

## **A Study on Competition Between *Hydrilla verticillata* and *Mayaca fluviatilis***

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### **ABSTRACT**

*Mayaca fluviatilis* is an exotic ornamental aquatic introduced to the country via the ornamental aquatic plant industry. The plant is now identified as a potential invasive in the country. The plant morphologically resembles *Hydrilla verticillata* and, a native aquatic while growing submerged in the water. *Hydrilla verticillata* has been recorded for its invasive behavior in the Western Province of Sri Lanka while *M. fluviatilis* is still at its early stages of spread with restricted distribution. Therefore information on *M. fluviatilis* is lacking as it has only been recently recognized as a problematic plant. The present study was conducted with the objective of evaluating inter-specific competition between *M. fluviatilis* and *H. verticillata*. A competition experiment was designed with five treatment combinations viz. terminal shoots of *M. fluviatilis* only (control), terminal shoots of *H. verticillata* only (control) and different combinations of *M. fluviatilis* and *H. verticillata*. The experimental plots were arranged in Completely Randomized Design and plant growth parameters were recorded after eight weeks of planting. Data were analyzed by using Minitab statistical software (version 16). With the introduction of *H. verticillata*, all the growth parameters of *M. fluviatilis* were reduced of which, shoot number root number and root dry weight were significantly ( $p < 0.05$ ) reduced. On the other hand, with the introduction of *M. fluviatilis*, all the growth parameters of *H. verticillata* were increased of which, length of newly formed shoots, shoot dry weight and shoot number were significantly ( $p < 0.05$ ) increased. Therefore, due to the competition, with the introduction of *M. fluviatilis*, the growth performances of *H. verticillata* were increased. Based on the present study, in a situation where *H. verticillata* and *M. fluviatilis* both species coexist, *H. verticillata* will have a competitive advantage over *M. fluviatilis*. Hence, the results

*suggest that despite the similar ecology, H. verticillata may outcompete M. fluviatilis in many situations.*

**KEYWORDS:** Competition, Hydrilla verticillata, Invasive aquatic, Mayaca fluviatilis

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## **Introduction**

Ornamental aquatic plant trade is a blooming industry in Sri Lanka. Currently, 368 plant species including cultivars and hybrids have been listed as traded under ornamental aquatics plant industry in the country and out of which 76% are exotic species. Interestingly 30% of these plants have been recorded for their invasive behavior elsewhere in the world (Yakandawala *et al.*, 2013). Once escaped from the controlled environment some of these plants are capable of invading into natural ecosystems causing irreversible damage to the biodiversity (Yakandawala and Dissanayake, 2010). Many such events have been recorded globally (Maki and Galatowitsch, 2004). *Mayaca fluviatilis* Aubl. is one such plant that has been introduced into the country via the ornamental aquatic plant trade and now has started invading the natural environment. *Mayaca fluviatilis* belongs to the monogeneric monocot family Mayacaceae. It is a perennial herbaceous submerged plant and commonly known as stream bog moss. Recent studies recorded it as naturally occurring in a water body in the Gampaha district in the wet zone of Sri Lanka (Yakandawala and Yakandawala, 2007). Now, *M. fluviatilis* has recorded in 22 other pools/ditches close proximity to the initial location in wet zone of the country (Yakandawala *et al.*, 2014). Certain countries recognized it as a problematic plant such as a quarantine weed (European & Mediterranean Plant Protection Organization, 2007) or as a problematic weed in Florida Lakes in USA (Hanlon *et al.*, 2000). Currently Sri Lanka categories it under potential invasive species.

*Hydrilla verticillata* (L.f.) Royle (Hydrocharitaceae) is a native aquatic that has been identified as an invasive aquatic plant in the Western Province (Bambaradeniya, 2001 and 2008). It is a rooted, submersed perennial monocot often grows abundantly and has become a serious aquatic weed globally. In particular, it has caused substantial ecological and human-related problems in many aquatic systems around the world (Murphy, 1988). *Hydrilla* reproduces mainly from fragments of stems and it also reproduces by growth of axillary buds (turions) and subterranean tubers (Langeland, 1996).

*Mayaca fluviatilis* while growing as a submerged plant still is capable of growing on wet soil during the dry periods. While growing submerged the plant superficially resembles *Hydrilla*. According to Keane and Crawley (2002), competitive exclusion by native plant species seems to be a major force resisting exotic invasions. Studies on the control of invasive species suggest that competition can reduce invasive plant growth more than herbivory (Lonsdale and Farrell 1998, Müller-Schärer 1991). An understanding of the role of competition in plant invasions requires the study of both the ability of the invader to grow and increase in population size in the

recipient community, and the recipient community's tolerance of the invading species (Vila` and Weiner, 2004).

A large body of evidence supports rapid contemporary adaptation of introduced plants to novel environments (Prentis et al. 2008) and the competitive ability of Hydrilla is well documented (Mony *et al.*, 2007; Spencer and Ksander, 2000 ). However, information on *Mayaca* is lacking as it has only recently recognized as a problematic plant. Therefore, this study was conducted with the objective of evaluating inter-specific competition between *M. fluviatillis* and *H. verticillata*.

## **Material and Methods**

### ***Collection of Plant Material***

Plant materials of *H.verticillata* were collected from populations maintained at the Wayamba University of Sri Lanka while plant materials of *M. fluviatillis* were collected from natural populations in the Pugoda area in the Gampaha district. The collection locations of the *M. fluviatillis* populations are given in Figure 1.



**Figure 1. Location of the *M. fluviatillis* populations in the Pugoda area in the Gampaha District**

### ***Experimental Site***

The experiment was carried out in a net house (70% shade) during the period from September to November in 2014 at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura.

### ***Arrangement of Plant Material***

Terminal shoots of both species were cut into 10 cm length fragments and existing branches, roots and flower buds were removed and planted in plastic containers (diameter x height: 35 × 15 cm) filled with 1500 g of media (Top soil: sand 2:1). The containers were filled with 6.5 L of water and placed inside a net house. The water level of each container was maintained at a constant level throughout the experiment.

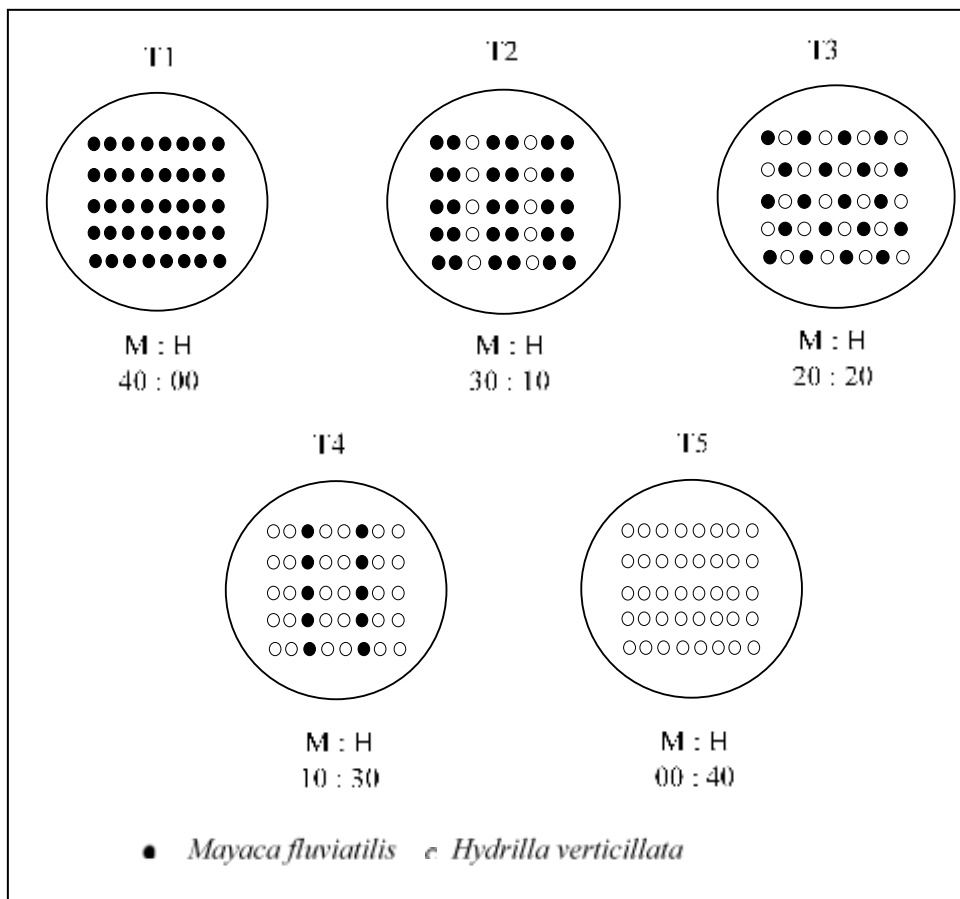
### ***Experimental Design***

The experiment included five treatment combinations *viz.* terminal shoots of *Mayaca* only (control), terminal shoots of *Hydrilla* only (control) and three different combinations of *Mayaca* and *Hydrilla* as given in Table 1.

Forty terminal shoots were planted per container and the method of planting (arrangement of plants in the container) is given in Figure 2. The containers were laid out in a Completely Randomized Design (CRD) representing three replicates per treatment. Hence altogether 600 terminal shoots 300 each from *Mayaca* and *Hydrilla* were used in the experiment.

**Table 1. The Number and ratio of terminal shoots of each species used per container in each treatment**

<b>Treatment</b>	<b>Combination</b>	<b>Number and Ratio of Plants / Container</b>
T1	<i>Mayaca</i> only	40 : 00
T2	<i>Mayaca:Hydrilla</i>	30 : 10
T3	<i>Mayaca:Hydrilla</i>	20 : 20
T4	<i>Mayaca:Hydrilla</i>	10 : 30
T5	<i>Hydrilla</i> only	00 : 40



**Figure 2. Arrangement of shoots of *M. fluviatilis* and *H. verticillata* in each treatment**

### Data Collection and Analyses

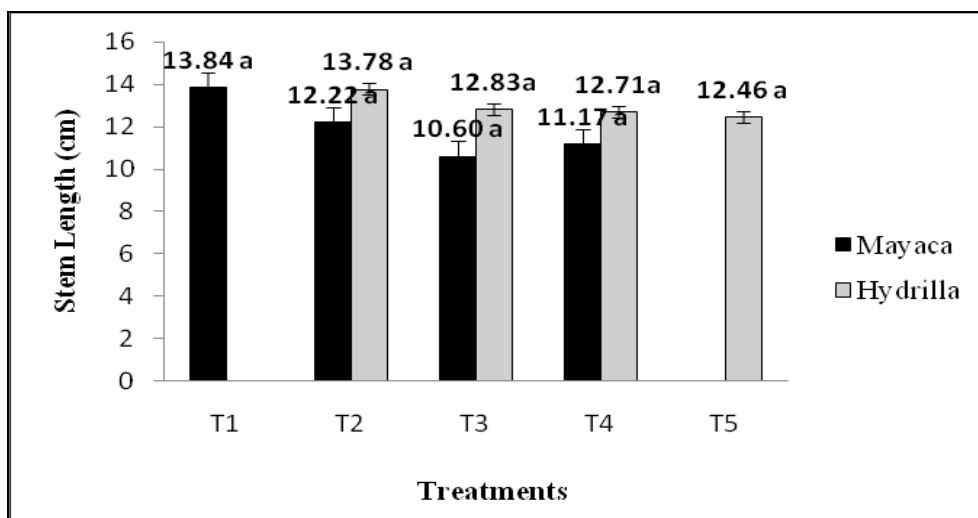
Plant growth parameters *viz.*, length of the main stem (cm), length of the newly formed shoots (cm), shoot number, root number and shoot and root dry weight (g) (oven dried at 80 °C for 48 hours) were recorded after eight weeks of planting. Data were analyzed by General linear model and Tukey method in the Minitab statistical software (version 16).

### Results

The experiment conducted to investigate the inter-specific competition between *M. fluviatilis* and *H. verticillata*, clearly showed a significant change in growth parameters of both species under different treatments.

### Length of the Main Stem

Mean stem length of *Mayaca* varied between 10.60 cm to 13.84 cm (Figure 3). However, there were no significant differences ( $P > 0.05$ ) among treatments. The treatment with only *Mayaca* plants (T1) recorded the highest mean stem length compared to other treatments. The mean stem length of *Hydrilla* varied between 12.46 cm to 13.78 cm and there were no any significant differences among different treatments. Compared to other treatments the control treatment with only *Hydrilla* plants (T5) showed the lowest stem length. The highest stem length was recorded in *Mayaca:Hydrilla* 3:1 (T2) treatment.

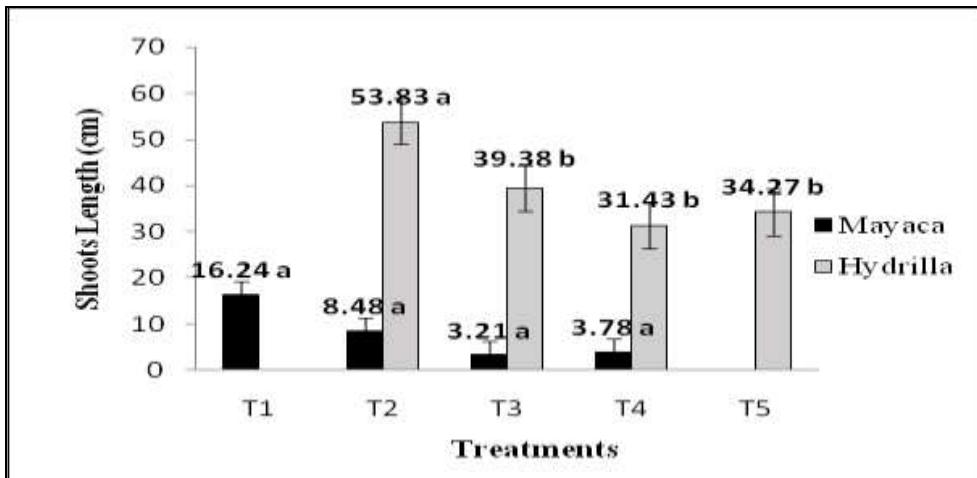


Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 3. Mean stem length of *M. fluviatilis* and *H. verticillata***

### Length of the Newly Formed Shoots

The average length of the newly formed shoots of *Mayaca* was decreased with the introduction of *Hydrilla*, where the highest shoot length was recorded in T1 (16.24 cm), while the lowest was recorded in T3 (3.21 cm). However, a significant difference was not observed (Figure 4). The average length of the newly formed shoots of *Hydrilla* was increased with the introduction of *Mayaca*. A significantly high shoot length of *Hydrilla* was recorded in the *Mayaca : Hydrilla* 3:1 (T2) treatment (53.83 cm) compared to other treatments and there were no any significant differences among other treatments (T3, T4 and T5). Compared to *Mayaca*, shoot lengths were higher in *Hydrilla* in all the treatments.

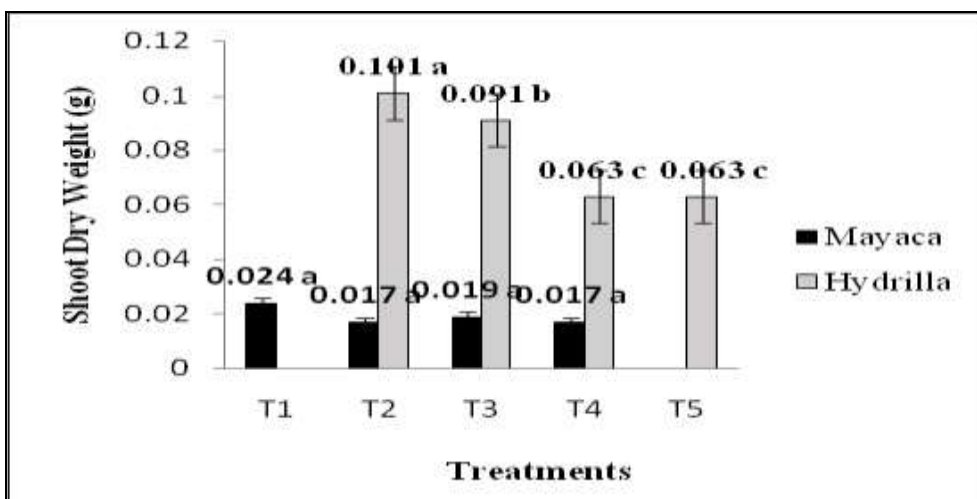


Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 4.** The average length of the newly formed shoots of *M. fluviatilis* and *H. verticillata*

### Shoot Dry Weight

In *Mayaca*, the mean shoot dry weight varied between 0.024 g to 0.017 g and there were no any significant differences among different treatments (Figure 5). The highest stem dry weight was recorded in the control treatment with only *Mayaca* (T1). Significantly high ( $P < 0.05$ ) mean stem dry weight (0.101 g) of *Hydrilla* was recorded in the *Mayaca* : *Hydrilla* 3:1 treatment (T2). While significantly low stem dry weights were observed in control treatment with only *Hydrilla* (T5) and *Mayaca* : *Hydrilla* 1:3 (T4) treatment (0.063 g respectively).

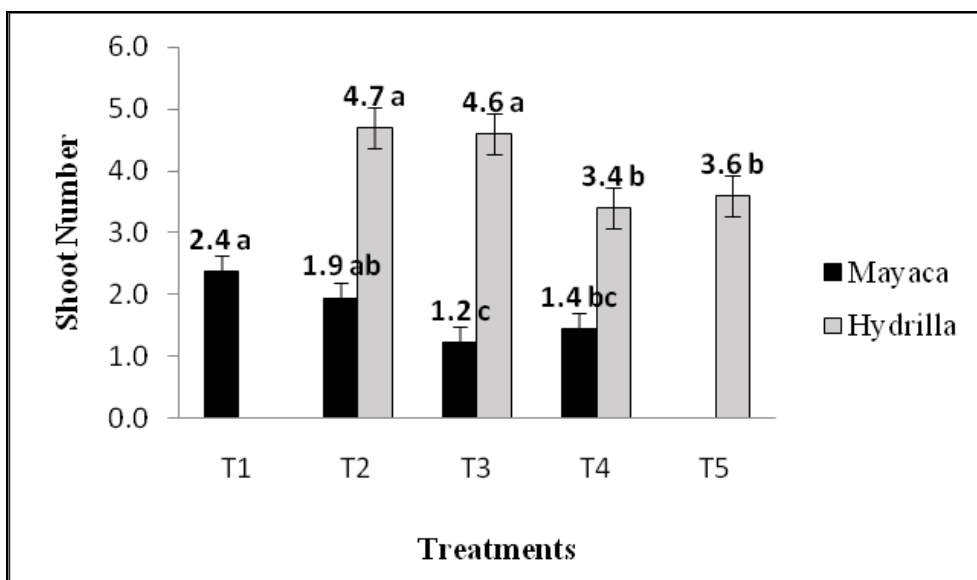


Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 5.** Mean shoot dry weight of *M. fluviatilis* and *H. verticillata*

### Shoot Number

The highest average shoot number (2.4) in *Mayaca* was recorded in the control (T1). (Figure 6). The shoot number was significantly reduced with the introduction of *Hydrilla* and it was significantly low in the control treatment with only *Hydrilla* (T5) and *Mayaca* : *Hydrilla* 1:3 (T4) treatment. With the introduction of *Mayaca*, *Hydrilla* produced more shoots and significantly high shoot numbers were recorded in the T2 and T3 compared to T4 and T5. Compared to *Mayaca*, number of shoots were higher in *Hydrilla* in all the treatments.

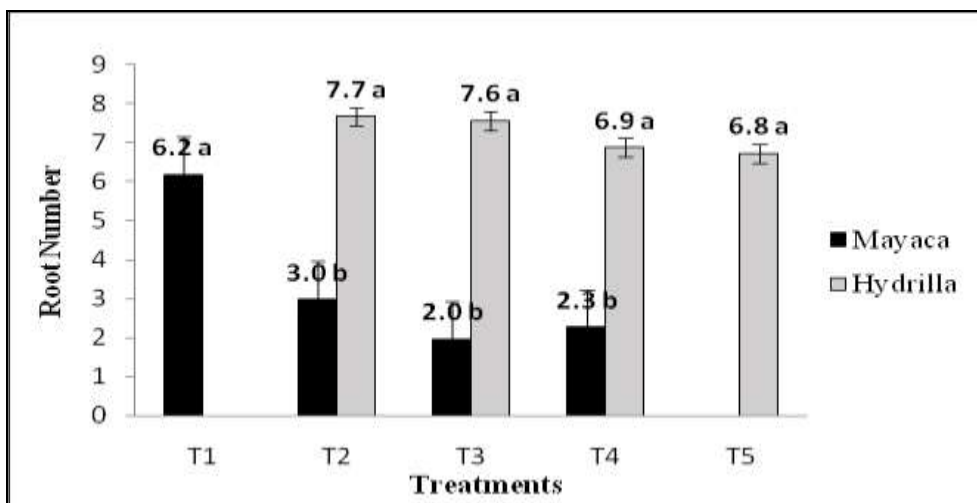


Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 6. Mean shoot number of *M. fluviatilis* and *H. verticillata*  
Root number**

In *Mayaca*, the highest mean root number (6.2) was recorded in the control where only *Mayaca* plants were used (T1) (Figure 7). In the presence of *Hydrilla*, root numbers of *Mayaca* were significantly reduced. However, there were no significant differences in the root numbers among treatments T2, T3 and T4. In *Hydrilla*, root numbers were not significantly different among treatments. However, an increase trend in root number was noted with the increase in the number of *Mayaca* plants. Compared to *Mayaca*, the total numbers of roots were higher in *Hydrilla* in all the treatments.



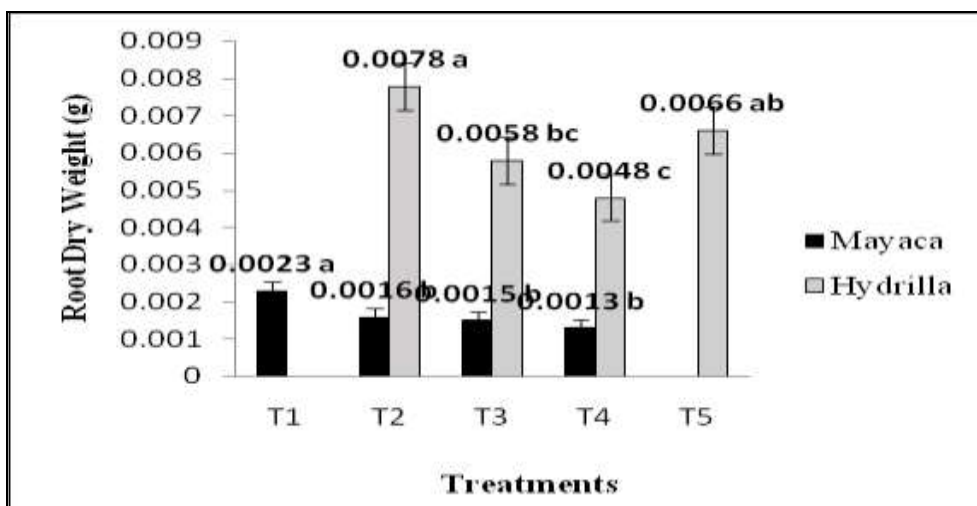


Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 7. Mean root number of *M. fluviatilis* and *H. verticillata***

### Root Dry Weight

In *Mayaca*, a significantly high root dry weight was recorded when only *Mayaca* was present (T1) (Figure 8). However, with the introduction of *Hydrilla*, root dry weight was significantly ( $P < 0.05$ ) reduced but there was no significant difference among treatments T2, T3 and T4. The mean root dry weight of *Hydrilla* was not significantly different in control (T5) and T2. The lowest root dry weight of *Hydrilla* was recorded in T4 which was significantly different from T2 and T5. Compared to *Mayaca*, root dry weights were higher in *Hydrilla* in all the treatments.



Means with same letters represent non-significant differences ( $p < 0.05$ )

**Figure 8. Mean root dry weight of *M. fluviatilis* and *H. verticillata***

## **Discussion**

The success and impact of alien species depend on their biological attributes, the environmental characteristics of the invaded ecosystem and the biotic interaction with the receptive community (Keane and Crawley, 2002). When an exotic is introduced, competition for limiting resources is probably the first interaction the species encounter with the recipient community (Crawley, 1990) and high competitive ability of the exotic species has been mentioned as a key factor promoting successful invasive potential (Roy, 1990).

In aquatic plants, the most intense competition may be expected to occur between plants occupying the similar position in the water column (Tilman, 1982). *Hydrilla verticillata* and *M. fluviatilis* both are submerged plants typically attached to the bottom of the water body. Hence, if coexist, both plants will compete for the similar resources. The present study clearly recorded the inter-specific competition among *H. verticillata* and *M. fluviatilis*.

During the present study, with the introduction of *Hydrilla*, all the growth parameters of *Mayaca* were reduced of which, shoot number root number and root dry weight were significantly reduced. Though stem length, length of newly formed shoots and shot dry weights were reduced, there were no any significant differences. Hence, we could conclude that due to the competition with *Hydrilla*, the growth performances in *Mayaca* were reduced.

On the other hand, with the introduction of *Mayaca*, the growth parameters in *Hydrilla viz.*, length of newly formed shoots, shoot dry weight and shoot number were significantly increased. Though there is no any significant effect, stem lengths, root number and root dry weight were increased. Therefore, due to the competition, with the introduction of *Mayaca*, overall growth performance of *Hydrilla* was increased.

Studies conducted by Spencer and Ksander (2000) has also indicate a strong competitive ability of *Hydrilla* in the presence of American pond weed *Potamogeton nodosus*. Further, in another study (Mony *et al.*, 2007) also indicates that, *H. verticillata* may outcompete *Egeria densa* in many situations, probably due to its higher plasticity.

The inter-specific competition affects *Mayaca* in a negative way and it affects *Hydrilla* in a positive way. Hence there is a possibility to control *Mayaca* using *Hydrilla*. However, as these species are perennials and as they were in their early stages of growth it is difficult to conclude which species would over compete the other in long term. Distinctly fewer studies have been carried out on interference among submerged plants. Therefore, further field studies should be conducted to see whether it is possible to eliminate *Mayaca* using *Hydrilla*. The present study shed some light to the inter-specific competition between two submerged aquatic plants and this information will be useful in further studies.

## **Conclusions**

*Hydrilla verticillata* and *M. fluviatilis* both occur in similar habitats though they do not occur together naturally in the country. Hence, if coexist, both plants will compete for the similar resources. Based on the present study, in a situation where *Hydrilla* and *Mayaca* coexist, *Hydrilla* will have a competitive advantage over *Mayaca* as growth parameters are significantly increased in *Hydrilla*, whereas it was significantly decreased in *Mayaca*. Hence, *Hydrilla* could out compete *Mayaca* in an event of a competition.

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