Spraying cold herbicide in the heat – Does it affect ryegrass?

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Abstract
Herbicide spray temperature has been shown to impact efficacy of control in giant ragweed (*Ambrosia trifida* L.), canadian fleabane (*Conyza canadensis* (L.) Cronq.), palmer amaranth (*Amaranthus palmeri* S. Wats) and pitted morning glory (*Ipomoea lacunose* L.). This study examined whether a similar effect could be found for annual ryegrass (*Lolium rigidum* Gaud.), the most economically damaging weed in Australia. Two herbicides, clethodim and glyphosate were each mixed with water at 5, 10, 15 and 20°C before being immediately applied to annual ryegrass at two development stages, 2-3 leaf and tillering. Comparison of biomass 21days after herbicide application showed no difference in efficacy due to temperature for either herbicide at either growth stage. This indicates that low temperature herbicide treatments do not effect control of annual ryegrass plants growing in warm conditions.

Keywords
Weed control, application.

Introduction
Herbicides are the dominant method for weed control, however the efficacy of these chemicals has been shown to be impaired by the characteristics of their carrier water. Turbidity, pH and hardness of water are all properties that should be considered when planning herbicide treatments as they can have a marked effect on herbicide potency (Stahlman and Phillips 1979). Accordingly, these water characteristics are often accounted for in herbicide label recommendations by herbicide dosage. The temperature of targeted weeds is also a consideration as cold plants have slower growth and regulation, reducing herbicide uptake and consequential efficacy (Pline et al. 1999). Another aspect however, the temperature of the herbicide mixture is rarely considered.

Recent studies have shown that herbicide mixture temperature can reduce efficacy (Devkota et al. 2016). Herbicide treatment temperature is dictated by the storage conditions of the water used. Water temperature can vary widely depending on source (surface or bottom of dams, water tank in sun/shade) as well as the construction material (polyethylene, concrete, iron). Greater control has been demonstrated for glyphosate plus dicamba against palmer amaranth (*Amaranthus palmeri* S. Wats), giant ragweed (*Ambrosia trifida* L.) and pitted morning glory (*Ipomoea lacunose* L.) when applied at midrange (22°C) vs. low (5°C) temperatures. This study examined whether there was a similar effect on annual ryegrass (*Lolium rigidum* Gaud.), Australia's most economically damaging weed (Llewellyn et al. 2016). In this experiment the efficacy of two herbicides (clethodim and glyphosate) was assessed with a range of mix and application temperatures (5, 10, 15, 20°C) at two growth stages (two weeks and five weeks post germination) for a population of annual ryegrass with no known herbicide resistance.

Methods
Ryegrass seed was placed in 90 mm plastic Petri dishes lined with filter paper (Advantech No. 2) and covered with 7 mL of deionised water. The Petri dishes were sealed with parafilm and stored in a growth chamber (12 hr 15/25°C day/night cycle). After five days, seedlings were transplanted into 500 mL plastic trays (10/tray) containing commercial potting mix and placed in a glasshouse maintained at 20-30°C. This process was repeated after a three-week interval. Each treatment was replicated four times, with replicates blocked and randomised. Once the second group of ryegrass seedlings reached the 2-3 leaf stage, herbicide treatments were applied to both groups of plants.

Herbicide and adjuvant was mixed with water at four temperatures, 5, 10, 15 and 20°C. Temperatures were maintained with the use of a heating pad or an ice bath. Each treatment was applied with a laboratory boom-sprayer, equipped with T-jet flat fan nozzles at a speed of 5 km hr^{-1}. Output from the sprayer was calibrated

at 85 L ha^{-1} at a pressure of 250 kPa. Treatment application was grouped by herbicide and spray equipment was cleaned between each herbicide by rinsing the spray apparatus with 4% hypochlorite solution and water. Application order of each treatment and replicate was randomised within each herbicide group. Each application was completed in approximately 5 seconds to reduce temperature shifts, including priming spray lines with each treatment before application. Clethodim was applied at 120 g a.i. L^{-1} with 1% adjuvant Hasten, glyphosate was applied at 648 g a.i. L^{-1} with adjuvant Wetter TX at 0.2%. Air temperature in the spray cabinet at time of application was 26°C. After treatment, plants were returned to the glasshouse and watered as necessary. Above ground biomass cuts were taken 21 days after herbicide application and dried in a 40°C fan-forced dehydrator for 7 days. Dry weights of treated plants were converted to a percent of unsprayed control. Data was analysed with ANOVA using R studio (R Core Team 2014).

Results and Discussion

At both growth stages each herbicide provided complete control of ryegrass, with no surviving plants after 21 days. No significant difference was found in the reduction of biomass by varying temperatures for either herbicide within a growth stage. The reduction of biomass between the two growth stages was significant at every temperature tested ($P < 0.05$) within the herbicide treatment, although there were no differences between herbicides (Table 1).

Table 1. Percent reduction in annual ryegrass biomass when treated with clethodim (60 g a.i. L^{-1}) or glyphosate (450 g a.i. L^{-1}) mixed and applied at four temperatures during two growth stages. Measured 21 days after treatment.

Herbicide	Clethodim		Glyphosate	
Plant age	2 weeks	5 weeks	2 weeks	5 weeks
Temperature (°C)	Biomass reduction (%)			
5	89	51	84	47
10	85	33	84	52
15	90	52	83	42
20	92	39	87	56

This study demonstrates that low spray temperatures did not affect clethodim or glyphosate efficacy on annual ryegrass grown in warm conditions (26°C). A contrast to this analysis would be to repeat with (10 °C) cooler air to replicate winter conditions and assess any effect on efficacy. A significant difference was detected in the % biomass reduction between plants after 5 weeks of growth vs. 2 weeks. Although all plants were killed by herbicide treatment, the older 5 week old plants had less biomass reduction. This difference in the reduction of biomass indicates that annual ryegrass, although ultimately controlled, will still compete for soil moisture and nutrients before death, reinforcing the importance of early weed control. Future research might examine differences in of herbicide spray temperature on herbicide resistant ryegrass.

References

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