Constraints to greater use of pulses and forage legumes on acid soils of the high rainfall zone of south-eastern Australia - focus groups and a farmer survey

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Abstract
Reliability of legume rotation options on low pH soils of the high rainfall zone (HRZ) of south-eastern Australia needs improvement. This report summarises results from the consultation phase of a project that aims to provide farmers and advisors with information to improve the "performance" of legume species under local environments and improve understanding of rotational benefits these species can provide to the farming system. Data collected from a farmer survey, focus meetings and interviews were used to describe the current role of pulses and legume forage crops and pastures in farming systems, to identify factors limiting their adoption in the HRZ and to guide research priorities. Results revealed 77% of surveyed farmers sow legume species on part of their main cropping area annually. Of these 65% sow pulse crops for grain, 11% grow these species as 'manure' crops, 37% sow legumes for hay or silage and 74% sow a legume-based pasture for grazing. The process identified opportunities to expand legume use through improved technology, including strategies to avoid weed seed bank build up; tolerance to the HRZ environment; nodulation of legume species, including adaptation of rhizobia strains; disease resistance of pulses; understanding of the role for micro-nutrients; and optimisation of yield and nitrogen fixation and guidelines for more accurate nitrogen budgeting. Quantification of the benefits of legume species to the farming system is needed. Agronomic, financial and climatic factors should be considered along with a comparison of crop sequence options, particularly those incorporating legume species into the dominant cereal/canola system.

Introduction
Extensive agricultural production in the high rainfall zone (HRZ) is dominated by mixed farming systems. Ewing and Flugge (2004) reported a shift from livestock dominant systems and the development of "a more diversified production system based around an increased proportion of cropping", driven by innovation and economic signals. MacEwan et al (2010) reported further expansion of cropping in the HRZ of south-eastern Australia in response to economic and climatic drivers.

Cropping area in the HRZ has expanded significantly since the early 1990s, particularly in southern Victoria where, for example, from 1995 to 2010 the area sown to grain crops increased 600% in the Ararat and Golden Fields Local Government Area of south-western Victoria (SW VIC) (Burns 2015). However, HRZ cropping systems are dominated by cereals and canola. Riffkin and Thrall (2013) considered that lack of diversity and reliance on fertiliser nitrogen (N) is likely to negatively impact on the long-term economic and environmental sustainability of current broadacre cropping systems of the HRZ.

There is a need for profitable legume rotation options on low pH soils of the HRZ, but research, development and extension (RD&E) investment has focused on the medium and lower rainfall zones. A Grains Research and Development Corporation (GRDC) funded project is supporting investigations by NSW Department of Primary Industries (DPI) into the role of legume crops and pastures in building the resilience of HRZ cropping systems, specifically through reduced reliance on fertiliser N; improved management of herbicide resistance; and improved integration of pastures and forage crops in cropping systems.

The preliminary phase of this project involved consultation with famers and other stakeholders to: (i) benchmark the current use and role of legume species in cropping systems; (ii) assist in identifying factors limiting adoption of legume crops and pastures and implementation of effective crop sequence management in the HRZ; and (iii) identify research priorities.

Methods
The regions targeted for the GRDC project were those with a long-term average annual rainfall of above 550-600 mm in southern NSW and north-east Victoria (VIC), and above 450-500 mm in the south-east of South

Australia (SA)-VIC Border, SW VIC and Gippsland regions and in Tasmania (TAS). Regions of altitude above approximately 500 m and those with topsoils of pH above 6.0 ($CaCl_2$) in were not included in the study.

Baseline data gathered from farmers, private and public sector advisors, consultants and technical specialists were used to describe the current role of legume crops and pastures in farming systems on the acid soils of the HRZ of south-eastern Australia. The approach involved three activities: (i) farmer survey; (ii) focus meetings; and (iii) interviews with farmers, advisors, consultants, technical specialists and researchers.

Survey

In 2014 farmers from the target area were invited to complete 10 survey questions that were developed and delivered using SurveyMonkey®, an online survey platform. Farmers provided details on location, farm size, crop and livestock enterprise mix, cropping area, cropping sequence on the main cropping soils and legume species used. They were also asked to consider and rate (i) factors that may influence their decision to include legume crops and/or pastures in crop sequences and (ii) areas in which they require more information or technology to increase their confidence to use legume species. The listed options were rated as either 'Not at all important' (with a rating of 1), 'Not important', 'Somewhat important', 'Important' or 'Very important' (with a rating of 5). The results were then analysed to provide a rating average and ranking.

The analysis of the 221 usable survey responses provides baseline data on adoption of legume crops and pastures in cropping systems, the factors affecting crop sequence decisions, and provides an indication of the information and technology gaps that need to be addressed in order to improve adoption of these species.

Focus meetings

A series of 5 focus meetings were conducted in 2014: 2 in VIC and 1 each in NSW, SA and TAS. The 52 attendees included 35 farmers and 17 agribusiness representatives or advisors. The facilitated discussion provided an overview of the diverse cropping systems of the HRZ, farmer understanding of legume agronomy, including regional variation, and detail on factors limiting legume performance and adoption.

Interviews

Individual interviews with 40 farmers (who had also filled out the survey), advisors, researchers and technical specialists from the study area provided context and detail of the issues identified through the survey and meetings, as well as factors not raised but potentially impacting on legume performance. These also provided an insight into the farming systems and practices of the broader population of farmers not represented in the survey and focus meetings.

Results and discussion

The 221 farmers responding to the survey manage in the order of 488,000 hectares, of which approximately 282,000 hectares is cropped annually. Average farm size is 2,166 hectares (excluding outliers), with an average of 1,323 hectares (61%) cropped annually. Most respondents (86%) operate mixed farming systems, with the other 14% describing their system as 'intensive cropping' (i.e. no livestock enterprise).

Individuals interviewed for this study suggest that these results over-estimate the significance of cropping in the HRZ, particularly in the SW VIC, SA and TAS regions and reflect the cropping bias of the sample of farmers participating in the survey. However, advisors report continued expansion of the cropping area in SW VIC. This is opposite to the apparent trend in the NSW Slopes and SA-VIC Border regions, where crop area has reportedly stabilised or even declined in response to unpredictable cropping seasons, a buoyant lamb market, and reliability of return and perceived lower risk associated with sheep versus crop enterprises.

The current role of legume species in farming systems

From the survey results 77% of farmers annually sow legume crop and/or pasture species on their main cropping areas. Of these farmers: 65% sow and harvest pulse crops for grain, 11% sow legume species as brown or green manure crops, 37% sow legume species for hay or silage production, and 74% sow pasture legume species for grazing.

Since the early 1990s canola has replaced lupin as the break crop of choice on the better drained soils across most regions of the HRZ. While *L. angustifolius* is grown across all regions, L. albus plantings are confined to well-drained soils of the Slopes of NSW. The study indicates that lupin is considered a low maintenance,

low input crop that can be "sown and forgotten". It is the dominant pulse in the NSW-VIC Slopes region where many farmers are sowing lupin crops without fertiliser.

Faba bean is the pulse crop best adapted to soils prone to waterlogging and is the pulse of choice in the SA, SW VIC and Gippsland regions. Despite having a relatively high management requirement, the area sown to faba bean is predicted to increase as farmers (and advisors) gain confidence and experience. Prompted by reports of high yields and grain prices, and lack of advisor experience, farmers are undertaking their "own research" on faba beans, trialling small areas (30-100 ha) to develop experience and confidence.

The study suggests that legume species are rarely sown as brown or green manure crops on the high-value farming country of the HRZ. Most farmers are reluctant to forego a year of income and therefore 'manuring' is likely to be a last resort option when there is an unexpected 'blow-out' of herbicide resistant weed populations, most commonly annual ryegrass (*Lolium rigidum*). A hay or silage cut, which provides a potential income source, is the preferred practice to prevent weed seed set. Manure crops are often low input and sown with minimal fertiliser or weed management, which is likely to compromise legume dry matter production and N fixation.

Poor quality of pastures, dominated by naturalised annual species is a concern of VIC, SA and TAS advisors interviewed for this study. Reported sub-optimal performance of pasture legumes was attributed to low priority of the livestock enterprise leading to minimal investment in fertiliser and pasture improvement, poor species and/or variety selection and poor understanding by some farmers and advisors of basic pasture management principles. Advisors noted that many farmers see the pasture phase as a "fix-all" and opportunity to start the cropping phase "with a clean slate". However, weed management, legume content and growth in these pastures is often poor and N fixation is likely to be very low.

Factors affecting crop sequence decisions

In order to gauge the factors that may influence the decision to include legume crops and pastures in crop sequences, the survey asked farmers to rate the relative importance of a number of listed factors, from 'Not at all important' (with a rating of 1) to 'Very important' (with a rating of 5). The results were analysed to provide the ranking and rating averages shown in Table 1. Farmers were also asked to rate the relative importance of areas of information and technologies, which they require to increase their confidence in using legume species in crop sequences (Table 2).

Table 1. The ranking and average rating of factors that influence farmers' decision to include legume crops and pastures in their cropping sequence. The percentage of respondents who considered the factors presented as either 'Very important' or 'Important' is shown in parentheses.

Factors that may influence crop sequence decisions	Overall rank	Rating average
Increased weed management options	1 (89%)	4.3
Financial return of crop and system	2 (87%)	4.3
Disease management	3 (70%)	3.9
Diversity of income sources	4 (63%)	3.7
The cost of N fertiliser	5 (52%)	3.5
Ability to manage seasonal variability	6 (44%)	3.3
Pest management	6 (41%)	3.3
Logistics	8 (27%)	3.0

Responses from the survey and focus meetings indicate that weed management, estimates of break-even crop yield and simple gross margin calculations drive the crop sequence decisions of most farmers. It is apparent that the majority of farmers do not place an economic value on the additional rotational benefits of pulse crops such as N contribution or disease and weed management, and consider that every 'crop' must be profitable in its own right. As commented by a farmer at the SA focus meeting: "Farmers … often keep cropping as it is easy and delivers short-term financial gains (cash flow)".

The study results suggest that many farmers and advisors focus on the performance of cereals and canola and give limited consideration to the role of legumes in crop sequences beyond weed and disease management and production. However, the interview process identified industry knowledge gaps and indicated that key aspects of legume agronomy and management, which are likely to be compromising legume growth and

performance, are either unknown or are being overlooked. Application of known principles and development of new technologies has potential to improve performance of legume species through increased yield and N fixation. There is considerable information available that can be applied to the HRZ to improve legume performance through, for example, weed seed bank management, effective nodulation of legume species and legume nutrition (both macro and micro-nutrients). Further technical advances are needed in disease resistance and adaptation of legume crops and associated rhizobia strains to the HRZ environment.

Table 2. The ranking and rating average of areas of information and technology required to increase farmer confidence in the use of legumes in crop sequences. The percentage of respondents who considered the factors presented as either 'Very important' or 'Important' is shown in parentheses.

Information and technology gaps	Overall rank	Rating average
Weed management and herbicide options	1 (82%)	4.2
Legume crop and pasture options adapted to soil and climate	2 (81%)	4.1
Improved features of existing varieties e.g. disease resistance	3 (75%)	4.0
Quantification of financial benefits of legume crops & pastures	4 (72%)	4.0
Disease management	5 (68%)	3.9
Specific agronomy packages for legume species	6 (64%)	3.8
Stability of markets	7 (64%)	3.7
Improved inoculation (nodulation) of legume species	8 (54%)	3.6
Integrated pest management	9 (52%)	3.5
Trace element requirements of legumes	10 (48%)	3.4
Infrastructure and grain delivery options	11 (48%)	3.3

Conclusions

Although farmers across all HRZ regions are concerned about their over-reliance on canola, which they view as a high input, high risk crop, the lack of experience of most farmers and advisors in crops other than cereals and canola has limited the adoption of alternatives. The study suggests that dominance of the cereal/canola crop sequence and generational change has affected industry knowledge of agronomic principles essential for the performance of legume species in the HRZ.

There is potential to improve the performance of legume species on HRZ acid soils of south-eastern Australia. However, this requires concurrently building capacity of farmers and advisors to ensure effective adaptation of outputs from relevant RD&E investments in the medium and lower rainfall zones, and alkaline soils of the HRZ. Research aimed at improving disease resistance and adaptation of legume species to HRZ environments is also needed.

Most farmers aim to minimise the complexity of farming systems and the majority are unlikely to adopt unfamiliar technologies that increase the complexity of their system unless they have are provided with compelling evidence of the relative advantage of new practices or technologies and have access to experienced technical support. Financial studies comparing crop sequence options must provide long-term "whole of system" analyses that "separate the financial return for the crop and the system". There is a need to quantify the risk and consequences of crop sequence decisions, particularly with regard to management of herbicide resistance and disease.

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