Autumn cleaning *Ornithopus compressus* L. (yellow serradella) pastures: a novel, broad spectrum weed control option that exploits delayed germination.

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Abstract

Yellow serradella (*Ornithopus compressus* L), an annual pasture legume adapted to deep, sandy, acidic soils, is known to have a delayed germination pattern at the break of season. The differential in germination pattern between yellow serradella and many weed species could provide a window of opportunity to control weeds with low cost, broad spectrum herbicides after the break of season without jeopardizing legume persistence. The robustness of this novel weed control strategy was evaluated in 2007 in long term serradella (cv. Santorini) based pastures at Cunderdin and Tincurrin, WA, where the dominant weed was capeweed (*Arctotheca calendula*) and annual ryegrass (*Lolium rigidum*) respectively. There were three knockdown treatments; these differed only in their timing. Plots were sprayed (glyphosate 450 g ai/ha) on 7 May, 8 June or 4 July at Cunderdin; and 4 May, 10 June or 21 June at Tincurrin. As the break of season was not decisive, knockdown sprays were applied 7-18 days after germination inducing rainfall events. The first knockdown effectively controlled capeweed; however, the second knockdown date was more effective in achieving adequate control of ryegrass. Overall the optimum knockdown date appeared to be a trade-off between available feed-on-offer and level of weed control achieved. The strategy proved to be very robust as serradella emerged over a wide time period (>8 weeks). This low cost weed control strategy could be used routinely to renovate yellow serradella pastures and could also be employed to manage herbicide resistant weeds and deplete weed seed banks in a non-crop phase. “Autumn cleaning” is the term proposed for this novel weed control strategy.

Introduction

A pasture based rotation offers the opportunity to restore soil fertility and deplete weed seed banks with strategies not readily available in crop, such as brown manuring, grazing and silage production (Ferris 2008, Revell and Thomas 2004). Yellow serradella (*Ornithopus compressus* L) is suited to the acidic, infertile sandy soils across much of the low to medium rainfall zones of the WA wheatbelt. It is hardseeded, forms persistent seed banks and has a number of unique dormancy attributes that might be exploited in mixed farming systems (Taylor 2005). For instance, germination appears to be delayed by 10-14 days after the break of season and spread over four weeks in *cv.* Santorini (Taylor and Revell 2002). Revell and Taylor (1998) suggested that this phenomenon (slow imbibition of soft seeds) could provide the opportunity to use a knockdown herbicide to control weeds that germinate more rapidly than serradella after the break of season. This paper reports on the robustness of this novel strategy across two contrasting environments and its potential use within integrated weed management (IWM) systems that target herbicide resistant weeds. The application of a broad spectrum, knockdown herbicide which exploits the differential in germination pattern between weeds and some pasture legume species is hereafter termed autumn cleaning.

Methods

Two sites with an established serradella seed bank (*cv.* Santorini) were selected in 2007 near Cunderdin and Tincurrin. Before implementing treatments, the size of the legume seed bank was estimated by collecting soil cores (84 mm diameter, depth ~8 cm) across each site in a grid pattern (8 cores per replicate). Free seed and pod segments were extracted using dry and wet sieving techniques (i.e. flotation and panning) followed by air aspiration and hand cleaning. The first germination inducing rainfall event was on 23 April (17 mm) at Cunderdin and 16 April (24 mm) at Tincurrin.

Three knockdown treatments (glyphosate 450 g ai/ha) plus a control were implemented at each site (Table?1). A spray bike was used to apply these “autumn cleaning” treatments (early, mid and late) after germination inducing rainfall events. There were 5 replicates per treatment at Cunderdin and 3 at Tincurrin; plots were 5 m x 20 m and were not grazed. The impact of treatments on pasture density was measured by counting the number and type of seedlings within 12 cores (84 mm diameter) per plot at the end of winter (9 Aug, Cunderdin; 22 Aug, Tincurrin). Biomass was also cut from 6 (0.05 m^2) quadrats per plot at Cunderdin (23 Aug) and 4 (0.1 m^2) quadrats per plot at Tincurrin (22 Aug) to estimate feed-on-offer (FOO). Analysis of variance (GenStat? 2007, release 10.2) was used to assess the impact of knockdown date on seedling density, composition and FOO; analyses were based on square root transformed data.

Table 1. Timing of knockdown “autumn cleaning” treatments applied across yellow serradella based pastures at Cunderdin and Tincurrin, 2007

Knockdown spray		Cunderdin	Tincurrin
Control	Unsprayed	-	-
S1	glyphosate 450 g ai/ha	7 May	4 May
S2	glyphosate 450 g ai/ha	8 June	10 June
S3	glyphosate 450 g ai/ha	4 July	21 June

Results and Discussion

Site and seasonal conditions

The break of season was not decisive: rainfall events in April, May and June were sporadic and generally less than 10 mm (Figure 1). Consequently, serradella and weed seedlings emerged from the seed bank as distinct cohorts (following rainfall events >10 mm) and the three knockdown treatments were implemented over a wider time period (8 weeks) than originally planned (4 weeks). At Cunderdin the initial serradella seed bank was approximately 365 kg/ha and the dominant weed was capeweed (*Arctotheca calendula*). By contrast, the initial serradella seed bank at Tincurrin was approximately 45 kg/ha and the dominant weed was annual ryegrass (*Lolium rigidum*); there was also 250 kg/ha of dormant subclover seed.

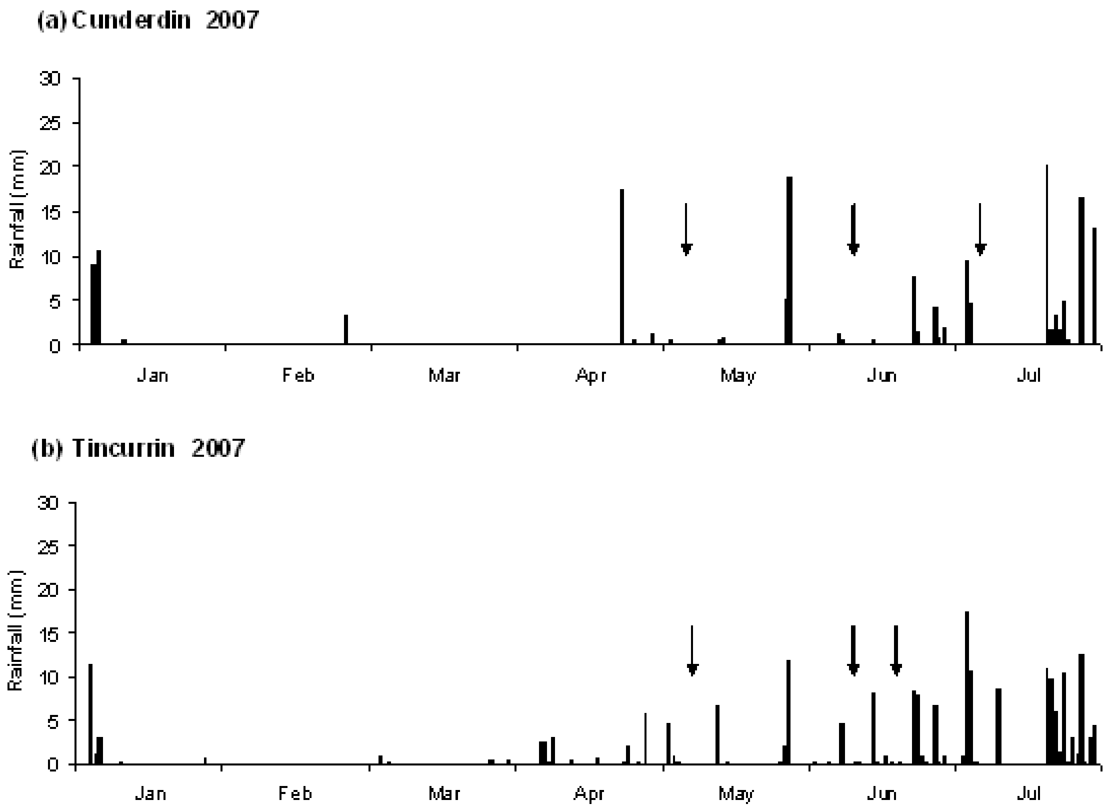

Figure 1. Daily rainfall during January-July at Cunderdin and Tincurrin. Arrows show dates when glyphosate (450 g ai/ha) was applied as a knockdown "autumn cleaning" treatment across yellow serradella based plots
(7 May, 8 June and 4 July at Cunderdin; and 4 May, 10 and 21 June at Tincurrin).

Impact of knockdown date on serradella density

Knockdown date had a significant impact on serradella density, biomass composition and FOO at the end of winter (Table 2). The glyphosate knockdown effectively killed serradella and weed seedlings that emerged prior to spraying, thus pasture production was dependent on subsequent regeneration from serradella and weed seed banks. At Cunderdin, by 9 August the number of serradella seedlings that re-established after the first (7 May) and second (8 June) knockdown treatments was significantly ($P<0.001$) greater than in the unsprayed control (Table 2); and regeneration density after the last knockdown treatment (4 July) was similar to that in control plots (1400-1600?pl/m^2). At Tincurrin, serradella density after knockdown treatments was much lower than at Cunderdin; a reflection of an eight fold difference in the size of the initial seed bank. Notwithstanding, serradella re-established and its density, though similar across all treatments on 22 August (130 - 270 pl/m^2), comprised a greater proportion of the total number of seedlings with successive knockdown date (increasing from 6 to 48% of seedlings). Overall, autumn cleaning date proved to be very robust as serradella emerged over a very wide time period at both sites (April to August). By contrast most Mediterranean annual pasture species take just 1 or 2 days for soft seeds to fully imbibe and germinate. This was evident at Tincurrin, as very few subclover seedlings regenerated after the first knockdown treatment.

Table 2. Seedling density and feed-on-offer (FOO) following a knockdown spray across an established yellow serradella pastures near Cunderdin and Tincurrin, WA. Square root transformed data are in parentheses.

(a) Cunderdin

Spray date	Density (pl/m^2) 9 Aug 07			FOO (kg/ha) 23 Aug 07		
	Serradella	Capeweed	Total	Serradella	Capeweed	Total
Control	1580 (39.5)	63 (7.6)	1700 (41.0)	1350 (36.7)	1670 (40.8)	3280 (57.3)
S1 – 7 May	2880 (53.1)	21 (3.5)	3000 (54.1)	1950 (44.1)	300 (16.8)	2500 (50.0)
S2 – 8 Jun	3050 (55.2)	9 (2.3)	3150 (56.1)	1330 (36.4)	15 (3.1)	1440 (37.8)
S3 – 4 Jul	1420 (37.5)	0 (0.0)	1430 (37.6)	270 (16.5)	0 (0.0)	290 (16.9)
LSD(P=0.05)	(8.36)	(3.06)	(8.19)	(2.93)	(3.71)	(2.71)

(b) Tincurrin.

Spray date	Density (pl/m^2) 22 Aug 07			FOO (kg/ha) 22 Aug 07		
	Serradella	Ryegrass	Total	Serradella	Ryegrass	Total
Control	130 (11.3)	15 (3.1)	2010 (44.8)	90 (9.2)	400 (19.8)	2280 (47.4)
S1 – 4 May	220 (14.7)	100 (10.0)	2110 (45.9)	150 (12.0)	470 (21.6)	720 (26.5)
S2 – 10 Jun	270 (15.9)	35 (5.7)	860 (29.0)	100 (9.8)	30 (5.4)	260 (16.0)
S3 – 21 Jun	220 (14.3)	20 (3.7)	460 (21.4)	50 (6.6)	10 (3.0)	60 (7.2)
LSD(P=0.05)	(7.25)	(5.36)	(5.05)	(4.43)	(4.32)	(7.09)

The delayed germination pattern in some yellow serradella lines and commercial varieties has been attributed to slow imbibition of field-softened seeds (Taylor 2005). Interestingly, the progress of slow imbibition can be reversed by dehydration (Taylor and Revell 2002). This may have been an important factor that enabled serradella to emerge over such a long time period (>8 weeks) at both sites which experienced intermittent rainfall separated by lengthy dry periods in 2007.

Impact on pasture composition and FOO

Even though the absolute density of capeweed at Cunderdin was fairly low (4% of plants) in the unsprayed control plots (Table 2), individual plants were very large and comprised 51% of the pasture biomass (by weight) on 23 August. Knockdown treatments resulted in significant gains in legume content (% biomass) and control of capeweed. The first knockdown treatment (7 May) depleted capeweed content to 12% (by weight) and later knockdown treatments resulted in almost pure swards of serradella (>90%). However foregone FOO at the end of winter increased from 24 to 91% with successive knockdown dates.

At Tincurrin, annual ryegrass comprised 18% of the unsprayed control treatment (by weight) on 22 August. Interestingly, the first knockdown treatment (4 May) resulted in an increase in ryegrass plant density and relative content (65% of total biomass). The later knockdown treatments achieved greater control of ryegrass but forgone FOO was significant across all treatments (68-97%) on 22 August. The impact of the early knockdown treatment was likely due to the elimination of the dense subclover component from the pasture mix and, in turn, bare areas developing for other species to establish. Although plots were not grazed in this study, grazing prior to the application of a herbicide knockdown would help to minimise foregone FOO.

The results showed that autumn cleaning generally increased serradella composition; however, the more delayed the knockdown the greater the impact on FOO. Thus the optimum knockdown date appears to be a trade-off between available FOO and level of weed control achieved. At Cunderdin the early knockdown effectively controlled capeweed, whereas a later spray date was required to achieving adequate control of ryegrass at Tincurrin. Clearly these results are a reflection of the germination pattern of serradella and the dominant weed species.

Currently options for selective weed control in serradella based pastures are limited and generally expensive (Valentine and Ferris 2006). The results from this study suggest that autumn cleaning with low cost, broad spectrum herbicides could be used routinely to renovate yellow serradella based pastures, particularly where capeweed is a problem weed. If adequate feed is available to meet livestock demand, autumn cleaning might also be used to control herbicide resistant ryegrass during a non-crop phase/year as part of an integrated weed management system. However, a very late knockdown (July-August) may limit growth and compromise yellow serradella seed-set if the season cuts off early. On fine-textured soils in low to medium rainfall areas *Trifolium dasyurum* (eastern star clover) *cv.* AGWEST Sothis might be exploited in a similar way as it is reported to have markedly delayed germination (Loi *et al.* 2006).

Conclusion

This study demonstrated that there is a wide window of opportunity to control weeds within yellow serradella based pastures with low cost, broad spectrum herbicides after the break of season. The optimum timing of a knockdown in autumn is a trade-off between FOO and the proportion of the target weed controlled. The size of the serradella seed bank, dominant weed species, knockdown date and presence of other pasture legume species collectively had a bearing on the outcome from autumn cleaning. When capeweed is the dominant weed, there appears to be little benefit in delaying beyond the first flush of weed emergence, by contrast, where annual ryegrass is the dominant weed, it appears as if a greater delay in spray date is required to achieve adequate weed control. Clearly, the success of autumn cleaning is related to the differential in germination pattern between serradella and weed species. Overall, autumn cleaning appears to be a cheap and effective weed control tool. However, this strategy needs to be evaluated across a wider range of seasons, sites and serradella varieties in order to develop sound recommendations. The application of autumn cleaning across other pasture legume species with a delayed germination pattern, such as *Trifolium dasyurum cv*. AGWEST Sothis, should also be evaluated in order to apply this strategy across a wider range of environments

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References

Ferris (2008). Depleting weed seed banks within non-crop phases for the benefit of subsequent crops. Proceedings of the 16th Australian Weeds Conference, eds RD van Klinken, VA Osten, FD Panetta and JC Scanlan, pp. 477-479 (Queensland Weed Society, Brisbane).

Loi A, Nutt B and Revell C (2006). *Trifulium dasyurum* L. (Eastern star clover): Exploiting a novel pasture species for innovative strategies to control weed seed banks. Proceedings of the 13th Australian Agronomy Conference, Perth. Australian Society of Agronomy. http://www.regional.org.au/au/asa/2006/poster/environment/4472_loia.htm. Accessed 23 April 2008.

Revell CK and Thomas, DK (2004). Management of crop weeds through the strategic use of annual pasture. Proceedings of the 14th Australian Weeds Conference, eds BM Sindel and SB Johnson, pp. 145-149 (Weed Society of New South Wales, Sydney).

Revell CK and Taylor GB (1998). Imbibition and germination of yellow serradella seeds. Proceedings of the 9th Australian Agronomy Conference, Wagga Wagga, NSW. Australian Society of Agronomy. http://www.regional.org.au/au/asa/1998/1/036revell.htm. Accessed 23 April 2008.

Taylor GB (2005). Hardseededness in Mediterranean annual pasture legumes in Australia: a review. Australian Journal of Agricultural Research 56, 645-661.

Taylor GB and Revell CK (2002). Seed softening, imbibition time and seedling establishment in yellow serradella. Australian Journal of Agricultural Research 53, 1011-1018.

Valentine C and Ferris DG (2006). The impact of herbicides on pasture legume species – a summary of scientific trial results across 8 years. Agribusiness CropUpdates -Weeds, Burswood International Resort, Perth, Western Australia, ed A Douglas, pp111-116. http://www.agric.wa.gov.au/content/PW/WEED/Weeds2006.htm. Accessed 23 April 2008.