Low cost pasture legume establishment for sandy soils in the Victorian Mallee

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Abstract
Field experiments on two soil types, sand and loam, were established at Walpeup in north-west Victoria in 2015. The aims of the experiments were to compare the establishment, regeneration and production of annual medics, serradella, bladder clover and vetch. The field plots were established by seed pod or scarified seed and either sown with a cereal in 2015 or sown as monocultures in 2016. The experiments set out to prove or disprove the hypotheses that; (1) "Sowing forage legumes with a cereal is a reliable and low cost method of establishment" and (2) "There are better adapted, and more productive, forage legumes than vetch for the Mallee". Sowing both traditional and alternative pasture legumes with a barley crop in the year prior to the pasture phase was shown to be as productive as sowing them as monocultures at, at least twice the seeding rate in the pasture phase. However the barley grain yield was reduced by more than 0.5 t/ha as a result of the alternate pasture barley row sowing configuration. In the 2016 pasture phase, vetch sown as a monoculture was found to be similar, or more productive, than the annual medics and serradella. The 2016 annual medic production was generally similar irrespective of cultivar, being sown as pods or seed or whether it was sown with barley in 2015 or sown as a monoculture in 2016. The aerial seeded serradella and bladder clover were more productive in 2016, when sown with barley in 2015, than when spread into crop residue in February 2016.

Keywords
Undersowing, annual medics, serradella, bladder clover, vetch.

Introduction
A progressive shift from cereal dominance to more diverse rotations in the low rainfall Mallee region of south-east Australia has increased the likelihood of interest in the re-inclusion of legume pastures in the farming systems. Current returns from the livestock industries support this farming option as an alternative to growing legume field crops. To improve the viability and attractiveness of pasture systems, field experiments were undertaken to compare the establishment and production of: traditional (annual medic), current (vetch), and alternative pasture legumes (serradella and bladder clover) by sowing these species with a cereal in the year prior to the pasture phase, as opposed to sowing as monocultures in the pasture phase. Benefits which may accrue from this approach include a lower required seeding rate and less labour and machinery requirements to seed the pasture area in the pasture year.

Methods
In the 2015 field experiments, 12 treatments in 3 replicates of 6 row 10 m x 1.5 m plots, at two sites (a sand and a loam soil type) were established. Seed pod or seed were sown in alternate 3 rows of pasture and 3 rows of barley at 25 kg/ha in Year 1 (2015) or sown in all 6 rows as a monoculture in 2016 (Year 2). In 2015 barley at 50 kg/ha was sown in all 6 rows of the 2016 pasture treatment plots.

Pasture legume treatments

1. A mixture of Charano, Eliza and Margurita serradella pod segments, unscarified Bartolo bladder clover seed and Harbinger annual medic pods sown in alternate rows to 25 kg/ha of barley in April 2015.
2. Annual medic (cultivars listed in Tables 1 and 2) and Volga vetch commercial seed sown in alternate rows to 25 kg/ha of barley in April 2015.
3. The mixture of serradella pod segments (listed in treatment 1), unscarified Bartolo bladder clover seed and Jaguar annual medic pods spread on barley stubble in February 2016.
4. Annual medic (cultivars listed in Tables 1 and 2) and Volga vetch commercial seed sown as monocultures in barley stubble in April 2016.

Measurements
In 2015 pasture plant establishment and seed yields were collected from 3 x 0.2 m^2 quadrats taken within the 15 m^2 plots. Barley grain yields were estimated by harvesting the plots with a plot harvester in November 2015. In 2016 pasture plant regeneration and establishment, biomass and seed yield measurements were collected from 3 x 0.1 m^2 quadrats taken within each of the 15 m^2 plots. Plots were harvested with a grain plot harvester in December 2016 to estimate the potential to produce on farm commercial pasture seed yields.

Statistical analysis
Analysis of variance (ANOVA) using Genstat 5, was carried out on the plant establishment/regeneration, pasture biomass and seed yields data that was collected from 2016.

Results
Growing season and total annual rainfall in 2015 was 140 mm and 235 mm, in 2016 it was 300 mm and 394 mm.

Sand site
In 2015 the barley sown in the alternate 3 rows to the pastures yielded 2.4 t/ha, whereas the 6 rows of barley yielded 3.3 t/ha. Harbinger medic sown as pods (establishment method 1) resulted in fewer plants (2 plants/m^2) than all other pasture types (>10 plants/m^2, data not presented). The annual medic cultivars shown in Table 1 (establishment method 2), produced more seed than the Harbinger medic pods, Bartolo and Volga vetch. The serradella produced no seed. The vetch contaminated the header harvested barley grain sample at more than 3%, with 0.8% pod contamination by the plant pod retention medic Jaguar.

In 2016, the 2015 sown PM250 and Jaguar medics established more plants than the 2016 monoculture treatment of the same species (Table 1). The 2015-sown Volga and 2016-sown serradella and Bartolo treatments established fewer plants than all other entries. The 2016-sown vetch had higher October biomass and seed yields than the medics, the 2015 sown serradella and the bladder clover, which were higher than the 2016 sown bladder clover and serradella. Vetch yielded more than a tonne of header harvested seed, serradella yielded 120 kg/ha of seed and the bladder clover and annual medics yielded less than 20 kg/ha.

Table 1. 2015 and 2016 seeding rates (kg/ha), 2015 seed yield (kg/ha), 2016 plant regeneration and establishment (plants/m^2), biomass (tDM/ha) and seed yields (t/ha) of forage legumes sown as pods or seed with barley in 2015 or as monocultures in 2016 on the sandy soil site.

Establish. method (sandy soil type)	Pasture cultivar	2015/16 Seeding rate (kg/ha)	2015 Seed yield (kg/ha)	2016 Regen Establish (plts/m^2)	2016 Biomass (tDM/ha)	2016 Seed yield (t/ha)
1 (2015)	Harbinger medic pods	10	23	55	2.9	1.19
1 (2015)	Serradella pods	9	0	42	3.5	1.45
2 (2015)	PM250*Medic	2	72	160	3.4	1.28
2 (2015)	Jaguar Medic	2	50	145	2.7	1.15
1 (2015)	Bartolo Bladder clover	4	38	24	1.7	1.88
2 (2015)	Volga Vetch	10	17	6	2.3	1.86
3 (2016)	Jaguar medic pods	45		53	2.3	1.02
3 (2016)	Serradella pods	18		1	0.6	0.48
4 (2016)	PM250*Medic	5		111	3	1.43
4 (2016)	Jaguar Medic	5		77	3.1	1.20
3 (2016)	Bartolo Bladder clover	8		2	0.3	0.12
4 (2016)	Volga Vetch	20		37	4.7	3.75
	LSD (P=0.05)			*38.1*	*0.67*	*0.55*

* PM 250 is a powdery mildew tolerant (Harbinger type strand medic).

Loam site
In 2015, the barley sown in the 3 alternate rows to pastures yielded 2.7 t/ha and 6 rows of barley yielded 3.5 t/ha. Plant establishment varied from 5 plants/m^2 for the Harbinger medic sown as pods (establishment method 1) to 19 plants/m^2 for Sultan (establishment method 2) (data not presented). The 2015 sown annual

medic cultivars Sultan and Parabinga and Volga vetch produced more seed than the Harbinger medic pods and Bartolo bladder clover. Serradella produced no seed (Table 2).

In 2016, plant establishment was lower for the 2015 sown serradella and vetch and the 2016 sown bladder clover and serradella than for all other treatments. The 2016 sown vetch and the 2015 and 2016 sown Sultan and Parabinga produced similar biomass in October. The 2016 sown vetch produced more seed than all other treatments. Vetch yielded more than 1.5 t/ha of header harvested seed, serradella yielded 70 kg/ha, bladder clover yielded 90 kg/ha, and the annual medics all yielded less than 10 kg/ha of harvested seed.

Table 2. 2015 and 2016 seeding rates (kg/ha), 2015 seed yield (kg/ha), 2016 plant regeneration and establishment (plants/m^2), biomass (tDM/ha) and seed yields (t/ha) of forage legumes sown as pods or seed with barley in 2015 or as monocultures in 2016 on the loam soil type.

Establish. method (loam soil type)	Pasture cultivar	2015/16 Seeding rate (kg/ha)	2015 Seed yield (kg/ha)	2016 Establish (plts/m^2)	2016 Biomass (tDM/ha)	2016 Seed yield (t/ha)
1 (2015)	Harbinger medic pods	10	28	59	4.2	1.35[1]
1 (2015)	Serradella pods	9	0	12	4	2.08
2 (2015)	Sultan*Medic	2	46	34	4.8	1.65
2 (2015)	Parabinga Medic	2	46	55	5.1	1.7
1 (2015)	Bartolo Bladder clover	4	18	23	3.5	2.0
2 (2015)	Volga Vetch	10	44	3	2	1.84
3 (2016)	Jaguar medic pods	45		47	4.2	1.46
3 (2016)	Serradella pods	18		1	0.5	0.39
4 (2016)	Sultan*Medic	5		66	4.8	1.61
4 (2016)	Parabinga Medic	5		56	5	1.59
3 (2016)	Bartolo Bladder clover	8		1	0.6	0.14
4 (2016)	Volga Vetch	20		47	5.5	3.74
	LSD (P=0.05)			*20.2*	*0.82*	*0.51*

* Sultan is a sulfonurea tolerant barrel medic.

Conclusion

Historically, undersowing annual medics in the cereal crop preceding the pasture phase has been the recommended establishment method (Amor and Mann 1965). These authors argued that there was little initial return when medics were sown into cereal stubble. However, undersowing was largely abandoned in the 1970s, partly due to the widespread use of selective broad-leaf and residual in-crop herbicides (Wells 1972). Poole and Gartrell (1970) also found that undersowing annual legume pastures to wheat in the low to medium rainfall areas (300-400 mm annual rainfall) of Western Australia was frequently unsuccessful due to their inability to compete for water, light and nutrients. They also reported grain yield losses as a response to annual medic competition. Ultimately, Carter (1974) recommended sowing annual medics directly into the cereal stubble at higher seeding rates to maximise production, weed competition and seed yield in the year of establishment.

The results from this study suggest that sowing pastures with a cereal provides a reliable and low cost method for establishing forage legumes as a monoculture due to lower seeding rates and fewer farm operations. For example, Harbinger medic pods and seed of current medic cultivars sown with barley in 2015 at 10 and 2 kg/ha respectively, produced adequate seed in 2015 to regenerate at higher or comparable levels and were as productive as similar treatments sown in 2016 at 4.5 and 2.5 times the seeding rate.

The potential for legume damage from selective broad-leaf and residual in-crop herbicides is reduced with extended cropping phases and less chemical broad-leaf weed control required in the final year of the phase. The concern about competition restricting both pasture establishment and crop yield is at least partly unfounded. Latta and Blacklow (2001) found that the separation of seed rows minimises competition of both crop and pasture. These authors reported successful lucerne establishment with alternate row sowing with barley and comparable grain yields of the barley when sown in all or just the alternate rows.

In terms of alternative pasture species, the serradella mixture of cultivars sown with barley in 2015 was as productive in 2016 as the other 2015 sown treatments on the sand site. However this species was less productive on the loam site possibly due to low plant numbers. The total lack of seed production in 2015

meant that 2016 serradella establishment was from 2015 sown seed, which was 70% hard at time of sowing. The reason for the failure of the February 2016 surface spread serradella and Bartolo (with at least 30% soft seed), to establish at populations at least comparable with the 2015 establishment of the same lines and seed supply, is unknown. Insect collection is a possibility as the seed was left uncovered until shallow tillage was carried out in late April. Soft seed imbibition following 4.5 mm of rain on the 18 March is also possible.

A further advantage for expanding the use of forage legumes is the opportunity to harvest an on-farm seed supply. The vetch yielded more than 1 t/ha of grain in 2016 but is not suitable for sowing in a grain crop as it contaminated the barley crop above acceptable grain receival levels. The vetch also did not regenerate successfully and therefore its use is restricted to being sown as a monoculture or sown in a forage cereal. Potential alternatives to vetch for on-farm seed supply include Jaguar annual medic pods. This cultivar was initially promoted because of its inherent plant pod retention capability and the opportunity to harvest pods with a normal header. However it did not yield an adequate amount of commercially harvested seed pods at the experimental site in 2016, making the use of the medic seedpod sowing strategy problematic, although previous research has reported useful Jaguar pod harvest yields (Latta 2011).

The aerial seeded serradella mixture and bladder clover may also provide potential seed supply on farm. In this study the harvested seedpod yield was limited to approximately 100 kg/ha. The field sites received above average growing season rainfall in 2016 (300 mm), so these yields may be higher than expected in seasons when the rainfall is lower casting doubt on the capacity of these species to consistently produce economic on farm seed yields in this environment. However, based on the serradella and bladder clover yields collected from the soil surface (1.5 to 2 t/ha), there would seem to have been loss issues with the harvesting process as the seedpods and seed heads were retained on the plant at the time of harvest. This may also have been part of the reason for the low Jaguar medic pod yields with more than 1 t/ha collected from soil surface.

The vetch sown as a monoculture in 2016 was equally, or even more, productive than all other entries. However in terms of pastures suitable for sowing with the cereal, the serradella was shown to be well-adapted to the deeper sandy soils. Serradella production was comparable to the medics from only 30% the plant population. In the Mallee, these soils are often sown to lupins, and therefore serradella may provide an alternative, lower cost option for mixed farmers if the seed can be harvested economically on farm. The Bartolo was comparable in performance to the serradella on the loam site and less productive on the sand site, which supports the promoted adaptation traits of the two pasture species.

The medic cultivars Sultan and Parabinga on the loam and the strand medics Jaguar and PM250 on the deeper sand performed similarly The individual advantages of the medic cultivars are based on their specific attributes, sulfonurea tolerance of Sultan and powdery mildew tolerance of PM250 (which was clearly evident in the high rainfall September 2016), and the pod retention of Jaguar, although not evident in 2016.

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