EFFECT OF FOLIAR HERBICIDES ON EMERGENT BOGMOSS (*MAYACA FLUVIATILIS* AUBL.) IN NORTH QUEENSLAND, AUSTRALIA.

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ABSTRACT

Bogmoss (*Mayaca fluviatilis* Aubl.) is an exotic perennial aquatic plant that can grow fully submerged, in the form of semi-floating mats, or as a semi–terrestrial plant on wetland margins. Infestations of bogmoss have been found in several locations within Queensland and New South Wales. In tropical north Queensland, the weedy potential of bogmoss is demonstrated by its formation of monocultures and subsequent blocking of agricultural drains and natural water courses, resulting in flooding and damage to infrastructure.

Control options for management are limited with many challenges to controlling weeds in flowing aquatic systems. To increase the management options we tested the effectiveness of five herbicides on emergent bogmoss growing in large tubs in a glass house. The herbicides tested are all registered for use within aquatic situations. Although the water was not running, this was the closest practicable set-up to test the effect of the chemicals on emergent bogmoss.

We found that all herbicides tested were able to achieve high mortality of bogmoss, within 15 weeks, however, ProcellaCOR® and Reglone® showed the best results for overall reduction of living biomass. Further investigation would be required to see if the successful results in tubs would transfer across to real-life moving water situations.

Keywords: aquatic weed, invasive, wetlands, aquarium plants

INTRODUCTION

Bogmoss is a perennial aquatic plant that can grow either fully submerged, in the form of semi-floating mats, or as a semi–terrestrial plant on the margins of wetlands. It has been cultivated as a decorative plant for use in the aquaria trade and has subsequently been mismanaged and naturalised in the environment. It threatens the biodiversity, drainage capacity, and recreational use of water bodies (Madigan and Vitelli, 2012). This aquatic species is found in several locations within Queensland and New South Wales and its weedy potential is evident in Tropical North Queensland, (Figure 1).

Near Silkwood, North Queensland, bogmoss currently infests over 2 km of agricultural drains where it is the dominant species and is reported to block the drains and cause localised flooding. Standard agricultural maintenance spraying of the drain by the landholder has failed to halt the spread of this weed. The drains flow into wider, deeper, natural watercourses which are not managed and contain abundant bogmoss.
In conjunction with the Cassowary Coast Regional Council, a pilot trial was established using the application of black plastic and shade cloth to the drain. This successfully killed the bogmoss but was impractical in this location due to high rainfall levels and periodic

strong wind conditions (e.g. flooding, cyclones) necessitating frequent removal and replacement of the plastic or shade cloth.

Previous herbicide trials (Madigan and Vitelli, 2012) including screening and rate refinement, investigated the application of herbicides to the submerged mass of small amounts of bogmoss in water containers. The results from these trials are beneficial for treating infestations within standing bodies of water, however they may not effectively control aquatics in moving water bodies, such as drains, streams, rivers. In these situations, treatment of the underwater biomass will not be feasible, and the above-water (emergent) portion will have to be treated instead. This trial, whilst not able to address the issues of running water, investigated herbicide treatment of above water biomass, with a large proportion of biomass underwater.

This trial tested the effectiveness of five herbicides on emergent bogmoss growing in large tubs in a controlled environment. The herbicides are all registered for use within aquatic situations and were determined with consideration of current label registrations and input from aquatic herbicide experts. Roundup Bi-active® had been previously trialled and found relatively ineffective. Although the water was not running, this is the closest practicable set-up to test effects of herbicides on emergent bogmoss, and results should transfer across to moving water situations.

METHODS AND MATERIALS

Twenty plastic tubs (MegaBins™) of 800 L capacity (100 X 100 X 80 cm) were evenly placed within a secure temperature-controlled glasshouse at the Centre for Wet Tropics Agriculture (CTWA), in South Johnstone, north Queensland. Each tub contained twelve 20 cm pots filled with a 4:1 sand:soil mixture. Bogmoss plants, including a portion of substrate from the collection site, were collected from near Liverpool Ck (Latitude: 17.72°, Longitude: 146.05°) and planted into the pots.

Fresh creek water was added to cover the newly transplanted material by 20 cm. As the stems grew over time and reached the water surface more water was added to encourage stem elongation. The aim was to progressively lengthen stems to approximately 60 cm then allow the biomass to thicken and emergent stems to mature. Once 100 % coverage of the tub surface was achieved, and bogmoss had emerged approximately 5 cm above the water level it was considered representative of field conditions.

Rexolin® trace elements aquatic plant fertiliser was applied at label rates every two weeks to provide nutrients to the bogmoss plants for the duration of the trial. The average water temperature during the experiment was 24.3°C and measured using individual HOBO® data loggers placed in each tub. The plants received natural filtered ambient light which fluctuated seasonally and effected all tubs equally. Herbicide treatments were allocated to each individual tub in a randomised block design. The allocated treatment for each tub was applied in August 2021 using a handheld gas pressurised sprayer (Preval® Power Unit) as shown in Figure 2. This application method allowed even coverage with a small volume of spray and prevented off-target drift from occurring. Each treatment used a spray volume of 150 mL /1 m^2 bin also included 0.1 mL of Nemo® wetter. The treatments used are shown in Table 1.

Table 1. Herbicides and application rates used in the trial.

Active Ingredient	Trade name	Rate	Product rate

		(g a.i /m²)	(mL or g /m²)
flumioxazin	Valor®	0.042	0.084
endothal	Cascade®	0.59	1.18
diquat	Reglone®	0.2	1.0
triclopyr	Renovate®	0.365	1.02
florpyrauxifen-benzyl	ProcellaCOR EC®	NA	0.234
coca beta	NEMO®	NA	0.1
control	control	NA	NA

Figure 1. Bogmoss in an agricultural drain near Silkwood, north Queensland

Figure 2. Spraying bogmoss in the glasshouse

After herbicide application, the treatment effect was assessed weekly. Four 25 x 25 cm floating quadrats were placed centrally on the tub surface and two observers individually visually assessed the tubs using a rating system (Tub Plant Health Rating) with the final rating being the mean of all ratings for each tub The rating system was scaled 1 through to 6 and is described in Table 2.

Table 2. Rating system for bogmoss assessment

Rating	Description
1	Alive,100% green stems, no brown stems.
2	Appears alive, mostly green, less than 50% brown stems
3	Appears alive, some green, more than 50% brown stems.
4	Appears dead, 100% material down to pot surface brown, some reshooting.
5	Appears dead, 100% material down to pot surface brown, no reshooting
6	Dead, 100% material down to pot surface is brown, rotting, gone.

A digital photo from a set point was taken of each tub at each assessment to provide added confidence in the assessment over time. The experiment was concluded after 15 weeks, when a clear result was obtained. At this time all pots were given an in situ final health assessment rating (Individual Plant Health Rating), where each of the assessors gave a rating for each plant and then the mean of these become the final rating and a representative pot from each treatment plus a healthy control pot were removed from the water and photographed.

RESULTS

The results show that all herbicide treatments were highly effective. All treatments scored well in the Individual Plant Health Rating and showed full death in the individual pots pulled out and photographed at the conclusion (Figure 3) of the trial. However, not all treatments were so successful in the Whole Tub Plant Health Rating, with ProcellaCOR EC® and Reglone® performing the best, producing the highest overall reduction of living biomass in the whole tub.

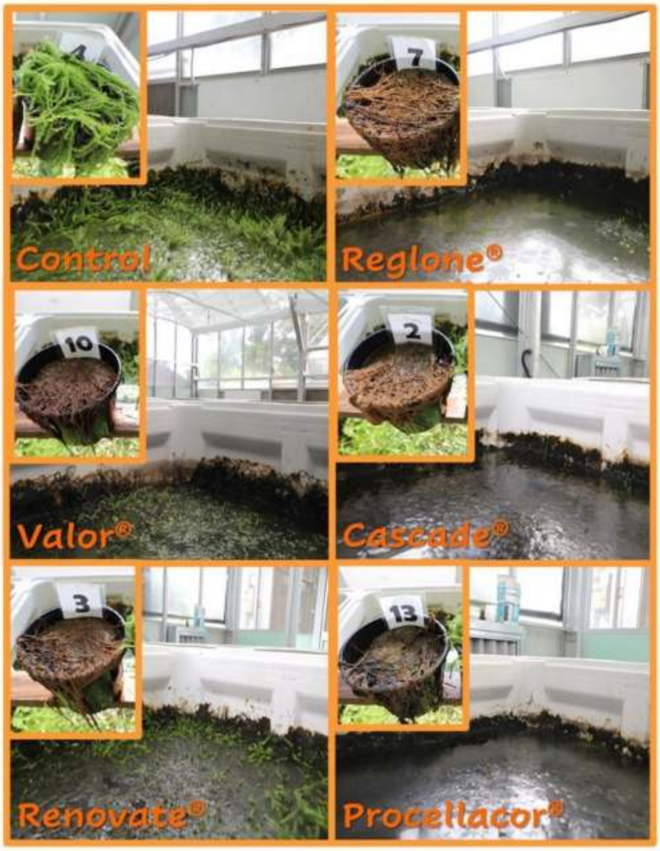

Figure 3. Example individual pots (inset) on background photo of example whole tub for each herbicide, as labelled, at conclusion of experiment (15 weeks after treatment)

Table 2. Comparison of herbicide treatments quantified by plant health ratings. Fishers Protected LSD test, One Way Anova. Means within a column that do not share a letter are significantly different ($P < 0.05$).

Active Ingredient	Trade name	Whole tub plant health rating	Individual pot plant health rating
Control	NA	1.08 a	1.37 a
flumioxazin	Valor®	2.71 b	4.85 b
triclopyr	Renovate®	4.16 c	5.3 b
diquat	Reglone®	4.74 c	5.89 b
endothal	Cascade®	4.86 c	5.98 b
florpyrauxifen-benzyl	ProcellaCOR EC®	4.87 c	6.00 b
		LSD 1.303	LSD 1.84

DISCUSSION

Madigan and Vitelli (2012) found flumioxazin, triclopyr, diquat and endothal to be effective. Their replicated microcosm study, conducted in 2-L aquaria, showed >90% biomass reductions of bogmoss at 120 DAT. Although application rates are not directly comparable as they treated the water column, whereas we applied herbicides to emergent foliage, their trial did identify high levels of activity for the same herbicides.

Flumioxazin (as Valor®) successfully controlled bogmoss in our trial. Flumioxazin is a systemic herbicide, and available in Australia as an effervescent tablet (e.g. Clipper®). Bickel *et al* (2022) conducted outdoor pond trials which demonstrated that foliar and subsurface flumioxazin application provide excellent Amazon frogbit (*Limnobium laevigatum*) control (95 -100% biomass reduction) at intermediate label rates. This demonstrates that similar results could be expected in field trials of flumioxazin for the control of bogmoss.

Studies in New Zealand by Champion *et al.* (2008a) found triclopyr (Garlon®) to be effective on the following aquatic and wetland weeds: grey willow (*Salix cinerea*), alder (*Alnus glutinosa*), crack willow (*Salix fragilis*), primrose willow (*Ludwigia peploides*), water celery (*Apium nodiflorum*), water cress (*Nasturtiam officinale*) and monkey musk (*Mimulus guttatus*). Champion *et al* (2008b) also notes that "Triclopyr TEA appears to provide similar control of broadleaf wetland weeds as glyphosate but is much more selective with limited damage to non-target sedges, grasses and rushes". Renovate® 3 (triclopyr a.i.) is a systemic broadleaf herbicide used for selective shoreline control of a variety of broadleaved aquatic plants and brush. Our trial showed that Renovate® was also able to control emergent bogmoss in the glasshouse. Lamb (2020) states "that Procellacor™ can effectively control Yellow floating heart (*Nymphoides peltata*), an aquatic floating leaf plant, in a relatively large reservoir and that the post-treatment impacts to water quality are relatively minimal and short lived". ProcellaCOR® was also effective in our trial and can be applied directly into the water at the depth of the invasive plants or applied as a foliar treatment. As a systemic herbicide, weeds absorb the herbicide through the entire structure and roots, with the plant dying off over a period of two to four weeks and breaking down naturally.

Dugdale *et al.* (2012) found both endothal and diquat (same active ingredients as Cascade® and Reglone® respectively) to be highly effective on several aquatic weeds in a screening trial in Victoria including Cabomba (*Cabomba caroliniana*), sagittaria (*Sagittaria platyphylla*), elodea (*Elodea canadensis*), floating pondweed (*Potamogeton sulcatus*), ribbon weed (*Vallisneria australis*) and egeria (*Egeria densa*). Endothal and diquat were also successful in out experiment. Diquat is not systemic and will only kill parts of the plants that it contacts, so for best results, an even and complete coverage with good penetration of the spray into the target foliage is necessary. Diquat acts rapidly on the green parts of all plants and is locally systemic. Although endothall is considered a contact herbicide, many field observations suggest that it might have systemic activity (Oritz *et al* 2019).

All the herbicides performed well in the individual plant health ratings, however there were differences with the tub health ratings, suggesting that some treatments, e.g. flumioxazin, may have caused fragmentation to occur, i.e. some plant parts to remain alive, that could potentially regrow. In Singapore, Yakandawala and Dissanayake (2010) found that manually fragmented vegetative parts of 2 cm length could develop into new bogmoss plants which indicates that herbicides that causes total death would be preferable to those that might cause live viable fragmentation. Therefore the treatments that rated best in the Tub Plant Health Rating may be advantageous, i.e. Procellacor and Reglone®.

The impact of the herbicides tested on co-occurring aquatic flora was not investigated in this study but could be done as part of further field trials.

CONCLUSIONS

The experiment found all herbicides tested to be able to control bogmoss. The application of these results to the field would be the next step to provide better management solutions for bogmoss.

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OPTICAL/THERMAL/NIGHT VISION EDGE AI CAMERA TRAP WITH REMOTE TRIGGER

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ABSTRACT

eVorta Pty Ltd has already built a largely successful platform for AI Camera Trap monitoring. We have taken this technology and created a device that can operate autonomously in the field, is IP68 waterproof, has a thermal camera along with night vision and optical cameras with satellite communication capability.

We want to present on how this device can be used as an Edge AI remote trapping tool to capture invasive species or even native species of interest.