Summer sowing: a new alternative technique to introduce annual pasture legumes into mixed farming systems

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Abstract
Annual pasture legumes are conventionally sown in late autumn or winter after the main cropping program is completed. Farmers in general sow scarified seed with high germination levels (70-90%) following an application of knockdown herbicide to control established weeds. This method of sowing seriously reduces early winter pasture production because the cold winter conditions restrict the growth rate of legumes. Notably, recent surveys conducted in the Western Australia wheatbelt have highlighted that the cost of pasture establishment and the unreliability of the traditional autumn sowing, particularly in dry years, are major constrains to pasture adoption.

Summer sowing is a new technique that has been developed to lower the cost and increase the reliability of pasture establishment. This technique firstly utilises un-scarified pasture legume seed with high level of hard-seededness to prevent undesirable germination in summer, and secondly exploits the breakdown of the hard-seededness to provide an adequate number of germinating seeds under favourable conditions in autumn. Hence, the pasture legume will establish as regenerating pasture using full use of the growing season. Summer sowing enables farmers to sow pasture without interfering with their cropping operations using pasture legume seed or pods produced on farm.

Key Words
French serradella, yellow serradella, clover

Introduction
Annual pastures in mixed cereal livestock systems throughout southern Australian regions have been traditionally based on species broadly adapted to the prevalent soils and climate, and have the ability to regenerate naturally after an initial sowing/establishment phase (Wickham et al. 2007). Species such as subterranean clover (*Trifolium subterraneum*) and annual medics (annual *Medicago* spp.) have dominated annual pasture sowings in Australia (Nichols et al. 2007); however in the last decade, pasture legume markets have benefited from the domestication of new pasture legume species such as French serradella (*Ornithopus sativus*), yellow serradella (*Ornithopus compressus*), biserrula (*Biserrula pelecinus*), gland clover (*Trifolium glanduliferum*) and bladder clover (*Trifolium spumosum*) (Loi et al. 2005). Importantly, these new species can be directly harvested with standard grain harvesters allowing seed to be produced at relatively lower cost, in contrast, to the high cost and labour intensive use of suction harvesting for subterranean clover and annual medics (Nutt and Loi 1999). Additionally, these new annual pasture legumes have created the opportunity to develop novel pasture establishment systems using self produced sources of unprocessed dormant (hard) seed. In particular it targets species with high levels of hard-seed which are easily harvested but are difficult to process to the high level of germination required using typical establishment techniques (Loi et al. 2008).

Examples include hard-seeded forms of French serradella or yellow serradella where large amounts of podded seed can be easily produced on-farm with conventional multi-crop machinery. This seed can have less than 10% germination unless the surrounding pod is removed and the seed coat scarified. To avoid these extra processing steps, dormant podded seed can be "Twin sown" with a crop in autumn and during the following summer and autumn (under the crop stubble), the hard-seed of the legume will gradually breakdown and become able to germinate with rains over late autumn and winter (Loi et al. 2008). Another technique "Summer sowing" involves the dormant podded seed being sown (drilled) soon after the crop has been harvested (early summer). The seed coat breaks down over summer and becomes germinable at the break of the season ensuring a similar regeneration to Twin sowing. This paper reports on Summer sowing establishment technique and compares it to conventional sowing where scarified seed is drill sown after the break of the season into a paddock sprayed previously with a knockdown herbicide to control weeds.

Methods

Three separate field trials over two years were conducted in the Northern agricultural region of the Western Australia wheatbelt. They included, a 2010 trial located in south-east Mingenew on a fine textured sandy loam soil (pH 5.0 H_2O), and two 2011 trials situated at south-east Coorow and west Mingenew, both on loamy sand soils (pH 5.0 H_2O). The trial design included two different sowing dates, either early summer (February) or early winter (June), and three sown pasture legumes. These included two alternative pasture legumes, French serradella cv. Margurita, yellow serradella experimental line 87GEH72.1a and subterranean clover cv Dalkeith used as a control. Pods of French and yellow serradella for the summer sowing treatment were sourced from header harvested material with minimal post-harvest processing and resulting in a low level of germination (<10%). For the winter sowing treatment seed was extracted from the pods and scarified to a level which resulted in greater than 75% germination. Subterranean clover was used only in the winter sowing treatment, because of its high seed germination level at harvest which makes it unsuitable for summer sowing. Summer sowing plots (50 x 5 m) were planted by drilling pods into the dry soil using an Aitchson miniseeder at 50 kg pod/ha to 1 cm depth, into cereal stubble on February 16, 2010 at Mingenew and February 3, 2011 at Mingenew and Coorow. Winter sowing plots were sown by drilling scarified seed into moist soil at 10 kg seed/ha to 1 cm depth on June 2, 2010 at Mingenew and May 31, 2011 after the application of a knockdown herbicide (1.5 L/ha of Roundup CT®). Seed was inoculated by combining pod or seed with 10 kg/ha of Alosca® granules, Group S for serradella and Group C for clover. All treatments were top dressed with 150 kg/ha of 3:1 superphosphate:potassium chloride and sprayed with 120 mL/ha of Talstar® (bifenthrin 100 g/L) and 1 L/ha of Kerb® (propyzamide) after sowing. Establishment was assessed at the end of June 2010 and 2011 by seedling counts in 10 quadrates (40 x 25 cm) randomly placed in each plot. The regenerating swards remained un-grazed throughout the year. Available dry matter was estimated on August 4, and September 23, 2010 and on August 14 and September 5 2011 from material cut with knives from 3 randomly placed open quadrates (0.1 m^2) in each plot and dried at 60°C. Three samples (0.1 m^2) of mature pods per plot were harvested and threshed to assess seed yield. A randomised block design was used to allocate the factorial combinations of sowing time (winter vs summer) and the species (French serradella, yellow serradella and subterranean clover). Note the subterranean clover was not sown in summer sowing and the experimental design was an incomplete factorial with 3 blocks. The REML procedure of GenStat for Windows (Edition 14) was used to fit a linear model to this design and a different variance for each species was estimated.

Results

The Mingenew site received good opening rains in late April and May in both years (Table 1), which resulted in the majority of the seedlings in the summer sown treatment emerging by May, which was almost 3 to 4 weeks earlier than those conventionally winter sown. The levels of hard-seededness breakdown in French and yellow serradella were adequate in both years across the three sites to ensure a sufficient regeneration for the summer sowing treatments which compared favourably with the number of seedlings/m^2 with winter sowing treatment (Table 2, 3 and 4). The Coorow site in particular, showed a high level of pod softening during the summer months enabling the summer sowing treatments to achieve a greater seedling number established compared to the winter sowing treatment (Table 4).

Table 1. Monthly average rainfall (mm) for the site of Mingenew (2010 and 2011) and Coorow (2011) in Western Australia.

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mingenew 2010	0.0	0.0	24.4	21.8	44.0	17.8	71.3	60.2	4.5	1.0	0.0	22.6	267.6
Mingenew 2011	22.0	68.8	3.0	27.4	114.6	65.4	75.2	108.6	49.4	61.4	16.8	7.6	620.4
Coorow 2011	56.6	15.0	0.2	1.4	30.4	30.4	55.4	38.2	21.2	68.4	16.6	35.4	369.2

Summer sown treatments of Margurita at Mingenew 2010 recorded almost 4.5 t/ha of dry matter in winter and 9.3 t/ha in spring compared to the plots conventionally sown in early winter which produced only 0.7 t/ha in mid winter and 4.6 and of dry matter in spring (Table 2). Similarly, herbage cuts of 87GEH 72.1a at the Mingenew 2010 site recorded 2.9 t/ha of dry matter in winter and 8.7 t/ha in spring compared to only 0.8 t/ha in mid winter and 4.9 t/ha in spring for the same cultivar conventionally sown (Table 2).

Seed yields reflected dry matter yields (Table 2) with the yellow serradella summer sown plots recording the highest pod yield (2176 kg/ha). Subterranean clover, which was used as a comparator, performed similar to the winter sowing French serradella treatment and both were negatively affected by the early finish of the season.

Table 2. Measurements of three annual pasture legumes including plant density, dry matter (DM) production and seed yield when sown at two different times: at the break of the season (conventional) or in summer (summer sowing) at Mingenew in 2010.

Variable	Cultivar	Conventional sowing	Summer sowing	LSD (P=0.05)
Sampled 31/05/2010 - Plants/m^2	Margurita	262	169	55
	87GEH72.1a	331	372	77
	Dalkeith	195	n/a	n/a
Sampled 5/08/2010 - DM t/ha	Margurita	0.7	4.5	0.3
	87GEH72.1a	0.8	2.9	1.0
	Dalkeith	0.6	n/a	n/a
Sampled 23/09/2010 - DM t/ha	Margurita	4.6	9.3	1.9
	87GEH72.1a	4.9	8.7	1.9
	Dalkeith	2.6	n/a	n/a
Sampled 27/11/2010 Seed Yield kg/ha	Margurita	311[#]	1359[#]	458
	87GEH72.1a	1423[#]	2176[#]	1025
	Dalkeith	217	n/a	n/a

[#] Seed yield expressed as pods (seed percentage in French serradella = 65%, and in Yellow serradella = 37%)

Similar results were recorded in 2011 at both sites for dry matter yield; however large differences between treatments were not shown for seed yields because of the mild season conditions in spring with sufficient rain in the months of September and October.

Table 3. Measurements of three annual pasture legumes including plant density, dry matter (DM) production and seed yield when sown at two different times: at the break of the season (conventional) or in summer (summer sowing) at Mingenew in 2011.

Variable	Cultivar	Conventional sowing	Summer sowing	LSD (P=0.05)
Sampled 31/05/2011 - Plants/m^2	Margurita	330	510	69
	87GEH72.1a	340	410	74
	Dalkeith	210	n/a	n/a
Sampled 14/07/2011 - DM t/ha	Margurita	-	1.2 (0.06)*	-
	87GEH72.1a	-	1.1 (0.14)*	-
	Dalkeith	-	n/a	-
Sampled 5/09/2011 - DM t/ha	Margurita	3.7	6.1	2.0
	87GEH72.1a	3.1	5.9	1.3
	Dalkeith	3.0	n/a	n/a
Sampled 4/12/2011 Seed Yield kg/ha	Margurita	694[#]	600[#]	479
	87GEH72.1a	3287[#]	3148[#]	1871
	Dalkeith	767	n/a	n/a

[#] Seed yield expressed as pods (seed percentage in French serradella = 65%, and in Yellow serradella = 37%), * Standard error

Conclusion

Traditionally, forage legumes are sown after the main cropping program is completed and require the application of a pre-sowing knockdown herbicide to control established weeds. This treatment seriously reduces early winter pasture production which is then compounded by the slow growth rate of legumes under the cold winter conditions. Establishing paddocks using the summer sowing technique allow the pasture legumes to start growing immediately after the break, thus the plants may take advantage of the favourable growing conditions offered in autumn.

Our results have shown the delay in sowing of pasture legumes by 2-4 weeks can equate to an overall production loss of 2-3 tonnes of dry matter through winter, which can be avoided with the use of the summer sowing technique. Summer sowing also increases the flexibility of the system, since it does not interfere with crop operations after the break of the season and generally is carried out in the time of the year when farmers are not heavily involved in other farm operations. This technique has the ability to lift the legume component in a pasture which has been degraded by a range of factors such as drought and/or intensive cropping.

Summer sowing can be used to produce a green fallow, where the legume pasture can be brown manured to provide high nitrogen residues and organic matter to benefit the subsequent crops.

Table 4. Measurements of three annual pasture legumes including plant density, dry matter (DM) production and seed yield when sown at two different times: at the break of the season (conventional) or in summer (summer sowing) at Coorow in 2011.

Variable	Cultivar	Conventional sowing	Summer sowing	LSD (P=0.05)
Sampled 31/05/2011 - Plants/m^2	Margurita	220	1013	297
	87GEH72.1a	302	776	301
	Dalkeith	213	n/a	n/a
Sampled 14/07/2011 - DM t/ha	Margurita	-	1.5 (0.08)*	-
	87GEH72.1a	-	1.1 (0.10)*	-
	Dalkeith	-	n/a	n/a
Sampled 5/09/2011 - DM t/ha	Margurita	1.2	4.1	1.9
	87GEH72.1a	2.3	4.7	1.2
	Dalkeith	1.3	n/a	n/a
Sampled 4/12/2011 Seed Yield kg/ha	Margurita	489#	348#	457
	87GEH72.1a	1128#	1188#	855
	Dalkeith	173	n/a	n/a

Seed yield expressed as pods (seed percentage in French serradella = 65%, and in Yellow serradella = 37%), * Standard error.

Summer sowing also reduces establishment cost firstly, by minimising seed processing particularly in the case of serradella where seed extraction is difficult and expensive and secondly, sowing does not require a pre-sowing application of herbicide. Hard seed breakdown studies (Loi and Nutt unpublished) have suggested that it is of paramount importance to sow the pasture legumes by the start of the summer to exploit maximum hard-seededness breakdown and thus ensure an adequate regeneration of the annual legume at the break of the season. It is also recommended to select paddocks that have been cropped for two or three years with expected low weed populations in the pasture phase, not to delay the sowing operation later than the end of February and to remove crop stubbles as much as possible prior sowing.

Current cultivars available and suitable to summer sowing are Margurita hard seeded French serradella, Agwest Bartolo bladder clover (data not shown), Avila yellow serradella and if commercially released a new line of yellow serradella 87GEH72.1a. New studies are currently underway to investigate the potential of other species/cultivar for summer sowing. The requirement to sow hard-seeded cultivars in summer or early autumn does lose some of the flexibility to tactically respond to seasonal conditions and this needs to be balanced against the clear productivity advantages demonstrated.

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