Interaction between wheat establishment timing and pre-emergent herbicide choice on growth and competition of annual ryegrass

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Summary: Between 2018-2021, nine field trials were conducted across the Western Australian grain belt to assess the interaction between wheat time of sowing (either dry sowed with no pre sowing weed germination or delayed sowing with emerged weeds killed with glyphosate), wheat seeding rate and pre-emergent herbicide choice. With three new pre-emergent herbicides, cynmethalyn (Luximax®), bixalone (Overwatch®) and the mix of aclinofen-pyroxasulfone and diflufenican (Mateno Complete®) released in 2021, this report presents findings from the Dandaragan site in 2021. This study found that early (dry) sowing outyielded delayed sowing, however delayed sowing reduced annual ryegrass seed production. The seed production of annual ryegrass correlated with soil persistence of pre-emergent herbicide choice. This study measured that trifluralin(Triflur X®) and prosulfocarb + metolachlor (Boxer Gold®) degraded the fastest resulting in increased annual ryegrass seed production. Pyroxasulfone (Sakura®), Mateno Complete and Overwatch were highly residual resulting in reduced ryegrass seed production. Increasing wheat seeding rates consistently reduced annual ryegrass seed production. This study demonstrated the need to compensate for the lack of a pre-sowing knockdown herbicide application with increased crop competition and a more residual pre-emergent herbicide choice.

Key words: wheat, weeds, annual ryegrass, pre-emergent herbicides, time of seeding, crop competition, herbicide degradation

INTRODUCTION

In the southern grainbelt of Australia, dry sowing has become popular as it enables growers to plant larger areas with limited machinery, within or before the optimum planting time to maximise yield potentials. At the same time, there has been an increased prevalence of grass weed populations with increased seed dormancy that emerge later to evade knockdown (glyphosate/paraquat) herbicide applications. To control these late emerging individuals there are several pre-emergent 'residual' herbicides that can be safely used within no tillage farming systems to provide an extended period of herbicidal activity. These herbicides are often applied directly to the soil prior to planting.

To control these late germinating populations, it has long been advised that growers should delay sowing of weedy paddocks to maximise the weed control effectiveness of knockdown applications. However, any delay in sowing results in a sharp decline in crop yield potential. Previously, dry sowing techniques have relied upon low weed seed banks as they place significant reliance on longevity and efficacy of soil applied herbicides that are often applied a long time before crop and weed germinating rains.

It has, however, been identified that with some pre-emergent residual herbicides, early sowing may now be the optimum weed control strategy as crops sown early into higher soil temperatures grow at a faster rate and have a competitive advantage against later emerging weed cohorts. Crops that are sowed late generally grow more slowly and take longer to close their canopy, giving weeds a greater opportunity to establish and grow. Earlier sowing, when soil temperatures are generally warmer, provides an opportunity to increase the crop's competitive advantage against weeds while maximising crop yield potentials. However, the early use of pre-emergent herbicides leads to increased rates of herbicide dissipation and microbial degradation. Past research by Minkey (2017) demonstrated that pre-emergent herbicides decayed more rapidly in warm soil conditions; with Sakura® (pyroxasulfone) decaying at the slowest rate and Boxer Gold® (prosulfocarb + s-metolachlor) and trifluralin decaying faster. The potential degradation of pre-emergent herbicides may therefore offset the value of increased crop competitiveness from earlier sowing.

MATERIALS AND METHODS

Experiments were conducted at Dandaragan in the Western Australian grain belt. The first time of sowing (TOS1) took place in the first week of May and the second time of sowing (TOS2) in the first week of June. Each trial was direct sowed into cereal stubble. A factorial combination of wheat seeding rate, pre-emergent herbicide and time of sowing (TOS1 plus TOS2 (four-week delay) was randomised in complete blocks with four replicates (Table). The wheat variety used was Scepter (Intergrain Australia), which is a high yielding, mid-late maturing variety, sowed at 25cm row spacing, with the seeding rate treatments outlined in Table 2. The site was sown with no tillage tine openers with press wheels to provide sufficient seed–soil packing and promote good weed germination. All plots were planted at one sowing depth (approx. 2cm) to minimise the confounding effects of emergence rate and seeding depth differences on biomass and grain yield. Immediately prior to sowing, the whole experimental area was treated with 1.5L/ha Roundup Ultramax (Glyphosate 540g/L, Sinochem Australia), 100ml/ha Lontrel (Clopyralid 750g/L, DowAgrosciences Australia), to control all germinated weeds; followed by the application of each individual plot's pre-emergent herbicide treatment (Table 2).

To control dicotyledonous species such as wild radish (*Raphanus raphanistrum* L.), all plots had a post-emergent application of 670ml/ha Velocity (210g/L Bromoxynil + 37.5g/L Pyrasulfotole, Bayer Australia). For the duration of this study, no additional annual ryegrass control was applied. To ensure optimal wheat growth, 100kg/ha Gusto Gold (Summit Fertilisers Australia) (N – 10.2%, P – 13.1%, K – 12%, S – 7.6%, Cu – 0.07%, Zn – 0.14% and Mn – 0.01%) was drilled 3cm below the seed to minimise contact with the germinating wheat seed. To optimise crop growth, supplementary nitrogen fertiliser in the form of urea (Summit fertilisers Australia) (N – 32%) was applied to all plots.

Table 1. Factorial combinations of wheat density, pre-emergent herbicide treatment and TOS of wheat at Dandaragan site in 2021.

Treatments	Comments
Factor 1 - Crop density treatment description	
Low	100 plants/m^2 (sowed at 45kg/ha)
Optimum	150 plants/m^2 (sowed at 68 kg/ha)
High	200 plants/m^2 (sowed at 90 kg/ha)
Factor 2 - Time of sowing treatment description	
TOS1	Dry sowed (4 May 2021)
TOS2	Later sowing after opening rainfall (3 June 2021)
Factor 3 - Pre-emergent herbicide treatment description (knockdown plus)	
Nil (knockdown only)	Nil herbicide applied control (knockdown glyphosate only)
Triflur X® 2.0L/ha	Trifluralin 480 gai/L
Boxer Gold® 2.5L/ha	s-Metolachlor 120 gai/L + Prosulfocarb 800 gai/L
Sakura® 118g/ha	Pyroxasulfone 850 g ai/kg
Overwatch ® 1.25L/ha	Bixlozone (Isoxazolidinone) 400 g ai/L
Luximax® 500mL/ha	750g ai/L Cinmethylin
Mateno Complete® 1L/ha	400 g ai/L Aclinofen + 100 g ai/L Pyroxasulfone and 66 g ai/L Diflufenican

At 10 weeks after emergence (WAE), wheat establishment and ryegrass density was assessed. Above-ground biomass samples of annual ryegrass were removed 27 WAE in three 0.25m^2 quadrats per plot. From these samples, the number of ryegrass panicles were counted. To estimate annual ryegrass seed production collected panicles from each plot and thrashed to extract seed. The number of seeds extracted was counted using an S-25 optical seed counter (Data Technologies, Kibbutz Tzora, Israel). At 28 WAS, the whole plot was machine harvested to determine grain yield. Grain samples (400g) were analysed for moisture and protein.

Herbicide bioassay. Starting at the time of pre-emergent herbicide application (week 0) soil samples were collected from each plot at 14-day intervals. Soil samples were collected by sampling six 30mm diameter cores per plot to a depth of 6cm form the interrow. Soil samples were immediately transferred into sealed plastic trays with no holes and stored at <15°C for no more than 24 hours. Upon receipt at the University of Western Australia, all soil samples were moistened within the sampling trays using 75ml deionised water containing TWEEN 20 ionic surfactant (Polyethylene glycol sorbitan monolaurate, Sigma Adrich Australia). Fifty seeds from the known herbicide susceptible annual ryegrass biotype (VLR1) were sowed at 1cm depth of the moistened soil in each tray before being placed in a temperature-controlled naturally lit glasshouse (15°C night 25°C day). To ensure adequate seed germination, the containers were sealed for 24 hours before lids were removed for the remainder of the growth period. All trays were watered daily to maintain field capacity. The above-ground shoot length was measured 21 days after sowing, with the percentage shoot length inhibition calculated as per (Khalil et al., 2018b) using the following formula:

Inhibition (%) = 1-(Lt/Lo) x 100% [1]

where: Lt is the shoot length measured in the herbicide-treated soil or crop residue and L0 is the shoot or root length in the untreated soil or crop residue as per (Khalil et al 2018a; Khalil et al 2019b)

RESULTS

At the Dandaragan site, the first time of sowing (TOS1) was 4 May and the second time of sowing (TOS2) was on 3 June. The soil in the top 10cm was a yellow grey sandy loam with a pH 5.6 $Cacl_2$ and organic total carbon content of 1.56%. The first TOS was sowed into moist soil with no pre seeding ryegrass germination. The second TOS was sowed into similar soil moisture following a significant ryegrass germination. Following sowing, subsequent rainfall was average with acceptable soil moisture for the rest of the season.

Pre-emergent herbicide persistence bioassay . Immediately following sowing and at two weekly intervals thereafter, soil samples were taken from the top 10cm of soil from the inter-row region where herbicide would have concentrated following seeding. Using the herbicide susceptible annual ryegrass population VLR1, it was demonstrated that for both TOS1 and TOS2, Sakura, Overwatch and Mateno Complete were the most persistent herbicides, limiting ryegrass shoot length to <42% of the untreated control (%UTC) in both TOS1 and TOS2 at 14 WAS. Triflur X degraded at a fastest rate in TOS1 and TOS2 with ryegrass growth of 86% of the UTC for TOS1 and 88% for TOS2 at 14 WAS. Among the herbicides tested Boxer Gold provided the lowest efficacy of control from the first week after application, with ryegrass growth of 17 and 28% of the UTC respectively. In TOS1, Overwatch was the most persistent herbicide, however in TOS2, Mateno Complete maintained its persistence resulting in a shoot length of <12% of the UTC at 14 WAS (Figure 1).

Effect of pre-emergent herbicide efficacy, time of crop seeding and wheat seeding rate on ryegrass seed production. The application of herbicides reduced ryegrass seed production with Triflur X, Boxer Gold and Luximax providing the least ryegrass control. When these herbicides were used, delaying sowing (TOS2) and increasing wheat seeding rates further decreased ryegrass seed production. The use of more residual herbicides (Sakura, Overwatch and Mateno Complete) greatly reduced ryegrass seed production, however in these treatments, delayed TOS (P>0.05) and increased seeding rates (P>0.05) did not further reduce ryegrass seed production.

Wheat yield. A significant effect of TOS was found (p<0.001), with early TOS increasing yields (Figure 2). The choice of pre-emergent herbicide or seeding rate did not have a significant effect on yield owing to the high rainfall throughout 2021 and lower ryegrass densities leading to high yields.

CONCLUSION

This study demonstrated the need to compensate for the lack of a pre-seeding knockdown herbicide application with increased crop competition and a more residual pre-emergent herbicide choice. Dry sowing (TOS 1) outyielded delayed sowing (TOS 2) at the Dandaragan site, however the number of annual ryegrass seeds produced at the end of the season was consistently greater in the TOS1 where less residual herbicides (Triflur X, Boxer Gold and Luximax) were used. Bioassay assessments concurred with the ryegrass seed production data demonstrating that herbicides such as Triflur X and Boxer Gold were not highly residual, whereas, Sakura, Mateno Complete and Overwatch were more residual resulting in reduced ryegrass seed production and often higher wheat yields. While early sowing with an excellent pre-emergent herbicide is considered important for maximising wheat yield, this study found that wheat densities should be practically increased to maximise wheat competitiveness and further reduce ryegrass seed production.

ACKNOWLEDGMENTS

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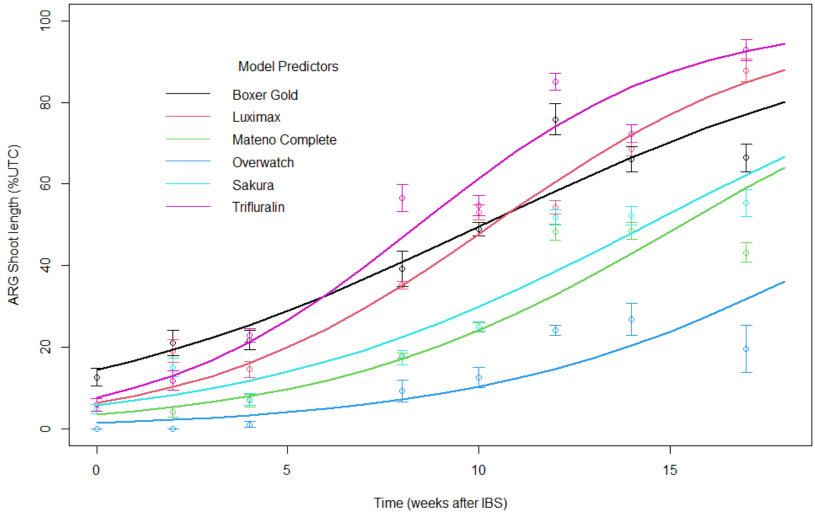
REFERENCES

Khalil, Y., Siddique, K., Ward, P., Piggin, C., Bong, S., Nambiar, S., Trengove, R., Flower, K. (2018) A bioassay for prosulfocarb, pyroxasulfone and trifluralin detection and quantification in soil and crop residues. Crop and Pasture Science 69, 606-616.

Khalil, Y., Flower, K., Siddique, K., & Ward, P. (2019). Rainfall affects leaching of pre-emergent herbicide from wheat residue into the soil. PloS one, 14(2)



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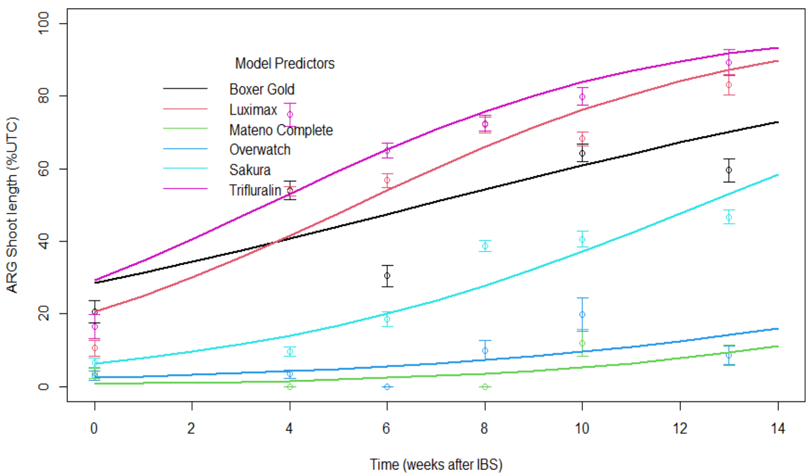

B.

Figure 1: Herbicide bioassay results. A (TOS1) and B (TOS2) Model predictors for shoot length inhibition of annual ryegrass (VLR1) grown for 21 days in soil sampled at 14-day sampling intervals from plots treated with 1. Nil herbicide (not shown as it is 100%), 2. Trifluralin 480 gai/L, 3. Boxer Gold (S-metolachlor 120 gai/L + prosulfocarb 800 gai/L), 4. Sakura (pyroxasulfone 850 gai/kg) (n=4), 5. Mateno Complete® (aclinofen 400gai/L+ diflufenican 66gai/L + pyroxasulfone 100gai/L), 6. Overwatch ® (bixlozone (isoxazolidinone) 400g/L), and 7. Luximax® (750g/L cinmethylin) (n=4).

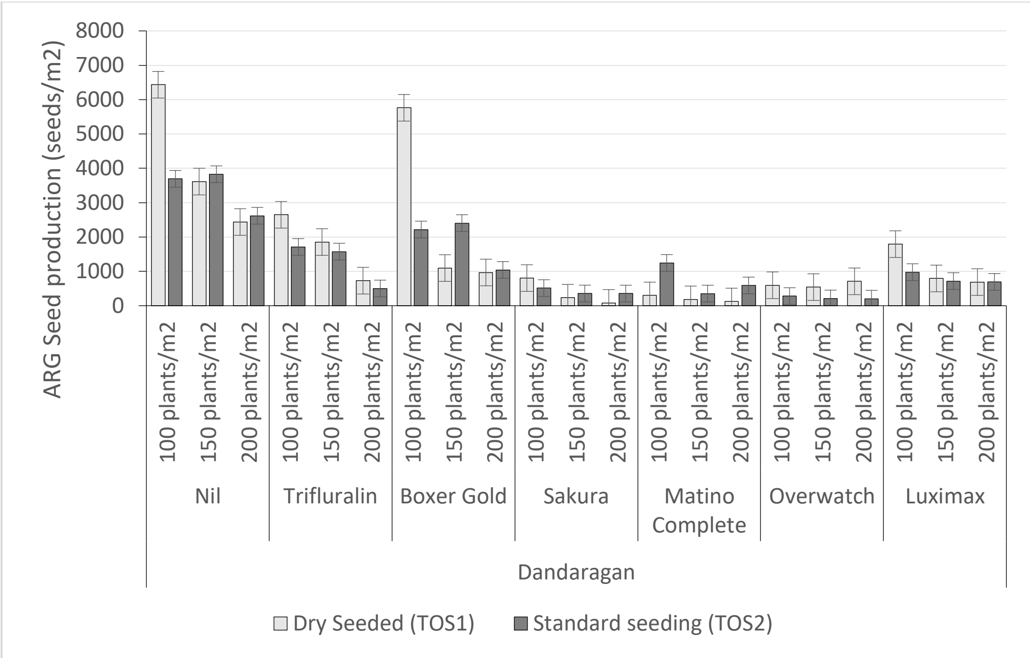

Figure 2. Annual ryegrass seed production

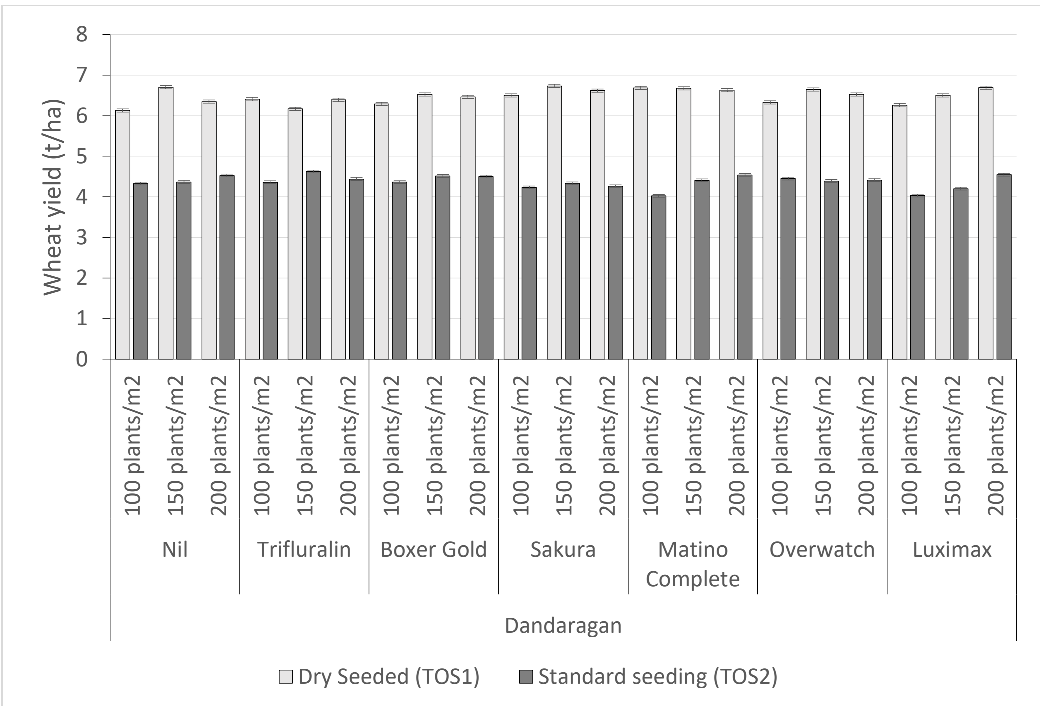

Figure 3. Wheat yield from TOS, wheat seeding rate, and pre-emergent herbicide treatments