final report

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Nyabing Final Report

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Abstract

Nyabing growers were searching for a pasture that could be incorporated into a cropping system with lower cost of establishment and offering high feed biomass to increase farm productivity. This project forms part of MLAs Producer Research Site program that is part of the southern Feedbase Investment Plan. In particular, this project supports the MLA-funded project *B.PSP.0013 – Pasture legumes in the mixed farming zones of WA and NSW: shifting the baseline*.

The MLA-funded trial of new hard seeded legume species in southern WA has allowed a visual comparison on legume pastures (2014 to 2016) and the site highlighted Margarita Serradella, Prima Gland Clover, Bartolo Bladder Clover and Dalkeith Sub clover may have a system fit, offering high feed values and carryover nitrogen. Dalkeith had the highest seed weights in 2016 as other aerial varieties were frosted. Scimitar Medic was poor to establish in the first year (2014), however displayed good regeneration in year three. Trends indicated higher soil N content from higher biomass pastures and barley leaf tissue tests confirmed higher N content. Trends also suggested barley yields in 2015 were greater following high production pastures strips in 2014, but not significantly.

The investigation into low cost establishment was partly associated with on farm seed production with the ability to harvest erect aerial pasture seeds with an open front header due to time and labour savings. The harvest with open front headers was difficult due to speed and low cutting height but it did show seed could be collected. Previously no growers had direct harvested pasture seed with an open front header which 6 local growers have adopted in 2016 growing Bartolo Bladder Clover and Margarita Serradella.

Serradella seed with barley seed as “twin sowing” was seeded at the same depth and did not germinate successfully in the first year. By 2016 the serradella had low plant numbers at the start of the season but enough biomass by September to warrant the method as low cost establishment option.

Executive Summary

Farmers in the Nyabing district have given some new pasture species the green light to enter into mixed cropping systems. A 3 year MLA funded New Legumes Pasture Producer Research Site showcased first hand to growers the feed biomass, nitrogen contribution and growth attributes including aerial seed height.

Producer Braden Johnston explained that growers were looking for a "low cost pasture establishment system that was able to regenerate after a cropping phase and produce bulk feed".

Establishing a Producer Research Site provided a firsthand comparison's for growers to assess the value of a new alternative legume pasture. Scimitar Medic, Dalkeith Sub Clover, Margarita Serradella, Bartolo Bladder Clover and Prima Gland Clover had similar early growth (200kg/ha dry matter) at eight weeks after establishment in first year. Biserrula and Eliza were lower feed quantities at the early pasture cuts. By September 2014 the stand out feed values were in the Dalkeith clover, Bartolo Bladder clover and Prima Gland Clover which produced up to 5.1t/ha. The Medic and Biserrula were 50 to 75% lower in feed levels in late September in the first year.

The paddock was returned to a barley crop in 2015. Bartolo Bladder Clover had low plant numbers at the break of the season (second year) before going into a barley crop, but with its hard seeded characteristic good plant numbers emerged in 2016.

Prima Gland had a prolific germination and to a lesser degree Margarita Serradella in April 2015 with an early break and both maintained a strong seed regeneration in the third year. Eliza Serradella proved to be soft seeded with good germinations early in 2015 but low plant counts in 2016.

By the third year the regenerated pastures were offering feed values between 1.5t/ha and 2t/ha with the Bartolo, Scimitar Medic, Dalkeith and Margarita performing well. The only pasture that did not regenerate was the Eliza Serradella.

Time of sowing was investigated between sowing dry in March and then sowing closer to the break to of the season in April. The dry sowing pastures had lower early feed on offer in the first year due to the seed kept as unscarified to maintain its hard seeded characteristic. By year 3 the pasture counts and yields were similar to the pastures sown at the break of season.

The Biserrula numbers were potentially impacted by the incorrect inoculant Group C being applied in year one, but still adequate plant establishment in 2016 despite being the second lowest on the pasture counts. Medic was also potentially affected in its first year growth due to incorrect inoculant.

There were no consistent differences between the use of ALOSCA and Nodulator products for inoculating dry sown pastures between pasture biomass, Nitrogen carryover or nodulation or subsequent crop yield.

Bartolo Bladder Clover, Margarita Serradella, Prima Gland Clover were productive pastures similar or slightly above Dalkeith sub clover in the two pasture phases.

As part of the research site, soil Nitrogen values were determined after the first year of pasture growth. High biomass species such as Serradella and Bladder clover contributed more nitrogen into the system in 2014 and this has delivered higher barley crop yields in the following year, but this

result was not significant only a trend. This trend was reconfirmed in the soil N and barley tissue N appears which in comparison biomass pastures contributed less N to the system.

Alternatives to re-establishing hard seeded pastures in the cropping system have been thought to achieve a lower cost system by investigating 'twin sowing' and pasture harvest with a conventional header. The harvest on the aerial seeded pastures in the trial was difficult due to speed and low cutting height but it did show seed could be collected.

The frost impact on aerial seeded varieties could be a limiting factor in further adoption of these varieties despite their high feed on offer.

The twin sown plot with Serradella sown at the same depth as the barley did not germinate as successfully in the first year. However there were enough plants in 2016 to warrant that this method as low cost could provide a way of introducing that species into a pasture stand.

The three year project had several field days and workshops extended variety information and system approaches enabling adoption increase. Ben Sutherland established Margarita Serradella in 2016 and found a fit for the serradella on the deeper sands and tried Bartolo on the heavy soil types. Several other growers have introduced Bartolo, Margarita and Biserrula over the past 2 years and using open frost harvesters to collect seed from aerial varieties.

The continuation of adoption will be dependent on weed control options which are limited and the persistence of the hard seeded varieties which needs more than 3 years for assessment.

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1 Background

The Nyabing Farm Improvement Group involves 21 farm business entities and 38 individual growers. From this there were 12 core growers that were consistently involved over the three years. The group has focused mostly on cropping and soil health in the past however grower's attention to pastures has resurged with the prices for meat and wool in last 5 years in the Nyabing area. Several members have participated in the Lifetime Ewe Management Course.

Livestock is utilised in most grower's production systems, except 3 producers who are solely cropping operations. Livestock have remained in the system due to frost prone country, weed control options with pastures and to a small degree the legacy from previous generation farming.

Pasture production has been predominately sub clover, Dalkeith and Nungarin. The composition and pasture density has been low in the Nyabing area where paddocks have come out of a cropping phase to return to a grazing paddock.

The new legume pasture species would ideally have fast growth rates, prolific seed set, early sowing adaptability and herbicide tolerance. The selected species would ideally be hard seeded for lengthy dormancy within a cropping rotation.

Clover harvesters have been the standard machine (hire or own) to collect pasture seed from sub clovers buried in the ground. In 2014 there were no growers that had harvested tall standing aerial seeded pastures with an open front harvester in the district.

Re-establishing pastures in the cropping system over large areas requires a lower cost system hence using the investigation into conventional harvesters to collect seed from aerial pastures. Clover harvesters require multiple cultivate passes prior to use and exposes the ground to erosion. It is a labour intensive job that is slow and creates a hot and dusty work environment in the heat of the summer after grain harvest.

While stock have remained in the mixed farming system, majority of businesses are over 50% cropping, with the average more likely 70% cropping. Canola hectares have increased dramatically in the past 15 years in the Great Southern taking the place of pastures as a 'clean up' tool. With the increase in weeds herbicide resistance pastures are now re-entering the arena and the challenge is working out how to establish and build a seed bank while still cropping.

Building a seed bank with hard seeded pastures offer multiple benefits and aims to provide longevity to a pasture within a cropping rotation. Hard seeded varieties offer the ability to seed earlier when small rain events won't trigger a full germination.

Growers were keen to assess the options of dry seeding pastures with ALOSCA and Nodulator products to deliver nitrogen fixing rhizobium. Dry sowing cereal and legume grain crops has become a standard practice in the region in order for the crop to germinate on subsequent rains opposed to soil moisture as dry starts to the season have been more frequent.

The focus on easy care stock management and cost effective feed supply which means quantifying feed levels is critical. The adoption of grazing crops in the feed gap in April and May has been successful in the Nyabing area and now allows opportunity to establish pastures with some relief of grazing pressure. There has been minimal research in our area to date on new legume pasture species.

2 Projective Objectives

New legume species (and appropriate sowing times) will be evaluated. Their role in increasing overall on-farm productivity will be determined based on their increased early production potential and nitrogen fixation.

This project forms part of MLAs Producer Research Site program that is part of the southern Feedbase Investment Plan. In particular, this project supports the MLA-funded project *B.PSP.0013 – Pasture legumes in the mixed farming zones of WA and NSW: shifting the baseline*.

MLA Agreement Extract Aims:
1. Established the value of alternative legumes and their appropriate sowing times for the Nyabing district.
2. Determined the value of alternative legumes for adding nitrogen to soil.

Aims:
- To establish a cereal crop in 2015 over the 29 pasture plots established in 2014.
- To determine the Nitrogen carry over in the soil from new legume pastures on subsequent crop and yield results in 2015.
- To determine the success in under sowing (twin sowing) pod Margarita in 2014 with the 2014 barley and its ability to establish as a regenerative pasture in 2015.
- To determine the pasture regeneration in year three following an establishment year then a cereal crop
- To determine the ability to harvest seed with an open front header.

3 Methodology

The group undertook the investigation into the new legume pastures species hosting a large scale research site and inviting growers to participate in field days and information sessions over three years during various phases of the pasture regeneration cycle. At the research site six legume pasture varieties were sown alongside Dalkeith sub clover as a seeded comparison pasture that is dominant in the area. There was one control plot that was unseeded and hard a history of Dalkeith and Nungarin sub clover and other native pastures comprising of 50% legume base.

Four plots were sown early in March to compare the use of dry sowing with inoculants ALOSCA and Nodulator using hard seeded pastures Margarita Serradella (sown as 22kg/ha seed in pod form) and 15kg/ha Bartolo bladder clover using unscarified seed.

As part of the system approach to combine a hard seeded pasture with barley seed, there was one “twin sown” plot to determine if a legume pasture could be established underneath a crop.

Legume Pasture Species	Retail Seed Cost $/kg	Seeding Rate kg/ha	Cost $/ha	Hard or soft seeded	Summer sowing	Twin Sowing	Harvesting
Bartollo Bladder clover	6.05	12	72.6	Hard	Yes	Yes	Conventional open front
Margarita French Serradella	9.00	12	108	Hard	Yes	Yes	Conventional open front
Eliza French Serradella	5.50	12	66	Soft	No	No	Conventional open front
Scimitar Medic	6.80	12	81.6	Hard	No	No	Clover vacuum harvester
Casbah Biserrula	6.20	10	62	Very Hard	No	No	Conventional open front
Prima Gland clover	5.60	10	56	Hard	No	No	Conventional open front
Dalkeith sub clover	5.20	12	62.4	Hard	No	No	Clover vacuum harvester
Source: Paul Omodei Planfarm 2017 and 2014 Ballard Seed Costs							

3.1 Research Sites

3.1.1 Site Information

Soil testing was conducted prior to trial setup in 2014. The site had excellent phosphorus and potassium levels, pH average around 5.5 and Organic Carbon at 1.5%, see Appendix 15.

Rainfall data recorded from DAFWA located nearby, see Appendix Seven. The three years the trial was conducted were good rainfall seasons. The trial was seeded on GPS run lines.

This project was conducted at Braden and Kate Johnston's Property "Fourwinds" on North Kuringup Rd, Nyabing, in the Shire of Kent. A consistent soil gradient from gravel soils (west end) to a partial clay soil type (east end). The paddock was treated with 1.2t/ha lime in 2013 and has had a rotation of canola 2011, barley 2012 and barley 2013. Latitude and Longitude of the site -33.42425929 and 118.33091717.

Fig. 1: MLA Pasture Trial Site on Kuringup Nth Road, Nyabing WA following 2015 barley harvest over 30 pasture plots, note East West harvest runs on each plot established in 2014.

3.2 Treatment and Design

3.2.1 Treatment

In 2014 a 12m DBS seeder with canola boots set at 0.5cm sowing depth was used to sow a 450m long strip of the combinations:

- Unscarified seed of Margarita Serradella and Bartolo Bladder clover was sown on 13 March 2014 under dry soil conditions with ALOSCA and Nodulator as separate inoculant comparisons with 2 different seeding rates of 22kg/ha Margarita and 15kg/ha Bartolo.
- The 450m strip of each variety was replicated three times to include: Scimitar medic, Casbah Biserrula, Prima gland clover, Margarita serradella, Bartolo bladder clover, Eliza French serradella was on 17 April against the standard pasture Dalkeith sub clover with two replicates.
- Margarita serradella was combined with barley (termed twin-sown) on 27 May 2014 which means they will be under sown with the crop in 2014 as hard seed at the time of normal sowing and will germinate the following year. This is an alternative method of establishment to the summer or normal sowing in the year of pasture.

Date Sown	Treatment	Pasture and Inoculant
13 March 2014		
	1	Bartolo Bladder Clover 15kg/ha seed + Nodulator 5kg/ha
	2	Bartolo Bladder Clover 15kg/ha seed + ALOSCA 10kg/ha
	3	Margarita Serradella 22kg/ha Pod + Nodulator 5kg/ha
	4	Margarita Serradella 22kg/ha Pod + ALOSCA 10kg/ha

		Pasture	Seed Rate
17 April 2014			
	5	Bartolo Bladder Clover	12kg/ha
	6	Scimitar Medic	12kg/ha
	7	Casbah Biserrula	10kg/ha
	8	Prima Gland Clover	10kg/ha
	9	Eliza French Serradella	12kg/ha
	10	Margarita Serradella	12kg/ha
	11	Dalkeith sub Clover	12kg/ha
	12	Control plot – 50% self-sown clover	

A All seed for the 17 April sowing was scarified for germination.
B Bartolo and Margarita sown on 13 March was unscarified seed/pod
C All pastures sown with Nodulator 5kg/ha.Only Group C inoculant was applied to all pastures which was an error when the producer was setting up the seed and inoculant packets at sowing.

There was a control plot which was unseeded and pasture species that were present in paddock comprising of 50% legume base and main species Dalkeith sub clover.

3.2.2 Trial Design and Layout

Trial Type:	Replicated Broadacre Scale	
Plot size:	12m (seeder and header width) x 450m	
Total No plots:	30 plots	
Untreated control:	1 plot	
Number of 2014 Treatments:	6 pasture species, 3 replicates	18 plots
	1 pasture species, 2 replicates	2 plots
	2 pastures with inoculants, 2 replicates	8 plots

1 under sown pasture with barley	1 plot
1 control plot	1plot

In 2015, the trial site was sown with barley, except for the Plot 1 strip that was twin sown in year one, thus allowing the serradella to germination as a pasture in year two.
Strips of fertiliser at varying rates (30 and 60 units N) were spread across the main plots to establish where a nitrogen response becomes apparent.

Nitrogen rates were applied across pastures at 30kg/ha N and 60kg/ha N as Liquid UAN (Urea Ammonium Nitrate) and remaining area as untreated, so 30 plots x 3 = 90 plots

Plot size: Nitrogen Strip 12m x 66m

Number of N Strips 1 x 30kg N/ha and 1 x 60kgN/ha

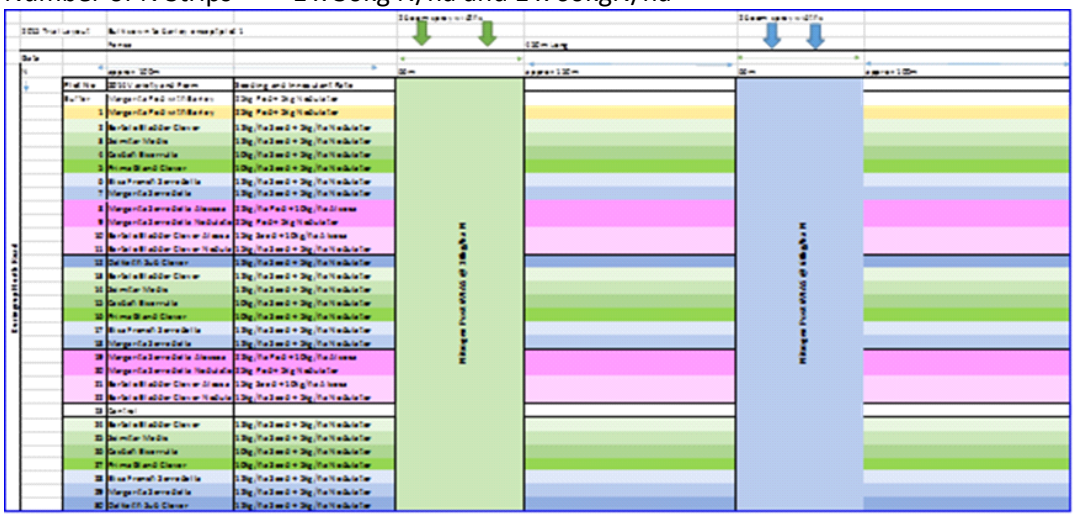


Fig. 2: Treatments from 2014 and N strips 2015 with all plots except Plot 1 sown to Barley in 2015

In 2016 the Trial site returned to the plot layout as per 2014 (see Appendix 6 for larger version). All plots were regenerated pastures that were seeded in 2014.

3.3 Monitoring

3.3.1 2014 Data Collection

Pasture Cuts 20 June 2014 - Pasture cuts were taken from quadrants eight weeks after germination (20 June). Four cuts were taken in each plot using 0.5m x 0.5m quadrants. The four cuts were combined into composite samples to obtain a total of 29 samples and photos recorded. Samples were wet weighed, then dried in an oven at Katanning AgDept 70°C for four to five days, then reweighed to determine Food On Offer (FOO) as kg DM/ha.

Pasture Cuts September 2014 - Pasture cuts were taken from quadrants on 23 September with pastures at full flower and start of podding. Three cuts were taken in each plot (plot 2 to plot 30) using 0.5m x 0.5m area. The samples were combined to give a total of 29 samples. Samples were wet weighed, then dry weights were obtained after oven drying at Katanning AgDept.

Nodulation on serradella was assessed from 15 plants, from four sample areas of Serradella on 5 October 2014 with roots intact. Samples were sent to Murdoch University for nodulation assessment. The purpose of the nodulation assessment was to determine if there was any variety

difference between Nodulator and ALOSCA under dry sowing. Eight plots (Bartolo and Margarita Serradella) were sampled in total, by digging down 10 to 15cm and taking a whole plant and placing into a clear freezer bag. Samples were express posted to Perth at 4.30pm from Katanning and arrived the next day. Murdoch University conducted nodulation ratings and weighed plant samples to determine the efficacy of the nodulation (see appendix 13).

Animal Management - The site was fenced in early July 2014 as the remainder of the paddock is cropped to canola. The number of grazing days will be recorded. Exclusion cages will be placed in each plot to allow a measurement of non-grazed plant production to take place. Exclusion cages were placed across all 30 treatments.

3.3.2 2015 Data Collection

The twin Sown or under sown Serradella established in 2014 was a pasture regeneration in 2015: 4 Pasture cuts of the Serradella pasture were taken in June and mid October 2015 to determine the biomass. The samples were oven dried at 60^{o}C to determine kg DM/ha.

Soil Nitrogen was measured form soil cores at depths 0-10cm, 10-20cm and 20-60cm at the end April 2015 prior to sowing the trial to determine the Ammonium Nitrate, Organic C and Nitrogen levels. A hydraulic depth corer was used to extract five cores which were combined into one sample and sent to CSBP Soil and Plant Laboratory. The full 30 plots were not sampled due to budget constraints, instead a range reflecting the biomass levels in 2014 were decided on and listed in appendix 10.

Tissue Testing - Tissue testing was conducted at the end July with 20 whole top plant samples. The tissue testing was done on all 29 plots seeded to barley (plot 1 was not sown to barley as it was a regenerative pasture in 2105), plus on each Nitrogen rate, so a total of 87 samples were taken.

Green Seeker (NDVI) measurements were to be taken, however with wet crop and winds the device had to be returned before readings could be completed.

Pasture Assessment – Plant Counts were done prior to knockdown to see what germination there was after year one. A visual recording of pastures under crop on scale one to five was completed within each plot to determine the density of the pasture stand during the cereal crop phase.

Yield Data - Each plot was centrally harvested using an open front conventional harvester and yield data analysed to determine any crop growth differences. Yield data was analysed using SMS software and yield maps. The use of a small plot header to do Nitrogen cuts was originally planned but was found to be cost prohibitive, however the data obtained using yield monitoring and maps was sufficient.

3.3.3 2016 Data Collection

Pasture Counts were completed six weeks after germination 19 May 2016 with five counts per plot on 30cm x 30cm area.

Pasture cuts were taken from each plot in four locations and separated into pasture species sown or other species on 20 September 2016. The other species comprised of native pastures, Dalkeith/Nungarin sub clover or weeds such as wild turnip, milk thistle but predominately capeweed. The pastures were cut just above ground level. Samples were oven dried for four days and then weighed.

Seed collection was done by hand from 4 areas in each plot from a 22cm x 22cm area, sieved, sorted and weighed to determine seed mass. Collection was done on 14 November which was suitable for all varieties having firm pod seed and dry stems.

Sub clovers were dug from the ground and then sieved, cleaned and weighed. The burrs were then thrashed in a thermomix to produce clean seed weight, then a final sieve.

Pasture seed harvest was intended to be done with a weigh trailer to measure the pasture yield however due to severe frost the plots were not worth harvesting for seed using a conventional header. To determine the harvest with a conventional harvester, 12 plots were harvested without recording yield. Records were kept on height, ease of harvest and any issues.

3.4 Monitoring with Growers

Field walks conducted at the research site enabled growers to assess pasture biomass and growth. This was done physically in year one with farmers involved in cutting pastures to determine weights and Paul Omodei explaining the importance of quantifying feed on offer.

The spring field walk in 2014 focused on growers seeing the flowering stage and pastures had reached their peak growth. Key speakers were Jeremy Lemon on Nitrogen on fixation from pastures, pasture species attributes with Neil Ballard and herbicide options with local agronomic agency. The site attracted Dr John Howieson and Angelo Loi and travelling colleagues to visit the site and view varieties post the field day.

The 2015 year was sown to barley and so only a few growers attended the June field walk to see if any response could be identified in carryover Nitrogen and the N soil test results were discussed.

The 2016 focus on pasture regeneration attracted growers who were keen to see how well the pastures had self-seeded and regenerated in 2016. Neil Ballard focused on the system of establishing pastures and the agronomy requirements including dry sowing, seed dormancy, building the seed bank and harvest with open front conventional headers. The barley yields were discussed and growers were visually assessing the growth of the regenerated pastures.

3.5 Statistical analysis

As final statistics for comparison across years, ARM statistical analysis program was used through Hodge and Rohde Pty Ltd. The confidence interval was run at 95% for statistical reports.

Throughout the duration of this project statistics have been supported by the Department of Agriculture and Food WA Gen Stat program, and in particular a key individual Jeremy Lemon who had similar projects in Nitrogen and Pastures. Murdoch University offered to assist with statistics

then withdrew the offer at the end of 2014. Some basic statistical analysis in excel has been done for 2015 with assistance from Planfarm. In addition a biometrician from the Department of Agriculture was also able to preview and comment on the trial design and data in 2016.

3.6 Economic analysis

Due to a large amount of data showing trends opposed to statistical significance the additional value of feed has not been costed for the findings. There has been a cost of direct harvest of aerial seeded pastures as compared to cost of clover harvesters, see appendix 8.

Additional N benefit from pasture crops did not have a significant impact on yield and the control plot did not respond to higher rates of N that created issues with costing the N response.

3.7 Extension and Communication

Over the three year Producer Research Site there were a total of six field walks. The largest field walk was held in 2014 with impressive pasture growth and several key note speakers.

Paul Omodei was the key extension person associated to the project. Field days were hosted at the site to encourage growers to view and ask questions on the pastures.

Newsletters were prepared and published in the Nyabing News on behalf of the Nyabing Farm Improvement Group. There were three annual newsletters.

4 Results

4.1 Measured trial result

4.1.1 Pasture Growth

The pasture growth was exceptional in 2014 under a fantastic growth year. In 2014, the site experienced no summer rain in January and February. The first planting on the 13 March was into dry soil followed by 4.6mm rain. The pastures sown on 17 April were sown into moderate moisture and had an excellent germination after opening rains on 27 April recorded 22mm. Following this rainfall event all pasture species sown on 17 April and 13 March had germinated with clear rows visible down the length of the trial.

Fig. 3 Pastures establishment 12 June 2014 Serradella (left) and Bartolo (right) with good plant emergence and density.

Early growth rates at 20 June approximately eight weeks after germination had weights ranging from 40kg/ha to 160kg/ha. There was considerable variation between the same pasture species over the 0.5m^2 areas sampled. The biserrula and the March sown Margarita and Bartolo as unscarified seed were the lower growth plots, but data was not significant.

The end of season biomass produced by the pastures showed Prima Gland to produce the greatest dry matter at 5.10t/ha. This was followed by Bartolo Bladder clover 4.18t/ha and Dalkeith sub clover 4.10t/ha. However it should be noted that a large amount of subterranean seed on the Dalkeith was held on the tendrils, with formation of seed which would have contributed to the weights in the Dalkeith.

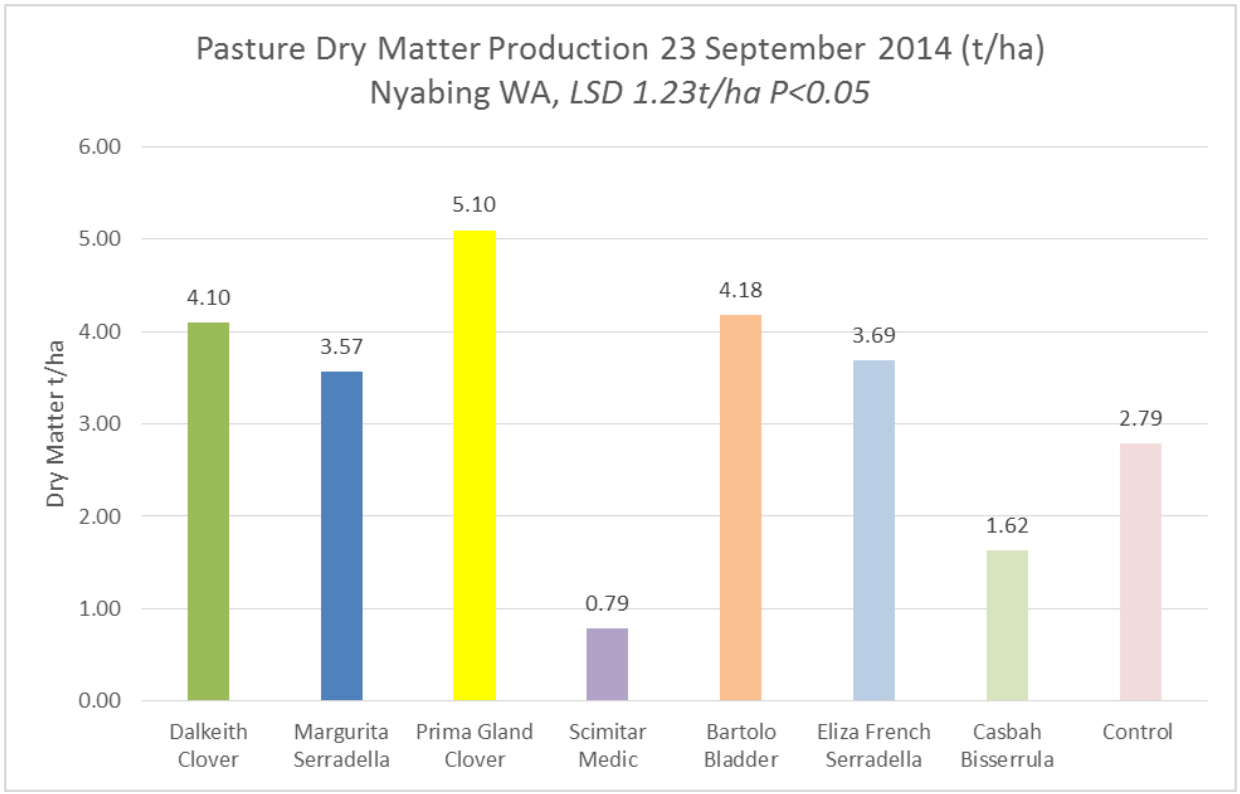


Fig. 4 Pasture Dry Matter Production (t/ha) 23 September 2014 with New Legume Pastures

The Serradellas had similar growth (wet weights) to Dalkeith, Prima Gland and Bartolo, but lower dry matter weights at 3.57t/ha and 3.69t/ha (Margarita and Eliza).

Casbah Biserrula had poor growth which was primarily due to incorrect inoculant group, however plot 26 on the north end there was good Biserrula. Medic was a poor performer, which is also likely due to incorrect inoculant group.

The pasture composition in the Medic and Biserrula had other native species and introduced species present in the paddock including hare's foot, woolly burr and Dalkeith. The Biserrula had between 33% to 57% (as weight percentage) other species and Scimitar Medic consists of 41% to 88% (as weight percentage) other species.

Fig. 5 Prima Gland Clover Stand on 23 September 2014 with 5.10t/ha dry matter average.

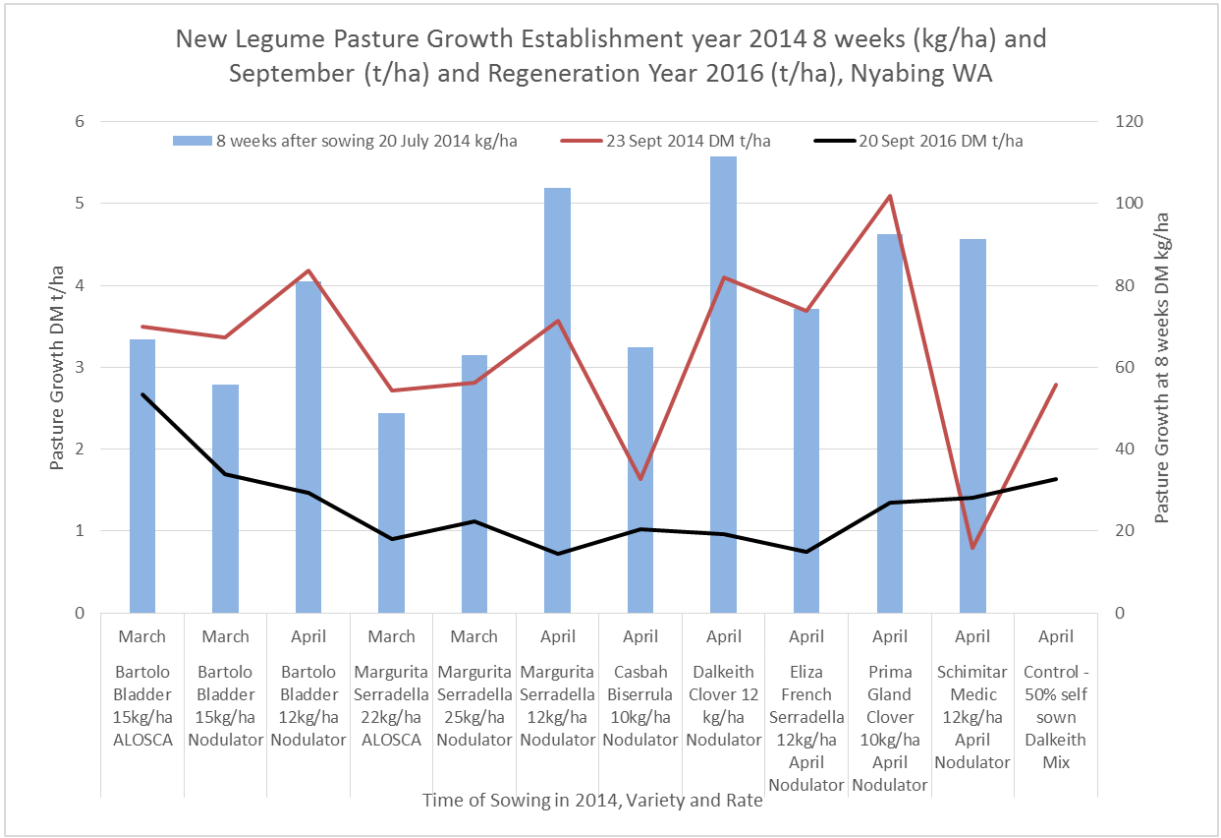


Fig 6. Pasture Weights from 8 weeks after Establishment 20 July 2014 (kg/ha) and 23 Sept 2014 (t/ha) and Pasture Weights on Regenerated Pastures in 2016 20 Sept 2016 (t/ha) from pasture species only

Stock grazed for 3 days over 15ha with a total of 670 hoggets in 2014. The pastures were reduced to a 2cm height. The site was evenly grazed. While there was no preferential grazing recorded the recovery growth post grazing was most evident in Prima Gland followed by Bartolo. Pasture exclusion cages did not visually show any difference on 23 September at the time of pasture cuts, therefore cuts were all taken from the grazed area only.

Table 1 Pasture Yields t/ha and Nitrogen Content as DM N% in 2014 conducted by Department of Agriculture

April Sown	20 June 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**	**100.00**	**2.21**	**62**

Note: For comparison only as one replicate missing and only one plot as a control which was not included in the statistics.

In conjunction with the Department of Agriculture some sub samples were taken from the pastures and analysed for Nitrogen content. This was expressed as Dry Matter Nitrogen Contents as a % and converted to Nitrogen as kg/ha in the tops of pasture leaf.

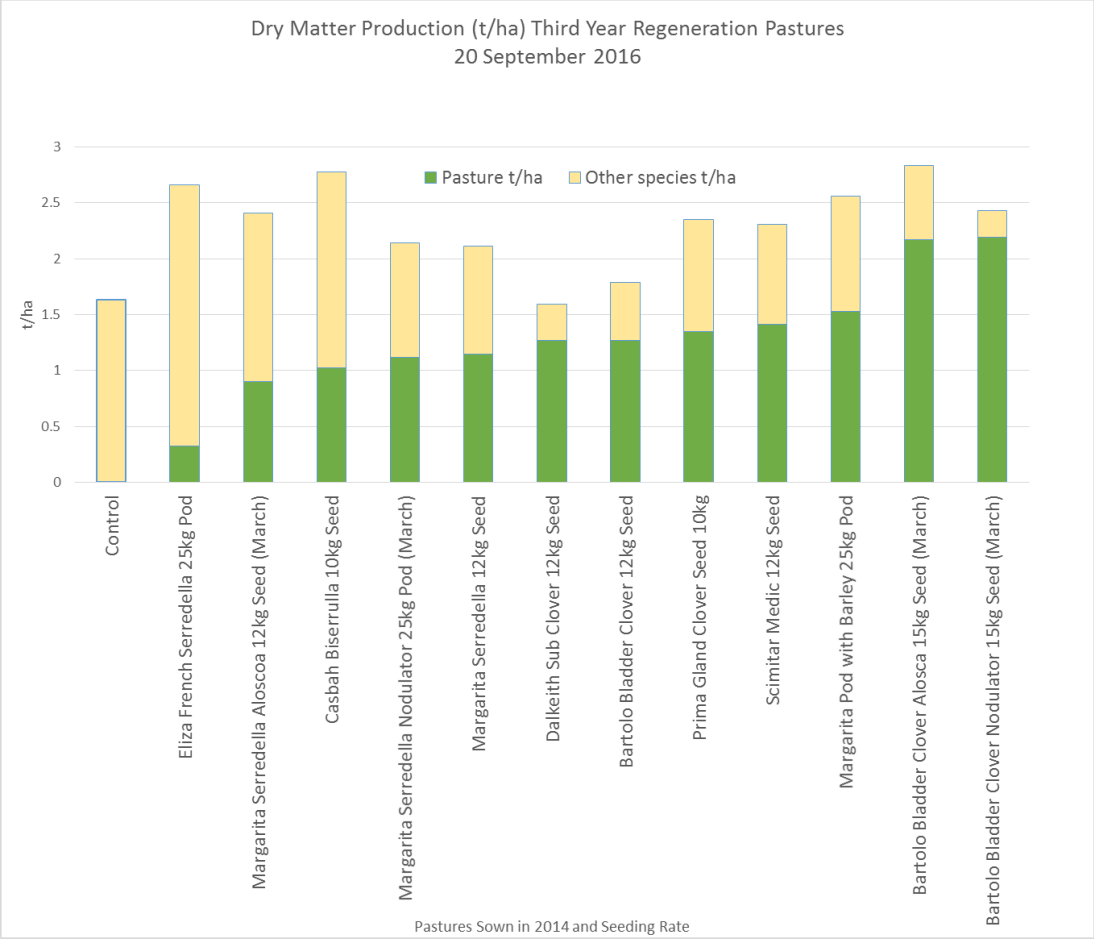


Fig. 7 Dry Matter Pasture Production (t/ha) from Regenerated Pastures 20 September 2016, Pastures sown in 2014, then barley 2015, not significant differences.

In the 2016 regeneration pasture year the Margarita twin sown with barley and Medic had good pasture composition at 1.5t/ha and Bartolo plots had upto 2t/ha dry matter. Eliza Serradella struggled and consequently a large percentage was other species. Biserrula despite having low numbers in 2014 still had just over 1t/ha dry matter.

4.1.2 Pasture Regeneration Number

Dalkeith sub clover, Bartolo bladder clover and Prima Gland Clover regenerated strongly since establishment in 2014. Prima Gland was well established within the barley crop in 2015. Eliza Serradella was soft seeded with higher plant numbers at the start of 2015 but fewer plants in 2016. In contrast Margarita Serradella had higher numbers in 2016 regeneration.

The site was grazed with 450 ewes and lambs for 2 weeks over 100ha which including the pasture trial and surrounding barley crop in late June 2016.

Table 2 Pasture numbers in 2015 and 2016 following 2014 establishment year.

	Pasture Legumes Established in 2014	Month Sown in 2014	Avg Plant number per m2		
			2015 before Knockdown Early Break 14/04/2015	2015 in crop Mid Season 21/07/2015	Regenerated 2016 6 weeks after germination 09/05/2016
1	Bartolo Bladder 15kg/ha ALOSCA	March	2	2 a	433 abc
2	Bartolo Bladder 15kg/ha Nodulator	March	1	5 a	329 cd
5	Bartolo Bladder 12kg/ha Nodulator	April	2	4 a	474 ab
3	Margurita Serradella 22kg/ha ALOSCA	March	150	8 a	208 ef
4	Margurita Serradella 25kg/ha Nodulator	March	300	8 a	130 fg
10	Margurita Serradella 12kg/ha Nodulator	April	150	2 a	261 de
6	Casbah Biserrula 10kg/ha Nodulator	April	5	7 a	125 fg
7	Control - 50% self sown Dalkeith Mix	n/a	25	3 a	289 de
8	Dalkeith Clover 12 kg/ha Nodulator	April	100	12 a	539 a
9	Eliza French Serradella 12kg/ha April Nodulator	April	200	5 a	39 gh
11	Prima Gland Clover 10kg/ha Nodulator	April	1000	77 a	400 bc
12	Schimitar Medic 12kg/ha Nodulator	April	50	11 a	246 de
37	Margurita Undersown in Barley May	May		3	11
LSD P=.05			**n.s**	**41.9**	**110.83**
Standard Deviation			**1 Replicate**	**24.08**	**63.68**
CV			**only**	**215.62**	**23.77**
Replicate F				**0.524**	**0.358**
Replicate Prob(F)				**0.6027**	**0.7047**
Treatment F				**2.058**	**20.151**
Treatment Prob(F)				**0.0938**	**0.0001**

Fig 8. Margarita Serradella 3rd year after establishment September 2016 Nyabing WA.

Fig 9. Dalkeith Sub Clover 3rd year after establishment, September 2016 Nyabing Producer Producer Research Site Site.

Fig.10 Bartolo August 2016 3rd year after establishment September 2016 Nyabing WA.

4.1.3 Nitrogen Contribution from Pastures

Soil Carry Over Nitrogen

The residual soil N from the high biomass pastures in 2014 was not significantly different to the control plot. However trends were evident that the higher biomass pastures (Prima, Dalkeith, and Serradella) had greater N than the lower biomass medic and Biserrula. However the probability of repeatability of results is low as indicated by the statistics in appendix due to variability in data.

The 0-10cm range had the highest N concentration and N deeper in the profile was not adjusted for plant availability at depth.

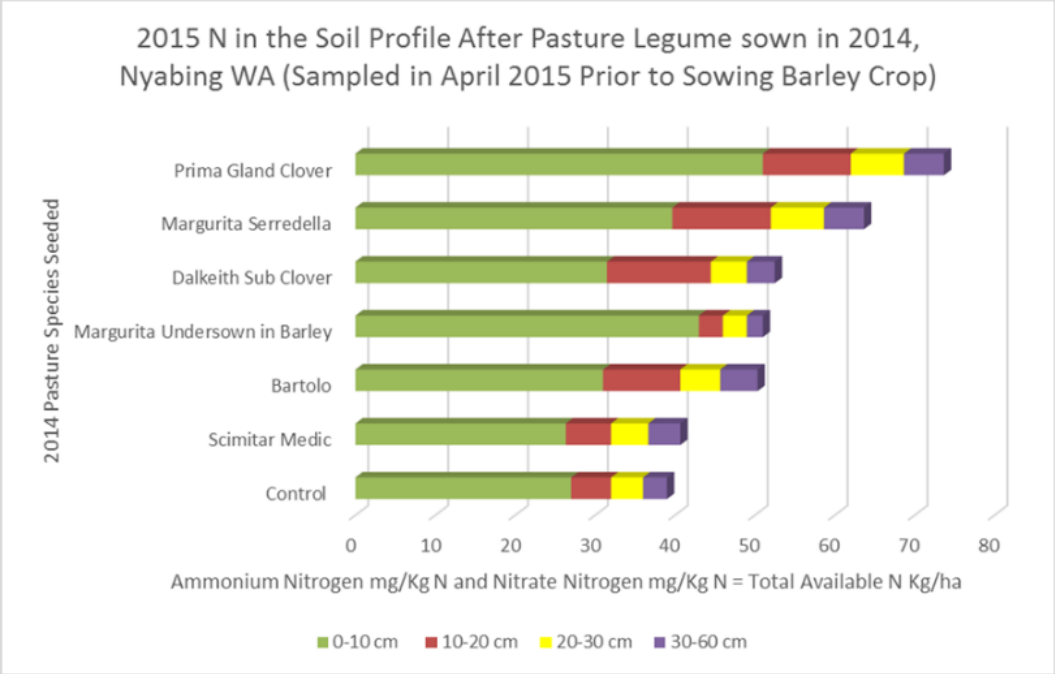


Fig. 11 Total Available N (if assumed all N available at depth) sampled 20 April 2015 , not significantly different.

Nitrogen Application Response to Barley 2015

In order to determine if optimum amount of nitrogen was produced from the pasture species in 2014 to support a barley crop in 2015, additional Nitrogen test strips were applied to determine any rate response from applied Nitrogen. Nitrogen was applied at seeding as Agstar 80kg/ha which is equivalent to 11.4kg N. No other additional fertiliser N was applied except for the two test strips.

The 70L/ha Flexi N (29.5 kg N/ha) and 140L/ha Flexi N (59.08 kg N/ha), both were higher N % in the plant tissue than the standard pasture plots. However at 140L/ha the Flexi N was lower in N concentration in the whole tops than the 70L/ha. The “greenness” in the Flexi N strips was visually evident at sampling.

The trial site visually indicated a response to Nitrogen as liquid UAN applied on 18 June 2015 at 3 to 4 leaf stage across 2 strips. The high biomass pastures over 3t/ha dry matter in 2014 continued to show additional Nitrogen in leaf tissue as compared to the control and this was also evident in the Nitrogen soil testing earlier in 2015.

Despite the crop looking visually greener this did not translate to a significantly higher grain yield. The control plot was lower yielding by only 100kg/ha and was not a significant difference.

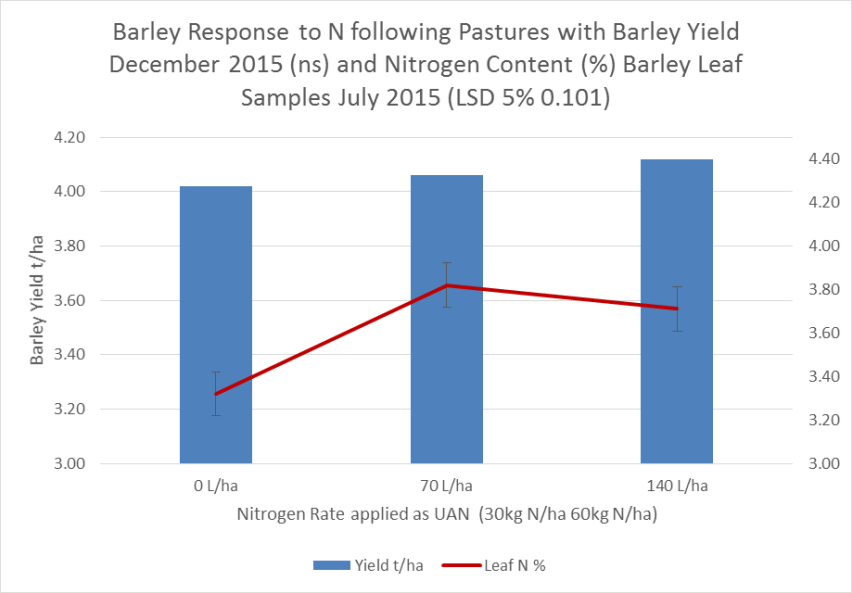


Fig. 12 Barley Response to N following, Yield (t/ha) December 2015 and Nitrogen Content (%) Leaf Tissue Test July 2015

Table 3 The Effect From Legume Pastures Planted in 2014 Leaf Tissue Test (Nitrogen %) in Barley when UAN was applied on 18 June 2015 and sampling on 13 July 2015

Treatment	**Leaf Tissue Test (% Nitrogen) 13/07/2015**		
UAN Rate	**0L/ha**	**70L/ha**	**140L/ha**
Control - 50% self sown Dalkeith Mix	2.97 m	3.55 d-k	3.44 g-k
Casbah Biserrula 10kg/ha April Nodulator	3.08 lm	3.62 c-j	3.55 d-k
Bartolo Bladder 15kg/ha March ALOSCA	3.26 klm	3.9 a-d	3.68 b-j
Schimitar Medic 12kg/ha April Nodulator	3.08 lm	3.72 b-h	3.38 h-l
Bartolo Bladder 15kg/ha March Nodulator	3.37 i-l	4.08 a	3.9 a-d
Margarita Serradella 22kg/ha March ALOSCA	3.34 i-l	3.79 a-g	3.83 a-f
Margarita Serradella 25kg/ha March Nodulator	3.48 f-k	3.92 abc	4.01 ab
Bartolo Bladder 12kg/ha April Nodulator	3.33 jkl	3.89 a-d	3.68 b-i
Dalkeith Clover 12 kg/ha April Nodulator	3.44 g-k	3.81 a-f	3.59 c-k
Eliza French Serradella 12kg/ha April Nodulator	3.52 e-k	3.91 abc	3.85 a-e
Margarita Seradella 12kg/ha April Nodulator	3.61 c-j	3.85 a-e	3.99 ab
Prima Gland Clover 10kg/ha April Nodulator	3.4 h-l	3.86 a-e	3.67 b-j
LSD P=.05	**0.351**		
Comp. Trt. LSD	**0.349**		
Standard Deviation	**0.213**		
CV	**5.89**		
Replicate F	**15.963**		
Replicate Prob(F)	**0.0001**		
Treatment F	**5.217**		
Treatment Prob(F)	**0.0001**		

Barley leaf tissue tests recorded higher N content % when UAN was applied on the poorer growth strips in 2014 pastures Medic, Biserrula and Control plot.

Majority of barley leaf tissue tests recorded a positive Nitrogen lift in leaf tissue between the 0L/ha UAN and the 70L/ha N. Further increases in the 140L/ha rate were not evidenced and in general declined the Nitrogen content in the leaf tissue.

4.1.4 Nitrogen Interaction with Barley Crop Yield

The barley crop was harvested with a John Deere S680 conventional header by harvesting all plots in one direction. MAPIQ services were used to collate over 7500 data points from harvest and overlay the GPS application of the Nitrogen strips onto the yield map to determine the data points from the 2 UAN rates.

All barley yields grown on pasture plots in 2014 out yielded the control plot, however the yield response was not significant at the 95% confidence interval.

There was a trend that the pastures that contributed to the higher soil N in with high biomass in 2014 translated to slightly higher barley yields in 2015.

The control plot did not appear responsive to N rates and this suggested an additional yield interaction.

The 2014 Bartolo and Margarita plots showed little response to N rates in 2015 barley crop yields averaging around 4.1t/ha.

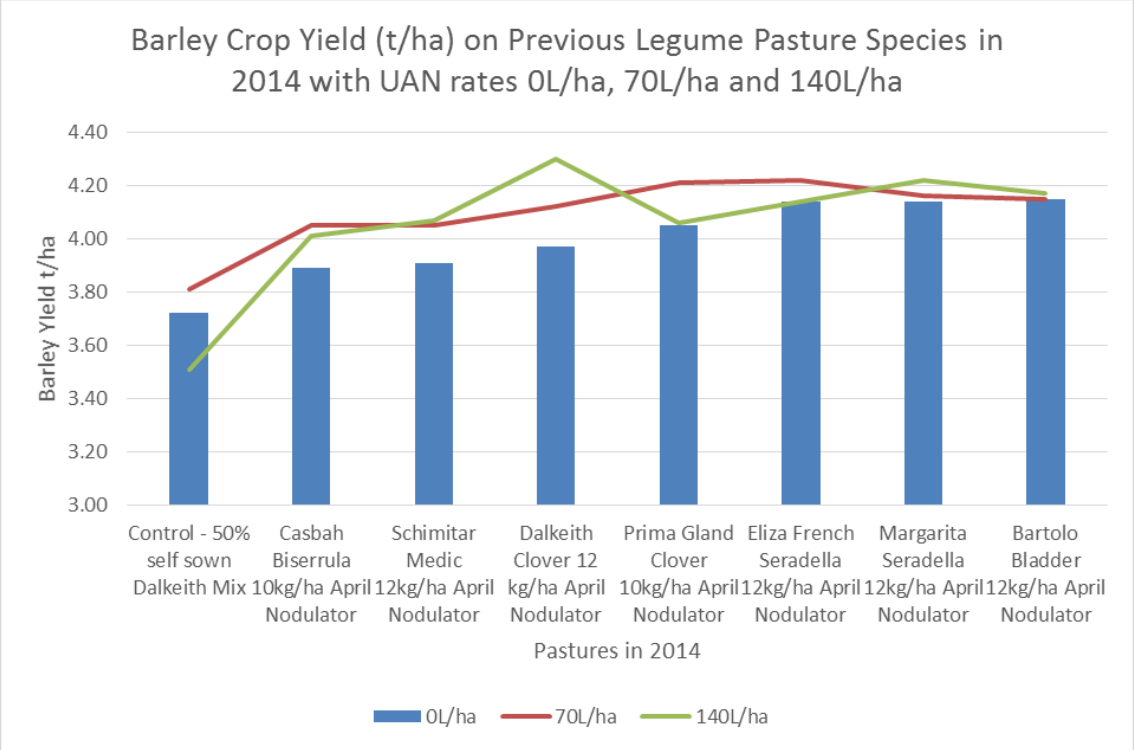


Fig. 13 Barley Crop Yields 1 December 2015 following Pastures sown in 2014 as Compared to UAN Strips applied at 70L/ha (30 units N) and 140L/ha (60units N), not significant.

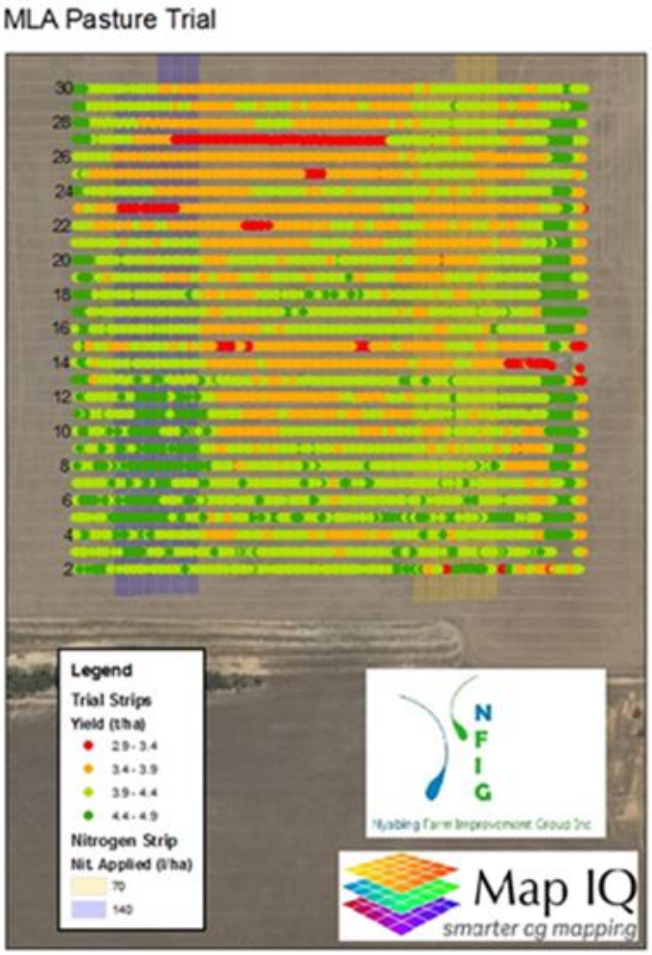


Fig. 14 John Deere S680 Yield Map for the Barley Crop harvested in December 2015 prepared by MapIQ

4.1.5 Nodulation

The incorrect nodulation Group C (error at seeding) was used on the Biserrula and the Medic which impacted the nodulation on these species. Therefore is was decided to only focus on the treatment differences of Nodulator and ALOSCA on Bladder clover and Serradella sown in April. The sampling technique and number of treatments was done in the field with Dr John Howieson.

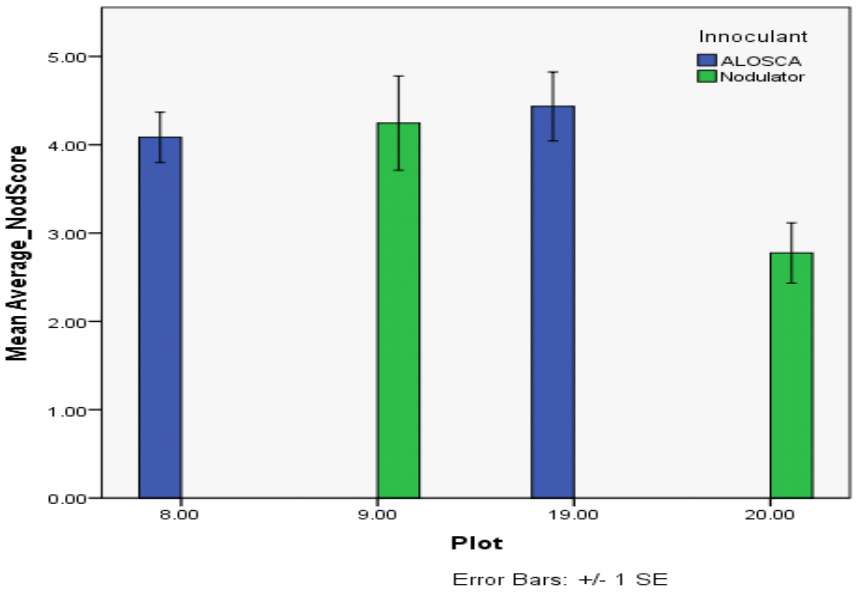


Fig. 15 Serradella Nodulation Score between ALOSCA and Nodulator 30 Sept 2014, Source Murdoch University, LSD

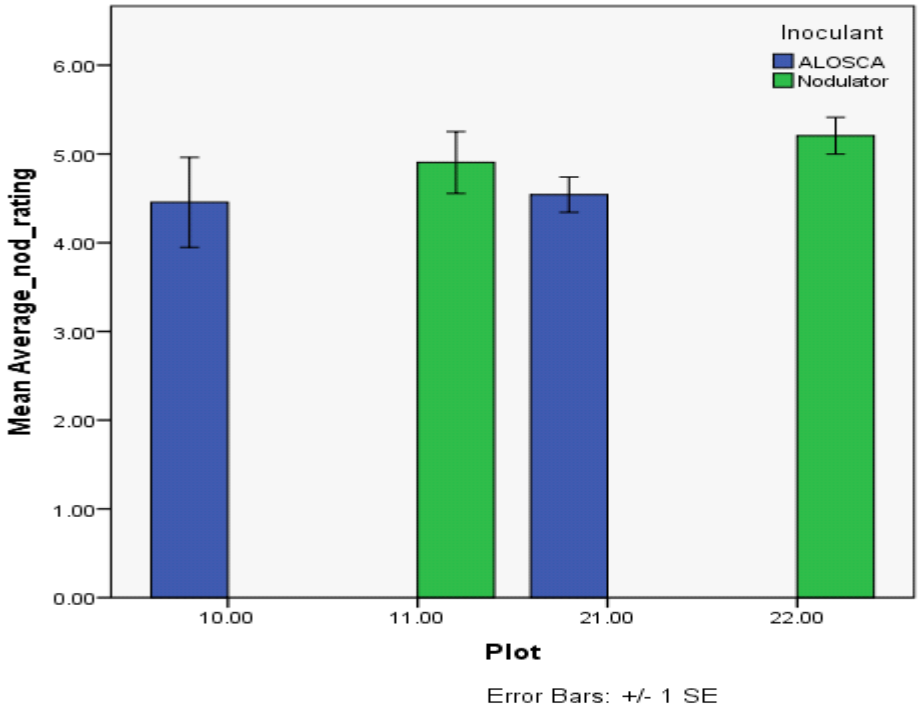


Fig. 16 Bartolo Nodulation Score between ALOSCA and Nodulator 30 Sept 2014, Source Murdoch University.

Both Bartolo and Margarita had moderate to average nodulation. Based on nodulation rating alone there is no consistent and significant result in ALOSCA as compared to Nodulator product.

While the average dry weights are statistically higher in the ALOSCA plots and the nodulation scores were close but not statistically significant (significant at the 10% level). "There is also a strong correlation for weight to nodulation score which demonstrates that there is a consistent relationship between the measurements" (Pers Com. *Tom Edwards 2014)*

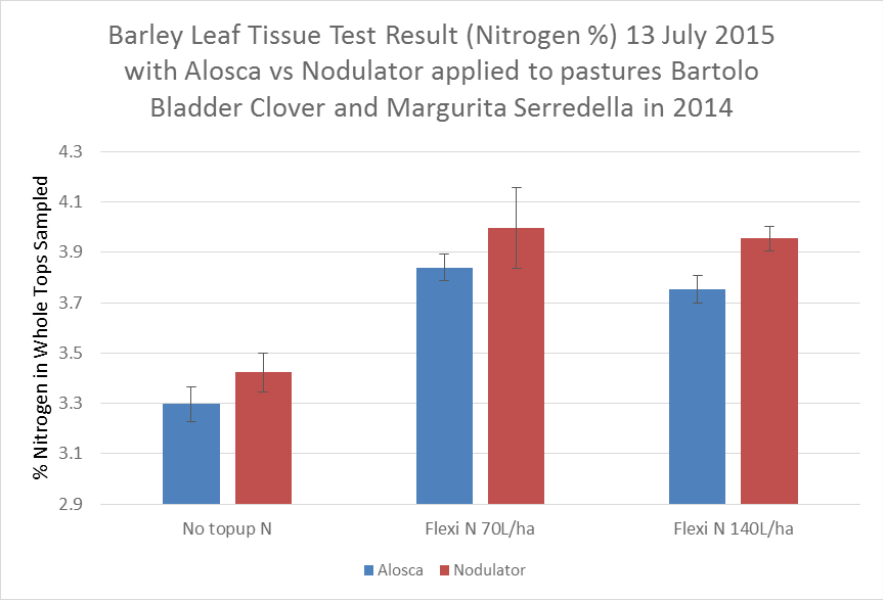


Fig. 17 Barley Leaf Tissue Test Results in 2015 Comparing Nodulator and ALOSCA carryover effects.

Both Margarita and Bartolo sown as unscarified seed and pod seed were combined to assess products which suggested slightly higher N content in Nodulator plots. The barley leaf tissue test taking whole tops indicated that Nodulator had significantly (see appendix for statistics) more impact on Nitrogen content when applied to pastures in the previous year.

This did not translate to higher barley crop yields with Serradella with Nodulator averaging 4.16t/ha with ALOSCA and 4.12t/ha with Nodulator. Bartolo also showed no difference in barley yields with inoculants applied in 2014.

Nodulation on all the new pasture species was assessed looking at five pasture plants from each pasture type. A summary of nodulation was done, however only from one replicate as an indication as three pastures had the incorrect inoculant applied. Plants were dug up and roots visually ranked on nodulation using a reference scale provided by Murdoch University.

Table 4 Estimated Nodulation from One Replicate September 2014

Very Good	**Good**	**Poor**
Margarita Serradella Eliza Serradella	Bartolo Bladder Clover Dalkeith Sub Clover Prima Gland Clover	Casbah Biserrula Scimitar Medic

4.1.6 Twin Sowing to Establish Pasture

A barley crop was seeded in 2014 with serradella seed mixed in with the crop seed. The regeneration pasture in 2015 was a mix of volunteer barley and serradella. The Serradella was sparse with low numbers in 2015 hence the low and variable dry matter weights at both pasture cuts, see appendix 12.

Although the plants while only low density at six to seven plants per 10 metre square by October 2015, they were large, vining and well podded. However, early pasture cuts in June showed low growth in the Serradella at the start of the season at 155kg/ha dry matter.

The plants that did establish well in 2015 were adequately podded and this plot was not grazed or harvested. By 2016 the twin sown serradella plot had 11 plants at the start of the season in May as compared to the seeded serradella plots with over 200 plants.

The nodulation in 2015 was assessed on 15 plants collected from the Twin sown Serradella plots. Nodulation was moderate to very low with large fluctuations in samples. The rating scale and results are listed in appendix 13, as 1 being low nodulation, 5 moderate and 8 the highest at extremely abundant.

4.1.7 Harvest Assessment with Open Front Header and Pasture Yields

A conventional open front harvester John Deere S680 with a 40 ft draper front with finger reel harvested the pastures in 2016. The harvest was done to gauge height and ability to feed into the header front with no seed yield recordings due to frosted pastures. Bartolo had spread into nearly all plots to some degree. Serradella plants and Prima gland had also ventured into other plots but only in low numbers.

Neil Ballard inspected the site on 14 October 2016 and frost had impacted all pasture species. Bladder clover had frosted flowers but the lower flowers underneath appeared unaffected. Pod weights were taken and then seed was thrashed and recorded as a clean seed weight. All pastures had their yields affected, except the Dalkeith sub clover, Scimitar medic and control plot which was Dalkeith dominant.

The Dalkeith seeded plot had exceptional yield which could be attributed to a sub clover base to the paddock in addition to the seed set in 2014 and 2016. The seed collection yields had high variability (403kg/ha $lsd_{>0.95}$) so there were no significant differences between ALOSCA and Nodulator. Low seed yield from the frost event made it difficult to assess the impact of the nodulation treatments. There were no pods present on the Eliza Serradella plants despite there being a good ground cover, showing it is highly sensitive to frost.

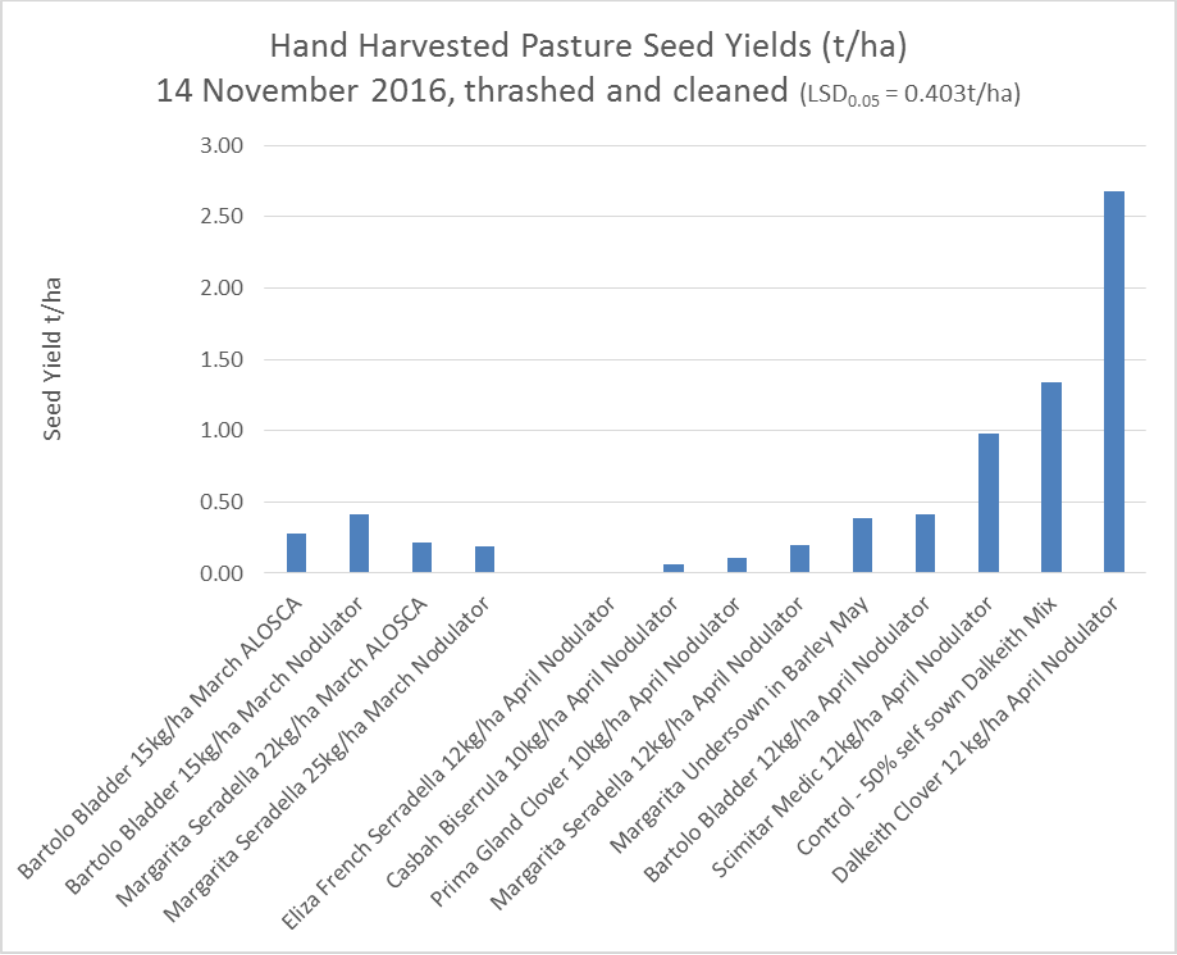


Fig. 18 Pasture Seed Yields (t/ha) 2016 after Establishment in 2014 then barley crop in 2015 with pastures impacted by frost in September and October 2016

4.2 Extension and communication

Date	Activity	Number of people
June 2014	**Pasture field day walk held 20 June 2014** - Feedback forms completed - All participants keen to attend in September to see growth levels between species. - Under sowing hard seeded varieties was of interest to the group - Bartolo and Margarita growth rates were commented as the stand outs. - The growers were impressed by the germination and growth rates to date - Visual demonstration on pasture cuts to equate FOO was beneficial although half of the group had done pasture cuts previously with Lifetime Ewe Management	20 producers attended plus 5 industry, DAFWA x 1, Landmark x 3, Paul Omodei. - Email distribution list utilised for invite and project variety listing sent to 23 email addresses inviting over 38 individuals. - Advertised in the Nyabing News with MLA logo to local farming region.

Sept 2014	**Spring Field Walk Completed 17 Sept 2014**
	- Field Walk in conjunction with NFIG day
	- MLA approval sort for flyer
	- Feedback:
	  - One of the most impressive pasture stands and trials
	  - Nitrogen fixation learnings were key feature
	  - Growers would be trying some Bartolo and Serradella next year
	  - Weed control options were important in adopting these varieties
		- 52 attended morning session at trial site, with 27 producers and industry people
		- 60 emails sent to producers
		- Advertising in the Nyabing News and Pingrup Post
		- Bulk community email to all residents in the Shire of Kent

July 2015	Tour at Pasture Demo with Paul Omodei and Alana Starkie Share N findings from soil sampling and discuss pasture strategies. Good opportunity to establish how many tissue tests and what growers wanted to understand, N differences between ALOSCA and Nodulator. Low attendance with spraying and sheep work in the area.	10 people attended. 35 people were emailed. Text messages also sent 1 week prior and 1 day prior.
Feb 2016	Newsletter published in Nyabing News No presentation night held as no harvest data until processed in May	110 distributed

June 2016	Morning Field Walk 8 June 2016 hosted by Paul Omodei	Local farmers invited via email, twitter from NFIG president. Advertising locally. Low attendance 12
July 2016	Drone fly over for Media Production with Paul Omodei. Difficulty with audio	4 farmers and film crew
September 2016	Tour over Pasture Regeneration – Neil Ballard - Handouts provided to those that attended with 2014, 2015 and 2016 data. Neil Ballard presented and discussed practical information on managing and establishing pastures. Focus on harvestability and setup.	Local and surrounding groups/farmers invited. 15 growers and 2 presenters. A large number could not attend due to spraying and shearing time of year.
March 2017	Final Wrap Up Presentation – Braden Johnston PowerPoint photo presentation to growers on findings for 3 yrs and pasture program on their farm - Bartolo adopted in their system - Some issues with herbicide brew - Just purchased 3 clover seed harvesters to collect sub clover seed	14 growers and David Pfieffer Synergy Consultant
April 2017	Grower Case Study prepared for publication, but not released	Farm Weekly Fairfax Media

The spring field day in 2014 was the most successful event and well attended. On the basis of the feedback forms and the comments discussed on the day the pasture trial was impressive and was likely to result in new pasture species adoption in the area.

In June 2015 a field walk was held to discuss the soil carryover Nitrogen with growers. Consultant Paul Omodei met with the group and attendance was low. There was no spring field walk held as visually only the barley crop was covering the plots and majority of discussion would come after crop yield results.

In the final pasture regeneration year in 2016, Neil Ballard focused on legume pasture traits, their regeneration at the site and overall system suitability. The discussion also centred on the practicalities in conventional harvester setup to harvest aerial seeded pastures. Management issues in relation to weed control and insect control were also discussed.

Neil emphasised as a key part to introducing a new legume species was building a seed bank and stressed the importance on timing in returning a paddock back to a crop sequence following pasture establishment. Year one was to treat the pasture as a crop with attention to agronomy and ensure a strong stand and only short tactical grazing times. After first year establishment a grain crop could be grown but it was important to return the paddock back to pasture in year 3 for hard seeded

species. Generally in establishing hard seeded pastures 2 seed sets should be targeted within 3 years of establishment. (Pers Comm N Ballard 2016)

Cropping rotations with hard seeded varieties such as serradella, medic gland and sub clover are responsive to good regeneration if allowed to return to pasture seed set 1 in 3 years. Biserrula seed can remain a lot longer under a cropping phase (up to 5 years) before returning to its pasture. It is thought that Bartolo will persist longer but this has yet to be determined (Pers Comm N Ballard 2016).

Handouts provided to growers showed that the higher growth species in 2014 added more N into the system and a trend (not significant) to yield improvement in the subsequent barley crop.

Fig. 19 Drone Image 20 July 2016, with dark green strip on left Dalkeith Sub Clover.

Fig. 20 Pasture Field Walk September 2014 Nyabing

4.3 Participant reactions

Grower to grower learning is a key driver in adoption, so having a Producer Research Site was a hands on visual aid for information delivery on new pastures and strategies. A key success was how well the pastures established under a high rainfall year in 2014. Due to the impressive stands this research site fast became a talking point. Having key speakers at the first pasture field day well received by growers. A survey showed that knowledge gain had lifted and growers were willing to adopt.

On the basis of the feedback and the comments discussed on the day the pasture trial was impressive and was likely to result in new pasture species adoption in the area.

Growers were presented with an evaluation form for the day to gauge the knowledge and skills after the field day and their willingness to act on the information provided. Grower's names were recorded for all field days.

The speakers were ranked on scale of 1 to 5 (1 = poor) and Paul Omodei ranked highest, followed by Braden Johnston. This highlighted that farmers enjoy learning from farmer stories and experiences.

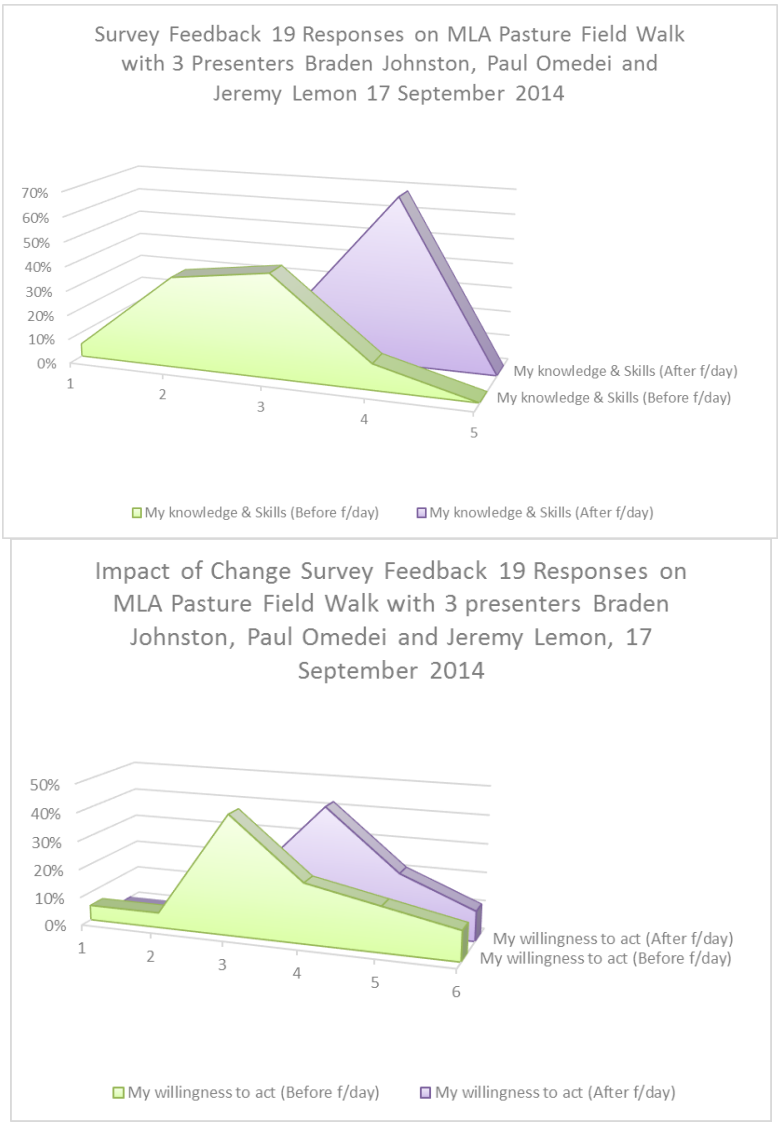


Fig 21. Survey Results on Knowledge and Skills and Willingness to Act before and after Field Day 2014

Braden Johnston found Bartolo looked to perform well on his farm and handles grazing pressure. As mostly a meat producer with early lambing, Braden strives for growing higher density pastures. The farm currently has good clovers, mostly Dalkeith and some medic. Braden has been introducing Bartolo Bladder clover and while it had many positive attributes Bartolo was frosted and broadleaf weed control was difficult without damaging the clover plants.

Given the frost impact on Bartolo, Braden has purchased three clover harvesters to linkup and source his own sub clover seed. In 2017 Braden collected pasture seeds and burr from 10ha Dalkeith and 5ha Bartolo using the clover harvester. This was contrasting to what the expectation was to harvest Bartolo with an open front header. Having raked the Bartolo in the summer into windrows and having difficulty collected the windrows due to stones with the John Deere grain harvester, Braden decided to use the clover harvester which vacuums the seeds from the ground. Braden commented that the clover harvester was more successful at collecting Bartolo in 2017 but under the right conditions he would try the John Deere header again for direct harvest.

Six growers in the area directly harvested with open front headers in 2016. In 2014 there were no growers that had harvested aerial seeded varieties.

A few growers are under sowing pastures with cereals but with various objectives. In some cases oats are mixed with sub clover and seeded to provide an early feed option as the cereal while the legume is establishing and growing underneath. Other growers are strategically grazing crops that are early sown on opportunistic rains, then sheep are removed and crop is taken through to grain harvest.

Machinery investment into pastures has most notably changed with the use of open front headers to harvest pasture seed and disc openers for sowing pastures on existing bar or a dedicated pasture disc seeder.

According to Nyabing AgServices Tanya Germain (pers comm 2017) they have recently taken orders for biserrula and inoculant. She commented that while inoculant sales were up this year it was also due to a larger legume crop area.

4.4 Producer Research Site Program

There were wide aims of the research to look at the value of the new legume pasture species and the time of sowing. The group focused on management impact on time of sowing and comparing different inoculant products. The 'value' was also associated with management practices such as lower cost ways to harvest and plant pasture seed. The value was also assessed as to the growth production.

Some technical sampling aspects were altered during in the research project with the main modification to the research being the intensity of nodulation assessment. Given the incorrect inoculants were applied it was decided to focus on nodulation differences between ALOSCA and Nodulator.

In 2014 the seed yield was not determined through sampling which would have been more appropriate given there was no frost in 2014 opposed to 2016.

In 2014 there were some preliminary herbicide strips to see what weed control might be evident however this was purely visual and not documented due to unregistered mixes.

5 Discussion

Growers in the Nyabing Farm Improvement Group are around 60-70% cropping and the legume pasture base can be depleted and growers haven't looked to unlock the potential in the past.

The value of the research has been to lift the legume percentage in pastures in the surrounding district. The research site with the new pasture legumes hit home on the density that could be achieved in re-establishing pastures. The site was impressive in both 2014 and 2016 and growers looked to this site as a new benchmark in what pastures could achieve.

Dry sowing pastures worked effectively in the research site. By year 3 the dry sown Bartolo and Serradella pasture stands were comparable to the April sowing times in biomass however plant density was lower initally. The Nodulator and ALOSCA products performed similar on both Bartolo and Serradella.

Frost severely impacted seed set in 2016 across all the aerial seeded varieties. For this environment where pastures are deemed to be 'frost proof' part of the system, this could be a limiting factor in adoption of aerial seeded varieties despite their growth.

The site was grazed by stock in 2014 and 2016 but only at restricted times earlier in the season. Therefore these pastures have not been subjected to a full season grazing pressure. Within the site preferential grazing was not visually evident.

5.1 Outcomes in achieving objectives

5.1.1 Outcomes vs Objectives

Project objective	Outcome
1. Established the value of alternative legumes and their appropriate sowing times for the Nyabing district.	New pasture legumes performed well over the first year of establishment and in third year regeneration. Sowing times dry in March vs April were similar with due to late break to season end April 2014 Using scarified seed in April to had promote germination as compared to unscarified seed in March, did show a difference in pasture biomass in first year. In the third year the biomass was similar between scarified and unscarified but lower plant numbers. VALUE: Better pasture production through earlier sowing adoption in the Nyabing area
2. Determined the value of alternative legumes for adding nitrogen to soil.	• Nitrogen measured from the whole tops pastures indicated higher kg N/ha with dense crops such as Bartolo, Sub Clover and Prima Gland as compared to control. • Nitrogen was monitored and higher t/ha pastures in 2014 contributed to crop N in 2015 Barley yields were increased with the additional N available but only significant above control plot, but trend showed lower barley yields on medic and biserrula pasture plots in 2014 VALUE: Producers have linked better pasture density to more N contribution to the soil and subsequent cereal crop benefit
• Determine the success in under sowing (twin sowing) pod Margarita in 2014 with the 2014 barley and its ability to establish as a regenerative pasture in 2015	Twin sowing Serradella with barley was a compromise on seeding depth. While it did not establish well in 2014, by 2015 there were a scattering of plants (approx. 6 per 10m2) which provided around 300kg/ha feed with Serradella only. Numbers at the start of the 3rd year season were very low, however the Serradella by late in the season provided similar t/ha to the seed sown in 2014.

	There is likely a winner and a loser on seeding depth unless sowing similar seed size, ie canola. VALUE: Undersowing could be an acceptable low cost way to introduce a pasture into the system, however lower pasture growth in first few years is the compromise.
• Determine the pasture regeneration after 1 year of cereal cropping.	With 3 good seasons over the duration of the site, pastures regenerated well. Eliza Serradella was the only pasture to fail to re-establish in 2016. The most prolific seed producers were Prima Gland and Bartolo. VALUE: Hardseeded varieties demonstrated good regeneration numbers and growth following a cereal phase which enables growers to have a crop follow the setup pasture year.
• Determine ability to harvest aerial seeded pasture with open front header	Frost impacted aerial seeded pastures Slow process but seed could be harvested VALUE: Aerial seeded varieties offer a lower cost harvest option and collection during the November December period.

5.1.2 Issues with achieving objectives

Frost in the final year hampered seed collection and assessing how well the direct harvesting pastures could have been achieved.

The trial design was not robust and a biometrican should have been involved in the setup and randomisation. There were multiple aims incorporated into the trial which amounts to large data sets. The project plan includes so many activities that didn't always relate to the core aim, but rather secondary aims. If each plot was sampled for all activities the cost of project would exceed the budget. This trial work was good value for the number of facets that were incorporated.

5.1.3 Benefits to Producers

Pasture establishment has become a topically focus in the area, which is combined with the surge in lamb prices over $100 per head and 21 micron wool over 1000c/kg greasy.

In respect to MLA Producer Research Site the end result for practice change and benefit has been:

- Investment into machinery to seed pastures
- Variety adoption
- ALOSCA for inoculating
- Early sowing times
- Harvest of aerial seeded varieties
- Under sowing pastures with cereals

While some practice change may be due to outside influences, it has been noted that growers who have been in high percentage cropping rotations are taking on pasture renovation.

Early season breaks are treated with caution for risk on failure however as cropping has increased on dry sowing, so too has pasture in the district. Growers are using ALOSCA to inoculant with dry sowing. Grower Trenton Browne commented that "ALOSCA is suitable for dry situations, however if rain likely in 10 days then Nodulator is the preferred strategy".

Inoculation was a key part that growers will look to improve. This happened by default in respect to the same Group C Nodulator over all the species which was not suited to Serradella, Biserrula or Medic. However it was also evident that while a paddock hasn't grown that species before inoculant can travel in the wind (Pers Comm Howieson 2014). The biserrula despite having its wrong inoculant group had adequate growth in one plot and it was established at a nearby farm had previously grown biserrula so inoculant may have found its way in the prevailing winds. Serradella also had the wrong inoculant group but the paddock had grown lupins in the past which would have provided a rhizobial base for nitrogen fixing bacteria.

Growing additional nitrogen with pastures could be costed against response to N in the crop yields, however the yields were not statistically significant at the 95% confidence interval. The barley crop did yield an additional 420kg/ha between the highest Serradella and control (not significant), however with additional N on the control plot this did not increase yield to level of the Serradella. Therefore another interaction could be influencing the control plot such as phosphorus.

A key practice change was the adoption of pasture varieties that could be harvested with a conventional open front header. Harvest variable costs are estimated at $43/ha for direct heading Serradella compared to $200/ha for sub clover. This was based on two growers situations last year, however yields estimated on account that the Serradella was frosted. The efficiency rate is 11 times faster direct harvesting. The cost difference mostly for fuel and more so labour (see appendix 8). The seed cost per ha equates to serradella at half the cost of Dalkeith.

Feedback on harvesting aerial seeded varieties was that it could be achieved, however paddock selection important with high fire risk and header damage. The harvest experience from growers would have adopted Bartolo and Serradella was that it was 'slow going'. Crop lifters were used by some growers and not others. Serradella harvested after harvest had experienced pod shedding and with harvest rains and flattened the stand.

Establishing dense pastures acts as ground cover and competition to weeds. Growers could consider pasture legumes as cover crops offering weed competition and the use of non-selective chemicals.

Benefits	Disadvantages
Use existing header	High risk damage to header front on low cutting
No intensive labour in Feb/March period for sub clover harvesting	Pastures need harvesting early which conflicts with grain harvest
Ground is not exposed to wind erosion like sub clover harvesting	Higher fire risk with low cutting height
Additional labour already on farm at harvest time	
Faster process than clover harvester	

Table 5: Summary on Benefits and Disadvantages to Aerial Legume Pasture Harvest with Conventional Harvester compared to Clover Harvester

Braden Johnston had fitted his DBS Ausplow seeding bar with Disca-Mate (discs) onto the front of the bar to enable minimal disturbance when seeding pastures. Having used this to establish pastures other growers also learnt the value in minimal soil disturbance in trying to conserve moisture to establish pastures early. Three other growers have now invested in discs to establish pastures.

One of the growers in the group was actively undergoing a large pasture regeneration program and was using Bartolo Bladder Clover which gave confidence to other growers on scaling up a new variety. However since the frost event, this grower is now focussed on Prima Gland.

5.2 Promotion of research results and its effectiveness

The extension methods for local growers would be considered moderately successful as group delivery as growers won't typically read a large report or technical paper. Summary information was provided at each field day.

Wider extension on the research is limited to date, given that the project had a three year timeframe and final statistics not completed until March 2017. Following MLA approval of final report, the case study and information clip presentation can be extended beyond the local growers. MLA could assist with it's communication team

Extension could have been improved by tweeting burst of information on key points, however this could conflict MLA's policy. Facebook has not been used for the Nyabing Farm Improvement Group but again could have been a powerful means to update growers with photos of nodules, close ups on what new species look like and harvesting in action with short film clip. It is intended that the short film clip made will be tweeted by NFIG President and also put on NFIG website.

A media session was organised with Paul Omodei and a local farmer with a drone and camera crew aimed to collect background information on the trial achievements. Due to technical difficulty this has not been compiled to date.

The learning approach was based on the "see, do, get" principle by showing farmers what was able to be done at the research site then a few took the idea and then evaluated for themselves.

The local research work has had a direct impact on new varieties other than sub clover being adopted. The scale of adoption is estimated at 2000ha across seven growers. The work has probably highlighted at the existing dominant sub clover Dalkeith is well suited this environment and comparable on feed value. Growers have seen dense, bulky pastures offering feed values up to 5t/ha and now highly motivated to achieve more with their pastures.

Barriers to change were that the hard seeded nature and longevity of varieties still not fully determined after only three years trialling the varieties. Some growers were averse to using open front headers being so low to the ground to harvest aerial seeded varieties, but the use of an older second hand open front header just for pastures was discussed as an option.

5.3 Effectiveness of the participatory research process

Producers were largely captivated by the expanse of the research site with 30 plots and with good rainfall and pasture stands were very impressive in 2014. Presenters at field days were highly knowledgeable in their field and this was important to complement the host producer talking about their findings and background to the research. Growers took different aspects away from the research site due to speakers discussing various issues from Nitrogen, pasture establishment and variety traits.

"There are so many growers talking about this pasture site. I haven't heard so much discussion on pasture establishment and varieties in years." (T Browne pers comm 2017)
When the field walks were timed in with other events also on the same day, for example a spray group meeting and then a pasture information session, attendance was higher. Times of year varied on workloads with shearing in late September limiting attendance in 2016.

Nyabing Farm Improvement Group now has around 21 business members with most having 2 individuals to the business. Communications were directed at these members within a 50km radius of the site. For the larger field day in September 2014 wider advertising was undertaken to Dumbleyung, Kukerin and Pingrup.

While growers were interested in seeing pasture cuts and physically completing a demonstration cut, they were not keen to donate their time to do cuts over the whole trial.

The Participatory Research Process held some merits for growers being able to drive the research topic that was relevant to the area. The onsite field walks were able to promote discussion on which aspects could be focused on like the nitrogen impact from pastures. Growers needed to prioritise what the research questions were when deciding on sample intensity to remain within the budget.

The sharing of ideas and having an industry consultant at the site walks was the key value in groups involvement with the producer site. Ben Sutherland a mixed farmer located east of Nyabing found

the site and the field walk information sessions were “helpful in understanding the N fixing and N contribution from pastures”.

It was noted that growers liked the idea of seeing some of the establishment systems like twin sowing in a trial opposed to trying large areas on their own farm.

5.4 Future Research

Research gaps are in frost tolerance of aerial seeded pastures compared to less risk with sub clovers.

The future research predominately centres on grower feedback that suggests that new legume pasture adoption is limited by weed control options. This could be investigated as cultural, mechanical or herbicide. Herbicide tolerance packages to control broadleaf weeds turnip, radish, and capeweed would result in greater adoption of serradellas which are proving suitable on lighter soil types in the Great Southern. The acceptable level of damage to pastures must be balanced with building the pasture seed bank in the paddock.

Future research could be focused on spatial analysis to quantify pasture differences at high resolution. Current image capture at high resolution is available however the price is cost prohibitive. Potentially drone images could be more cost effective if fitted with correct cameras to do spatial variance. This would be valuable in 2017 as the paddock is going to remain a pasture.

It was suggested in a grower feedback session to develop a Self-Propelled Clover Harvester to increase efficiency in harvested sub clover burr.

6 Conclusions/ Key Messages /Recommendations

6.1 Key Messages

- The key learnings were that pasture quality and composition have been underachieving and the research site set a high benchmark.
    - Dalkeith sub clover appears to be a robust pasture species that offers comparable feed value and nitrogen contribution which will challenge the adoption of new varieties.
    - Bartolo Bladder Clover, Margarita Serradella, Dalkeith sub clover, Scimitar Medic and Prima Gland regenerated with good early numbers and biomass in year 3.
    - Eliza Serradella is soft seeded and regenerated poorly in the third year compared to Margarita Serradella.
    - Margarita for sandy country has been taken up by growers.
    - Bartolo was looking good as an alternative with growers adopting, however less tolerant of herbicides.

- There was a consistent trend that higher biomass pastures contributed to higher soil N, plant tissue N and slightly increased barley crop yields, however this trend was not significant.

- The correct inoculant is particularly important on some newer pastures which have not previously been grown.
- The use of ALOSCA and Nodulator on Serradella and Bartolo performed similar under dry sowing.
- Dry sowing early using pod seed for Serradella and unscarified Bartolo bladder clover regenerated adequate pastures by the third year, but less growth in establishment year.
- Twin sowing pastures with a crop could be a viable establishment option, however plant density was low.
- Frost impacted all pasture species except Dalkeith sub clover and Scimitar Medic which could limit the adoption of aerial seeded varieties in the Great Southern Region in WA.
- Harvesting with a conventional header was not as easy as anticipated but more economical than clover harvester.

6.2 Conclusion

The past three years have had excellent starts to the season with no false breaks and good rainfall years to assess the potential for the new legume pastures species in the Nyabing area.

The site has been exceptionally managed and there were little variance in data from insect or weed pressure. Frost however was a detriment to the seed yields in the final year.

The trial work was well supported by the Nyabing Farm Improvement Group members and group delivery was effective as evidenced by grower adoption of Bartolo and Margarita now growing in the area.

6.3 Recommendations

Bartolo Bladder Clover, Margarita Serradella and Prima Gland Clover offer a good fit for growers looking to grow their own seed, direct harvest and improve legume pasture percentage in the Great Southern. These varieties are susceptible to frost and growers concerned about frost risk should exercise caution.

The project has highlighted that new legume pasture species do have a fit into the Great Southern Area and offer a high feed base in dry matter production and carry over nitrogen benefits for subsequent cereal crops. Dalkeith sub clover when sown and well managed is still a top performer.

Dry sowing pod and unscarified Margarita and Bartolo can result in pasture yields comparable to scarified seed but with lower plant density grazing duration could be an issue.

Growers need to check soil type suitability before establishing new legume pastures given that the site was a pH 5.6 site.

A key challenge for adopting these new varieties is the development and extension of weed control options.

Producer research sites offer tremendous value in growers evidencing first hand on a large scale the change impact and allows them to visually assess practices.

7 Appendix

7.1 Photos

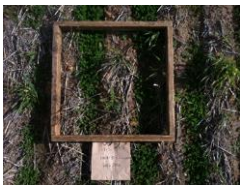
Appendix: 1 Photo from Field Walk 2 July 2015 – New Legume Species in Farming Systems. First year barley crop following pastures.

Appendix 2: Pasture Trial Site discussing conventional harvest of aerial seeded pastures and nodulation

Appendix 3: Pasture stand at Nyabing Producer Research Site Site WA September 2016

Appendix 4. Prima Gland and Eliza French Serradella 3rd year after establishment September 2016 Nyabing WA.

Appendix 5: Treatment Compiled Pasture photos 20 June 2014 0.5m x 0.5m square.

Bartolo Bladder Colver 12kg Seed + 5kg Nodulator	2		13		24	
Scimitar Medic 12kg Seed + 5kg Nodulator	3		14		25	
Casbah Biserrulla 12kg seed + 5kg Nodulator	4		15		26	
Prima Gland Clover 10kg Seed + 5kg Nodulator	5		16		27	
Eliza French Serradella 12kg Seed + 5kg Nodulator	6		17		28	
Margarita Serradella 12kg Seed + 5kg Nodulator	7		18		29	
Dalkeith Sub Clover 12kg Seed + 5kg Nodulator	12				30	
						0

Appendix 5 cont: Treatment Compiled Pasture photos 20 June 2014 0.5m x 0.5m square

Margarita Serredella 22kg Pod + Alosca 10kg/ha	8		19	
Margarita Serredella 25kg/ha Pod + Nodulator	9		20	
Bartolo Bladder Clover 15kg Seed + 10kg/ha Alosca	10		21	
Bartolo Bladder Clover 15kg Seed + 5kg/ha Nodulator	11		22	

Appendix 6: Plot Map

Fence

Gate

N

450m Long

Kuringrup North Road

Plot No	Sowing Date	Variety and Form	Seeding and Innoculant Rate
Buffer	May-27	Margarita Pod with Barley	25kg Pod + 5kg Nodulator
1	May-27	Margarita Pod with Barley	25kg Pod + 5kg Nodulator
2	Apr-17	Bartolo Bladder Clover	12kg/ha Seed + 5kg/ha Nodulator
3	Apr-17	Scimitar Medic	12kg/ha Seed + 5kg/ha Nodulator
4	Apr-17	Casbah Biserrulla	10kg/ha Seed + 5kg/ha Nodulator
5	Apr-17	Prima Gland Clover	10kg/ha Seed + 5kg/ha Nodulator
6	Apr-17	Eliza French Serredella	12kg/ha Seed + 5kg/ha Nodulator
7	Apr-17	Margarita Serredella	12kg/ha Seed + 5kg/ha Nodulator
8	Mar-13	Margarita Serredella Aloscoa	22kg/ha Pod + 10kg/ha Alsoca
9	Mar-13	Margarita Serredella Nodulator	25kg Pod + 5kg Nodulator
10	Mar-13	Bartolo Bladder Clover Alosca	15kg Seed + 10kg/ha Alsoca
11	Mar-13	Bartolo Bladder Clover Nodulator	15kg/ha Seed + 5kg/ha Nodulator
12	Apr-17	Dalkeith Sub Clover	12kg/ha Seed + 5kg/ha Nodulator
13	Apr-17	Bartolo Bladder Clover	12kg/ha Seed + 5kg/ha Nodulator
14	Apr-17	Scimitar Medic	12kg/ha Seed + 5kg/ha Nodulator
15	Apr-17	Casbah Biserrulla	10kg/ha Seed + 5kg/ha Nodulator
16	Apr-17	Prima Gland Clover	10kg/ha Seed + 5kg/ha Nodulator
17	Apr-17	Eliza French Serredella	12kg/ha Seed + 5kg/ha Nodulator
18	Apr-17	Margarita Serredella	12kg/ha Seed + 5kg/ha Nodulator
19	Mar-13	Margarita Serredella Aloscoa	22kg/ha Pod + 10kg/ha Alsoca
20	Mar-13	Margarita Serredella Nodulator	25kg Pod + 5kg Nodulator
21	Mar-13	Bartolo Bladder Clover Alosca	15kg Seed + 10kg/ha Alsoca
22	Mar-13	Bartolo Bladder Clover Nodulator	15kg/ha Seed + 5kg/ha Nodulator
23	Apr-17	Control	
24	Apr-17	Bartolo Bladder Clover	12kg/ha Seed + 5kg/ha Nodulator
25	Apr-17	Scimitar Medic	12kg/ha Seed + 5kg/ha Nodulator
26	Apr-17	Casbah Biserrulla	10kg/ha Seed + 5kg/ha Nodulator
27	Apr-17	Prima Gland Clover	10kg/ha Seed + 5kg/ha Nodulator
28	Apr-17	Eliza French Serredella	12kg/ha Seed + 5kg/ha Nodulator
29	Apr-17	Margarita Serredella	12kg/ha Seed + 5kg/ha Nodulator
30	Apr-17	Dalkeith Sub Clover	12kg/ha Seed + 5kg/ha Nodulator

7.2 Harvest Comparison Methods

Appendix 7: GRDC Weather Station Nyabing on Johnston's

	Year		
	2016	2015	2014
Jan	33.4	1	1
Feb	1	31.8	0
Mar	63	32.6	13.2
Apr	51.2	41.4	24.8
May	37.8	26.2	72.2
Jun	40.8	49.4	21.4
Jul	25.4	41.4	73
Aug	69.2	39.2	53.6
Sep	29	7.6	43.6
Oct	9.2	7.6	62
Nov	14.8	44	63.4
Dec	26.6	25.8	1.4
YTD	**401.4**	**348**	**429.6**

Appendix 8: Comparison on Harvest Cost with Direct Harvest using Open Front Header as Compared to Sub Clover Harvester

	Serradella Direct Harvest	**Sub Clover Clover Harvestor**
Machine Source *	MF9560	JD 8260R
Fuel L/hr	60	35
Ha/hr	4	0.35
Fuel L/ha Harvest (Tractor pulling/direct harvest)	15	100
Fuel $/ha Scarifying x2	-	10
Dessication spray prior to harvest	20	-
Labour $/hr	35	35
Labour $ /ha	8.75	100
Total Operation Cost $/ha	43.75	210
Yield Averages **	350kg	500kg
Harvest cost $/kg seed	0.13	0.41

* Nyabing Growers Ben Hobley Serradella Dec 2016 and Braden Johnston Clover Harvest I

** Yield Averages estimate only not actual yield due to frost on Serradella

Appendix 9: Harvest Notes on Direct Heading Pastures.

Pasture Variety	2014			2016				
	Harvest Rating Aerial seeded 0= not possible, 1= difficult, 5=easy	Height (cm)	Notes on Direct Harvestability	Height (cm)	Direct Harvest with John Deere S680	2016 December Harvest Observations with John Deere Header		
						Pickup	Feeding	Seed Collection
Margarita Pod with Barley	3	30	Fallen to the ground and sparse	12	Yes	Ok	Ok	Small amount
Bartolo Bladder Clover	3	10	Lodged	5	Yes	Ok	Ok	Frosted
Prima Gland Clover	4	20	Lodged and clumpy	20	Yes	Good	Fluffy	Frosted
Eliza French Serredella	5	15	Long vines and some flat spots	12	Yes	Ok	Ok	Nil
Margarita Serredella	4	15	" "	12	Yes	Ok	Ok	Small amount
Scimitar Medic	0	5	Too low to harvest	2	No	*Too low for direct harvest*		
Casbah Biserrulla	2	10	Pods held in the air still	2	No			

Appendix 10: Summary of Selected N Soil Test to 60cm depth in 2015

Treatment	Plots			Pasture Biomass 2014
Margarita Under sown to Barley 2014	1	n/a	n/a	Low
Control (Dalkeith, Nungarin lower density)	23	n/a	n/a	Medium
Scimitar Medic	3	14	25	Medium
Bartolo Bladder Clover	2	13	24	High
Margarita Serradella	7	18	29	High
Prima Gland	5	16	27	High
Dalkeith	12	30	n/a	High

Appendix 11: Dry Weights (kg/ha) in Twin Sown Serradella plot 1 established as pod Serradella seeded at 25kg/ha (plus Nodulator 5 kg/ha) seeded with a barley crop in 2014, sampled as a regenerative pasture in 2015 at 24 June and 10 October 2015.

	Sample Cuts Dry weight (kg/ha)					Pasture Dry
24 June 2015	1	2	3	4	n/a	Weight kg/ha
Serredella	324	0	27	270		**155**
Other (volunteer barley)	495	558	1143	864		**765**
					Total	**920**
10 October 2015 - Podding	1	2	3	4	5	**Pasture Dry Weight kg/ha**
Serredella	788	288	52	246	157	**306**

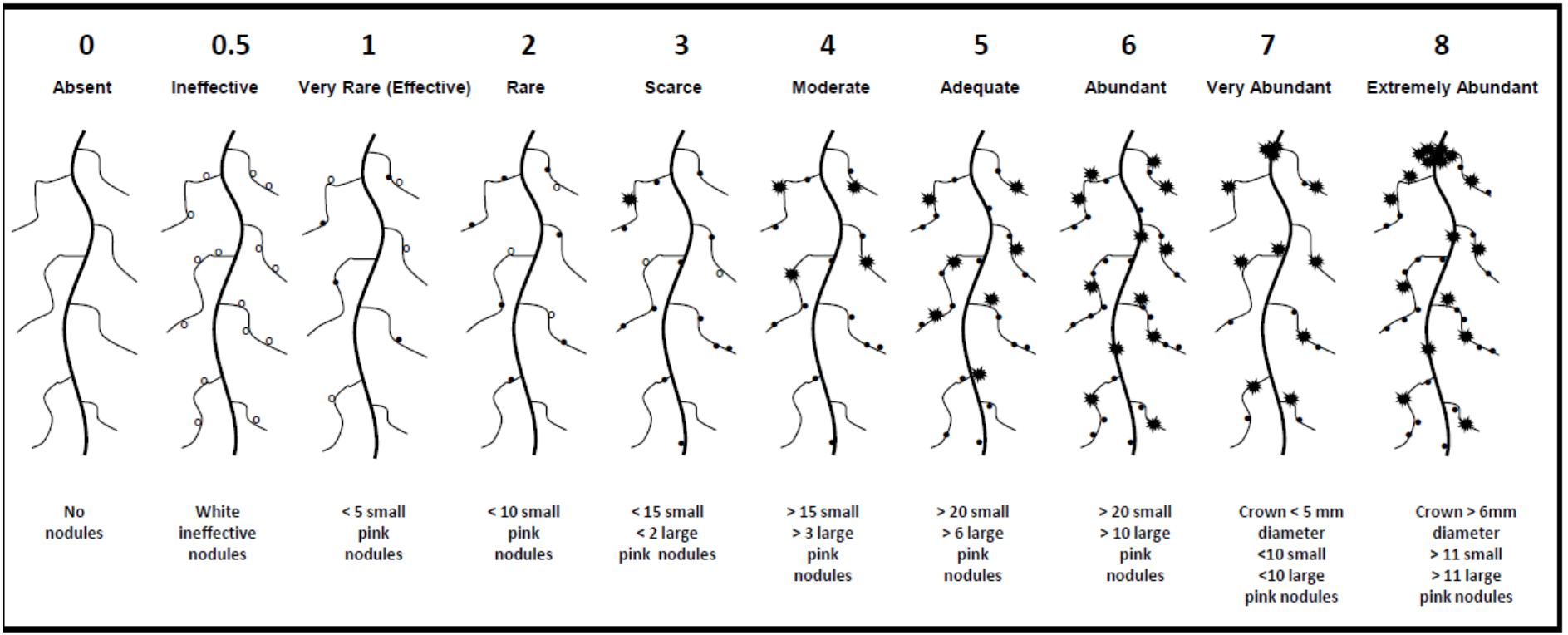
Appendix 12: Nodulation in Twin Sown Serradella

Plant Sample	Area 1	Area 2	Area 3	Area 4
1	7	4	3	7
2	5	4	2	7
3	3	4	2	4
4	5	6	5	6
5	6	5	4	6
6	3	4	4	3
7	2	6	5	3
8	4	3	4	3
9	6	3	3	4
10	3	2	6	3
11	3	3	2	1
12	4	7	1	2
13	7	2	4	2
14	7	2	1	2
15	2	2	2	2
Nodulation Avg	4.47	3.80	3.20	3.67
SD	*1.81*	*1.61*	*1.52*	*1.95*
SE	*0.47*	*0.42*	*0.39*	*0.50*

** Analysis done by courtesy Tom Edwards Murdoch University*

7.3 Nodulation Reference

Appendix 13: Nodulation Reference Sheet



Source: Murdoch University

Appendix 14: Statistical Analysis by Murdoch University Tom Edwards 2014

Samples collected Nyabing
Scored 7/10/2014

Species	Plot	Rep	No. of plants	TDW (kG)	Average TDW per plant (g)	Nodule average	Nodule score tally 0	0.5	1	2	3	4	5	6	7	8	Nod total
Bladder Clover	10	1	9	0.064	7.11	5.889							3	4	2		53
Bladder Clover	10	2	13	0.05	3.85	4.231			1	2		3	5	1	1		55
Bladder Clover	10	3	15	0.056	3.73	4.200					5	5	3	1	1		63
Bladder Clover	10	4	16	0.056	3.50	3.500			2	3	2	5	2	2			56
Bladder Clover	11	1	9	0.036	4.00	5.889							3	4	2		53
Bladder Clover	11	2	12	0.062	5.17	4.750			2			1	4	4	1		57
Bladder Clover	11	3	11	0.05	4.55	4.727					1	5	1	4			52
Bladder Clover	11	4	12	0.052	4.33	4.250				2	2	2	4	1	1		51
Bladder Clover	21	1	11	0.052	4.73	5.091			1	1	1	1		4	2	1	56
Bladder Clover	21	2	14	0.048	3.43	4.571				2	2	3	2	3	2		64
Bladder Clover	21	3	10	0.042	4.20	4.200				2	1	3	2	1	1		42
Bladder Clover	21	4	10	0.038	3.80	4.300				2	1	1	4	2			43
Bladder Clover	22	1	8	0.032	4.00	5.000				1		1	2	4			40
Bladder Clover	22	2	15	0.056	3.73	5.600				1		1	5	4	3	1	84
Bladder Clover	22	3	18	0.046	2.56	4.722				2	2	4	5	2	2	1	85
Bladder Clover	22	4	12	0.05	4.17	5.500				1	1	1	3	3		3	66
				TDW (kg)			**0**	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Serradella	8	1	11	0.042	3.82	3.636				2	4	2	2	1			40
Serradella	8	2	12	0.062	5.17	4.750				1	1	3	2	5			57
Serradella	8	3	12	0.026	2.17	3.583				3	5	2		1		1	43
Serradella	8	4	11	0.054	4.91	4.364			1	2	1	1	2	3		1	48
Serradella	9	1	15	0.022	1.47	3.133				6	4	3	1	1			47
Serradella	9	2	15	0.032	2.13	3.867				4	4	1	2	4			58
Serradella	9	3	9	0.032	3.56	5.667					2	1	1	1	2	2	51
Serradella	9	4	16	0.038	2.38	4.313				4	2	1	4	4	1		69
Serradella	19	1	11	0.024	2.18	3.636			1		5	2	2	1			40
Serradella	19	2	10	0.026	2.60	3.900			1	1	2	3	1	1	1		39
Serradella	19	3	8	0.04	5.00	5.000					2	1		5			40
Serradella	19	4	10	0.046	4.60	5.200				1	2			6		1	52
Serradella	20	1	25	0.026	1.04	2.400	1		7	6	8		2		1		60
Serradella	20	2	19	0.036	1.89	2.579			5	4	6	2	2				49
Serradella	20	3	18	0.04	2.22	2.333			9	1	3	4		1			42
Serradella	20	4	14	0.038	2.71	3.786			1	3	1	5	2	1	1		53

Serradella

Tests of Between-Subjects Effects					
Dependent Variable: Average_weight					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.354a	3	3.785	2.965	0.075
Intercept	143.101	1	143.101	112.108	0
Innoculant	10.644	1	10.644	8.339	0.014
Block	0.71	1	0.71	0.556	0.47
Innoculant * Block	6.25E-06	1	6.25E-06	0	0.998
Error	15.318	12	1.276		
Total	169.773	16			
Corrected Total	26.671	15			
a R Squared = .426 (Adjusted R Squared = .282)					

Bartolo

Tests of Between-Subjects Effects					
Dependent Variable: Average_weight					
Source	Type III Sum of Squar	df	Mean Square	F	Sig.
Corrected Model	2.338a	3	0.779	0.775	0.53
Intercept	279.391	1	279.391	277.954	0
Block	1.974	1	1.974	1.964	0.186
Inoculant	0.212	1	0.212	0.211	0.655
Block * Inoculant	0.152	1	0.152	0.151	0.704
Error	12.062	12	1.005		
Total	293.791	16			
Corrected Total	14.4	15			
a R Squared = .162 (Adjusted R Squared = -.047)					

Tests of Between-Subjects Effects					
Dependent Variable: Average_NodScore					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.814a	3	2.271	3.584	0.047
Intercept	241.391	1	241.391	380.873	0
Innoculant	2.243	1	2.243	3.539	0.084
Block	1.254	1	1.254	1.978	0.185
Innoculant * Block	3.317	1	3.317	5.234	0.041
Error	7.605	12	0.634		
Total	255.81	16			
Corrected Total	14.419	15			
a R Squared = .473 (Adjusted R Squared = .341)					

Tests of Between-Subjects Effects					
Dependent Variable: Average_nod_rating					
Source	Type III Sum of Squar	df	Mean Square	F	Sig.
Corrected Model	1.437a	3	0.479	1.039	0.41
Intercept	365.001	1	365.001	791.66	0
Block	0.15	1	0.15	0.325	0.579
Inoculant	1.241	1	1.241	2.692	0.127
Block * Inoculant	0.047	1	0.047	0.101	0.756
Error	5.533	12	0.461		
Total	371.971	16			
Corrected Total	6.97	15			
a R Squared = .206 (Adjusted R Squared = .008)					

Appendix 15: Initial Soil Test 2014

NUlogic

PC, WL & BJ Johnston - 28 Feb 2014 - Soil - 2014

ANALYSIS RESULTS	NFIG LEGUME TRIAL	NFIG LEGUME TRIAL	NFIG LEGUME TRIAL	NFIG LEGUME TRIAL	NFIG LEGUME TRIAL	NFIG LEGUME TRIAL
Paddock Name	A	B	C	D	E	F
Paddock Section	0-10	0-10	0-10	0-10	0-10	0-10
Sample Depth (cm)	Loam	Loam	Loam	Loam	Loam	Loam
Soil texture	Brown Grey	Grey Brown	Brown	Grey	Grey	Dark Grey
Soil colour	5	5	5	5	5	0
Gravel (%)	5.5	5.7	5.4	5.4	5.6	5.6
pH (1:5 CaCl2)	6.2	6.2	5.9	6.1	6.2	6.2
pH (1:5 H2O)	0.08	0.07	0.06	0.05	0.05	0.12
EC (1:5 H2O) dS/m	1.59	1.53	1.70	1.89	1.31	1.72
Organic carbon (Walkley Black) %	10	10	10	12	11	9
Nitrate nitrogen (KCl) mg/kg	7	3	4	5	2	3
Ammonium nitrogen (KCl) mg/kg	38	29	42	36	22	31
Phosphorus (Colwell) mg/kg	35	34	38	37	29	27
Phosphorus Buffer Index (PBI)	218	234	183	172	171	250
Potassium (Colwell) mg/kg	7.5	6.7	12.4	7.7	5.5	14.9
Sulfur (KCl-40) (mg/kg)						

7.4 Statistical Analysis Tables

Appendix 16:

MLA Pasture Trial Nyabing - Pasture Yield - wet matter (2014), dry matter (2014 and 2016) and seed yield (2016)

No.	Treatment	pasture 20/07/2014 WM kg/ha	pasture 20/07/2014 DM kg/ha	pasture 20/07/2014 WM kg/ha	pasture 20/07/2014 DM kg/ha	pasture 23/09/2014 WM t/ha	pasture 23/09/2014 DM t/ha	barley 21/07/2015 vigour 1-5	pasture 21/07/2015 count /m2	pasture 9/05/2016 count /m2	pasture 20/09/2016 total DM t/ha	pasture 20/09/2016 2014 Pasture t/ha	pasture 20/09/2016 other sps DM t/ha	pasture 20/09/2016 seed yield t/ha
				xcluding Trt 7 contro										
1	Bartolo Bladder 15kg/ha March ALOSCA	358.1 b	66.9 bcd	415 a	78.4 a	19.7 ab	3.5 b	3.5 cde	2 a	433 abc	2.84 a	2.67 a	0.165 a	0.28 cd
2	Bartolo Bladder 15kg/ha March Nodulator	290.68 b	55.7 cd	348 a	67.2 a	18.1 ab	3.37 b	4.5 bcd	5 a	329 cd	2.43 a	1.69 a	0.74 a	0.41 c
3	Margurita Serradella 22kg/ha March ALOSCA	300.33 b	48.9 d	358 a	60.4 a	16.7 ab	2.71 bc	4.0 b-e	8 a	208 ef	2.41 a	0.9 a	1.505 a	0.22 cd
4	Margurita Serradella 25kg/ha March Nodulator	332.5 b	63 bcd	390 a	74.6 a	17.4 ab	2.81 bc	4.0 b-e	8 a	130 fg	2.14 a	1.115 a	1.025 a	0.19 cd
5	Bartolo Bladder 12kg/ha April Nodulator	421.52 ab	81.1 a-d	422 a	81.1 a	24.7 a	4.18 ab	4.7 bc	4 a	474 ab	1.79 a	1.47 a	0.32 a	0.41 c
6	Casbah Biserrula 10kg/ha April Nodulator	297.33 b	64.8 bcd	297 a	64.8 a	5.36 c	1.63 cd	3.3 de	7 a	125 fg	2.77 a	1.023 a	1.757 a	0.06 cd
7	Control - 50% self sown Dalkeith Mix	0 c	0 e	0	0	12.6 bc	2.79 bc	3.0 e	3 a	289 de	1.63 a	1.63 a	0 a	1.34 b
8	Dalkeith Clover 12 kg/ha April Nodulator	398.68 ab	111 a	456 a	123 a	23.2 a	4.1 ab	4.5 bcd	12 a	539 a	1.6 a	0.965 a	0.625 a	2.68 a
9	Eliza French Serradella 12kg/ha April Nodulator	412.27 ab	74.2 a-d	412 a	74.2 a	22.6 ab	3.69 ab	4.0 b-e	5 a	39 gh	2.66 a	0.747 a	1.913 a	0.00 d
10	Margurita Serradella 12kg/ha April Nodulator	597.05 a	104 ab	597 a	104 a	24.5 a	3.57 ab	5.0 ab	2 a	261 de	2.12 a	0.727 a	1.387 a	0.20 cd
11	Prima Gland Clover 10kg/ha April Nodulator	451.12 ab	92.5 abc	451 a	92.5 a	24.1 a	5.1 a	3.7 cde	77 a	400 bc	2.35 a	1.347 a	1.003 a	0.11 cd
12	Schimitar Medic 12kg/ha April Nodulator	409.93 ab	91.4 a-d	410 a	91.4 a	2.85 c	0.79 d	3.3 de	11 a	246 de	2.31 a	1.41 a	0.893 a	0.98 b
37	Margurita Undersown in Barley May								3	11	2.56	1.53	1.03	
LSD P=.05		**213.096**	**42.613**	**181.758**	**36.233**	**10.048**	**1.555**	**1.23**	**41.9**	**110.83**	**1.523**	**1.0144**	**1.7285**	**0.403**
Standard Deviation		**122.446**	**24.486**	**104.439**	**20.82**	**5.774**	**0.894**	**0.7**	**24.08**	**63.68**	**0.875**	**0.5829**	**0.9932**	**0.231**
CV		**34.42**	**34.42**	**25.21**	**25.13**	**32.71**	**28.06**	**17.11**	**215.62**	**23.77**	**38.43**	**44**	**104.44**	**40.45**
Replicate F		**2.32**	**2.27**	**10.52**	**10.642**	**2.062**	**2.014**	**0.737**	**0.524**	**0.358**	**1.595**	**0.142**	**0.966**	**2.019**
Replicate Prob(F)		**0.1324**	**0.1376**	**0.0014**	**0.0013**	**0.1617**	**0.168**	**0.4951**	**0.6027**	**0.7047**	**0.2355**	**0.8687**	**0.4029**	**0.1673**
Treatment F		**3.955**	**4.363**	**1.608**	**2.399**	**4.861**	**5.027**	**4.045**	**2.058**	**20.151**	**0.652**	**2.387**	**1.054**	**33.248**
Treatment Prob(F)		**0.0077**	**0.0048**	**0.1964**	**0.0613**	**0.0028**	**0.0024**	**0.0063**	**0.0938**	**0.0001**	**0.7694**	**0.057**	**0.454**	**0.0001**

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Appendix 17:

MLA Pasture Trial Nyabing - Pasture Yield - wet matter (2014), dry matter (2014 and 2016) and seed yield (2016)

No.	Treatment	pasture 23/09/2014 WM t/ha	pasture 23/09/2014 DM t/ha	barley 21/07/2015 vigour 1-5	pasture 21/07/2015 count /m2	pasture 9/05/2016 count /m2	pasture 20/09/2016 total DM t/ha	pasture 20/09/2016 2014 sps DM t/ha	pasture 20/09/2016 other sps DM t/ha	pasture 20/09/2016 seed yield t/ha
1	Bartolo Bladder 15kg/ha March ALOSCA	19.7 a	3.5 a	3.5 a	2.0 a	433 a	2.84 a	2.67 a	0.165 a	0.28 a
2	Bartolo Bladder 15kg/ha March Nodulator	18.1 a	3.37 a	4.5 a	5.0 a	329 ab	2.43 a	1.69 a	0.74 a	0.41 a
3	Margurita Serradella 22kg/ha March ALOSCA	16.7 a	2.71 a	4 a	7.5 a	208 bc	2.41 a	0.9 a	1.505 a	0.22 a
4	Margurita Serradella 25kg/ha March Nodulator	17.4 a	2.81 a	4 a	8.0 a	130 cd	2.14 a	1.115 a	1.025 a	0.19 a
LSD P=.05		**8.643**	**1.431**	**1.3**	**9.26**	**143.42**	**1.574**	**1.6681**	**1.8948**	**0.438**
Standard Deviation		**2.716**	**0.45**	**0.41**	**2.91**	**45.07**	**0.495**	**0.5242**	**0.5954**	**0.138**
CV		**15.1**	**14.54**	**10.21**	**51.7**	**20.28**	**20.16**	**32.89**	**69.33**	**50.28**
Replicate F		**0.946**	**2.162**	**3**	**5.335**	**0.078**	**2.023**	**1.269**	**0.03**	**0.053**
Replicate Prob(F)		**0.4025**	**0.2378**	**0.1817**	**0.1041**	**0.7982**	**0.2501**	**0.342**	**0.8742**	**0.832**
Treatment F		**0.438**	**1.534**	**2**	**1.788**	**26.895**	**0.671**	**4.557**	**1.769**	**1.033**
Treatment Prob(F)		**0.7422**	**0.3669**	**0.2918**	**0.3225**	**0.011**	**0.6246**	**0.1224**	**0.3255**	**0.4895**

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Appendix 18:

MLA Pasture Trial Nyabing - Soil Nutrient Analysis - pre-sowing barley 2015

No.	Treatment	24/04/2015 organic C % 0-10	24/04/2015 Ammonia mg/kg 0-10	10-20	20-30	30-60	24/04/2015 Nitrate mg/kg 0-10	10-20	20-30	30-60	24/04/2015 Ammonia + Nitrate mg/kg 0-10	10-20	20-30	30-60	24/04/2015 N kg/ha 0-10	10-20	20-30	30-60
1	Bartolo Bladder 15kg/ha March ALOSCA																	
2	Bartolo Bladder 15kg/ha March Nodulator																	
3	Margurita Serradella 22kg/ha March ALOSCA																	
4	Margurita Serradella 25kg/ha March Nodulator																	
5	Bartolo Bladder 12kg/ha April Nodulator	1.63 a	3 a	1 a	1 a	1 a	28 a	9 a	4 a	4 a	31 a	10 a	5 a	4 a	47 a	14 a	7 a	7 a
6	Casbah Biserrula 10kg/ha April Nodulator																	
7	Control - 50% self sown Dalkeith Mix	1.66 a	3 a	2 a	1 a	1 a	24 a	3 a	3 a	2 a	27 a	5 a	4 a	3 a	41 a	8 a	5 a	5 a
8	Dalkeith Clover 12 kg/ha April Nodulator	1.69 a	5 a	2 a	1 a	1 a	27 a	11 a	3 a	3 a	32 a	13 a	4 a	3 a	47 a	20 a	6 a	5 a
9	Eliza French Serradella 12kg/ha April Nodulator																	
10	Margurita Serradella 12kg/ha April Nodulator	1.82 a	6 a	2 a	1 a	1 a	33 a	10 a	6 a	4 a	40 a	12 a	7 a	5 a	60 a	19 a	10 a	8 a
11	Prima Gland Clover 10kg/ha April Nodulator	1.74 a	2 a	2 a	1 a	1 a	49 a	9 a	5 a	4 a	51 a	11 a	7 a	5 a	77 a	17 a	10 a	7 a
12	Schimitar Medic 12kg/ha April Nodulator	1.54 a	5 a	1 a	1 a	1 a	22 a	4 a	4 a	3 a	26 a	6 a	5 a	4 a	40 a	8 a	7 a	6 a
37	Margurita Undersown in Barley May	1.5	4	1	1	1	39	2	2	1	43	3	3	2	65	5	4	2
LSD P=.05		**0.421**	**5.49**	**1.32**	**1.05**	**0.88**	**32.7**	**7.2**	**3.33**	**2.57**	**33.25**	**7.13**	**3.77**	**2.68**	**49.88**	**10.7**	**5.656**	**4.013**
Standard Deviation		**0.218**	**2.85**	**0.68**	**0.55**	**0.45**	**16.93**	**3.73**	**1.72**	**1.33**	**17.22**	**3.69**	**1.95**	**1.39**	**25.83**	**5.54**	**2.93**	**2.078**
CV		**13.17**	**71.13**	**43.44**	**64.54**	**53.67**	**53.52**	**54**	**45.21**	**47.83**	**48.32**	**43.58**	**41.96**	**38.16**	**48.32**	**43.58**	**41.96**	**38.16**
Replicate F		**0.763**	**0.494**	**0.077**	**0.91**	**2.878**	**1.164**	**1.247**	**0.209**	**0.02**	**0.963**	**1.179**	**0.296**	**0.308**	**0.963**	**1.179**	**0.296**	**0.308**
Replicate Prob(F)		**0.5015**	**0.63**	**0.927**	**0.445**	**0.122**	**0.366**	**0.344**	**0.817**	**0.98**	**0.427**	**0.362**	**0.753**	**0.744**	**0.427**	**0.362**	**0.753**	**0.744**
Treatment F		**0.779**	**0.769**	**1.899**	**0.943**	**1.162**	**0.945**	**2.946**	**1.755**	**1.951**	**0.853**	**3.434**	**1.785**	**2.22**	**0.853**	**3.434**	**1.785**	**2.22**
Treatment Prob(F)		**0.6117**	**0.618**	**0.21**	**0.52**	**0.419**	**0.519**	**0.092**	**0.239**	**0.201**	**0.569**	**0.066**	**0.233**	**0.16**	**0.569**	**0.066**	**0.233**	**0.16**

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Appendix 19:

MLA Pasture Trial Nyabing - Barley Leaf Nitrogen and Grain Yield 2015

No.	Treatment	barley 13/07/2015 Leaf N %		barley 1/12/2015 yield t/ha	
TABLE OF R MEANS					
Replicate 1		3.78		4.09	
Replicate 2		3.58		4.07	
Replicate 3		3.50		4.04	
TABLE OF A (FlexiN 2015) MEANS					
1	0 L/ha	3.32	c	4.02	a
2	70 L/ha	3.82	a	4.06	a
3	140 L/ha	3.71	b	4.12	a
LSD P=.05		**0.101**		**0.112**	
Standard Deviation		**0.213**		**0.235**	
CV		**5.883**		**5.788**	
TABLE OF B (Variety/SowingRate+Date/SeedTrt) MEANS					
1	Bartolo Bladder 15kg/ha March ALOSCA	3.61	bc	4.07	a
2	Bartolo Bladder 15kg/ha March Nodulator	3.78	ab	4.05	a
3	Margurita Serradella 22kg/ha March ALOSCA	3.65	ab	4.16	a
4	Margurita Serradella 25kg/ha March Nodulator	3.80	ab	4.12	a
5	Bartolo Bladder 12kg/ha April Nodulator	3.63	ab	4.16	a
6	Casbah Biserrula 10kg/ha April Nodulator	3.42	cd	3.99	a
7	Control - 50% self sown Dalkeith Mix	3.32	d	3.68	b
8	Dalkeith Clover 12 kg/ha April Nodulator	3.61	bc	4.13	a
9	Eliza French Serradella 12kg/ha April Nodulator	3.76	ab	4.17	a
10	Margurita Serradella 12kg/ha April Nodulator	3.81	a	4.18	a
11	Prima Gland Clover 10kg/ha April Nodulator	3.64	ab	4.11	a
12	Schimitar Medic 12kg/ha April Nodulator	3.39	d	4.01	a
LSD P=.05		**0.202**		**0.223**	
Standard Deviation		**0.213**		**0.235**	
CV		**5.883**		**5.788**	

Appendix 20

Treatment	Barley Yield t/ha 01/12/2015		
UAN Rate	**0L/ha**	**70L/ha**	**140L/ha**
Bartolo Bladder 15kg/ha March ALOSCA	4.00 a	3.92 a	4.28 a
Bartolo Bladder 15kg/ha March Nodulator	3.99 a	4.03 a	4.15 a
Margarita Seradella 22kg/ha March ALOSCA	4.15 a	4.05 a	4.27 a
Margarita Seradella 25kg/ha March Nodulator	4.14 a	3.93 a	4.31 a
Bartolo Bladder 12kg/ha April Nodulator	4.15 a	4.15 a	4.17 a
Casbah Biserrula 10kg/ha April Nodulator	3.89 a	4.05 a	4.01 a
Control - 50% self sown Dalkeith Mix	3.72 a	3.81 a	3.51 a
Dalkeith Clover 12 kg/ha April Nodulator	3.97 a	4.12 a	4.30 a
Eliza French Seradella 12kg/ha April Nodulator	4.14 a	4.22 a	4.14 a
Margarita Seradella 12kg/ha April Nodulator	4.14 a	4.16 a	4.22 a
Prima Gland Clover 10kg/ha April Nodulator	4.05 a	4.21 a	4.06 a
Schimitar Medic 12kg/ha April Nodulator	3.91 a	4.05 a	4.07 a
LSD P=.05	**0.392**		
Comp. Trt. LSD	**0.386**		
Standard Deviation	**0.238**		
CV	**5.86**		
Replicate F	**0.446**		
Replicate Prob(F)	**0.643**		
Treatment F	**1.439**		
Treatment Prob(F)	**0.1242**		

Appendix 21

MLA Pasture Trial Nyabing - Barley Leaf Nitrogen and Grain Yield 2015

No.	Treatment	FlexiN	barley 13/07/2015 Leaf N %		barley 1/12/2015 yield t/ha	
1	Bartolo Bladder 15kg/ha March ALOSCA	0 L/ha	3.26	e	4.00	a
2	Bartolo Bladder 15kg/ha March Nodulator	0 L/ha	3.37	de	3.99	a
3	Margurita Serradella 22kg/ha March ALOSCA	0 L/ha	3.34	de	4.15	a
4	Margurita Serradella 25kg/ha March Nodulator	0 L/ha	3.48	cde	4.14	a
13	Bartolo Bladder 15kg/ha March ALOSCA	70 L/ha	3.90	ab	3.92	a
14	Bartolo Bladder 15kg/ha March Nodulator	70 L/ha	4.08	a	4.03	a
15	Margurita Serradella 22kg/ha March ALOSCA	70 L/ha	3.79	abc	4.05	a
16	Margurita Serradella 25kg/ha March Nodulator	70 L/ha	3.92	ab	3.93	a
25	Bartolo Bladder 15kg/ha March ALOSCA	140 L/ha	3.68	bcd	4.28	a
26	Bartolo Bladder 15kg/ha March Nodulator	140 L/ha	3.90	ab	4.15	a
27	Margurita Serradella 22kg/ha March ALOSCA	140 L/ha	3.83	ab	4.27	a
28	Margurita Serradella 25kg/ha March Nodulator	140 L/ha	4.01	ab	4.31	a
LSD			**0.347**		**0.513**	
Standard Deviation			**0.153**		**0.227**	
CV			**4.13**		**5.54**	
Replicate F			**8.752**		**0.331**	
Replicate Prob(F)			**0.016**		**0.5789**	
Treatment F			**6.791**		**0.714**	
Treatment Prob(F)			**0.0038**		**0.7055**	

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.