7.3 IMPROVING YIELD AND PROTEIN CONTENT OF CROPS BY DEVELOPING PHASE AND LEY FARMING SYSTEMS USING ALTERNATIVE PASTURE LEGUMES

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Experiment sites:
Gnarwarre, Hamilton and Streatham

Background:
This GRDC- and DNRE-funded project has been undertaken to identify those alternative pasture legume species that, when sown in rotation with crops, have the capacity to improve crop plant productivity in the high rainfall zone of southern Australia.

Those trials, based on previous years' experimental research, were conducted to further collect information on (1) pasture performance in terms of herbage dry matter (DM) production, pasture seed yield, and self seedling regeneration; and (2) crop grain yield and quality characteristics. Pasture legumes are being assessed in either a 1:1 or a 2:1 pasture : crop rotation patterns.

Following the pasture phase, a crop is direct drilled onto the ground when regenerated pasture seedlings are sprayed out. Canola was introduced into the system research in 2000 and grown at both Gnarwarre and Streatham sites. The likely association between pasture performance and subsequent crop yield productivity response was therefore quantified.

Experimental treatments and related cultural practices:
At Gnarwarre, the Triazine-tolerant cultivar Pinnacle was direct drilled into the soil on 8th June at a depth of 2-3 cm using a cone seeder, with a sowing rate of 5 kg/ha. The fertiliser Super + trace @350 kg/ha was applied at sowing time. Telstar @100 ml/ha was used once to control RLEM; and Select @100 ml/ha was sprayed to control some grasses. The crop was hand-harvested on 14th December, with a sample of a 2 m^2 quadrat cut per plot being collected to determine grain yield. At Streatham, an early maturing cultivar Surpass 400 was sown on 16th August at a rate of 8 kg/ha, with seed direct drilled into the soil. The use of fertilisers etc were as per Gnarwarre; and a sample was harvested on 4th January 2001.

In addition, the herbage DM production of five different pasture legumes over growing seasons was assessed at both Gnarwarre and Streatham sites. At the Hamilton site, the performance of 4 subterranean clover entries was closely monitored.

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Results:

Pasture legume performance: HAMILTON

Following a 7 t/ha wheat crop (cv. Silverstar) in 1999 without the application of N fertiliser, the four subterranean clover entries (eg. Leura, Enfield, Trikkala and a mixture) showed excellent pasture regeneration in Autumn 2000, ranging from 2379 (in Trikkala) to 4282 plants/m^2 (in Leura). A total herbage DM of nearly 10 t/ha had accumulated on Leura or Trikkala paddocks with regenerated plants, resulting in a growth rate of ca. 45 kg/ha·day over the growing season.

Pasture legume performance: GNARWARRE AND STREATHAM

Balansa clover showed the best self regeneration among all pasture species at both sites, but due to the different sampling dates and environmental conditions, great variation also existed between the two sites (Table 1). Good herbage DM production from those five pasture legumes were recorded, with Arrowleaf clover producing the highest due largely to its longer seasonal growth and erect growth habit with thick stems.

Table 1:. Pasture legume regeneration and herbage DM production at Gnarwarre and Streatham in 2000

Pasture species	Regeneration rate (plants/m^2)[A]		Herbage DM (kg/ha)[B]	
	Gnarwarre	Streatham	Gnarwarre	Streatham
Balansa cv. Bolta	2013	7102	9298	9946
Persian cv. Nitro	498	6269	5928	6963
Subclover cv. Leura	770	6390	6660	8960
Red clover cv. Astred	383	28	4047	6019
Arrowleaf cv. Tas 663	675	517	11089	14362

[A] Seedling counts were made from soil cores or quadrat samples, depending on their densities, on 7th June and 18th May at Gnarwarre and Streatham, respectively. Values are the pooled data over plots.
[B] Cumulative DM with Arrowleaf extending to late January 2001. Red clover was re-sown to make up its poor self regeneration.

Canola grain yield:

The average canola density was 76 plants/m^2 at Streatham as against 60 plants/m^2 at Gnarwarre, with Bolta-based plots showing the highest density (100 and 85 plants/m^2 respectively). Plants grew more vigorously at Streatham than at Gnarwarre, and a higher average yield (1160 vs 704 kg/ha) was thus harvested at Streatham although the canola was delayed in its sowing by 2 months. Statistics indicated highly significant differences in the canola grain yield at both sites (in 2000), which are derived from the different treatments in 1999 (Table 2).

Table 2. Relationship between pasture herbage DM production (kg/ha) in 1999 and canola grain yield (kg/ha) in 2000 based on pooled experimental data of 6 different treatments (Astred not included due to the trial design) at Gnarwarre and Streatham

Treatments	Gnarwarre		Streatham	
	Herbage DM 1999	Canola grain yield 2000	Herbage DM 1999	Canola grain yield 2000
Bolta	5340	1235	6910	1377
Contin. crop	0	232	0	960
F/N (50 N)*	2000	370	2000	1171
Leura	4770	867	4060	1156
Nitro	6320	1016	6240	1337
Tas 663	3790	502	1327	972

* Assuming the 50 kg/ha N applied to the plots of the treatment "fallow/nitrogen" (F/N) equals to 2000 kg/ha herbage DM since 1 tonne of pasture legume DM is estimated to fix biologically 25 kg N.

Plants from those pasture-based treatments showing higher herbage DM production (in 1999) were found to produce higher grain yields, with the Bolta-based treatment producing the highest yield (1235 kg/ha and 1377 kg/ha at Gnarwarre and Streatham respectively). The yield from Nitro-based treatment ranks second. Whilst the continuous crop treatment resulted in the poorest grain yield, particularly at Gnarwarre site (232 kg/ha). Therefore, a close linear correlation between canola grain yield (y in kg/ha) in 2000 and the herbage DM production (x in kg/ha) in 1999 was detected among the 6 treatments as at Gnarwarre: $y = 0.1524x + 139.25$ ($r^2 = 0.8115$); and at Streatham: $y = 0.0599x + 957.01$ ($r^2 = 0.9021$).

Conclusions:

The pasture-crop rotation system has so far been successfully established in these sites, with the pasture plant productivity improved year by year. This is characterised by the building up of large pasture seed banks (data not shown) and good self regeneration following a crop phase.

Balansa, Persian and subterranean clovers are the preferred pasture legumes for this desirable farming system in the high rainfall zone, being able to produce large herbage DM at the early growing stages. On the other hand, Arrowleaf clover has great potential to extend the pasture growing season and to provide more quality pasture onto mid-summer.

Canola crop greatly benefits from these pasture legumes with higher DM production for at least its higher grain yield. This was achieved under the condition of no N fertiliser application throughout the system research. Similar positive responses in terms of grain yield and protein content has been reported previously with the wheat crop from this research. This encourages us to gather more useful information about the differential crop responses to the greatly improved pasture legume production under this farming system.

Other factors to be considered:

These results have so far demonstrated the successes and the effectiveness of the pasture legumes under the current 1:1 pasture : crop rotation system in improving plant performance of a subsequent crop. However, the establishment of a sustainable farming system in southern Australia entails more thorough research and will definitely benefit from trials with larger plots for such a system research, so that animal production in the pasture years can also be determined, and seed contamination across small plots minimised.