Breeding lucerne for southern Australian cropping districts

**PROJECT DETAILS**

**PROJECT CODE:** DAS347

**PROJECT TITLE:** BREEDING LUCERNE FOR SOUTHERN AUSTRALIAN CROPPING DISTRICTS

**START DATE:** 01.01.2002

**END DATE:** 30.06.2007

**SUPERVISOR:** DR ALAN HUMPHRIES

**ORGANISATION:** SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT CORPORATION (SARDI)

**CONTACT NAME:** ALAN HUMPHRIES

**Summary**

This lucerne breeding project focused on developing improved lucerne varieties for southern Australian environments in rotation with winter cereals. Lucerne is a deep-rooted perennial pasture legume that reduces ground water recharge and the associated effects of dryland salinity. Lucerne has never been developed for broad acre farming, and thus had a major downside in requiring careful rotational grazing management for good production and persistence, a difficult task in 100 hectare paddocks. This project developed a grazing tolerant lucerne variety that can be more easily managed in large paddocks by growers.

**Report Disclaimer**

This document has been prepared in good faith on the basis of information available at the date of publication without any independent verification. Grains Research & Development Corporation (GRDC) does not guarantee or warrant the accuracy, reliability, completeness or currency of the information in this publication nor its usefulness in achieving any purpose. Readers are responsible for assessing the relevance and accuracy of the content of this publication. GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on information in this publication. Products may be identified by proprietary or trade names to help readers identify particular types of products but this is not, and is not intended to be, an endorsement or recommendation of any product or manufacturer referred to.
Other products may perform as well or better than those specifically referred to. Check www.apvma.gov.au and select product registrations listed in PUBCRIS for current information relating to product registration.

Copyright
Grains Research and Development Corporation. This publication is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced in any form without written permission from the GRDC.

Old or Archival Reports (Projects that concluded in 2007 or earlier)
The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions
A grazing tolerant variety was developed using two cycles of selection for continuous grazing tolerance from trials in South Australia (SA) and Western Australia (WA). The resulting lucerne variety is expected to be much more tolerant to persistent sheep grazing than existing commercial varieties. Heritage Seeds Pty. Ltd. was successful in the open tender and has secured the rights to distribute and sell seed of the variety.

Advanced breeders’ lines of highly winter active lucerne were developed for potential future release. These lines display improved persistence on the acidic soils in WA than the best commercial option, SARDI Ten\(^\text{P}\). The lines will be further refined before being either directly released or integrated into a more broadly adapted variety.

Recommendations
The results of this research have confirmed that winter active and highly winter active lucernes are well suited to monocultures in phase rotations of 2-4 years. Highly winter active lucerne was generally less persistent than winter active lucerne across the regional evaluation sites, but was still able to produce higher yields at Katanning, WA because of its greater winter production. SARDI Ten\(^\text{P}\) repeatedly outperformed other winter active and highly winter active varieties in regional field trials.

Winter active varieties, such as the South Australian Research and Development Institute (SARDI) grazing tolerant variety, should be recommended for phases of lucerne in rotation with cereals where strict rotational grazing management (i.e. 1-2 weeks grazing followed by 4-6 weeks recovery) is not able to be practised. The intention (to be confirmed) is for the SARDI grazing tolerant variety to be managed with 3-6 weeks grazing followed by 4-6 weeks recovery.

Highly winter active varieties, such as SARDI Ten, should be recommended for phases of lucerne in rotation with cereals where strict rotational grazing can be practised. These varieties are able to produce the highest potential yield in southern Australia due to the winter dominant rainfall pattern.

Outcomes
The development and release of a new grazing tolerant variety will result in extended areas sown to lucerne in previously unadapted environments and expanded areas cultivated with lucerne within the current regions. This will result in the following economic, environmental and social outcomes:

Economic outcomes
Increased grain production in southern Australia through the inclusion of lucerne varieties developed specifically for rotation with grain crops. The grazing tolerant variety is the first lucerne to be released in Australia that was developed for broad acre cropping systems where the inability of growers to manage grazing pressure results in poor adoption of the species. The inclusion of lucerne in rotation with cereal crops has been widely shown to increase grain yield and quality through; 1) slow
release of nitrogen (N) from decaying lucerne roots, providing a benefit to following crops in the next 2-5 years, depending on soil type and mineralisation rates, 2) improvements in root growth and rooting depth of wheat crops following lucerne from bio-pore channels left by decaying roots, 3) reductions in grass weeds through non-specific herbicide options in the lucerne phase of the rotation, and 4) reductions in cereal diseases.

A lucerne phase is a diversification and risk management tool for grain growers, given its ability to produce out of season forage following summer rainfall. This provides growers with an income in years often severely affected by a winter drought.

Environmental outcomes
An increase in the area of lucerne sown in Australia will greatly reduce deep water drainage that leads to ground water recharge, resulting in dryland salinity and eutrophication of ground and surface water bodies.

The provision of new varieties will be responsible for increased adoption of this perennial species, which is clearly required if lucerne is to have a significant wide-scale environmental impact.

Social outcomes
The economic and environmental benefits of including lucerne into dryland farming systems will increase the sustainability and resilience of the cropping enterprise in southern Australia, keeping families and businesses on the land.

There are major savings to social infrastructure costs associated with reducing dryland salinity, including reducing the cost of pumping saline groundwater from beneath buildings, and maintenance of roads. The visible aspects of dryland salinity i.e. dead trees and barren wasteland could be responsible for the deterioration of morale among country people.

Achievements/Benefits
Lucerne has been identified as the most promising herbaceous perennial to mitigate the effects of dryland salinity, one of the most important and challenging problems facing land managers. The capacity derives from the ability of its deep root system to use a high proportion of the rainfall, and of the plant to respond quickly to rainfall whenever it falls throughout the year.

Lucerne is a major pasture plant in Australia, currently being grown over 3.2 million hectares (Mha), although a further 27Mha also has the capacity for lucerne production.

The prospects for lucerne in Australia are discussed by Robertson (2006, ‘Lucerne Prospects’). Ultimately, economic factors will be responsible for driving the uptake of lucerne in Australia, namely the recovery of the livestock industry and the capacity of grain growers to focus on long-term ‘whole farm’ economic and sustainable options. Successful integration of lucerne into cropping systems requires growers to maximise the benefits of lucerne. One major benefit is its year round ability to produce quality forage.

One of the greatest barriers to lucerne adoption is its perceived difficulty to manage grazing to maximise the benefit of the available feed. Broad acre growers have large paddocks and little infrastructure required for rotational grazing (electric fences, water points, etc.). However, lucerne is a pasture that traditionally requires strict rotational grazing (recommendations are based on 1-2 weeks grazing followed by 4-6 weeks recovery).

New variety release
The greatest achievement of this project was the release of a variety that is more tolerant to grazing. This is important because it breaks down this barrier to adoption. While details of ‘best management practice’ still need to be developed, observations suggest this variety will be productive and persistent with a 1:1 rotation, or 4-6 weeks grazing followed by a similar recovery period. This reduces the number of paddocks required to grow lucerne from six to two. Benefits to the industry are clear, and include improved grain and livestock production, diversification of crops and industries, risk management and resilience of the industry to withstand seasons with low and variable rainfall patterns, and environmental sustainability through more efficient use of water.

Germplasm development
In addition to releasing a grazing tolerant variety, there are a number of other outcomes resulting directly from this research:

· An extensive period of trialling lucerne across a range of environments in SA and WA provided information on the performance of existing varieties, and a basis for selecting improved germplasm in the development of future varieties.

· 161 breeders’ lines with improved adaptation to the low-medium rainfall environments in SA and WA were developed.
Advanced highly winter active germplasm was developed with the potential for future release. The material is currently being further refined to increase its marketability over existing highly winter active varieties (namely SARDI Ten$^\text{(*)}$) currently used in this environment.

Direct involvement in the collection, characterisation and seed multiplication of lucerne genetic resources, including over 1,000 accessions in the past nine years, and new collections from Kazakhstan and Azerbaijan.

Acid tolerance
This material may have improved tolerance to acidic soils and needs further evaluation. This goal will be supported with existing research to develop a matching acid-tolerant rhizobia (Cooperative Research Centre (CRC) Salinity).

A hydroponic system at pH 4.5 with 3$\mu$M Al was used to measure regrowth root length (RRL) to indicate relative aluminium (Al) stress in a range of germplasm. Plants with a high RRL were selected and combined to form new populations more tolerant to Al stress. The results of a diallel analysis suggested a complex genetic nature and expression of Al tolerance. The existence of significant general combining ability (GCA) variance in RRL may also suggest the feasibility of improving Al tolerance through enhanced root regrowth using phenotypic recurrent mass selection to pyramid desirable Al-tolerant genes, focusing on parental lines and elite individual plants expressing long regrowth roots.

The project has undertaken a range of soil pot studies to quantify levels of improvement in acidic soils. The results showed that germplasm selected under field conditions in WA had improved root growth in soils not high in Al.

Farming systems
Research into the potential applications of winter dormant lucerne in Australian farming systems.

Research into overcropping lucerne with wheat by Humphries and Latta et al. investigated the potential of sowing wheat into lucerne with a range of winter activity levels. Very winter dormant germplasm has potential for use in an over-cropping farming system, where annual crops are sown each year into a permanent base of lucerne. The lucerne is dormant during winter and hence less competitive with crops during its growing season.

Over-cropping experiments at Roseworthy, SA and Katanning, WA showed a lower grain yield penalty in two out of four combined seasons from over-cropping winter dormant lucerne in comparison to more winter active varieties. Winter dormant lucerne had the same effect of reducing soil water content to buffer against deep drainage and subsequent ground water recharge. Preliminary evaluation of winter dormant germplasm has shown that it is possible to select low spring yielding lines, which may have reduced competition at this time.

Continuous grazing experiments showed that winter dormant lucerne germplasm is very grazing tolerant. A lucerne for over-cropping would also have to be very persistent, to reduce the number of times the lucerne had to be re-sown. The regional evaluation trials have shown that this material is at least as persistent as winter active germplasm over the four years of grower managed field trials, with new material from Azerbaijan expected to add even greater drought tolerance and persistence in hostile environments.

Scientific knowledge and training

- Contribution to new scientific knowledge on lucerne selection and breeding, resulting in the publication of seven journal papers, six refereed conference publications and a large number of technical publications.

- Training of several research and technical staff, including Alan Humphries, Xianguang Zhang, Ben Ward, Steve Rudd (SA), and Kathi Davies, Darryl McClements, Chris Matthews and Tom Bailey (WA).

- The completion of a PhD from Alan Humphries (submitted in September 2007), supported through research in this project.

Other research

Further research should be directed to determine if the improved grazing tolerance of this new variety will allow a two-paddock rotation (approx. 35 days grazing, followed by 35 days recovery) to be used without adverse effects on plant survival, pasture and animal production. This management could replace the strict rotational grazing management of 7-14 days grazing, followed by approx. 35 days recovery, which is recommended for current varieties. Greater adoption of lucerne in phase rotations with cereal crops can then be expected as there are no requirements for additional fencing or intensive sheep management.
Very winter dormant lucerne germplasm has potential for use in an over-cropping farming system (where annual crops are sown each year into a permanent base of lucerne) or as a summer active component of a pasture mixture in low-high rainfall environments. The lucerne is dormant during winter and hence less competitive with annual crop or pasture species during their growing season. In herbage yield trials, the winter dormant sub-species were shown to be as productive as conventional lucernes over spring and summer. Improved drought and grazing tolerant accessions collected from Azerbaijan are now held at SARDI Genetic Resources Centre and offer a great incentive for further research with this germplasm.

**Intellectual property summary**

The grazing tolerant variety will be protected by Plant Breeder’s Rights (PBR) and intellectual property (IP) will be shared in accordance with the equity determined for this project, which is 44% SARDI, 40% GRDC and 16% Department of Food and Agriculture WA (DAFWA).

**Additional information**


