GRDC Regional Cropping Solutions Network

Final Report: Rotation renewal, profitable legume phase options. Proj. no. 06.07.2014 (SCF00003)

Introduction

Intensive cropping across WA grain areas has led to a decline in cropping diversity with associated problems of declining soil fertility, increasing crop diseases and associated dependence on cropping fungicides and reliance on herbicides as the main weed control strategy. Profitable legume breaks, both crops and pastures, are needed to increase rotation diversity and develop more sustainable farming systems. Newer hard seeded and aerial seeded pasture species offer cheap seed by on farm harvesting allowing dense sowing rates along with the potential for pastures to regenerate with dense swards after a one to three year sequence of crops.

GRDC's Albany Regional Cropping Solutions Network identified legumes in crop rotations as a priority subject for the region. Four grower groups expressed interested in cooperating in the project supervised by Jeremy Lemon from DAFWA. Stirlings to Coast Farmers (SCF) is the lead group with Southern DIRT and West Arthur Trials Group (WATG) participating with project staff and project trial sites. Lakes Information and Farming Technology (LIFT) is participating with additional measurements being taken from their MLA funded research site and the Nyabing Farm Improvement Group (NFIG) have joined after the project started as they have good management of their MLA site and are interested in valuing legume pastures in crop rotations.

Objectives

The purpose of this project is to demonstrate establishment, management and viability of legume phase options in cropping rotations with appropriate agronomic management packages. This was to be achieved by establishing trial sites with four grower groups to demonstrate a range of new pasture species relevant to each group and measure the benefit to subsequent crops. Measurements from the experiments will be used to estimate the economic benefits of the legume break to the rotation including grazing value, reduced inputs including nitrogen fertiliser and changes to crop yields.

Planned outputs:

1. Field production information and economic analysis of the data to include the value of the grazing and expected crop yield boost of the pasture phases will be produced.
2. The project team will report information gathered from the project's trial sites with field day and crop updates presentations (where held, SCF and DiRT) during 2014/15 and 2015/16.
3. Use rural radio media (grower group staff have a working relationship with ABC through Owen Grieve) and the rural print media, plus GGA website to create awareness of the investigations and the outputs from the project.

A published report of all results and economic analyses (developed with specialist contracted economist) will be produced.

Trial locations

Stirlings to Coast Farmers – Gnowellen (Wellstead) -34.4485 118.5068

Southern DiRT – Kenmare (W Woodanilling) -33.5614 117.1877

West Arthur Trials Group – Darkan -33.3645 116.7286

Lakes Information and Farming Technology – Lake Grace -33.2593 118.4861

Nyabing Farm Improvement Group – Nyabing -33.4243 118.3206

Methodology

The field work component of this project comprised of five sites. SCF, Southern DiRT and WATG conducted pasture legume trials during 2014 followed by crop in the 2015 season funded by this project. LIFT and NFIG conducted similar trials with pasture legumes followed by 2015 crop largely funded by MLA projects. Additional measurements to those planned in the MLA activity assessed N benefits as part of this GRDC project.

All sites were implemented using grower equipment - four sites were managed by each group's R&D coordinator. The LIFT site was managed by a small group of growers with consultant support.

Five new hard seeded pasture species/cultivars were selected that were most appropriate for each site. Three or four control treatments of volunteer pasture and one non legume treatment were included in the design to describe fertiliser N rate responses in the cereal phase in year 2. This will describe the relative benefit of a legume break year and an indication of the crop response in terms of equivalent N fertiliser.

SCF and Southern DiRT sites were fenced for grazing control consistent with best practice grazing management in the establishment year and to obtain dry matter assessments.

Two replicates of 10 treatments made 20 plots at each RCSN funded site. Seeder width plots up to 15m wide and 200m long were established to allow header and weigh trailer grain yield measurement in the year 2 crop phase. The MLA sites were header width and longer.

Measurements year 1:
Initial soil characterisation by profile to 1 m depth with N P K S, OC, and pH analysed by layer.
Pasture establishment was counted
Two or three pasture cuts measured seasonal growth rates. Pasture composition was estimated visually at each cut.
The September cut near peak biomass measured maximum N accumulation in tops.
Pasture seed production was estimated by quadrat harvesting at two sites.

Measurements year 2:
Pasture germination densities prior to knockdown spraying
Feb/March soil samples measured N mineralisation at a time most growers sample
May N profiles –estimated total summer/autumn mineralisation of N from legume residues
Early crop emergence and weed counts were taken
DM and N uptake at about Z30 assessed relative plant nitrogen uptake

Grain yield is to be measured together with protein will estimate of N content in the grain and total N export.

Results by site

Stirlings to Coast Farmers – Gnowellen (Wellstead)

Project officer: John Blake; host farmers Jeff and Kate Stoney

Site 11 km WNW from Wellstead. Site is 280m by 400m long

Paddock history; 2013 barley, 2012 canola, 2011 low clover pasture, 2010 barley. Longer term poor pasture alternating with crop.

Soil: gravelly water repellent sand over gravel (30 to 40 cm to clay) duplex, flat site in a flat landscape

Soil test samples down full profile taken 14 March and 26 March.

Potassium levels all > 50 ppm. Main concern is P levels at <16 ppm and pHCaCl at 4.9 to 4.6. Serradella was deemed to be best suited to this site.

2014 details

Pasture sowing date: 25 April 2014. Sowing unit used was a DBS 12m bar.

Fertiliser rate: 80 kg/ha TEK Phos. 4:1. (N:P:K:S; 0:7.2:9.9:8.1 & trace elements)

Seed: all pasture seeds were certified seed with germinations >70% and purity >98%. Saia oats were sourced from a neighbouring farmer for the grazing oats treatment.

Legume Inoculation: as the sowing on 25 April was dry (7 mm for the 4 months prior), Alosca granules were used at 10 kg/ha sown with the legume seed. Only 9mm rain was received in the post Anzac rain leading to a partial germination as sub soil had many dry areas. Dry furrow walls led to large furrow row infill.

Table SCF 1: Treatments in the SCF Gnowellen site. All legume plots had appropriate rhizobium strain (S and C) drilled as 10 kg/ha Alosca.

Treatment	Two reps of each treatment randomised	Seed rate
1	Volunteer pasture year 1; nil N yr 2	
2	Volunteer pasture year 1; 0.5 N yr 2	
3	Volunteer pasture year 1; 1.0 N yr 2	
4	Volunteer pasture year 1; 2.0 N yr 2	
5	Bladder clover	9 kg/ha
6	Saia oats for grazing	60 kg/ha
7	Margurita serradella (dehulled seed)	9 kg/ha
8	Santorini yellow serradella, gland clover mix	6&6 kg/ha
9	Santorini yellow serradella	7 kg/ha
10	Casbah biserrula	5 kg/ha

Herbicides: 25 g/ha Broadstrike plus 55 g/ha of Diuron granules and wetter applied post emergent (12 June) after first emergence of pasture species was beyond 3 leaf stage. Select for grass control (including self sown barley) applied 10 July.

SCF Results

As planned and because of the severe non wetting zones at south and north ends of plots, the central part of the 400m plots had the most uniform establishment and is the area of all observations and sampling.

Table SCF 2: SCF Gnowellen emergence counts, first dry matter cuts and whole pod/burr weights.

	30 May establishment		1 August Dry Matter			
	sown species	vol sub clover	sown species	weeds	total DM	whole pod/burr
	pl/m2	pl/m2	kg/ha	kg/ha	kg/ha	kg/ha
Volunteer pasture year 1; nil N yr 2	0	10	95	775	870	28
Volunteer pasture year 1; 0.5 N yr 2	0	23	50	770	820	20
Volunteer pasture yr 1; 1.0 N yr 2	0	14	100	790	890	25
Volunteer pasture year 1; 2.0 N yr 2	0	19	60	840	900	15
Bladder clover	85	6	405	670	1075	98
Saia Oats	134	10	1365	455	1820	0
Margurita serradella	97	12	515	525	1040	648
Santorini serradella, gland clover	285	4	415	595	1010	93
Santorini serradella	116	12	480	460	940	113
Casbah biserrula	223	7	260	1005	1265	23
F prob.	<.001	0.106	<.001	0.024	<.001	
lsd 5%	36.4	12.1	114.4	284.6	274	

Capeweed suppression was achieved with Broadstrike and Diuron. Broadleaf herbicide could not be applied to the Biserrulla plots and broadleaf weed control was an issue in these plots although grazing 13-17 June did help.

Figure SCF 1 & 2: L, Santorini and Gland clover mix; R, Magurita serradella after first broadleaf spray and grazing 14-17 June. Electric was fence installed to manage grazing on the site within the paddock.

Grazing details

13-16 June - Crash grazing over full trial site. (364 Weaners for 3 days on 12 Hectares) Excluded after observations that sheep were selectively grazing the young pasture plants (not the more advanced cape weed) - especially the gland clover.

Biomass cuts taken 4 August 2014 before starting cell grazing. Cuts showed the head start capeweed got in the non wetting soils with a partial start and staggered emergence.

5-21 August - cell grazing - 4 cells of approx. 3 ha each. (North-South divisions across all plots). 363 hoggets for 4 days in each cell. Heavy grazing reduced cape-weed dramatically but also reduced sown species (especially clovers).

1-28 September - Spring grazing of controls and Saia plots only. A total of 10 plots (5.6ha) grazed as four blocks for a week each, a total of 28 days with 363 hoggets making 1815 grazing days per hectare

14 October-8 December - Sheep were grazed over the whole paddock including the control and Saia plots at 9.01 sheep/ha making a further 486 grazing days per hectare on the unsown control plots.

Note: The sown pasture plots had very little growth after grazing 5-21 August due to application of sprays and prior grazing to suppress the cape-weed together with dry conditions.

Spraying in September after rain with 2,4 DB and Diuron aimed to further suppress cape-weed. Pasture plots except Margurita plots 2 and 20 made virtually no further growth and senesced prematurely (Santorini, Gland Clover and Bladder clover). Spray-topping the whole trial on October 15 with Paraquat affected the Santorini more than other species. The trial area along with the paddock (except Margurita plots) had a second Paraquat spray on 11 December to control milk thistle and re-shooting ryegrass

The Margurita plots recovered from the herbicide treatments and continued growing and setting seed until early January. They were not grazed after August to maximise flowering and pod set.

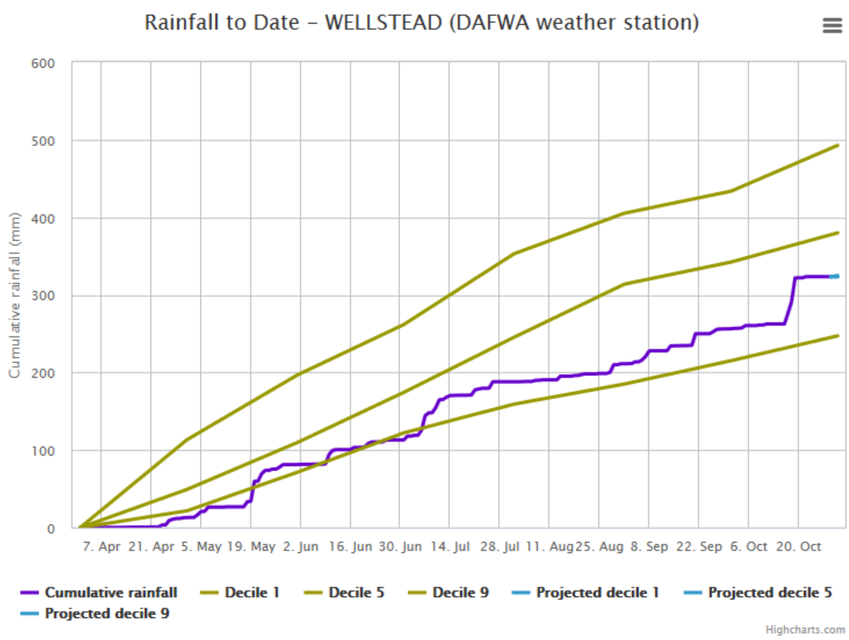


Figure SCF 2: Wellstead DAFWA weather station cumulative rainfall showing poor start until late May and dry mid July to end of August period.

Figure SCF 4 & 5: L - Margurita plot in mid December and R – Margurita pod covering 70% of soil surface.

2015 details

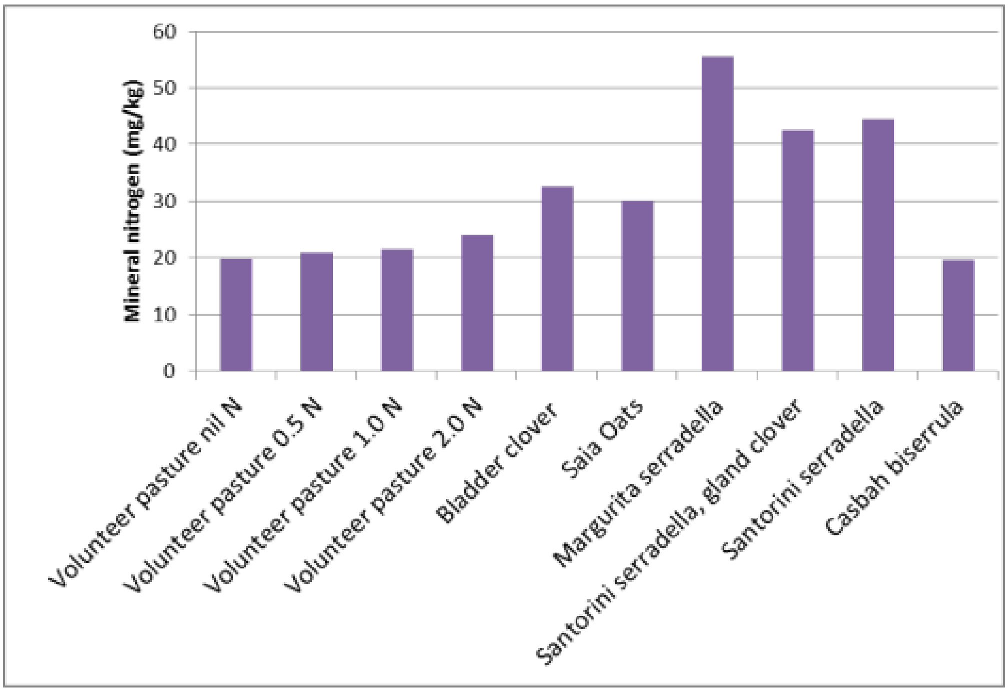
The trial area was grazed in common with a few paddocks over the summer period. 200 head of cattle were grazed over an area of 200 ha for 31 days which equates to about 300 sheep grazing days per hectare. The trial area is now being cropped along with the rest of the paddock. Calingiri wheat has been sown on 28 May with 100 kg/ha of Agflow Cu Zn (14 kgN/ha). Post sowing N rates will be applied as Flexi-N to volunteer pasture strips only. The pasture plots will grow without post sowing N to evaluate the N contribution from the pastures.

Soil nitrogen

Soil nitrogen 0-10 cm was assessed on 7 March and 19 May across all treatments. On 19 May soil profile samples were collected at the same time to assess the likely mineral N available to the early crop. The March results were only significant at the 10% level. This showed mineralised nitrogen levels reflecting pasture production from the 2014 season with the volunteer pastures having the lower N and the Margurita serradella which grew to mid January having highest levels. An odd result is that Saia oats had equivalent N to bladder clover, higher than volunteer pastures. The Casbah biserrula was as low as the volunteer pastures. While these can be calculated as equivalent kg/ha of mineral N, the later profile sampling shows mineralisation of legume residues continued (as expected) in the period between 7 March and 19 May. The value of this nitrogen to crops will depend on seasonal and soil conditions as losses can occur from leaching, denitrification and poor root growth.

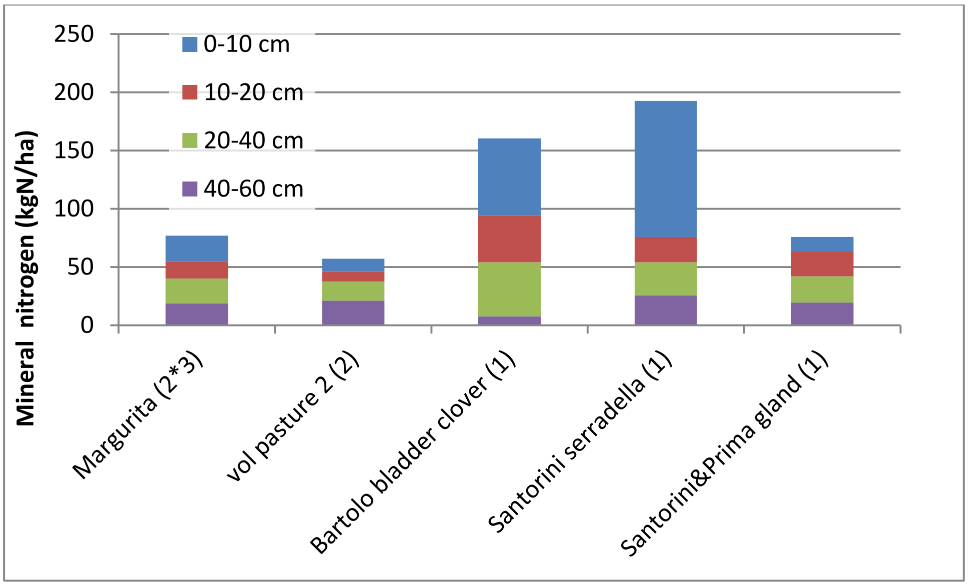
SCF Table 1: 0-10 cm nitrate plus ammonium levels sampled on 7 March 2015.

treatment	mineral N (mg/kg)	mineral N kgN/ha	N difference from volunteer.
Volunteer pasture nil N 2015	20	30	
Volunteer pasture 0.5 N 2015	21	32	
Volunteer pasture 1.0 N 2015	22	32	
Volunteer pasture 2.0 N 2015	24	36	
Bladder clover	33	49	16
Saia Oats	30	45	13
Margurita serradella	56	83	51
Santorini serradella & gland clover	43	64	31
Santorini serradella	45	67	34
Casbah biserrula	20	29	-3
F prob.	0.08		
lsd 5%	24.5		



SCF Figure 1: 0-10 cm nitrate plus ammonium levels sampled on 7 March 2015.

Soil profiles were sampled on 19 May 2015 to 60 cm depth. Only the graph is presented as the data is too variable to make any conclusions. Poor communication led to only two treatments being sampled well enough for comparison. Cattle grazing and camping led to urine patches which are the likely cause of the extremely high mineral N levels in the Bartolo and Santorini plots. The Margurita treatment, which was expected to have the highest mineral N, had about 11 kgN/ha more in the surface 10 cm and 20 kg mineral N/ha more to 60 cm depth than the volunteer pasture treatment sampled. The decline in 0-10 cm mineral N could be due to leaching of N with heavy opening rain or due to sampling error.



SCF figure 2: Cumulative mineral N to depth on 19 May 2015. Numbers in brackets are number of reps sampled (*3 is number of cores, others are only one core per plot).

Southern DiRT site - Kenmare, 22 km west from Woodanilling

Project officer Kayla Ringrose, host farmers Evan Hall and Bindi Murray.

Paddock history: 2013 barley, 2012 wheat 2011 oats cut for hay. Soil: gritty loam (35 cm) duplex, flat site in lower landscape.

2014 details

Sowing date 14 April 2014; dry sown, 100mL/ha chlorpyrifos and Talstar insecticides applied to site. No selective herbicides were applied during the early growing season as the grower found it too hard to manage selective herbicides across the species range, volunteer pasture, oats and vetch plots were spray topped in spring, species expected to set seed were not topped.

Table DiRT 1: plot treatments 2014

Treatment 2014	Sowing rate
Volunteer pasture; nil N in 2015 crop	na
Volunteer pasture; 0.5 N rate 2015	na
Volunteer pasture; 1.0 N rate 2015	na
Kojonup oats	45
Santorini yellow serradella	6
Cadiz French serradella	8
Margurita French serradella	6
Bartolo bladder clover	7
Urana sub-clover	8
Rasina vetch	52

All legumes inoculated with 10 kg/ha ALOSCA using appropriate rhizobium groups C, S and F.

Table DiRT 2: Establishment, legume percent, dry matter, grazing removal and spring N concentration in legume species.

treatment	19/6 establishment/m2	1/7 % legume	11/8 % legume	25/9 % legume	3/7 DM kg/ha	14/8 DM kg/ha	28/7 % removal	10/9 % removal	25/9 DM kg/ha	DM total nitrogen (%)
Bladder	236	16	36	32	179	1031	23	65	3312	3.73
Cadiz	178	16	34	30	191	934	15	50	2767	3.46
Kojonup	146	2	4	8	359	909	55	85	1017	1.26
Margurita	225	16	33	30	178	1081	18	45	3076	3.24
Rasina	70	28	35	30	228	991	50	85	2860	4.69
Santorini	127	13	44	33	159	1119	18	55	3940	3.37
Urana	130	19	37	31	185	1091	30	75	2900	3.74
volunteer	0	3	7	23	218	933	22	30	2629	1.45*
F prob.	<.001				0.092	0.856			0.014	
lsd 5%	11	v	v	v	58	ns	v	v	564	**

v, visual estimates, no analysis. ** bulked species samples from both reps. * capeweed N content

Table DiRT 3: Grazing on the 6 ha fenced site

Date In	Date out	Number	Breed
10/07/14	13/07/14	250 - 300	Merino ewes (12 months)
27/08/14	03/09/14	250 - 300	Merino ewes (12 – 14 months)

This calculates to about 416 to 500 sheep grazing days per hectare. This is a low stock rate but commensurate with the aim of producing a large seed set for harvest or paddock seed bank for regeneration of hard seeded species and leaves residue in paddock for summer grazing.

Figure DiRT 1: Spraytopped Rasina vetch plot between unsprayed Bartolo left and Santorini right on 20 November 2014.

2015 details

The fenced trial area was grazed for three periods over the summer as detailed in Table 1. This equates to about 3041 grazing days per hectare (8.33 animal equivalents/ha). The trial area is now being cropped along with the rest of the paddock with Stingray canola and 100 kg/ha Agstar extra (14 kgN/ha). Post sowing N rates of 0, 21 and 42 kgN/ha will be applied as Flexi-N to the planned 2014 volunteer pasture plots only. The 2014 sown pasture plots will grow without post sowing N to estimate the N contribution from the pastures.

DiRT table 1: Trial area grazing after pasture senescence.

animals	date in	date out	grazing days	grazing days/ha
500 Rams	13 Dec	8 Jan	13000	2167
1050 ewes	24 Feb	27 Feb	3150	525
1050 ewes	13 Mar	15 Mar	2100	350

Seed and pod yields

Seed production was measured on plots by collecting the top few centimetres of soil and cleaning seed from the samples. Only selected treatments were sampled due the amount of work involved in the process. Budworm was not detected in serradella until the end of flowering when nearly all seed was damaged. The vetch seed was also consumed by budworm but as a one year fodder species, seed bank is not a consideration. Volunteer subclover plots had low seed reserves, too low to be considered a viable legume pasture. The Urana and Bartolo had reasonable seed set, amounts that will lead to good regeneration after the 2015 crop.

DiRT Table 2: Legume pasture seed yields from 2014 sown and volunteer pastures.

treatment	legume seed kg/ha
Santorini serradella*	546
volunteer subclover	37
Urana subclover	358
Bartolo bladder clover	210
Cadiz serradella	0
Margurita serradella	0

* serradella seed is estimated as 30 % of pod weight.

Soil nitrogen

DiRT table 3: 0-10 cm soil mineral nitrogen (nitrate plus ammonium) on 15 March and 13 May 2015

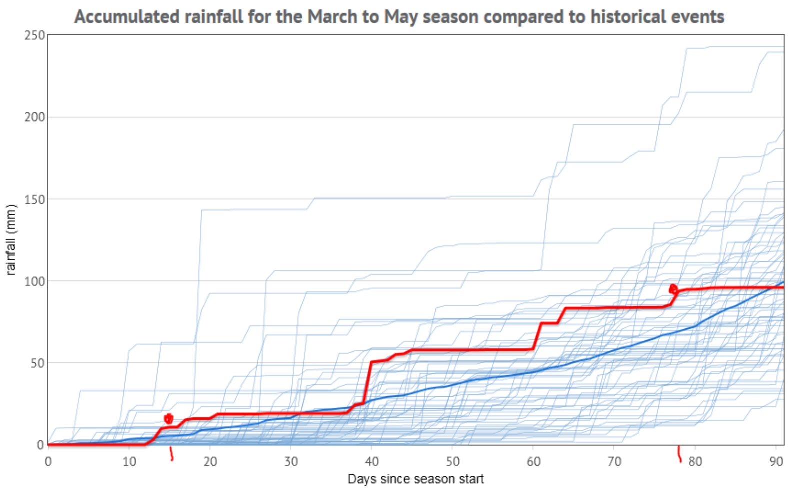
treatment	March mineral N (mg/kg)	May mineral N (mg/kg)
Volunteer pasture 1	12	39
Volunteer pasture 2	6.5	35
Volunteer pasture 3	9	28.5
Kojonup oat	17	45
Santorini serradella	10	33
Cadiz serradella	6.5	31.5
Margurita serradella	12	43
Bartolo bladder clover	8	24
Urana subclover	12	29
Raisina vetch	14	39
F prob.	0.41	0.85
lsd 5%	9.9 (ns)	30.7 (ns)

Profile mineral N was sampled on 13 May. This showed no significant relationship with 2014 pasture treatments.

Soil nitrogen in the surface 0-10 cm layer was measured on all plots on 15 March and 13 May 2015. The large site and sampling technique led to large variability reflected in table 3 which shows no significant differences among 2014 treatments. The results do illustrate the continuing mineralisation of organic nitrogen over the summer and autumn period with about 3 times the amount of mineral in in the top 10 cm of soil over the 8 weeks from mid March to mid May. See figure DiRT 3 which shows sampling dates in relation to patch point rainfall data. About 43 mm was recorded on 10 April.

DiRT table 3: Profile mineral nitrogen on selected treatments sampled 13 May 2015.

treatment	0-10 cm kgN/ha	10-20 cm kgN/ha	20-40 cm kgN/ha	40-60 cm kgN/ha	0-60 cm kgN/ha
Volunteer pasture 2	52.5	8.3	8.3	11.3	80
Rasina vetch	58.5	12.8	10.5	13.5	95
Bladder clover	36.0	6.8	6.8	6.0	56
Kojonup oats	67.5	9.0	9.0	8.3	94
Margurita serradella	64.5	9.0	12.0	10.5	96
F prob	0.531				0.389
lsd 5%	ns				ns



DiRT figure 1: Cumulative rainfall for nearby rainfall station 'Horseshoe', 1 March to 31 May 2015. Nitrogen sampling dates are marked with red points on the curve. Graph clipped from Australian CliMate.

West Arthur Trials Group site - Darkan

Project officers: Janelle Smith and Michelle Gooding, host farmer Neil, Jane and James Campbell, 5 km S from Darkan.

Paddock history: 2013 pasture, longer term pasture with no recent cropping history.

Soil: gravelly loam duplex, clay at 30 cm. Waterlogging prone moderate slope

2014 details

Sowing date: 11 June 2014; 1 L/ha glyphosate 450 and 0.35 L/ha chlorpyrifos on 6 June, 0.12 L/ha dimethoate on 2 July

Table WATG 1: WATG Darkan site plant establishment and early dry matter.

	sown species/ vol subclover	grass	weed	dry matter
	4 August	5 August	6 August	28 August
treatment	plants/m2	plants/m2	plants/m2	kg/ha
Oats 80 kg/ha	117	25	1	146
Rasina vetch 60 kg/ha	75	65	1	93
Margurita serradella 10 kg/ha	29	59	1	72
Blaza crimson clover 10 kg/ha	10	49	3	61
Prima gland clover 10 kg/ha	59	91	1	60
Dalkeith subclover 20 kg/ha	46	74	1	55
Volunteer pasture	27	218	23	58

Site abandoned - no statistics.

The site was abandoned due to poor establishment, variable distribution of water logging and poor weed control.

Figure WATG 1 & 2: 23 October images at the site showing variable legume survival and dense weeds.

2015 details

A new trial site was established as a follow up site from a small scale demonstration that raised great interest among members in 2014. The trial was set out by Ashton Gray, agronomist with ConsultAg in an existing sub clover pasture paddock at Scott Ewen’s property, 20 km north from Darkan. Spray timing was delayed with the 2015 dry and erratic start to the season. The plots are 2.5 m wide (width of hand boom) and 20m long, with the 8 treatments replicated 3 times.

Cuts will be taken later in the season, around September depending on spray timings and recovery, to measure Dry Matter availability and will also be analysed for pasture quality. Cuts will be analysed with results including Dry Matter, Crude Protein, Neutral Detergent Fibre, Digestibility of Dry Matter and Metabolisable Energy. This will test if the removal of some DM with herbicides can actually improve pasture, by increasing the quality of what is available.

In 2016 the site will be cropped over and strips of each treatment will be harvested with a small plot harvester to allow yield or grain quality differences from improved pasture/legume content to be assessed.

Lakes Information and Farming Technology site – Lake Grace

Contact: Grant Marshall, host farmer Royce Taylor 18 km S from Lake Grace.

Paddock history: 2013 barley.

Soil: rep 1, 7 cm sandy loam over clay; rep 3 is loamy sand with some lateritic gravel over clay.

2014 details

Sowing date: fertiliser 50 kg/ha CSBP doublephos, all sown species drilled with appropriate Alosca granular inoculum

Table LIFT 1: LIFT Lake Grace site treatments, sowing rates and spring assessments.

	treatment	% legume	% grass	% other	DM kg/ha	legume DM kg/ha	% N (Leco) *	kgN/ha in total DM
1	Izmir sub 15 kg/ha	92	5	3	1209	1113	2.40	29
2	Dalkeith sub 10 kg/ha	90	10	0	1619	1457	1.99	27
3	control/fallow	3	90	7	924	24	1.68	13
4	Margurita 12 kg/ha	83	17	0	816	744	3.11	22
5	Bartolo 10 kg/ha	70	30	0	490	290	2.59	11
6	Cadiz 10 kg/ha	78	23	0	1033	854	3.04	30
7	fertiliser only 50 kg/ha	8	77	15	377	29	1.95	5
8	farmer mix 8 kg/ha	67	33	0	726	476	2.77	18
9	Angel medic 8 kg/ha	60	32	8	590	375	2.10	14
10	control/fallow	0	100	0	430	0	1.59	6
11	Casbah biserrula 8 kg/ha	93	7	0	1377	1258	3.14	43
	F prob				<.001	<.001	<.001	<.001
	lsd 5%				471	479	0.162	16.4

* reps 1 and 2 analysed - funding constraint from addition of Nyabing FIG site. DM cuts from 3 reps.

Figure LIFT 1: View to north along rep 1 plots on 16 September 2014. L-R Cadiz, Bartolo and Margurita showing consistent grazing throughout the season. Plots are 270 m long, 3 banked replicates

2015 details

This site has been cropped as planned this season, sown on 27 May with Mace wheat and 60 kg/ha Mallee extra compound fertiliser supplying 9 kgN/ha. Rates of nitrogen will be applied across all plots similar to the Nyabing site. No soil sampling nor pasture emergence counts were conducted. This remains a very basic input – output trial.

Nyabing Farm Improvement Group site – Nyabing

Project officer, Fiona Hobley; host farmers Braden and Kate Johnston; 21 km NE from Nyabing.

Paddock history: 2013 barley, 2012 barley, 2011 canola

Soil: gravel soils (west end) to a partial clay soil type (east end)

2014 details

Sowing date: 13 March dry 'summer' sowing, 17 April was the main (dry) sowing of the full range of species. All treatments germinated following 22 mm rain on 27 April. Fertiliser was 82% AgStar with 18% MoP at 80 kg/ha of the blend. Herbicide: 1 kg/ha propyzamide applied with 0.3 L/ha chlorpyrifos and 0.2 L/ha Talstar.

Table NFIG 1: NFIG Nyabing site plant establishment and early dry matter. Other treatments not presented are summer sown Margurita and Bartolo comparing Alosca and Nodulator legume inoculation systems.

	20 Jun DM kg/ha	23 Sep DM t/ha	23 Sep % legume	23 Sep DM N%	tops N kg/ha
Bartolo bladder clover	162	4.18	100	2.27	95
Scimitar medic	183	0.79	36	1.42	11
Casbah biserrula	130	1.62	53	1.78	31
Prima gland clover	185	5.10	100	2.01	103
Eliza french serradella	146	3.69	86	2.53	95
Margarita serradella	208	3.57	94	2.99	108
Dalkeith sub-clover*	223	4.10	100	2.55	105
F prob		<.001	<.001	<.001	<.001
lsd 5%		1.234	21	0.318	32.2
control (nr)	na	2.79	100	2.21	62

(nr) only one plot of control treatment (volunteer pasture), not included in stats. - for comparison only. *Dalkeith treatment analysed with missing plot as only 2 replicates sown.

Figure NFIG 1: NFIG Field walk with 27 producers in a total of 54 attending. 23 September 2014.

Grazing – 670 hoggets were grazed over the 15 ha site for 3 days. This equates to 135 grazing days per hectare. All species were grazed evenly to about 2 cm height.

2015 details

The site was grazed by 520 sheep for a total of 6 weeks on the entire 100 ha paddock over the summer period. This equates to 218 grazing days per hectare or 0.6 sheep per hectare on an annual basis. The site has now been sown with Latrobe barley and 80 kg/ha Agstar (11.4 kgN/ha). The site will have cross strips of an additional 30 and 60 kgN/ha as Flexi-N about 4 weeks after sowing.

Pre cropping germination

Estimates of pasture legume regeneration were made on 21 April 2015 from one replicate. There were vast differences in establishment in keeping with expectations based on hard seededness and germination patterns in the first season after establishment. Data is not presented here from different sowing times in 2014 which then emerged at the same time following germinating rains together with some treatments with alternative inoculation methods which had no effect on 2014 pasture establishment and production.

NFIG table 1: Estimated density of regenerating pasture legumes on 21 April 2015.

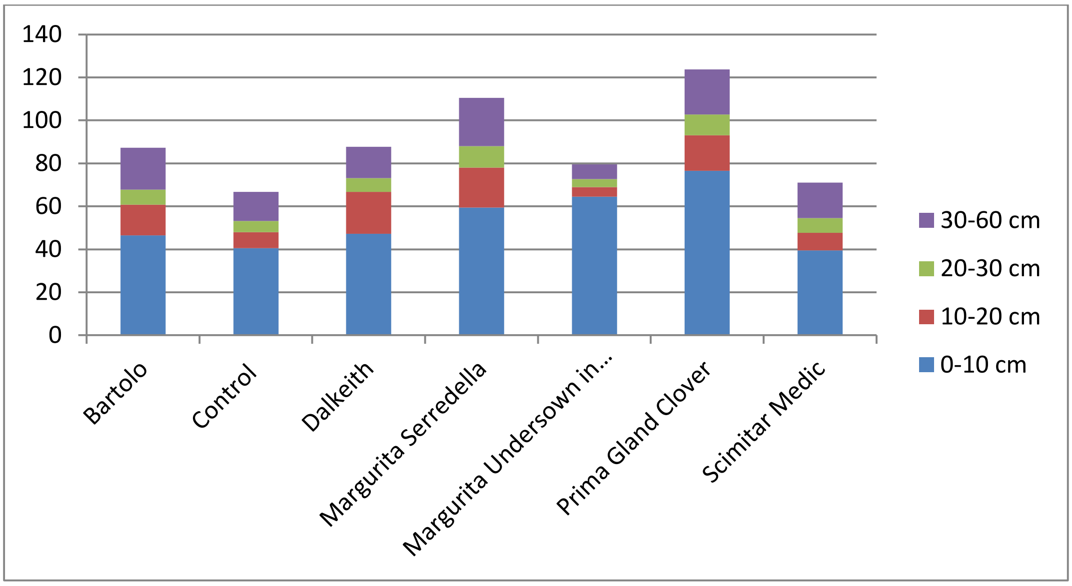
species	2014 sown	population est. plants/m2
Barley with Margurita	April	1
Bartolo bladder clover	April	2
Scimitar medic	April	50
Casbah biserrula	April	5
Prima gland clover	April	1000
Eliza French serradella	April	200
Margurita serradella	April	150
Dalkeith Clover	April	100

Soil nitrogen

NFIG table 2: Amounts of mineral nitrogen per layer to 60 cm depth on 2014 pasture legume treatments sampled on 20 April 2014. Treatments have 3 replicates except those noted with number of reps. in parentheses. Layers 10-20, 20-30 and 30-60 were not statistically analysed.

	kg mineral N/ha per layer					
2014 treatment	0-10 cm	10-20 cm	20-30 cm	30-60 cm	0-60 cm	OC %
Bartolo bladder clover	47	14	7	20	87	1.63
Control (1)	41	8	5	14	67	1.66
Dalkeith subclover (2)	47	20	6	15	88	1.69
Margurita serredella	60	19	10	23	111	1.82
Margurita undersown in barley (1)	65	5	4	7	80	1.50
Prima gland clover	77	17	10	21	124	1.74
Scimitar medic	40	8	7	17	71	1.54
F prob	0.655	na	na	na	0.223	0.71
lsd 5% min.rep	82.3 ns	na	na	na	78.6 ns	0.67 ns
lsd 5% max-min	67.2 ns	na	na	na	64.1 ns	0.55 ns
lsd 5% max.rep	47.5 ns	na	na	na	45.4	0.39 ns

Soil coring on 13 April sampled to 60 cm depth separated into layers. Soil analyses were converted to amounts of mineral N per hectare by adding nitrate and ammonium values and multiplying by a default bulk density of 1.5. Mineral N results reflect the variability of sampling across large sites. The statistical analysis reflects the unequal replication among treatments along with the variability. The only significant result at 95 per cent confidence is that Prima gland clover which had the highest dry matter measured in spring 2014 also had the highest mineral N to 60 cm depth. The biserrula treatment had the same low level of soil mineral N as the unsown control indicating the lack of nodulation in 2014. As would be expected after one pasture year, Organic Carbon levels were the same for all treatments sampled.



NFIG figure 1: Amounts of mineral nitrogen per layer to 60 cm depth on 2014 pasture legume treatments sampled on 20 April 2015.

Discussion of results (compared with objectives)

Specific sites

The **SCF** site was on water repellent sand in a patchy 2014 season break leading to low densities and high variability across the site. Weed management was difficult due to staggered germination and low dry matter which delayed herbicide applications leading to dry matter and seed set damage on some treatments. Margurita recovered well and continued growing and setting seed until early January 2015. Grazing was successfully managed with temporary electric fencing. Seed sampling has only been collected to pods and burrs without full seed extraction due to the intensity of this procedure. The site was well prepared with multiple herbicide applications for the crop phase in 2015 at a cost to the legume production and seed set with the exception of Margurita serradella.

The **Sthn DiRT** site was established in a prominent roadside location between Woodanilling and Albany Highway. Establishment was successful in both seasons but weed control was not implemented during the early and mid 2014 growing season. Treatments that would not have seed set compromised were spray topped, i.e. volunteer pasture, oats, vetch, and subclover. Other treatments were not topped and the weed implications will be assessed in the 2015 canola crop. The current intention is to grow Roundup Ready canola. The serradella treatments were infested by budworm in spring, reducing seed set.

The first intended **WATG** site was withdrawn by the grower prior to sowing pasture in 2014. A substitute site was selected at short notice on a long term pasture paddock. The site suffered from water logging which stopped most legume growth and nodulation which together with poor weed control has led to the site being abandoned. An alternative activity to evaluate herbicides to prepare existing subclover pasture paddocks for following crop has been implemented by the group and better meeting the groups priorities of managing existing sub-clover pastures for composition, quality, seed set and N fixing in rotation with crops.

The **LIFT MLA** site was inspected in September 2014 to assess the value of the site for this project. The site was selected and established well but limited experience with managing research sites in this group led to the site being continuously grazed throughout the season, dry matter data is limited to one assessment near senescence under moderate grazing pressure and pasture seed set of aerial species was compromised. Some treatments were spraytopped while others were not so as not to reduce the seed set of aerial seeded species. The site has limited value for this project but the project manager has maintained contact with the group offering assistance and interpretation with harvest results.

The **Nyabing Farm Improvement Group** also has an MLA pasture species site which was well managed and had managed grazing, allowing good dry matter accumulation and seed set of all species. The Biserrula and Scimitar medic treatments failed to nodulate due to incorrect inoculum (poor advice) but all other species nodulated well. This site is valuable to this project with competent observations and measurements.

Project as a whole

This RCSN project is meeting most of the planned objectives. Some measurements have not been performed as well as possible and a few omitted. The pasture establishment and production phase had mixed success due to soil and seasonal conditions together with difficulties managing several species in adjacent plots by volunteer trial host growers.

The scope and intensity of measurements was ambitious, more than could be expected from grower group staff with limited experience in many aspects of the measurements required. Large plots introduce more variability than smaller sites. Point sampling such as soil profile testing, dry matter and seed harvesting often reflects this variability rather than treatment differences. Whole plot measurements such as grain harvesting is more reflective of treatment effects. Point sampling results can support the whole plot result but correlations may not be strong.

Despite these issues, a large amount of data has been collected and will prove valuable to illustrate the management required for introducing new aerial seeded and alternative pasture species. The 2015 grain harvest data will be a vital component of valuing pastures as break phase.

The project is yet to be completed and the main communication output, a publication of measured results in the establishment year, first crop year responses and a longer term economic analysis is still to be produced. Measurements from the establishment year do not reflect the value of regenerating pastures as herbicide inputs can be greater with light grazing required to maximise seed set.

Work to be completed

- The 2015 grain harvest and analysis of 2015 crop measurements.
- Legume regeneration at the break in 2016 will complete most of the field work.
- Discussions have started with suitable consultants to undertake the economic analysis.

A publication aimed at growers and consultants will be produced by middle of 2016. The results of the trials, more general recommendations on legume pastures in crop rotation with some grower experiences and a summary of the economic analysis will be the content.

Implications

This project is providing a focus on pasture species, inoculation, weed control and overall management together with the crop nitrogen benefits and crop responses. This project is a large-plot Development and Extension project, part of a much broader effort of many industry participants in developing new pasture systems in crop rotations.

In the absence of profitable crop legumes for most soils in the SW of WA, legume pastures offer several benefits to intense and continuous cropping rotations. The farm financial benefits of these benefits will be better estimated at the completion of this project.

- Crop yield boost from crop disease break and nitrogen fixation
- More sustainable weed control through alternative options (Integrated Weed Management)
- Diversity of income from livestock
- Less hectares are sown during peak times when pastures are self regenerating

Recommendation

The project should continue as planned to capture the full value of the investment to date. The planned measurements will gather data to evaluate the cropping benefits in this phase of improved legume pastures in cropping systems. All sites are progressing as planned with good grower cooperation and grower group involvement. The agreed variation to the WATG site will meet the priorities of this group, delivering information on the cropping benefits of managing existing pastures for better returns in 2016. The 2015 season has started well for most sites and will deliver credible information from the project and associated sites to help growers make informed decisions about the role of new pasture legumes and better pasture management in cropping systems.

The economic analysis will by nature be indicative values for pasture investment and returns. Returns are largely from future benefits when grazing established regenerating swards and weed and crop disease control which has only limited assessment in this project. Future values which will be estimated from interviews with producers who have established improved pasture systems.

Acknowledgements

Many people have been involved with this project which would not have been possible without their dedication and persistence.

Grower group staff, John Blake, Kayla Ringrose, Janelle Smith, and Fiona Hobley

Host Farmers, Jeff and Kate Stoney, Evan Hall and Bindi Murray, Scott Ewen, Royce and Anna Taylor, Brayden and Kate Johnston.

Appendices

Communication and extension activities

SCF. No field walk visits were made to this project site during the 2014 season but the project and site were explained at two field walk events while viewing a more accessible MLA site with many similar treatments. On 3 July 50 attended and 18 September with 70 attended the MLA site. At the September event, John Blake SCF research consultant, presented the MLA site supported by site host Ashton Hood. Jeremy Lemon explained the Gnowellen site, principles of nitrogen dynamics and the value of pasture legume nitrogen in crop rotation. Results from the Gnowellen site were detailed in the Summer SCF Focus eNewsletter sent to all 60 members and about 20 Agribusiness sponsors and members.

A brief update of the site was presented in the Winter 2015 edition of the SCF Focus newsletter.

Southern DiRT. A site visit was part of the 24 September 2014 field day with about 50 attending. Kayla Ringrose explained the trial and Jeremy Lemon spoke about the dynamics and value of pasture nitrogen for crops. Articles updating project work and results were published in the group's newsletter in February and April and in the group's email update in May.

WATG inspected their failed site as part of a field walk on 2 October. There was relevant discussion about good management for pasture sowing and Mr Lemon delivered the nitrogen dynamics in crops following pastures presentation.

The **LIFT** site was not followed closely in this project as it is funded by MLA with frequent reporting scheduled. Jeremy Lemon visited the site in spring to assess its relevance to this project. The site has had limited management and data collection with misunderstanding between LIFT and a consultancy group.

NFIG conducted two field walks in 2014, one on 20 June with 30 attending and 17 September with 52 attending. The site visit in September was a major component of their spring event. Jeremy Lemon presented at this site along with Neil Ballard and Paul Omodei.

Other events at which Jeremy Lemon spoke on the value legume nitrogen were the Gillamii spring field walk (25 attending), SCF west field walk (45 attending) and a Southern DiRT economics of pastures and N event (9 agribusiness).

Specific lessons on sowing new pastures into a cropping system.

Non wetting. Pastures are commonly sown dry to avoid clashes with crop sowing. Non wetting is a particular issue with pasture establishment with small seeds, shallow sowing and survival of seed applied inoculum. Dry sowing means non wetting be can more severe than a wet sown paddock. At Gnowellen it has led to slow uneven emergence putting the small seeded pasture species at a disadvantage to regrowth cereal and capeweed which are both adapted to early growth under stressed conditions.

Low seed rates mean the pasture is at a relative disadvantage in weedy situations. Pastures are commonly sown in response to increasing weed numbers in cropping paddocks so need to have high seed rates to compete effectively with paddock weeds. Weed competition is part of the reason for poor performance of existing pasture species regenerating after crop.

Weed control must be effective to obtain legume dominance for nitrogen fixing and seed set. Integrated Weed Management in the pasture phase is one of aims of incorporating pasture legumes in a cropping system. Some species have limited selective herbicides and do not offer significant herbicide rotation. The project sites have plots with several species which has provided challenges for effective weed control.

Grazing management is required to balance weed control, animal feed and seed set in the establishment year. This limits grazing value in the establishment year.

Budworm needs to be managed to prevent seed destruction of serradella species.

Specific inoculation groups need to be matched to species to ensure effective nodulation, growth and N fixation.

Questioning at the spring field walks indicated that many growers do not adjust crop N rates according to legume history. IF there is to be best N value from legumes, N fertiliser rates need to be reduced by the expected N available from the legume. If a set N rate is used there is a risk of over-fertilising in poorer seasons, only gaining yield benefit in above average seasons on soils with low Organic Carbon. This needs to be spelled out in extension of project findings. We had low to moderate basal N rates across these trials to ensure the legume N response has the best chance of being expressed by yield.

The experiments in this project are not designed to quantify other legume rotation benefits of weed, disease and insect control but there may be opportunities for relevant observations of some specific benefits.