Efficacy of Pre-emergent Herbicides on Ameliorated Soil

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Summary A field trial investigating amelioration of water repellent soil was established in 2020, with treatments comprised of spading, mouldboarding and an untreated control. Intact soil cores were taken from this site in 2020 and 2021 to establish pot experiments that investigated the interaction of soil amelioration and pre-emergent herbicides on annual ryegrass control. Spading and mouldboarding allowed earlier emergence and better shoot and root growth of annual ryegrass seeds in the absence of herbicide. The efficacy of pre-emergent herbicides varied with herbicide type and rate but were not affected by soil amelioration.

INTRODUCTION

Water repellent soils cover over two million hectares in Western Australia (Blake and Peltzer 2002). These soil types may delay seeding and reduce the yield potential of the following crop. Water repellence also results in staggered emergence, reducing the crop yield and making it difficult to control weeds at the appropriate growth stage (Blake and Peltzer 2002). The late emerging cohorts avoid control by pre-seeding, pre-emergent or early in-crop herbicides (Roper et al., 2015). Soil amelioration approaches such as deep ripping, deep spading and soil inversion alter physical and chemical soil properties and may bury crop residue, potentially changing the way pre-emergent herbicides affect weed or crop growth (Edwards et al. 2018). The behaviour of pre-emergent herbicides is dependent on multiple soil properties. The physical disturbance of the soil surface, burial of the weed seed or removal of the soil constraint could also affect weed seed emergence time and rate, as well as the weed's growth pattern (Chauhan *et al.* 2006). However, there is little research on the interaction of soil amelioration and the efficacy of pre-emergent herbicides. This study aims to investigate how the amelioration of water repellent soil influences weed emergence and pre-emergent herbicide behaviour.

MATERIALS AND METHODS

A field trial was established on a site with water repellent soil in Esperance, WA, where plots had been spaded, mouldboarded or left intact (untreated control). Intact soil cores were removed from this site to conduct two pot experiments at the Department of Primary Industries and Regional Development (DPIRD) Northam screen house in 2020 and 2021. The soil cores were placed in pots of 12 cm diameter by 10 cm height. All pots were maintained in the screen house and watered via rainfall to ensure weed growth occurred in standard seasonal conditions.

2020 experiment The trial was arranged in a randomised block design with four replications of each herbicide-amelioration treatment. Pre-emergent herbicides included pyroxasulfone (480 g a.i. L^{-1}), trifluralin (480 g a.i. L^{-1}), prosulfocarb (800 g a.i. L^{-1}), triallate (500 g a.i. L^{-1}), or water (non-chemical control) applied using a spray cabinet calibrated to deliver 100 L/ha spray volume, at 2 bar pressure, from Hardi-Iso F-01-110 nozzles at 50 cm spacing. Herbicide treatments were sprayed at full label rate, half the label rate or a quarter of the label rate. Soil collected from the field was spaded, mouldboarded or undisturbed. Three seeds of annual ryegrass (*Lolium rigidum* Gaud.) (cv 'Safeguard' from Nutrien Ag Solutions, Midvale, WA) were sown into each pot at a depth of 0.5 cm. In total, 168 pots were included in the 2020 experiment.

2021 experiment The trial was arranged as a randomised block design with three replications of each herbicide-amelioration treatment. The pots were treated with the same herbicides (pyroxasulfone, trifluralin, prosulfocarb, triallate or water as the control) and three tillage types (mouldboarded, spaded and intact) used in 2021. However, in contrast to 2020, the herbicide treatments were only sprayed at full label rate and half the label rate. Each treatment was applied to a pair of pots to allow two separate harvest times (i.e. 81 pots for harvest one on July 23 and 81 pots for harvest two on 30 July). Ten seeds of annual ryegrass were sown in each pot at a depth of 0.5 cm. In total, 162 pots were included in the 2021 experiment.

Data collection For both experiments, annual ryegrass emergence data was recorded twice a week for three weeks and plant growth stage was estimated by counting the leaf number. At three weeks old plants were harvested. Fresh root and shoot weight of each plant and shoot length was recorded. Root scanning was then conducted to measure root length and surface area (using WinRHIZO™ 2019, Regent Instruments, www.regentinstruments.com). Samples were dried at 105°C for a week before assessing root and shoot dry weight.

Statistical analysis A two-way ANOVA was used to assess the effect of soil amelioration on herbicide efficacy and weed germination in both 2020 and 2021 using Genstat (VSN International 2021). A square root transformation was used to control for heteroskedasticity.

RESULTS AND DISCUSSION

The emergence data for annual ryegrass in 2020 suggests that soil amelioration practices stimulated weed germination (Figure 1). Without any chemical control applied, annual ryegrass seedlings started to germinate 9 days after sowing in the pots with intact soil (1a), while the first germinations were seen 5 days and 6 days after sowing in mouldboarded soil (1b) and spaded soil (1c). In field conditions, spading or mouldboarding may bury 50-60% or 50-90% of the topsoil below 10 cm depth and place a layer of subsoil on the surface (Scanlan and Davies 2019). Therefore, both techniques may provide weed control by burying a portion of the weed seed (Roper et al., 2015). However, a proportion of seeds are likely to be left in the topsoil and may still be able to emerge (Scanlan and Davies 2019). In the current pot trials, all seeds were sown at a uniform depth, and emergence was more rapid in the ameliorated soil where water repellence was likely to be reduced. Rapid, uniform emergence will make the weeds easier to control with pre-emergent herbicides (Chauhan *et al.* 2006).

Pyroxasulfone and prosulfocarb achieved similar control in both years (Figure 2, Figure 3). In 2020 trifluralin and triallate were less effective while in 2021 only the half rate of triallate provided reduced control. Trifluralin applied in 2021 achieved 99% control but was less effective in 2020. Other growth parameters such as dry biomass and root length had a comparably similar pattern as seen in the emergence data (Table 1). The dry biomass of ryegrass treated with pyroxasulfone was close to zero in either intact or ameliorated soil. Except for prosulfocarb, other herbicide treatments were unable to show a significant reduction in terms of root length, root dry weight and shoot dry weight in the mouldboarded and spaded pots. In fact, the root length of trifluralin and triallate treated annual ryegrass increased 3-4-fold in ameliorated soil. On the other hand, prosulfocarb treatments had much shorter roots and suppressed biomass. It is clear there was an inconsistent effect of soil amelioration on herbicide efficacy and field trials on ameliorated sites are needed to clarify the impact. Several other studies showed varied results of herbicide efficacy in ameliorated soil. Buhler and Daniel (1988) concluded that control of giant foxtail (*Setaria faberi* Herrm.) was lower in a no-till system than a mouldboarded area.

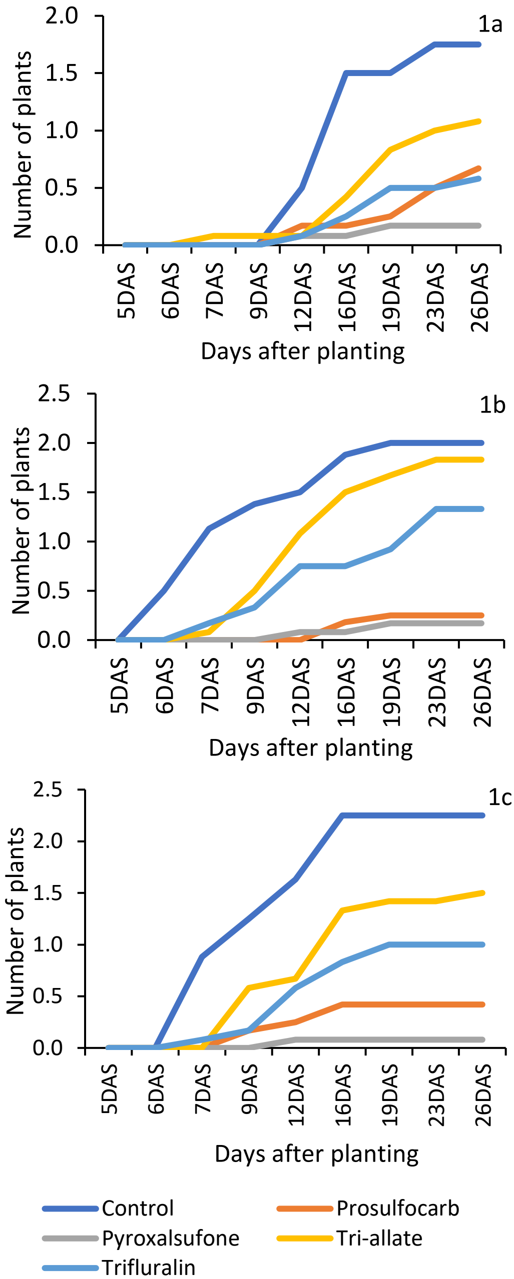

Figure 1. Emergence of annual ryegrass seeds over 26 days in pots with undisturbed soil with no soil amelioration (1a), mouldboarded soil (1b) or spaded soil (1c) in 2020. Annual ryegrass emergence was recorded and averaged over all herbicide treatments.

Comparably longer roots and more biomass can be seen in both ameliorated practices in the absence of herbicides due to improved soil structure and removal of water-repellent soil (Table 1).

Table 1. Annual ryegrass root length, root dry weight and shoot dry weight in 2021 collected from plants grown in intact, mouldboarded and spaded soil for three weeks. Data was averaged over herbicide rates. Letters indicate significantly different means when compared using ANOVA.

Measurements	Root Length (cm)	Root Dry Weight (mg)	Shoot Dry Weight (mg)
Intact	**50.82**	**23.68**	**17.47**
Control	389.93c	75.77c	41.9c
Prosulfocarb	20.63b	17.44b	17.06bc
Pyroxasulfone	0.38a	1.41a	4.82a
Tri-allate	24.53b	13.82b	13.47b
Trifluralin	16.44b	9.95b	10.08b
Mouldboard	**83.00**	**28.13**	**17.62**
Control	378.30c	100.67c	51.9c
Prosulfocarb	3.32ab	3.63ab	4.77a
Pyroxasulfone	8.22ab	0.95a	3.35a
Tri-allate	88.91bc	25.39bc	20.51bc
Trifluralin	59.28bc	10.03ab	7.58ab
Spaded	**96.02**	**20.47**	**14.66**
Control	421.48c	93.72c	43.47c
Prosulfocarb	10.23ab	5.21ab	7.6ab
Pyroxasulfone	0.12a	1.36a	4.22a
Tri-allate	94.03bc	16.88b	13.52b
Trifluralin	62.84bc	5.63ab	4.48a

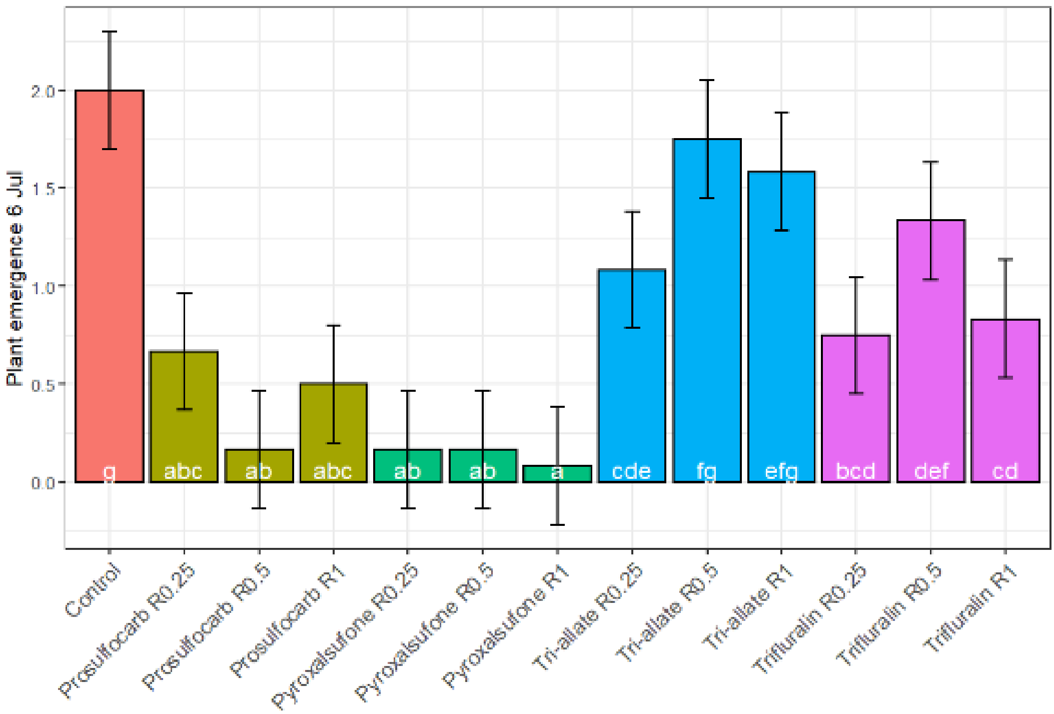

Figure 2. Annual ryegrass emergence in 2020, following pre-emergent herbicide treatments (control, pyroxasulfone, trifluralin, prosulfocarb and triallate) at full label rate, half label rate and quarter label rate, averaged over soil amelioration treatments (with 3 annual ryegrass seeds per pot).

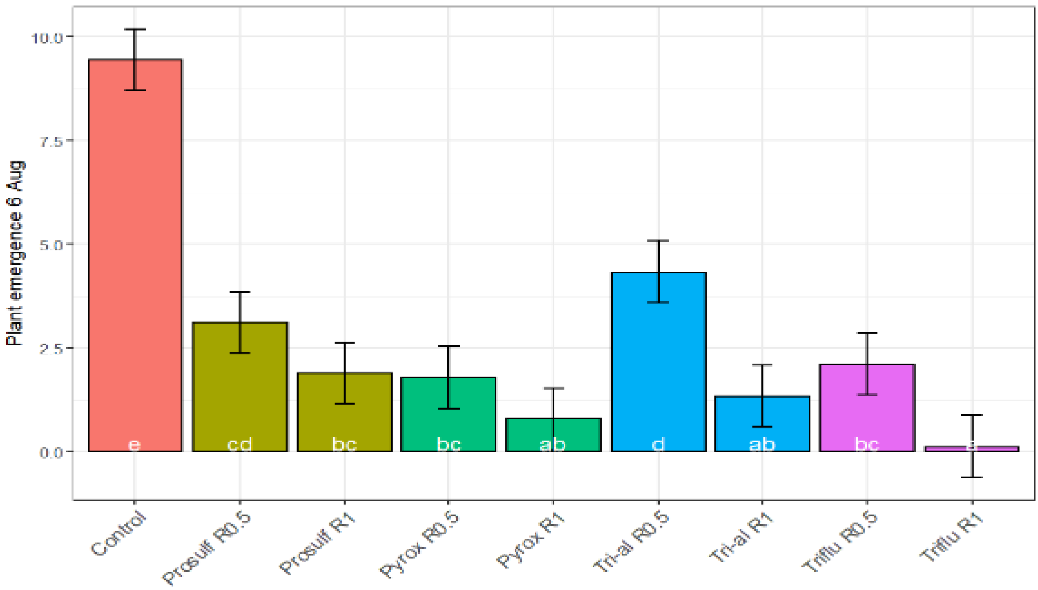

Figure 3. Annual ryegrass emergence in 2021, following pre-emergent herbicide treatments (control, pyroxasulfone, trifluralin, prosulfocarb and triallate) at full label rate and half label rate, averaged over soil amelioration treatments (with 10 annual ryegrass seeds per pot).

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