Pastures for low rainfall cropping systems

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INTRODUCTION

Pastures are a key component to farming systems in low rainfall cropping systems. The benefits of pastures in the low rainfall wheat sheep belt are experienced not only in the livestock enterprise, relied upon by 95% of farmers, but also in the cropping enterprise. Low rainfall farming systems extend from the South Australian and Victorian mallee through western NSW to western Queensland. My experience in low rainfall farming systems is limited to the boundaries of the Condobolin agronomy district.

There are several broad pasture types in the Condobolin district. These include native pastures, volunteer pastures, perennial grass/legume pastures and legume only pastures. This paper concentrates purely on improved legume pastures and their management for the cropping phase in the Condobolin district.

THE CONDOBOLIN DISTRICT

The Condobolin agronomy district covers the Lachlan and South Cobar shires, an area of over 2 million hectares producing close to 500,000 tonnes of wheat per year. The district takes in the towns of Tottenham in the north east, Lake Cargelligo in the south west, Tullibigeal in the south and Ootha in the east. Vegetation and soil type vary significantly across the district. Rainfall also differs but long-term averages do not vary more than 50mm from north to south. Figure 1. shows the Condobolin agronomy district.

CLIMATE

Farmers in low rainfall environments are susceptible to climatic risk. Farmers in the Condobolin district minimise this risk by matching inputs to the average water

Figure 1. CONDOBOLIN Agronomy District

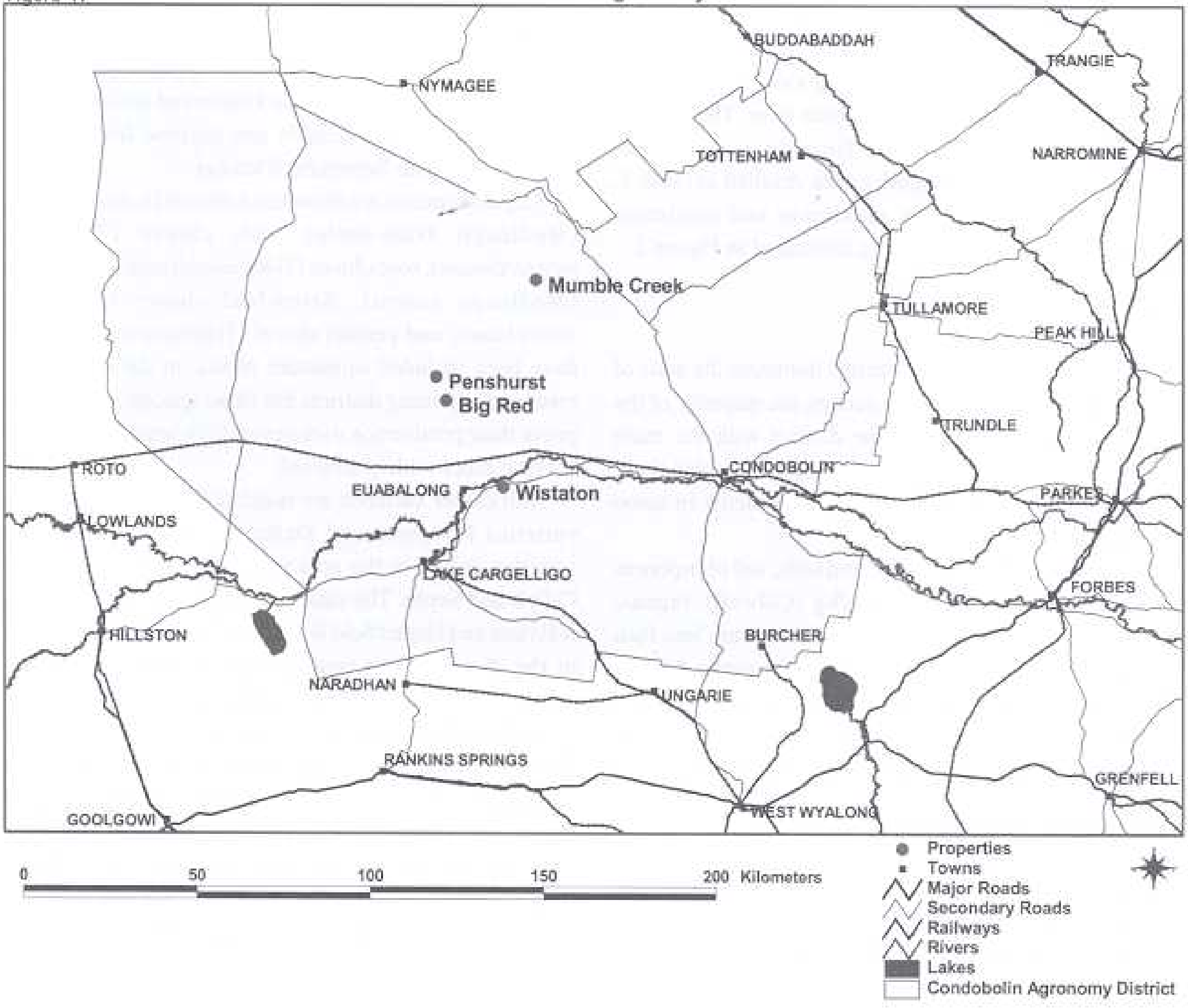
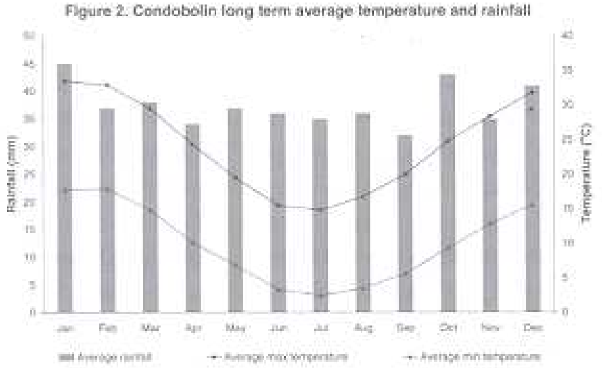


Table 1. Average monthly and annual rainfall for towns in the Condobolin district

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	N° Years
Condobolin	45	37	38	34	37	36	35	36	32	43	35	41	449	119
Tottenham	43	47	39	39	35	40	31	33	28	37	32	41	444	79
Mt Hope	36	29	35	26	35	34	32	32	27	38	29	35	388	114
Lake Cargelligo	37	28	35	29	35	37	33	34	30	38	30	32	397	116

Source: Australian Rainman

Figure 2. Condobolin long term average temperature and rainfall



limited yield potential of crops and pastures. In good seasons yield is limited by inputs, particularly phosphorus but in poor seasons rainfall is the main limitation to production.

Long term data shows that average annual rainfall ranges from 430-450mm north of the Lachlan river. This drops to 400mm west of Gunnebang along the river and increases slightly south of the Lachlan river. The average monthly rainfall figures for Tottenham, Mt Hope, Condobolin and Lake Cargelligo are detailed inTable 1. Long term mean monthly maximum and minimum temperatures for Condobolin are illustrated in Figure 2.

SOILS

Red earths and red brown earths dominate the soils of the Condobolin district. These occupy the majority of the flat and undulating areas in the district with the main exception being the alluvial clays along the Lachlan river. Hardsetting and crusting of soils are problems in some parts of the district.

In the surface (0-10cm) of the red soils, soil phosphorus levels are typically below 15mg/kg (Colwell), organic carbon levels are below 1.5%, sulfur levels are less than 5mg/kg (KCl-40) and pH ($CaCl_2$) is in the range 4.5-5.5. The cation exchange capacity of the red soils ranges from 5meq/100g to 11meq/100g. Aluminium levels tend to be well below 5% until pH ($CaCl_2$) drops below 4.6.

THE FARMING SYSTEM

Pastures in low rainfall cropping districts are managed according to the farming system. The farming system in the Condobolin district consists of several years of crop, predominantly cereal, and several years of legume pasture. Most farms in the district consist of both a crop and livestock enterprise however there are several farmers in the district who are moving to a crop only enterprise. The duration and management of each phase depends on the enterprise emphasis.

The pasture phase may last for up to eight years in a system where the emphasis is on the livestock enterprise. In comparison, those with a cropping emphasis will shorten the pasture phase to 3 or 4 years. There are however, many factors which will dictate the life span of a legume pasture in the low rainfall cropping zone. Such factors include: timber regrowth, native grass dominance, lucerne density, weed density, the size of the operation, commodity prices and regulatory requirements (Western Division).

PASTURE SELECTION

Pasture selection in the low rainfall cropping zone is restricted by rainfall, temperature, soil type and pH. Annual legume species must be able to flower and set seed before rainfall becomes less reliable and daytime temperatures start to rise in late September/October.

Legume species are therefore restricted to barrel medic (*Medicago truncatula*), sub clover (*Trifolium subterraneum*), rose clover (*Trifolium hirtum*) and lucerne (*Medicago sativa*). Arrowleaf clover (*Trifolium vesiculatum*) and persian clover (*Trifolium resupinatum*) have been included in pasture mixes on the strength of results in adjoining districts but these species will need to prove their persistence over several dry years before they become more widely adopted.

Sub clover varieties are restricted to the short season varieties Nungarin and Dalkeith while barrel medic varieties grown in the area include Parragio, Jemalong, Caliph and Sephi. The main variety of rose clover grown is Hykon and Hunterfield is the main lucerne variety grown in the district. The cost of lucerne seed is a major contributing factor to variety selection.

Pastures for cropping are sown as a mixed sward of the above species and varieties. The mix will depend on individual preference relating to grower experience and variety performance. The pasture mix is usually sown at a total of 3-4 kg/ha. Lucerne is usually sown at 1-2 kg/ha and the remaining 1-2 kg/ha consists of a combination of sub clover, barrel medic and/or rose clover.

PASTURE ESTABLISHMENT

Cover Cropping

An estimated 95% of the area sown to legume pastures is sown under a cover crop. Those undertaking this practice argue that there is considerable financial benefit in undersowing when compared with sowing alone. Farmers in this system are prepared to accept a one year in ten failure and many consider that even with this failure the figures still stack up in favour of undersowing.

Bruce Watt, Condobolin farmer and veterinarian, is an advocate for undersowing and uses low rates (15kg/ha) of oats as a cover crop. The surface moisture retention due to the trash from cover crop is the biggest benefit according to Bruce Watt. Improvements in lucerne vigour and annual legume germination were observed in pasture with stubble cover when compared to pasture without stubble cover.

Economic comparisons of undersown pasture versus sown alone pasture rarely account for all of the factors necessary to give an unbiased outcome. Such factors include the increased biomass from sown alone pastures and the improved seed set of the annual component. The implication of the improved biomass and seed set is not only increased livestock production, but also higher nitrogen fixation, slower weed infestation and slower degeneration of the legume component.

Growers are encouraged to sow a single strip of sown alone pasture without a cover crop in each undersown paddock to provide a visual comparison of the two methods but for unexplained reasons this simple comparison is rarely made. Sowing only every second row to improve light interception is a practice not widely adopted but one that has merit and perhaps should be more strongly promoted.

Brownlee and Scott (1974) demonstrated, in experiments at Condobolin, that there is an inverse relationship between crop and medic dry matter production when cover cropping. That is, the more biomass produced by the crop the less biomass produced by the medic. The reduction in medic dry matter production related to a decrease in pod production.

Growers in the district generally reduce cover crop sowing rates from 40kg/ha to 35 or 30kg/ha as a compromise between wheat yield and pasture establishment. An 80% crop establishment at 30-35kg/ha will still provide a plant density of 70-80 wheat plants/m^2. This density is still well above the optimal 30-50 plants/m^2 density suggested by Scott and Brownlee (1974) and may be one of the contributing factors to the frequently reported failure of sub clover and medic to persist.

Improvements in sowing technique

Improved pasture establishment in the district over the last ten years has been widely attributed to machinery improvements. Larger machinery has allowed pasture to be sown on time thereby effectively increasing the length of the season and increasing seed set of annuals. Improved depth control has also been noted by growers as a reason for superior pasture establishment.

There are many different sowing methods used in the area. Airseeders fitted with conventional wide points blow pasture seed onto scatter plates mounted at the rear of the toolbar and rely on a covering device to lightly cover the seed with soil. Airseeders fitted with narrow points have scatter plates mounted on the front of the toolbar and rely on the soil thrown from the tynes as well as the covering device. Some machines rely on a press wheel for seed to soil contact, dropping pasture seed immediately in front of the press wheel.

WEEDS, HERBICIDE USE AND WEED CONTROL

Herbicide Use

A questionnaire of fifty central west farmers indicated that 8% of respondents were regularly using herbicides for weed control in pastures, 22% were sometimes using herbicides and 70% were not using herbicides (Roesner 1999). The economic benefit of herbicide application in the pasture phase needs to be proven in a range of seasons if adoption of this practice is to increase.

A recent experiment at Condobolin compared available soil nitrogen the year after a low level weed infestation of lucerne/annual legume with soil nitrogen after high level annual ryegrass (*Lolium rigidum*) infested lucerne stand (Roesner 2002). The results are shown in Table 2.

Table 2. Comparison of available soil nitrogen (N) at Condobolin in a lucerne/annual legume pasture with a low level weed infestation and lucerne stand with a high level weed infestation sown 1995 (Roesner 2002).

Year of pasture phase	Low level weed infestation of lucerne/annual legumes	High level weed infestation of lucerne	Difference between low level and high level weed infestation	$ Value of the extra N
	kg N/ha to 90cm ($NO_3^- + NH_4^+$)	kg N/ha to 90cm ($NO_3^- + NH_4^+$)	kg N/ha to 90cm ($NO_3^- + NH_4^+$)	Based on urea at $400/tonne
Year 2 (1997)	109	88	21	$18.27
Year 3 (1998)	136	95	41	$35.67
Year 4 (1999)	184	90	94	$81.78

The data suggest that the cost of a selective grass weed herbicide ($22/ha) to control annual grasses in pasture could be justified in year 3 (1998) and 4 (1999) based on the current price (87c/kg) of one unit (kg) of nitrogen. However these years were atypical growing seasons with average annual rainfall of 552mm and 574mm respectively. In years when rainfall is closer to the average, then the nitrogen difference between a low level and high level pasture weed infestation may not be so large and the return from the herbicide application may be much smaller.

The benefit of applying a selective grass weed herbicide to pastures extends well beyond the improved nitrogen status for crops. The reduction of disease in the following wheat crop, the decline in the grass weed seed bank, the improved feed quality are just some examples of further benefits. It is necessary also to consider the potential costs of herbicide application such as the onset of herbicide resistance, the potential for erosion due to loss of groundcover and the loss of autumn feed for the livestock enterprise.

Grass weeds are not the sole invader of legume pastures in the district. Broadleaf weeds such as saffron thistle (*Carthamus lanatus*), skeleton weed (*Chondrilla juncea*), capeweed (*Arctotheca calendula*), pattersons curse (*Echium plantagineum*) and indian hedge mustard (*Sisymbrium orientale*) are major weeds of improved legume pastures. A central west farming systems (CWFS) pasture survey (Bowman 2002) shows that broadleaf weeds account for up to 23% of the composition of lucerne and sub clover pastures in spring. The cost of controlling a mixed broadleaf and grass infestation with herbicide is significant and the benefits would need to be clearly defined to justify such an application.

The selective broadleaf herbicide mixes used in the high rainfall areas (e.g. diflufenican + bromoxynil + simazine) are either not cost effective in this area or impose severe damage to the species contained in the pasture sward. Furthermore, the ability of pasture legumes to recover from herbicide damage imposed by these mixes is reduced due to the shorter growing season. A diuron + 2,4-DB tankmix is sometimes applied in the establishment year to control saffron thistle and indian hedge mustard.

The use of paraquat as a spray topping application in legume pastures to reduce the seed set of saffron thistle and annual grasses is cost effective. The use of paraquat in year 3 of the above scenario may well have prevented the loss of nitrogen experienced in year 4. Well known Condobolin farmers Roger Todd, Stuart McDonald and Nigel Martin are just three of many who believe the strategic use of paraquat in the year preceding the fallow provides a low cost ($4.40/ha) option for a significant benefit to the cropping phase.

Farmers try to use the fallow period and the cropping phase as an opportunity to clean paddocks for the pasture phase. Nigel and Obbie Martin, Big Red, Euabalong claim that a highly competitive lucerne pasture will compete well with weeds for several years. They cite a strip in their front paddock where lucerne seed ran out at sowing. This strip consists of skeleton weed and saffron thistles while the third year lucerne stand remains relatively weed free.

NATIVE GRASSES

Native grasses can be invasive on recently cleared country. Attitudes toward native grasses vary but wiregrass (*Aristida ramosa*) and some stipa species are not looked upon favourably due to their poor digestibility and the grass seed problems they present to livestock. Queensland blue grass (*Dichanthium sericeum*), curly windmill grass (*Enteropogon acicularis*), wallaby grass (*Austrodanthonia* spp.) and cotton panic (*Digitaria brownii*), at low densities, are tolerated by those cropping as they protect the soil between lucerne butts over summer and they provide useful summer feed. A native grass dominant pasture with a lucerne density of less than 2 plants/m^2 is likely to be returned to crop.

Martin and Judy Doyle, Penshurst, Euabalong see the soil protection and summer feed offered by native grasses as a benefit. They do not consider native grasses at all detrimental to their cropping phase of two years. On Penshurst the breakdown of native grasses after cultivation depends on the amount of summer rain. Termites also contribute to the speed of breakdown of native grasses and are considered an asset.

Strategic grazing management is also widely used as a low cost form of weed control.

FERTILISER

Scott (1973) reported superior increases in barrel medic dry matter production when phosphorus banded at 5 or 10cm was compared with surface applied phosphorus. Scott (1980) showed that plant uptake of surface applied phosphorus was influenced by the amount of growing season rainfall and it was concluded that topdressing pastures with superphosphate would not give increased dry matter production in many seasons. The current recommendation, as a result of the research, is to supply phosphorus for the pasture phase when banding fertiliser with the final crop in the rotation.

Sulfur appears to be limiting in the surface but it is thought that levels are much higher in the subsoil. Barrel medic responses to sulfur were achieved in glasshouse experiments in 1980 however these results were not duplicated in field experiments at Condobolin (Hirth 1980). There has however, been significant use of low sulfur, high analysis fertiliser since 1980 and the suggestion made by Scott (1985), that a future sulfur deficiency problem was likely, would now warrant further investigation.

ACIDITY AND LIME

Lime is not used widely in the district however interest in lime application is increasing. Evans (pers. comm. 2001) investigated pH decline on a continuous cropping experiment at Condobolin. Where no nitrogen was applied pH declined by approximately half of one unit over a period of twenty years and where ammonium forms of nitrogen were applied at 50kg/ha the pH decline was one pH unit over the same time frame. The current farming and grazing practices are acidifying and there is need for research into the economic benefits of lime application in the district.

PASTURE BENEFITS TO THE CROPPING PHASE

Nitrogen

Assuming 20 kg/ha/mm is an achievable water use efficiency for wheat, then the water limited yield potential of wheat grown at Condobolin, using the French and Schulz (1984) model, based on average annual rainfall, is 2.75 tonnes/ha. This assumes a fallow efficiency of 20% and evaporative losses of 110mm. In average rainfall years leading district farmers are achieving yields greater than these at protein levels greater than 13%. This is achievable because fallow efficiencies are greater than 20% and evaporative losses may be lower than 110mm.

Nitrogen removal figures can be used to calculate the amount of nitrogen used by a wheat crop at a given yield and protein. A conversion figure is used to convert the protein content of the grain to a nitrogen content and the efficiency of transfer from soil to the grain is estimated. The amount of applied nitrogen can then be deducted from the figure to give an indication of the amount of nitrogen available to the first crop in the phase.

A total of 156 kg/ha nitrogen is required to achieve a 2.75 tonne/ha wheat crop at 13% protein (assuming a 40% efficiency of transfer from the soil to the grain). An estimated 10 kg/ha nitrogen is supplied as starter fertiliser and an estimated 30 kg/ha nitrogen is mineralised throughout the growing season of the crop. This indicates that pastures in the Condobolin district are providing 146 kg/ha to the first crop, 116 kg/ha of which is available at sowing. This figure is supported by soil tests conducted by Paul Lukins, former Condobolin district agronomist.

Paul Lukins tested soil nitrate levels at 0-60cm in more than 100 paddocks over the Condobolin district. Paddocks were tested after pasture, after one year of crop and after several years of crop. Paddocks out of legume pasture ranged from 80-160 kg/ha nitrate nitrogen. The large range in figures are assumed to be related to pasture management and time of testing.

Soil nitrogen levels tend to decline after the first crop. The Australian prime hard grain protein level of 13% is commonly achieved in the first crop after pasture but rarely achieved in the second or third crop. Soil tests have shown that very few growers had soil nitrate nitrogen levels (0-60cm) greater than 60kg/ha prior to their second cereal crop. The practice of deep soil nitrogen testing and nitrogen budgeting is increasing in the district but many farmers still use paddock history as their guide for the nutrient requirements of the crop. Where deep soil nitrogen tests are not meeting the demands of a target yield some farmers will pre sow fertiliser nitrogen.

Disease

The much touted disease benefits of the pasture phase to the cropping phase are possibly not realised in the Condobolin district due to the level of annual grass in the pasture. Central west farming systems pasture survey data suggests that annual grasses account for up to 40% of the composition of lucerne and sub clover pastures in spring (Bowman 2002).

Take-all (*Gaeumannomyces graminis* var. *tritici*) is controlled with a grass free fallow period of greater than nine months but crown rot (*Pseudograminearum*) requires a 24 month grass free period to avoid carryover. Even spray-topped legume pastures contain enough annual grasses to provide a host for the crown rot inoculum. Brennan and Murray (1998) found that the average yield loss from crown rot in wheat in the central west plains in 1998 was 4.8% compared with 1.2% for take all.

Soil structure and fertility

Chan *et al.* (2001) confirmed that perennial pastures improve the physical and chemical properties of hardsetting soils in low rainfall areas. Organic carbon, water-stable aggregation, hydraulic properties, friability and mineralisible nitrogen were improved under perennial pastures. Increasing organic carbon and soil quality were related to increasing pasture dry matter production.

The soil improvements were measured in the surface (0-2.5cm) after a period of 3-4 years of pasture. It was suggested by Chan *et al.* (2001) that if improvements were to extend below 2.5cm that a pasture phase may have to extend longer than 3-4 years in the low rainfall areas due to the low annual dry matter production.

While native grasses undoubtedly use nitrogen fixed by the legume portion of the pasture, the work of Chan *et al.* (2001) suggests that they contribute significantly to improved soil physical properties.

WHEN TO CROP AFTER PASTURE

The decision to pull a pasture out of production into crop depends on many factors. Rotations are loosely based on a time scale but there is flexibility to change if the need arises. There are few farmers in the district sowing pastures purely for a cropping phase so the decision to pull a pasture out of production still has much to do with the livestock enterprise.

The size of the property and the percentage of total area sown to crop is a factor influencing the decision when to crop. Where the cropping phase is three years and cropping accounts for one third of the total property area then it may be six years before paddocks are cropped again. If the time between cropping phases was reduced then the area sown to crop would need to be increased. Such an increase in cropping area may present an unacceptable production and price risk.

Stuart and Nat McDonald of Mumble Creek, 70km north west of Condobolin, have reduced stock numbers over the past five years and are moving toward a crop only enterprise. Lifestyle, labour and environmental issues are the reasons for the shift in enterprise focus. Sheep are considered to be a very labour intensive enterprise, presenting compaction and erosion problems in lucerne stands. The McDonalds sow a barrel medic, sub clover and lucerne mix and leave pastures out for seven years. Target yield and protein in the first crop after pasture is not currently being met and the pasture phase will be cut to 2 or 3 years in the future. They believe that the benefits of the fixed nitrogen and disease reduction decline after three years because weeds start to invade after that time.

Bruce Staniforth, runs a property north of Condobolin. His emphasis is on the livestock enterprise so he is looking to extend the pasture phase for as long as he can. Bruce Stanifoth runs cattle and believes the mix of native grasses and legumes provide well balanced cattle feed. Since sowing lucerne livestock production has improved significantly. Weaners are reaching target weights at least six months earlier than when lucerne was not sown. Timber regrowth is possibly the biggest factor contributing to his decision to crop pasture paddocks.

Other factors influencing the decision to crop pasture paddocks include regulatory requirements regarding cropping frequency in the Western Division and a low lucerne density.

LUCERNE REMOVAL

Lucerne removal at the end of the stand life for the cropping phase presents a problem. Nigel Martin used an offset disc for his primary cultivation and suggested that his stand was better several weeks after the cultivation than before it! After trialing different cultivation implements and different herbicide mixes Nigel is convinced that the primary cultivation must be with wide sweeps (e.g. a blade plough) to cut below the crown of the plant if removal is to be successful.

AN INTERCROPPING CASE STUDY

The potential for intercropping, which is the practice of growing annual crops in a permanent lucerne stand, is limited by growing season rainfall however it has been done successfully. Two growers west of Condobolin have successfully intercropped barley into lucerne with good results.

Steve Doyle operates a mixed livestock and cropping enterprise on his property Wistaton, 60 kilometres west of Condobolin. In 2001 Skiff barley was intercropped into a 2nd year lucerne stand. The intention was to use the crop as an alternative opportunity to remove pattersons curse, capeweed and skeleton weed from the lucerne stand.

The paddock was grazed heavily with sheep four weeks prior to spraying. The lucerne and the weeds, which were approximately 3cm in diameter, were given a period of 10 days to recover before spraying. Glyphosate 450g/L was applied on May 25 at a rate of 500mL/ha to control the weeds and to retard lucerne growth.

The paddock was sown in mid June 2001 with a flexicoil airseeder fitted with knife edge points on 9" spacings. The crop was sown at 35 kg/ha with 55kg/ha DAP (18:20:0:2) and 600g/ha of inoculated and lime pelleted lucerne seed. Lucerne was added to compensate for the expected loss of established lucerne plants from mechanical destruction.

The paddock required an in crop herbicide tankmix of diclofop methyl (Hoegrass®) 1L/ha and bromoxynil + diflufenican (Jaguar®) 600mL/ha to control ryegrass and broadleaf weeds that germinated after sowing. An application of amine would have served the dual purpose of retarding the lucerne and controlling the weeds if seedling lucerne was not present.

The paddock yielded 1.2 t/ha in a year where annual rainfall was 100mm below the long term average of 425mm. Growing season rainfall from June to November inclusive was only 167mm. It is difficult to quantify the yield loss associated with the competition from the lucerne as there was no part of the paddock excluding lucerne sown to barley.

There is considerable risk associated with the practice of intercropping, particularly in low rainfall environments. In the above situation where broadleaf weeds were beginning to dominate the lucerne stand the options were to pull the paddock out of pasture and into crop or to apply expensive selective herbicides with the risk of reinfestation. Both were expensive and risky.

Bare soil between lucerne plants in summer has been noted as a problem by many growers. The risk of wind and water erosion is increased where there is no groundcover between lucerne plants in summer. Dust in the wool is a problem faced by David Fishpool of Tottenham. When the wool was traced back to the paddock the problem was found to be worse on lucerne paddocks than on bare fallow paddocks. Oats will be intercropped into lucerne this year to help reduce the dust problem.

The benefits of intercropping include the reduction of contributions to the watertable, the ability to effectively apply phosphorus, the improved soil cover between lucerne plants with stubble, the ability to renovate the stand and the ability to use low cost herbicides to clean the lucerne stand.

CONCLUSION

The benefits of legume pastures in the Condobolin district to the cropping phase are improved nitrogen, improved soil structure, increased soil organic matter, reduced disease and the provision of alternative options for weed control. The extent to which these benefits are achieved depends on the management of the pasture phase.

The current management of pastures in the Condobolin district strikes a balance between the livestock and cropping enterprise. What is seen as a benefit to one enterprise may be detrimental to the other. The aim is to maximise livestock production without reducing the potential benefits of pastures to the cropping phase.

The challenge for farmers is to maintain a farming system that provides not only production benefits to the livestock and cropping enterprise, but also environmental benefits to ensure that their future in farming in the low rainfall environment continues.

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