Strategies to improve establishment of legume pastures to maximise break crop effects in low-rainfall environments

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Abstract

The break crop effect of grain and pasture legumes has been and continues to be characterised in a range of Australian environments. In the 2020 cropping season medic pasture benefits to subsequent wheat in the Southern Mallee were more than 90% with up to 3.0 t/ha of additional wheat yield, while a single year harvestable legume option (vetch) offered a 2.6 t/ha yield benefit to following wheat crops. For mixed pasture-cropping farms, reliable pasture production and subsequent break effects are critical to the adoption of improved production systems. Establishment of species that are new to a given environment can be a critical limitation to these productivity effects. Twin, Summer and Autumn sowing methods offer opportunities for low-cost establishment of pastures that take advantage of early autumn rainfall. Examination of sowing methods of a range of pasture legumes has revealed inconsistencies in which species x sowing time x season x site combination is optimal. Competition from weeds and background pasture species are additional barriers to the adoption of novel early (or dry) establishment approaches to pasture establishment in southern mixed farming systems.

Keywords
Serradella, Trigonella, Medic, Clover, Vetch, Summer sowing, Twin sowing

Introduction

On mixed pasture-cropping farms, reliable pasture production and subsequent cereal break effects are critical to the adoption of improved production systems. A significant obstacle to the adoption of new legume pasture species is the high cost of seed and difficulty in successfully establishing pastures to provide early season production, particularly in low-medium rainfall areas. The optimal establishment time for pastures in autumn is a compromise between early enough for sufficient rooting depth and biomass production, and late enough that the risk of a false break is low and high soil temperatures do not limit germination and seedling growth (Puckridge and French, 1983). Unfortunately, this sowing window coincides with the optimal sowing time for the main cropping program in mixed farming systems (Flohr et al., 2017).

Together with improved pasture cultivar options, systems need to be developed to help mixed farmers overcome logistic and economic issues surrounding pasture establishment. In Western Australia, sowing unscarified 'hardseed' of some pasture species, either in in late summer (Summer sowing) or with the proceeding crop (Twin sowing), have shown promise (Revell et al., 2012), but these alternative establishment methods have had limited evaluation in south-eastern Australia. This study examines the potential of different pasture legume species to be established more efficiently, thereby providing growers with greater flexibility in establishing pastures by avoiding clashes with peak sowing times, reducing establishment costs, increasing early season feed and the cropping sequence break effect.

Methods

Establishment Method Experiment

In the South Australian Mallee, three establishment methods were evaluated at Waikerie (2019) and Lameroo (2020) and included legume pasture species that have not been traditionally grown in the region (Table 1). Soil type at the Waikerie site is a red alkaline sand (0-10 cm pH $CaCl_2$ 8) and at Lameroo a deep sand (0-10 cm pH $CaCl_2$ 7). The residual effects of the methods implemented in 2019 were measured at Waikerie in 2020. Establishment methods evaluated were a) Twin-sowing, where 'hard' pasture seed/pod was sown with wheat seed in 2018 for 2019 pasture establishment at Waikerie, or with wheat seed in 2019 for 2020 pasture establishment at Lameroo; b) Summer-sowing, where 'hard' seed/pod is sown in February and softens to establish on the autumn break; and c) Autumn-sowing (control treatment representing farmer practice), where 'soft' seed was sown on the break of the season.

For pastures establishing in 2019 at the Waikerie site, Twin-sown treatments were sown on 5 June 2018, Summer-sown treatments were sown on 14 February 2019, and Autumn-sown treatments on 23 May 2019. For pastures establishing in 2020 at Lameroo, Twin-sown treatments were sown on 20 May 2019, Summer-sown treatments were sown on 18 February 2020, and Autumn-sown treatments on 28 April 2020. At each site, pasture and weed densities were recorded in June, and at least two measures of biomass production were recorded. The sowing rates for the legumes are reported in Table 1 and all legumes were inoculated with their specific rhizobia group using peat slurry applied at double the recommended rate. Granular inoculant (ALOSCA) was also sown with each legume at a rate of 10 kg/ha. After counts of pasture regeneration, all plots at Waikerie were sown to wheat (cv. Scepter) on 7 May 2020.

Table 1. Sowing rates of pod or seed (kg/ha) in Twin and Summer sown treatments and sown rate of germinable seed (kg/ha) in the Autumn sown treatment.

Legume	Twin and Summer sowing (kg/ha)	Autumn sowing (kg/ha)
PM-250 strand medic	35 (pod)	8
Trigonella balansae-5045	13 (seed)	5
Bartolo Bladder clover	13 (seed)	8
SARDI Rose clover	10 (seed)	8
Margurita French serradella	33 (pod)	8

Systems Experiment

A pasture systems experiment was established at Lameroo in 2018. Pasture treatments were SARDI Rose clover, Margurita French serradella, PM-250 strand Medic and Trigonella-5045. In 2019 pastures regenerated and new treatments of SARDI Rose clover, Margurita French serradella, PM-250 Medic were sown on 2018 wheat plots. The residual 'break' effect of the first two years of pasture phases on subsequent wheat yield was measured in 2020. These treatments were compared to continuous cereal and 2019 grain legume (field pea and vetch) treatments. In 2021, these plots are split to allow pasture regeneration to contrast with a second-year legacy pasture break effect as measured in a cereal crop.
All experiments were set up in a randomised complete block design with 4 replicates (blocks) and analysed by ANOVA using Genstat® V20.

Results

Establishment Method Experiments

In Waikerie the seasonal break (> 15 mm) occurred on 9 May 2019 with 20 mm rainfall, summed rainfall prior to 9 May 2019 was 22 mm. Treatment differences in pasture dry-matter production were measured at Waikerie in 2019, despite production being limited by rainfall (growing season rainfall 119 mm, average 164 mm) (Table 2). Production was greatest for summer- and autumn-sown PM-250 medic. Although Margurita French serradella and SARDI Rose clover produced more dry-matter when summer-sown, the overall production was lower, suggesting they are not well adapted to this environment.

Prior to sowing wheat in 2020, pasture regeneration was measured at Waikerie. Medic plots had the highest regeneration while regeneration of other pasture species was generally very low, which may be due to low seed set in 2019 or the wrong level of hardseededness for the species x environment combination (data not shown). In 2020, growing season rainfall at Waikerie was above average with 210 mm (average 164 mm) and wheat yield measurements were not significantly different between treatments (data not shown). Pasture regeneration after 1-year of crop will be assessed in 2021.

Growing season rainfall in 2020 was above average at Lameroo with 343 mm (average 270 mm). The seasonal break (> 15 mm) occurred in the first week of April with 22 mm rainfall. Summer fallow rainfall (November-March) was 147 mm. Establishment method had a significant effect on plant density (Table 2). Mean plant establishment (across all species) in Autumn sown treatments was 72 plants/m^2, Summer sown treatments was 29 plants/m^2 and Twin sown treatments was 14 plants/m^2 (Table 2). Weed density across pasture treatments was highest in Summer sowing (13 weeds/m^2) and Twin sowing (8 weeds/m^2), compared to Autumn sowing (3 weeds/m^2). There were considerable differences in biomass production at Lameroo for pasture species x establishment method x sampling time combinations (Table 2). Production was greatest for summer- and autumn-sown PM-250 medic at all sampling times and autumn sown Bladder Clover. Rose clover and French serradella produced less biomass at all sampling times than other species (Table 2). Summer and Autumn sown Trigonella produced biomass that was intermediate compared to other species. Weed management and competition from background medic remains a critical consideration with Twin- and Summer-sowing. There were significantly more broad-leaf weeds and background medic (data not shown) in the Twin- and Summer-sown plots compared to Autumn-sown plots, and weed competition in these non-grazed plots was an issue throughout the growing season. The residual 'break' effect of the pastures and establishment method on subsequent wheat yield will be measured at Lameroo in 2021.

Table 2. Measurements from establishment methods experiment near Waikerie in 2019 and Lameroo in 2020, including pasture and broad leaf weed plant establishment density (plants/m^2) and peak pasture biomass (t/ha).

	Waikerie 2019			Lameroo 2020		
Treatment	**Establishment (plants/m^2)**	**Weed density (plants/m^2)**	**Biomass (t/ha)**	**Establishment (plants/m^2)**	**Weed density (plants/m^2)**	**Biomass (t/ha)**
Autumn Bladder	186	33	0.48	89	2	6.18
Autumn Medic	124	24	0.42	51	3	5.97
Autumn Rose Clover	137	35	0.45	82	7	3.18
Autumn Serradella	179	36	0.52	70	2	3.04
Autumn Trigonella	131	42	0.32	67	3	4.41
Long fallow	NA	NA	NA	0	8	0
Summer Bladder	142	66	0.20	39	15	3.32
Summer Medic	87	80	0.81	25	15	6.27
Summer Rose Clover	146	88	0.32	20	12	1.38
Summer Serradella	352	92	0.12	22	17	2.10
Summer Trigonella	80	91	0.00	32	8	3.69
Twin Bladder	57	72	0.09	14	10	0.91
Twin Medic	53	108	0.30	14	9	3.60
Twin Rose Clover	39	128	0.08	13	8	1.57
Twin Serradella	124	126	0.18	21	7	1.84
Twin Trigonella	19	108	0.20	6	8	1.56
Vetch	53	31	0.32	47	2	6.49
Barley/ Wheat (grain)	134	36	2.35	100	1	5.10
LSD at P=0.05	41	42	0.10	14	6	1.61

Legume Break Effect

In the 2020 cropping season regenerating medic pasture benefits to subsequent wheat at a site near Lameroo were in excess of 90%, with up to 2.9 t/ha of additional wheat yield compared to the continuous cereal rotation, while a single year harvestable legume option (vetch) offered a 2.4 t/ha benefit to the following wheat crop (Figure 1). Pastures sown in 2018 that regenerated in 2019 offered a significantly higher break effect than those sown in 2019, but all produced at least 45% additional wheat yield. The magnitude of the break effect cannot be explained by measurements of pre-sowing soil mineral nitrogen or root disease infection, and assessment of the nitrogen and water balance to fully explain this effect is underway.

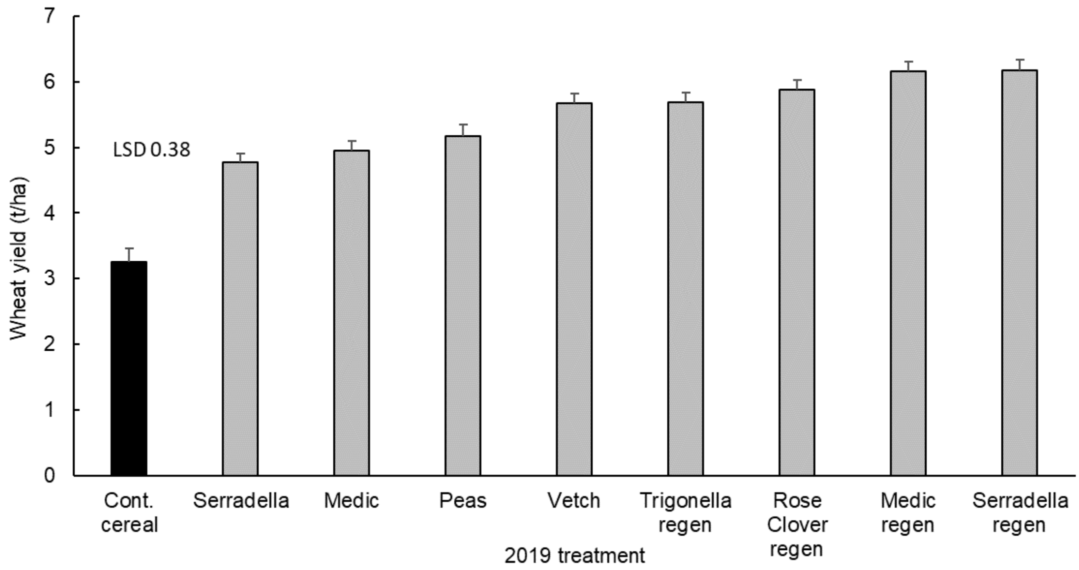

Figure 1. Wheat grain yield (t/ha) in 2020 following 2019 treatments of either sown or regenerating (regen) legumes compared against a continuous cereal control (LSD 0.38 at P=0.05). Error bars represent standard error of the mean.

Discussion and Conclusions

Legume species have an important role to play for both pasture and cropping production on mixed farming operations in the Mallee environment of southern Australia. Alternative pasture establishment methods have demonstrated potential in mixed farming systems, however, they are not suitable for all pasture legume species. Many pasture species are challenged in low rainfall environments with alkaline soils such as Waikerie (Av. annual rainfall 250 mm, pH 8). The benefits of a productive pasture system for subsequent crop yields are evident (e.g. at Lameroo) but production risk for pasture productivity is clear (e.g. Waikerie). Options to increase sowing flexibility and reduce production risk are critical to the realisation of substantial and consistent break effects.

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