Australian weed morphology and its potential impact on electric weed control application efficacy

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Summary Weed management is essential throughout Australia, however, the implementation of current mechanical and chemical weed control methods has been impeded by numerous factors. Therefore, Australia needs to consider alternatives, including electric weed control. However, this technology is untested in Australian conditions and a multitude of variables will affect the technology's efficacy which are yet to be analysed. One such variable is the weed's morphology which may impact application efficacy. Results of two pot trials conducted by DPIRD indicate that volunteer crops and winter weed species may be harder to control based on their morphology. Therefore, while electric weed control offers a new alternative weed control method for Australian systems, the morphology of the weeds treated will need to be considered to obtain optimum efficiency.

Keywords *Electroweeding, electrophysical, weed management, non-chemical, weed morphology*.

INTRODUCTION

Electric weed control or 'electroweeding' is where an electrical current is transferred through the target plant following plant-electrode contact (Vigneault and Benoit, 2001). This causes a pressure build up as the liquids inside the cells vaporise, causing them to rupture, killing the plant (Diprose et al., 1980). Electroweeding has proven a popular weed control method globally with numerous companies producing machines for various settings and interest is growing for their expansion into the Australian market. However, a multitude of variables will affect this technology's applicability and efficacy for Australia, and many are yet to be thoroughly researched.

One such variable is that of the weed's morphology, which alters the vegetative resistance and therefore, the energy threshold required to ensure the plant's complete death (Diprose and Benson, 1984, Diprose et al., 1980, Vigneault and Benoit, 2001). Morphological factors theoretically affecting efficiency of electric weed control include plant growth stage, shoot and root biomass as well as surface area (Diprose and Benson, 1984, Drolet and Rioux, 1983). More research is required on the characteristics of key Australian weed species to optimise electric weed control application.

Two pot trials were conducted between 2021-2022 to characterise morphological factors of common summer and winter weeds in Australia. This will allow us to predict the efficacy of electric weed control as a weed management option within Australia.

MATERIALS AND METHODS

In the first 'winter' pot trial (2021), seven winter weed species were grown in controlled glasshouse conditions (12-hour temperature cycle of 10/20°C) in a fully randomised design. In the second 'summer' pot trial (2022), eleven summer weeds were grown in a screenhouse at standard summer temperatures (20-40°C), also in a fully randomised design. The winter species included wheat cv. Mace (*Triticum aestivum* L.), double gee (*Emex australis* Steinh.), blue lupin (*Lupinus cosentinii* Guss.), and brome grass (*Bromus diandrus* Roth). The summer species were windmill grass (*Chloris truncata* R. Br.), button grass (*Dactyloctenium radulans* R. Br.), Feathertop Rhodes grass (*Chloris virgata* Sw), caltrop (*Tribulus terrestris* L.), wild radish (*Raphanus raphanistrum* L.), Afghan melon (*Citrullus lanatus* Thunb.) and heliotrope (*Heliotropium europaeum* L.). Several species were also grown in both trials, including annual ryegrass (*Lolium rigidum* Gaudin.), sow thistle (*Sonchus oleraceus* L.), and kikuyu (*Pennisetum clandestinum* Hochst. ex Chiov.).

For both trials, four plants of each species were grown per pot (16 cm diameter, 16.5 cm height) with three replicates. Each pot was lined with plastic bags with six drainage holes and filled with sand to within 2 cm of the top. Small seeds were tickled into the surface, and large seeds were sown at a depth of approximately 1 cm. Irrigation was applied as required to ensure healthy growth.

Harvest was 3-4 weeks after seeding, and plant growth stage (number of leaves or tillers per plant) and the fresh root and shoot biomass (per pot) were recorded. To obtain root biomass, the roots were thoroughly washed clean of all soil material.

Scans of both the roots and shoots were then performed on the Epson Perfection V800 Photo Scanner. The analysis of these scans was completed using WinRHIZO PRO (2005, https://regentinstruments.com/assets/winrhizo_software.html) for the roots, and ImageJ (2021, https://imagej.nih.gov/ij/) for the shoots. The roots and shoots were then dried for a week at 60°C before their dry biomass was determined.

A one-way ANOVA using plant species as the factor was performed on each data set of each trial in Genstat (21st Edition), and graphic outputs of this data were graphed using R (version 4.1.3).

RESULTS

Biomass In the winter pot trial, blue lupins had the greatest shoot biomass (Figure 1B), followed by wheat (P<0.001, LSD=0.454). Wheat, blue lupins, and brome grass had the greatest root biomass (P<0.001, LSD=0.280), although the difference between the blue lupin and brome grassroot biomass was not significantly different to kikuyu (Figure 1D). Alternatively in the summer pot trial, no significant differences were found between the species' shoot (P=0.084, LSD=0.208) or root (P=0.241, LSD=0.181) biomass (Figures 1A and C).

Shoot surface Overall, the winter species (Figure 2B) had a greater root surface area than the summer species (Figure 2A). However, there was no consistent difference between the broadleaf or grass species.

In the winter trial, wheat and blue lupins had a greater shoot surface area than the other species (P<0.001, LSD:63.510). For the summer species Feathertop Rhodes grass and heliotrope had the greatest surface areas (P<0.001, LSD=29.330).

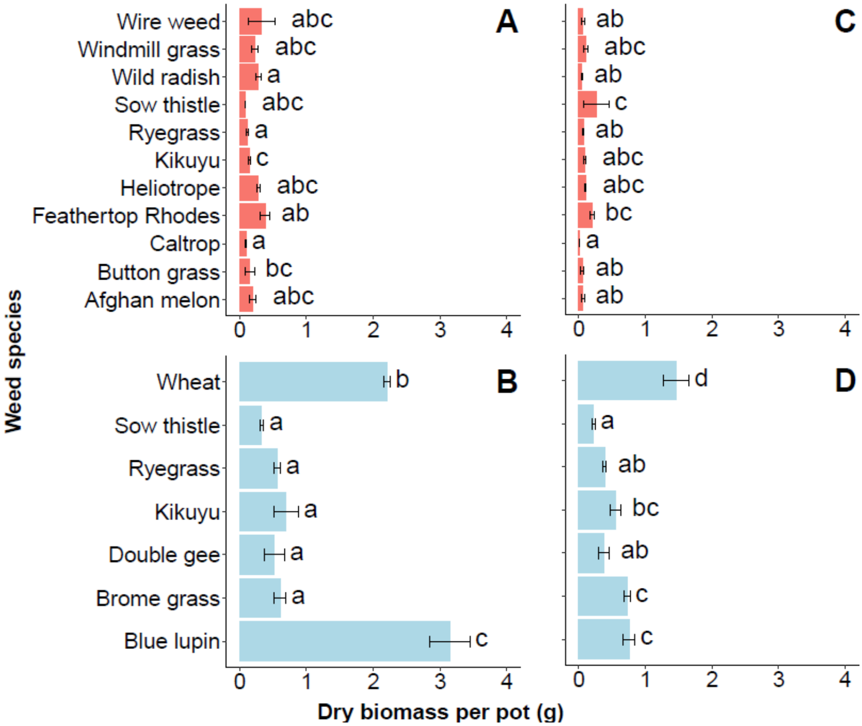

Figure 1. The mean dry biomass (g) per pot of the 'summer' (A) and 'winter' (B) shoots as well as of the 'summer' (C) and 'winter' root biomass (D) of each species in the pot trials. Letters on the columns indicate least significant differences between the means and the error bars indicate the standard error of 3 replications (3 pots of 4 plants).

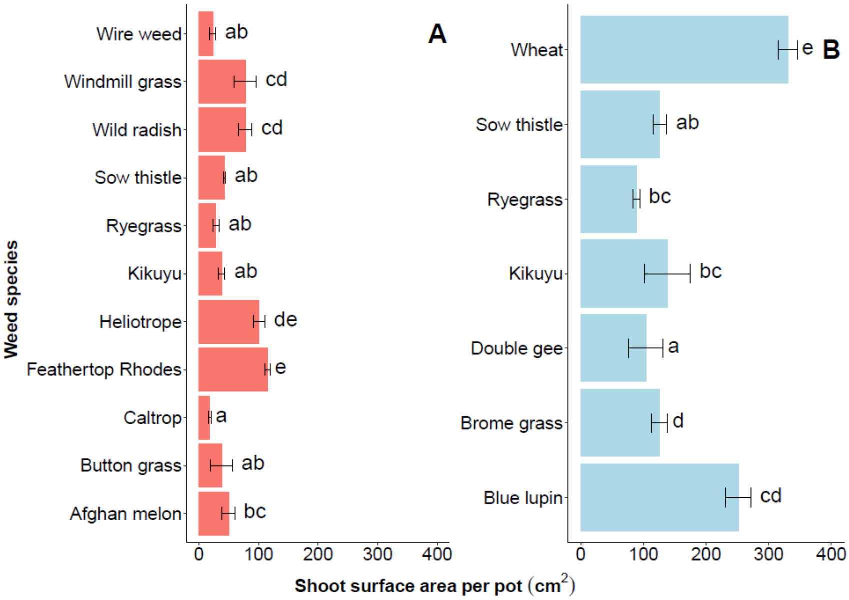

Figure 2. The mean shoot surface area (cm^2) per pot for each species in both the 'summer' (A) and 'winter' (B) pot trials. Letters on the columns indicate least significant differences between the means and the error bars indicate the standard error of 3 replications (3 pots of 4 plants).

Root surface and diameter The surface area of the roots (Figure 3) was greater than that of the shoots for most of the species, except caltrop and wild radish (Figure 2). However, the root surface area varied depending on the diameter of the root. Similar proportions of root surface area were found to occur in both the summer and winter pot trials between the diameter classes of 0-0.2 cm (Figures 3A and B) and 0.2-0.5 cm (Figures 3C and D). But these values were comparably lower for all species than the surface area of the thicker roots (>0.5 cm) (Figures 3E and F).

Across all root diameters, the winter species had a greater surface area when compared to those grown in summer, except for blue lupin roots in the 0-0.2 cm diameter range and double gee in the >0.5 cm range. There was no difference between grass and broadleaf species.

Out of all the species, wheat consistently had the greatest root surface area across all diameter classes. This was followed by brome grass. Yet, while the blue lupins returned comparably greater amounts of biomass and shoot surface area, the species was determined to have a very low proportion of finer roots (0-0.5cm) but the second highest proportion of thicker roots (>0.5cm) after wheat.

In the winter trial, a significant difference was found within the 0-0.2 cm (P<0.001, LSD=58.820), 0.2-0.5 cm (P<0.001, LSD=66.870) and >0.5 cm (P<0.001, LSD=160.100) diameter ranges.

In the summer trial, heliotrope had the greatest proportion of finer roots (0-0.5cm), while caltrop had the lowest. However, in the thicker roots (>0.5 cm), the greatest proportion of the surface area was found in Feathertop Rhodes grass. In this diameter class, caltrop still had the lowest proportion.

A significant difference between the species was found between both the 0-0.2 cm (P<0.001, LSD=14.180) and 0.2-0.5 cm (P<0.001, LSD=18.490). In the >0.5 cm diameter range, a significant difference was also found in the summer species, but to a lesser extent than seen within the other diameter ranges (P=0.019, LSD=54.720).

DISCUSSION

Volunteer crops and winter weed species may be comparably harder to control with electric weed control, due to their faster growth habits and comparably greater shoot and root biomass, as well as surface area as reviewed in Vigneault and Benoit (2001). Yet, it is noted that field trials should be undertaken to verify these findings. Like most weed control methods, it is likely that electroweeding efficacy in Australia will be dependent on the specific weed species treated.

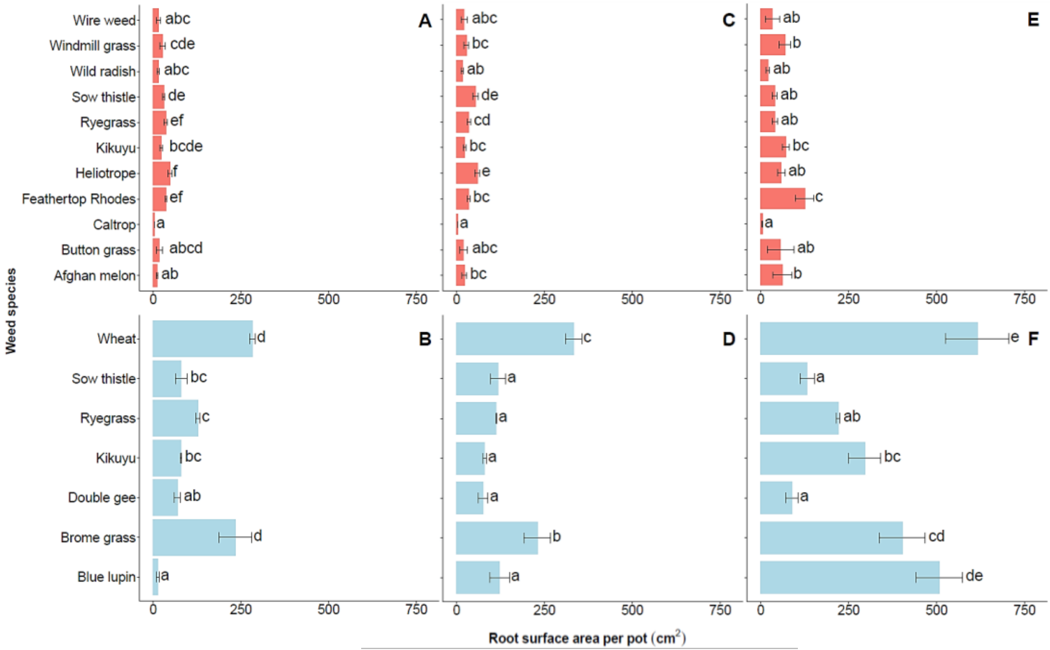

Figure 3. The mean surface area (cm^2) per pot of the roots between 0 – 0.2 cm diameter (A and B), 0.2 – 0.5 cm diameter (C and D) and >0.5 cm diameter (E and F) of each species in both the 'summer' (top graphs) and 'winter' (bottom graphs) pot trials. Letters on the columns indicate least significant differences between the means and the error bars indicate the standard error of 3 replications (3 pots of 4 plants).

Greater levels of biomass, as seen in the winter species of wheat and blue lupin as well as brome grass, have been indicated in the literature to reduce electroweeding efficacy. Often, only a portion of the plant is contacted by the electrode and the plant able to keep growing from the undamaged section (Diprose and Benson, 1984, Drolet and Rioux, 1983).

Studies have also indicated that extensive spreading or specialised root systems can allow for the treated plant to re-grow from undamaged root sections (Diprose and Benson, 1984, Drolet and Rioux, 1983). From these trials, it is indicated that this may be an issue with grasses with greater root surface area such as wheat and brome grass. However, limited research has occurred into the re-growth potential of these species following electroweeding and other weed control methods.

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