Is summer sowing as effective as winter sowing for introducing serradella into subtropical perennial grass pastures?

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Abstract
This experiment compared the performance of serradella (*French, Ornithopus* sativus; and yellow, *O. compressus*) sown into established perennial grass pastures in summer (February) using dormant pod segments (new summer sowing technology), with serradella sown into perennial grasses after the break of season using scarified seed (traditional method). Even though serradella summer sown into Gatton panic (*Megathyrsus maximu*s) had significantly lower seedling numbers compared to serradella summer sown into plots without perennials (25% less), serradella biomass and seed production was greater (92% more seed-set). Seed production in perennial grass plots was also significantly greater ($P<0.001$) in summer compared to winter sown plots (40% more). Overall, winter biomass production was highest in plots without a perennial base but the pastures were dominated by capeweed (*Arctotheca calendula*). Yellow serradella, experimental line 87GEH72.1a, flowered earlier than Margurita[A] French serradella, but produced similar amounts of biomass and seed overall, and appeared well suited as a companion annual legume. Summer sowing serradella pod-segments was as effective as winter sowing scarified seed for introducing a companion annual legume into subtropical perennial grass pastures.

Key words
Perennial pasture, Evercrop project

Introduction

About 50,000 ha of subtropical perennial grasses have been sown across deep sandy soils in the Northern Agricultural Region (NAR) of Western Australia (Larson and Howard, 2013). Benefits include year-round groundcover, reduced deep drainage, green feed over summer and increased animal production; however, there are concerns about the ongoing productivity of perennial grass pastures due to low or no annual legume content and inadequate nutrition (Dolling *et al*., 2015).

French serradella (*Ornithopus sativus*) and yellow serradella (*O. compressus*) are annual legumes well adapted to deep sandy soils and could be used as a companion annual legume to improve feed quality and drive the productivity of subtropical perennial grass pastures; however, sowing annual pastures immediately after the break of season often conflicts with demands of large annual cropping programs. Consequently, many annual legume pastures are sown late, under conditions too cold to promote rapid growth and good establishment. Loi et al. (2012) are promoting summer sowing as a way to establish hard-seeded annual pasture legumes without interfering with cropping operations. Summer sowing is a new technology where dormant, un-scarified, pasture-legume seeds (or pod segments) are sown in early summer; a high proportion of these seeds gradually soften over the summer-autumn period (3-4 months) and are ready to germinate at the break of season (Loi *et al*., 2012).

The aims of this study were (a) to compare the performance of serradella sown into established subtropical perennial pastures in summer (February) using pod segments, with serradella sown into perennial grasses after the break of season using scarified seed; (b) to evaluate the impact of a perennial base and herbicide suppression on serradella establishment, biomass production and seed yield

Materials and Methods

Site history & treatments

In 2011, perennial pasture plots (7 x 20 m) were established at 29° 12’ 30”S, 115° 10’ 32”E on a non-wetting, deep sandy soil 25 km west of Mingenew, using precision guidance technology (DGPS ± 2 cm accuracy)

and auto-steer. The site was originally set up to evaluate the viability of pasture cropping across Gatton panic (*Megathyrsus maximus*; rows 44 cm apart). In 2014, the 30 plots were re-allocated to seven pasture improvement treatments (Table 1). The new trial had a criss-cross design: seven main pasture improvement treatments and 2 herbicide treatments (± suppression) applied at right angles across these (14 treatments in total).

Table 1. Pasture improvement treatments

Trt*	Reps	Description – main pasture treatments (variety, sowing time/perennial)
1	4	Perennial grass control (i.e. no serradella)
2	3	87GEH72.1a Yellow serradella - summer sown into annual plots (i.e. no perennial grass)
3	3	Margurita[A] French serrardella - summer sown into annual plots (i.e. no perennial grass)
4	5	87GEH72.1a Yellow serradella - summer sown into perennial grass
5	5	Margurita[A] French serrardella - summer sown into perennial grass
6	5	87GEH72.1a Yellow serradella - winter sown into perennial grass

* The perennial grass was a 2.5 year old Gatton panic stand (Megathyrsus maximus); A grass selective herbicide was sprayed across half of each plot at a right angle to the main treatments.

Seeding & management inputs

French serradella (MarguritaA) and an experimental line of yellow serradella 87GEH72.1a (with a similar softening pattern to MarguritaA) were sown between perennial rows or into annual plots with a cone seeder (tines 22 cm apart) using precision guidance technology. Dormant pod segments were summer-sown into plots on 20 February (20 kg pod/ha plus 10 kg/ha ALOSCA®); and scarified seed was winter sown into plots on 21 May (7 kg seed/ha plus 10 kg/ha ALOSCA®) after a knockdown spray (540g/L glyphosate at 0.75 L/ha). Fertiliser (160 kg/ha Big Phos, N 13.5%, S 7.5%, Ca 18%) was top-dressed across all plots at seeding.

The trial was sprayed (21 May) with Broadstrike® (800 g/kg Flumetsulam at 25 g/ha) to control volunteer narrow-leafed lupins and broad-leafed weeds; and Select® (240 g/L clethodim at 500 mL/ha) was sprayed on 4 July across half of each plot to suppress the perennial grasses. A ride on lawn mower (cutting height ~8 cm) was used to simulate grazing just before winter seeding and immediately after biomass assessments on 25 June and 7 August.

Assessments & analyses

Serradella establishment was assessed in summer sown plots on 15 May and winter sown plots on 11 June (three weeks after seeding) by counting the number of seedlings long 1 m long rows at 8 random positions per plot. Biomass growth was assessed by sampling three 0.44 m^2 quadrats per plot on 25 June and 7 August; and following the application of Select, two quadrats per sub-plot on 27 August and 6 November. Serradella seed production was estimated by collecting pods from within three 0.2 m^2 quadrats per sub-plot and by assuming a seed to pod ratio of 63% for MarguritaA and 36% for 87GEH72.1a.

The impact of the three main factors (variety, sowing time/perennial and suppression) on serradella and total biomass (both cumulative to 27 August) and serradella seed production was analyzed by fitting linear mixed models using REML (residual maximum likelihood) to take into account the unbalanced strip plot structure of the design. The factor sowing time/perennial has factor levels of summer sowing with no perennial, summer sowing into perennial and winter sowing into perennial. In the case of total biomass there is also a forth factor level of no serradella. Analysis of germination data was simplified because the suppression treatment had not yet been applied so analysis of variance was used. All analysis was done in GenStat version 17.

Results

Germination and establishment

There was a decisive break to the growing season in 2014 in late April and good follow-up rains: overall the site received 56 mm in April and 54 mm in May. This promoted even germination and early winter biomass production in all plots. Notwithstanding, there were significant main effects for variety (P=0.004) and sowing time/perennial (P=0.035). When serradella was summer sown into annual plots at 20 kg/ha pod (i.e. no perennials), MarguritaA produced 149 plants m^2, while 87GEH72.1a only produced 79 plants m^2, possibly

due to a lower seed to pod ratio. Summer sowing MarguritaA into perennials instead of annual plots, resulted in 32% less seedlings, possibly due to increased competition. Establishment density was similar (average 113 plants m^2) for both species when sown in winter at 10 kg/ha of scarified seed.

Biomass production

For total cumulative biomass to 27 August, there was a highly significant effect of sowing time/perennial ($P<0.001$). However, the main effects of suppression and variety were not significant. The annual only plots produced the most total biomass (4.2 t/ha) but these were dominated by capeweed (*Arctotheca calendula*). By contrast, there were fewer weeds in all subtropical perennial grass plots. Perennial plots winter sown with serradella produced 2.2 t/ha which was not significantly different to the amount of biomass produced in perennial only plots (1.9 t/ha); by contrast summer sowing serradella into perennial grass plots increased total winter biomass by 42% (Figure 1).

In relation to serradella biomass, the main effect of suppression was not significant, but there were significant main effects of variety ($p<0.001$) and sowing time/perennial ($p<0.001$). Summer sowing serradella into perennial grass plots resulted in significantly higher serradella biomass than summer sown into no perennial, which in turn was significantly higher than winter sown into perennial. MarguritaA produced 550 kg/ha more winter biomass than GEH72.1a up until 27 August (averaged over all treatments). By the end of the winter growing season (November), legume biomass had almost doubled (av. 2.0 t/ha) due to rapid growth in spring.

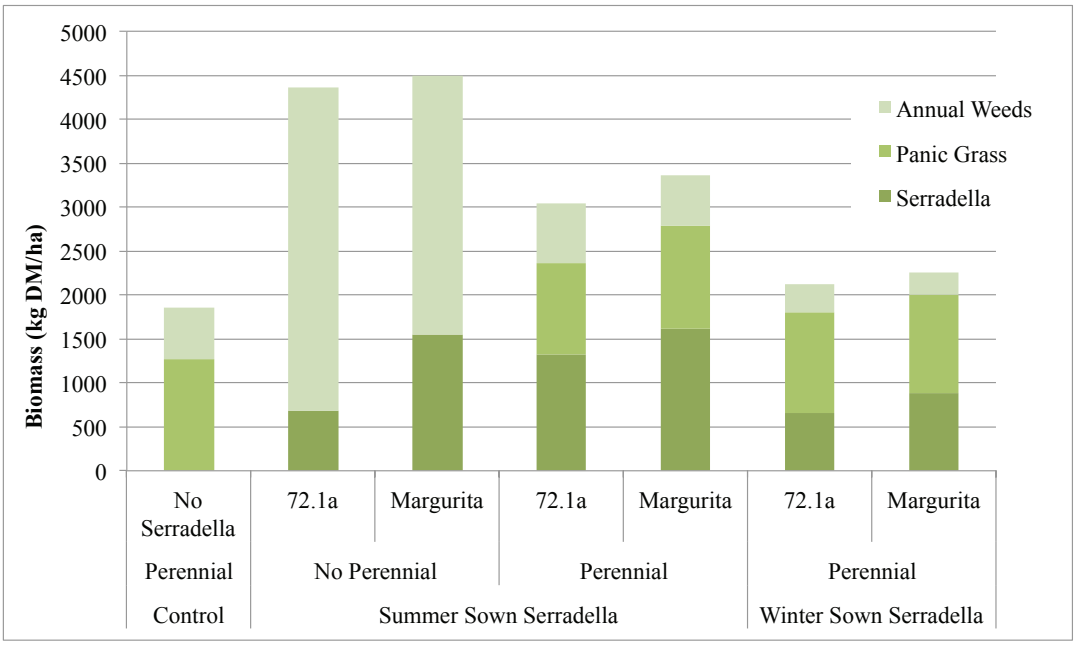

Figure 1. Cumulative biomass and pasture composition for pasture improvement treatments 87GEH72.1a (72.1a) and Margurita[A] up to 27August (Treatment 1 to 7, Table 1; Average LSD = 673 kg/ha for total biomass and 410 kg/ha for serradella biomass)

Serradella seed production

There was a highly significant effect of sowing time/perennial ($P<0.001$): summer sowing into perennials had significantly higher serradella seed production compared to winter sown into perennials. The main effect of suppression was not significant; however, there was a significant interaction of suppression with sowing time/perennial ($P=0.023$) reflecting that suppression had a positive effect when sowing into perennial but negative effect when sowing into no perennial. For summer sowing into perennial with suppression, MarguritaA produced 460 kg/ha and 87GEH72.1a 560 kg/ha of seed (Figure 2).

Discussion

This study found that establishing serradella in a subtropical perennial grass pasture can be done successfully by either sowing pod segments in summer or sowing scarified seed in winter. Summer sowing and a decisive break enabled serradella to germinate earlier and take advantage of a longer growing period (~3 weeks) compared to traditional winter sowing; and seedling emergence was uniform for all summer sown treatments

irrespective of the perennial base. By contrast, seedling emergence in perennial plots was delayed in a preliminary study at Dandaragan (Valentine *et al*., 2014). In that trial, sparse rainfall events in April were only sufficient to boost serradella growth in annual only plots. Serradella sown into plots without perennial gasses did not set as much seed as serradella sown into perennial plots due to greater weed competition. By contrast Valentine *et a*l. (2014) reported 24-43% reduction in serradella seed yield when sown into perennials, but that trial had fewer annual weeds and earlier germination in annual only plots. Even though Select® suppressed the growth of Gatton panic, the benefits to serradella performance were not as high as anticipated. In winter sown plots, a glyphosate knockdown also suppressed the perennials and likely accounts for the grass selective only promoting additional seed set where serradella was summer sown into perennial plots. These results indicate that herbicide suppression is not necessarily needed to establish an adequate seed bank for dense serradella regeneration in subsequent years. The experimental line of yellow serradella 87GEH72.1a was a prolific seed producer and appears well suited as a companion annual legume for subtropical perennial grass pastures in the medium rainfall zone of the Northern Agricultural Region.

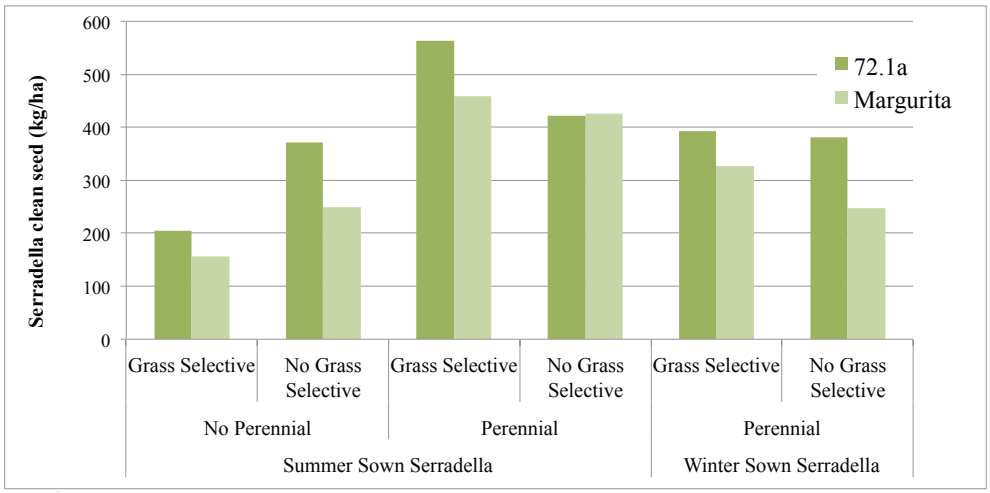

Figure 2. Impact of time of sowing, perennial grass and grass suppression on seed yield of 87GEH72.1a (72.1a) and Margurita[A] serradella (Treatment 2 to 7 ± grass selective, Table 1; Average LSD =187).

Conclusion

Summer sowing serradella pod-segments is an effective technique for introducing a companion annual legume into subtropical perennial grass pastures. However, the success of summer sowing in different years and sites might be influenced by the decisiveness of the break of season, the annual weed burden and the density and/or level of activity of the perennial pasture. Summer sowing could provide a cheaper, more convenient and timely method to establish a companion legume than traditional winter sowing.

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Acknowledgments

Thanks to Debbie Gillam and Sebastian Recabarren for technical support (Mingenew-Irwin group), the Geraldton RSU for seeding and spraying (DAFWA), Andrew Van Burgel for statistical analyses (DAFWA), and Andrew and Debbie Gillam for access to their farm to perform the research. This research was partly funded by MLA (Feedbase project) and GRDC (Evercrop project).