 mg/l.

Reasons for increased plant growth in flowing water are not well understood. We believe that nutrients were not limiting in this study and suspect increased growth of hygrophila and hydrilla in flowing water is due to a difference in the available amount of CO_2. From field measurements it is known that soon after sunrise in static or nonflowing conditions the CO_2 and HCO_3 concentrations begin to decline and can reach zero well before noon (Van *et al.* 1976). Further research on the effect of flow on growth of submersed aquatic plants is needed before any causative factors can be assigned to the different growth rates found in this study.

The relative amount of the total biomass of hygrophila and hydrilla produced in the different areas is indicated in Table 2. In the area planted with 50% hydrilla: 50% hygrophila, the mean biomass of both hygrophila and hydrilla appeared to be about 50% of the mean biomass of the areas planted separately with 100% hydrilla and hygrophila, respectively, under the four flow conditions. Though, under all flow conditions hydrilla had invaded the area planted with 100% hygrophila. Hygrophila does not produce abundant stolons and consequently did not invade or grow along the hydrosoil into areas where it was not initially planted.

The hydrilla shoots (data not shown) from area 50% hydrilla: 50% hygrophila were significantly shorter than shoots from area 100% hydrilla (sign-test, $p < 0.05$) during the entire study period. The length of hygrophila shoots from area 50% hydrilla: 50% hygrophila was not different than other hygrophila grown in the tanks and was apparently unaffected by the presence of hydrilla.

Considering the relative biomass of the different planted areas, hygrophila can compete well with hydrilla under different flowing conditions on a short term basis (six weeks). However, the differences in shoot lengths between the plants grown in their own population or grown in a mixed population indicate certain interactions between the two species. Furthermore, the invading of the hygrophila population by hydrilla points to the competitive capacity of hydrilla.

Assuming all things equal except for water flow, we would theorize that hydrilla will out compete hygrophila in static water. Under flowing conditions, hygrophila growth is increased five-fold, whereas hydrilla only responds with a 2-fold increase in growth. Under flowing water conditions, hygrophila will become much more competitive to hydrilla. Treatment of canals with herbicides of which hydrilla is susceptible would favor expansion of hygrophila which is more resistant to herbicides labelled for hydrilla control.

The theory discussed above seems to be supported by field experience. Hygrophila does not occur in Florida lakes. It does occur in the Suwanee River and under other flowing conditions. It has become a major problem in flood control canals in Florida, often replacing hydrilla, which was regularly treated with herbicides to control its growth.

In future studies with hygrophila it is important that the plants be grown in flowing water as the health and vigor of the plants improves dramatically under turnover times as low as 5 hours. Although static water tests for herbicide efficacy and other studies are important in studying hygrophila, the results of static water tests must be closely scrutinized because hygrophila growth is not optimal under static water conditions.

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