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Short Communication

The Efficacy of Herbicides in Controlling *Mayaca fluviatilis*: An Invasive Aquatic in Sri Lanka

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Abstract

The present study describes an attempt to investigate the efficacy of herbicides available in the market and its concentration to control Mayaca fluviatillis, a potential invasive aquatic plant in Sri Lanka. The experiment included 11 different treatments; five different herbicides/ herbicide mixtures sprayed on plants, each at two different concentrations and a control. A significant ($P < 0.001$) colour change, which resembles complete mortality, was observed 8 weeks after treatment with the herbicide Solid Pretilachlor at high dose (2.5 ml/L). Root dry weight and efficacy rate of the herbicide (100 %) also supports this observation. As other herbicides does not report 100% efficacy, Solid Pretilachlor at 2.5 ml/L could be recommended as an alternative method to mechanical control of M. fluviatillis with minimum environment impact as the plant is currently spread only in water bodies which are small in size and are not interconnected.

Keywords: Aquatic invasive, Efficacy, Herbicides, *Mayaca fluviatilis*, Pretilachlor.

Introduction

Mayaca fluviatilis (Mayacaceae) commonly known as Stream bog moss is a submerged, perennial herbaceous aquatic plant. The plant is widely distributed in Latin America from Mexico to Argentina, as well as in the West Indies, the southeastern United States, and central Africa[1] while it is not occurring naturally in Sri Lanka. It is popular as a background plant in aquariums and is propagated locally and exported by private sector aquatic plant growers in Sri Lanka[2].

However, according to Yakandawala and Yakandawala[3], it was recorded as naturally occurring in a water body in the Gampaha district in the wet zone of Sri Lanka. Subsequent studies recorded its further spread close to the same vicinity in 15 locations[4]. Consequently the plant has been recognized as a potential invasive plant in Sri Lanka. Certain countries have also recognized *M. fluviatilis* as a problematic plant, where it has been documented as a quarantine weed[5], a problematic weed in Florida Lakes in USA[6] and reported to be a plant that poses a high weed risk in Queensland, Australia[1]. Ornamental horticultural trade has been identified as a strong contributing pathway to the introduction and spread of aquatic invasive plants[7]. Compared to terrestrial plants, aquatic plants have indicated a higher probability of becoming invasive in new environments and therefore, perhaps deserve more urgent attention[8].

Established management strategies of aquatic invasive plants include different methods such as biological, chemical, cultural, mechanical and physical tools.

However, according to Richardson[9], each management tool has its own advantages and disadvantages. Furthermore, the implementation of different management techniques could become complicated since there may be multiple users, managers, and stakeholders that may be present on aquatic ecosystems. Selection of the best treatment or combination of treatments depends on the species of water plant, extent of the problem, economic considerations and local environmental conditions[10].

The control of *M. fluviatilis* has been carried out using Grass Carp (*Ctenopharyngodon idella*) in Florida, USA[5]. According to Yakandawala and Dissanayake[2], even a 2 cm fragment is capable of developing into a new plant, and therefore the mechanical control is not recommended as it could lead to further spread due to stem fragmentation. Herbicide control experiments have been undertaken on *M. fluviatilis* in New South Wales, Australia however, effective treatments have proved elusive[1]. In this backdrop studies were conducted with the objectives of determination of the efficacy of herbicides available in the market and its concentration to control *Mayaca fluviatillis* in Sri Lanka.

Materials and Methods

Collection of plant material: Plant materials of *M. fluviatilis* were collected from natural populations in the Pugoda area in the Gampaha district of wet zone of Sri Lanka and the experiment was carried out inside a rain shelter in 2014 at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.

Arrangement of plant material: Terminal shoots of 7 cm in length were separated and existing branches, roots and flower buds were removed. Thereafter, six terminal shoots were planted per glass containers (diameter x height: 5 × 15 cm) filled with 100 g of media (Top soil: sand, 2:1). The containers were filled with 150 ml of water and placed inside a rain shelter. During the study period, water was added as necessary to maintain a constant volume. Foliar fertilizer (Maxicrop 5 ml/L) was applied to the plants to enhance the growth once a week, for a month.

Experimental design: All the containers were laid out in a Completely Randomized Design (CRD) representing five replicates per treatment. The experiment included 11 different treatments; five different herbicides/ herbicide mixtures sprayed on plants, each at two different concentrations *viz.* recommended (high) and half of the recommended (low) rates respectively and a control. The control was sprayed with tap water instead of herbicide (Table-1). Each herbicide treatment was carried out after emptying the water from the container and by spraying the respective dose directly to the plants which was supposed to be immediately absorbed by plants and, after 6 hrs they were filled once again with water.

Data recording and analyses: Data were collected for the experiment on the effectiveness of herbicides after two months of planting, when the plants were actively growing and well established. Both visual and dry weight assessments were made for measuring the performance of *M. fluviatilis* under each treatment. The visual assessment of the application of the herbicide in terms of colour variation of plants were made on a six point Likert scale [1 for green (no herbicide effect) to 6 for brown (mortality)], after 3 days and thereafter weekly for 8 weeks after treatment (WAT). Data were analyzed by Kruskal - Wallis and Moods Median Test to compare the effect of the treatment.

At 8 WAT, all the plants were removed from each container and the final effect of the herbicide on the plant was recorded. The percentages of live and dead plants were calculated and plants were oven dried (800C for 48 hrs) to obtain dry weight. The dry weight data were analyzed by General Linear Model and means were separated by Turkey test.

The efficacy of the treatments was calculated as treatment dry weight relative to control using the following formula.

Efficacy of treatment = (Control dry weight - treatment dry weight) x 100/Control dry weight.

Results and Discussion

The effect of herbicide treatment in terms of colour variation: The experiment conducted to detect the effectiveness of herbicides in controlling *M. fluviatilis*, clearly showed a significant change in colour in plants among different treatments. The colours differed significantly ($P < 0.001$) among different herbicide treatments. A significant colour change which resembled complete mortality (brown colour) was observed 8 WAT with the herbicide Pretilachlor at high dose (T 7).

Table-1
Details of the treatment combinations used in the study

Treatment	Herbicide (Trade name)	Active ingredient	Rate of application (ml/L)	Level of application
T1	MCPA	M.C.P.A. 600g/ L	2.400	High
T2	MCPA		1.200	Low
T3	Nominee	Bispyribac-sodium 100g/L	0.750	High
T4	Nominee		0.375	Low
T5	Solo	Bispyribac-sodium 15g/L + Thiobencarb 900g /L	4.250	High
T6	Solo		2.125	Low
T7	Solid Pretilachlor	Pretilachlor 300g/L	2.500	High
T8	Solid Pretilachlor		1.250	Low
T9	Glyphosate	Glyphosate 360g/ L	11.500	High
T10	Glyphosate		5.750	Low
T11	Control	Tap water		

Table-2
Effect of herbicides on survival of *M. fluviatilis*, 8 WAT

Treatments	Live plants %	Mean Dry Weight (g)	Control % (Efficacy)
T_1	100	0.016^{ab} (±0.0010)	23.6
T_2	100	0.019^{a} (±0.0008)	14.4
T3	100	0.017^{a} (±0.0010)	18.6
T4	100	0.018^{a} (±0.0007)	15.4
T5	40	0.005^{c} (±0.0012)	77.9
T6	100	0.018^{a} (±0.0007)	11.5
T7	00	0.000^{d} (±0.0000)	100.0
T8	60	0.005^{c} (±0.0008)	77.9
T9	100	0.013^{b} (±0.0007)	36.1
T10	100	0.019^{a} (±0.0007)	11.1
T11	100	0.021^{a} (±0.0010)	00.0
P value		0.0000	

Means in a column with the same letters are not significantly different at the 0.05 level

Survival of *M. fluviatilis* after different herbicide treatments: The overall percentage of survival of *M. fluviatilis* plants in each treatment, 8 WAT is given in Table-2. Results indicated that 100% of plants die upon application of Solid Pretilachlor at high rate (T7). This was followed by 60% death in Solo high (T5) and 40% death in Solid Pretilachlor low (T8) rate. All the other treated plants showed 100% survival, 8 WAT. Adventitious roots and buds were observed in Glyphosate high and low (T9, T10) rate and MCPA high (T1) rate treated plants.

Effect of herbicide treatments on dry weight of Mayaca plants: Mean dry weight of *Mayaca* plants in each treatment 8 WAT is given in Table-2. The dry weight significantly differed ($P < 0.001$) among herbicide treatments. As all the plants were dead, no roots were recorded in the treatment with Solid Pretilachlor high rate (T7). Compared to other treatments, significantly low dry weights of were recorded in Solo high (T5) and Solid Pretilachlor low (T8) treated plants.

Efficacy of different herbicides: The efficacy of each treatment 8 WAT is given in Table-3. Efficacy rate of 100% was recorded by Solid Pretilachlor high rate (T7) treatment. This was followed by similar efficacy rates of 77.9% by Solo high (T5) and Solid Pretilachlor low (T8) rate treated plants. Low efficacy rates were recorded in all the other treatments.

The effectiveness of herbicides in controlling *Mayaca fluviatilis*: Herbicide application as a method to control invasive aquatic plants has long been a practice. Herbicides were successfully used to control aquatic plants such as *Elodea canadensis*[11] and *Hydrilla verticillata*[12]. Madigan and Vitelli[13] have experimented the effect of herbicides in controlling *M. fluviatilis* and the higher application rates of triclopyr, flumioxazin, endothal and diquat gave >90% biomass reductions at 120 days after treatment in Australia. However, as re-growth occurred, multiple applications have been recommended to provide long term plant control. The present study indicated the effectiveness of Solid Pretilachlor (2.5 ml/L) in controlling *M. fluviatilis* even after 5 weeks. Pretilachlor [2-chloro-2,6-diethyl-N-(2-propoxyethyl) acetanilide] a selective systemic herbicide is a chloroacetanilide herbicide which is widely used in rice fields for the control of several grasses, broad-leaved weeds and sedges[14]. Pretilachlor is absorbed primarily by the germinating shoots, and secondarily by the roots, with trans-location throughout the plant, giving higher concentrations in vegetative parts than in reproductive parts[15].

Therefore, this could be used to control further spread of *M. fluviatilis* successfully. Currently as *M. fluviatilis* has invaded into seasonal isolated water bodies in a restricted area of about 2 km^2, still it is possible to apply herbicides with a minimum impact to the environment. As these water bodies are not interconnected, the risk of downstream contamination is minimal. Further, application could be carried out in dry season when the water bodies are completely dry to minimize contamination. Further, Vidotto *et al.*[14] observed a low percolation rate and the high ratio of herbicide adsorption on the sediment after application of Pretilachlor where they suggest that Pretilachlor disappearance from the water was mainly as a

result of degradation. This further minimizes the risk of any accumulation of the chemical in the environment.

Conclusion

Recognition of *M. fluviatilis* as a problematic plant speaks the necessity of immediate action to prevent its further spread. The present study identified the effectiveness of the herbicide Solid Pretilachlor (2.5 ml/L) in controlling *M. fluviatilis.* It could be used to control *M. fluviatilis* with minimum environment impact as the plant is currently spread in only water bodies which are small in size and are not interconnected. As mechanical control could lead to further spread of the plant, the use herbicides to control Mayaca are an alternative solution. Out of the five different herbicides tested, only Solid Pretilachlor (2.5 ml/L) was successful in controlling *M. fluviatilis*. Further, the herbicide application could be carried out in dry season to minimize contamination.

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