

Guidelines for dryland cropping in south western New South Wales



Dryland cropping guidelines for south western New South Wales

A product of the *Western Wheat* project



NSW DEPARTMENT OF
PRIMARY INDUSTRIES



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Foreword

This publication has been drawn together from information gathered from a seven-year project (1999–2005), co-ordinated by NSW Department of Primary Industries (NSW DPI) and supported by the Grains Research and Development Corporation (GRDC).

The project 'Identifying productive, profitable and sustainable farming practices for low rainfall districts' (locally known as *Western Wheat*) had the objectives of:

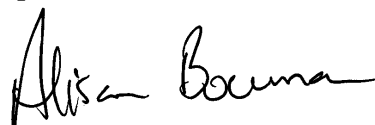
- developing strategies for productive and sustainable dryland farming practices in the low rainfall cropping zone of southern NSW; and
- co-ordinating a series of trials across the region to provide information on topical issues in each year of the project.

The *Western Wheat* project commenced in 1999 after staff from NSW Agriculture (now NSW Department of Primary Industries), through a focus group process with growers, identified there was a lack of agricultural research and development in the region south of Condobolin/Forbes and east of Hillston/Balranald in southern NSW. There was also scepticism by growers in this low

rainfall south western cropping zone of the relevance of the results generated in regions to the east of them to their own operations. The focus group process identified a range of issues growers wanted to investigate in their local areas.

The farming systems in the *Western Wheat* region are wheat based. The systems described in the following chapters are designed to enable growers to optimise their wheat production through improved rotations and the better management of soil, vegetation and water.

The wider geographic area of south western NSW, beyond the boundaries identified for *Western Wheat*, includes the operations of other farming systems projects and groups, also supported by the GRDC, primarily mallee Sustainable Farming Inc. and Central Western Farming Systems Inc. There are sections in this publication that include information from these projects and we acknowledge and thank these two groups for their co-operation.



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The *Western Wheat* region

1.1 Rainfall

For the purposes of this publication the *Western Wheat* region has been divided into three zones as defined by annual rainfall and shown in Figure 1.1:

- 400–450 mm annual rainfall zone
- 350–400 mm annual rainfall zone
- 300–350 mm annual rainfall zone

Rainfall across the whole of the south western region of NSW is relatively evenly distributed throughout the year. However, there can be a slightly dominant winter rainfall pattern in the south and a slightly dominant summer rainfall pattern in the north.

High evaporation over the summer months means rainfall from late spring to early autumn is largely ineffective for cropping. As a result winter cropping is the only viable dryland cropping option in the region.

1.2 Soils

There are four major soil types across the *Western Wheat* region as shown in Figure 1.2. The grouping of the soils into the following 4 groups is on the basis of texture and structure:

- Duplex soils
- Clays soils
- Massive earths
- Sands

Although soils in the north western portion of the region are relatively uniform, the scale used in Figure 1.2 does not highlight the considerable variability in the remainder of the region.

The combination of soil types that can occur at the paddock level can have a large impact on crop selection and management strategies.



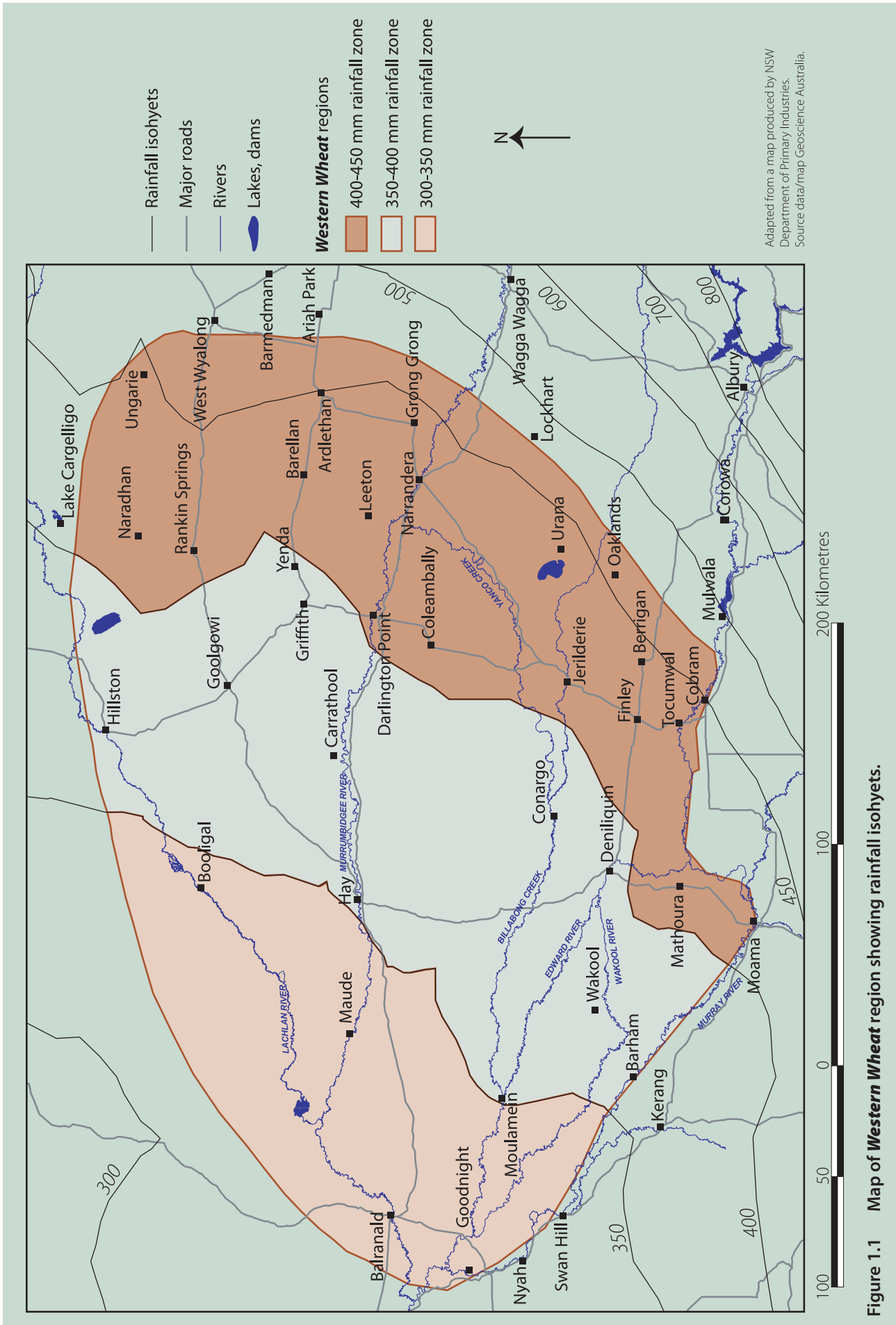


Figure 1.1 Map of Western Wheat region showing rainfall isohyets.

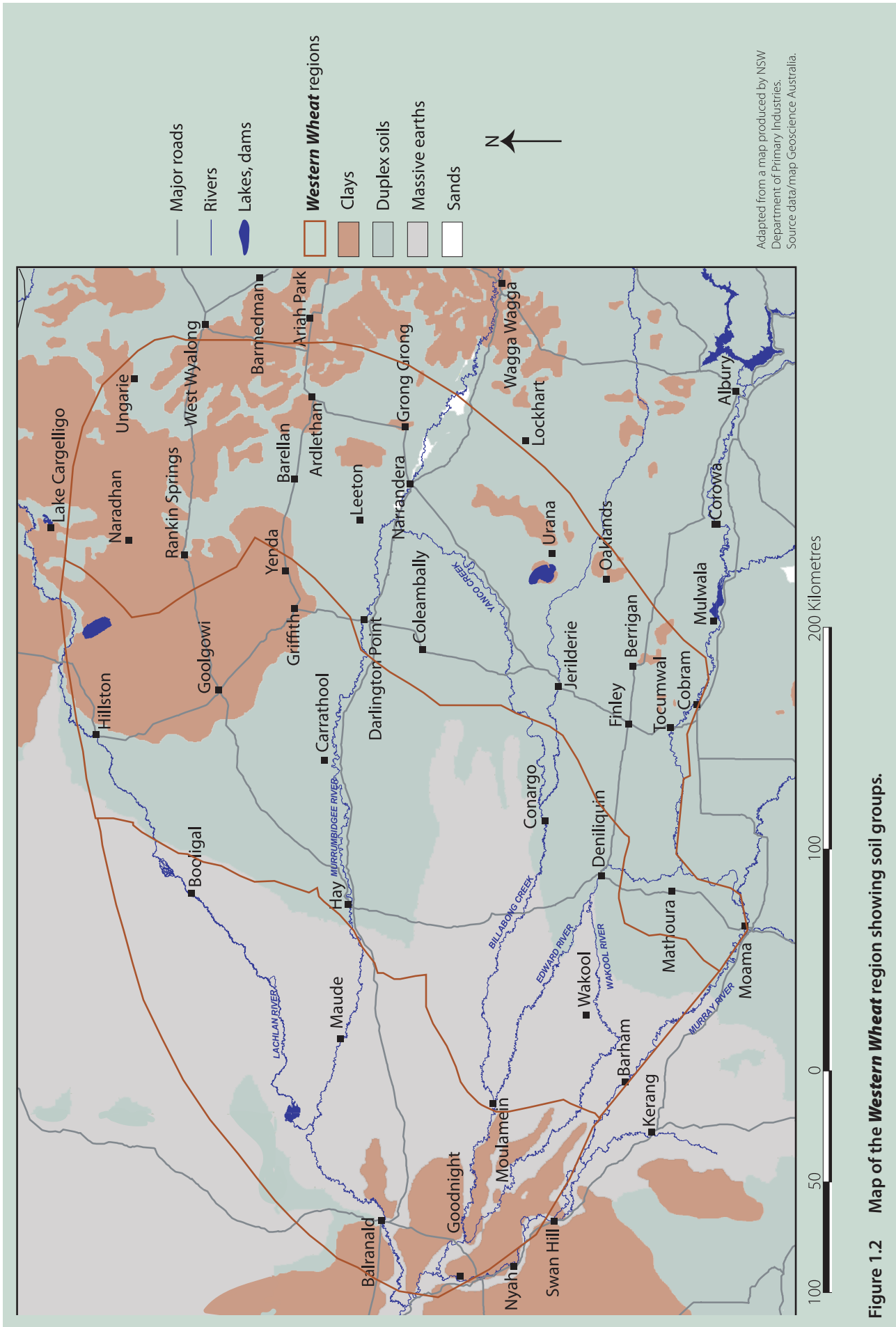


Figure 1.2 Map of the Western Wheat region showing soil groups.

1.2.1 Duplex soils

This soil group includes ‘mallee soils’ and the red duplex and red-brown earths. These soils occur in well-drained positions on the plains (associated with river ridges) and hill slopes. This group also includes grey soils with similar profiles to the red soils, which usually occur in drainage depressions. The grey soils are often found in close association with old stream complexes.

Soil properties

The duplex soils have a definite texture contrast between the topsoil (A horizon) and the subsoil (B horizon), with sandy loam to clay-loam surface layers overlying clay subsoils. The topsoil is usually 0.1-0.4 m deep but can be as deep as one metre and varies in colour from red to grey/brown. The subsoil may be sodic.

These soils are agriculturally diverse, with production potential largely dependent on the permeability of the subsoil. The soils with lighter textured or non-sodic, more free-draining subsoils are suitable for all winter cereals, pulses and lucerne and annual pasture production.

Due to the light texture of the surface layer, duplex soils have lower water holding capacity and a higher infiltration rate than the heavier red earths. They respond well to light falls of rain.

These soils have inherently very low phosphorus levels—as low as two parts per million (p.p.m.). Nitrogen levels of these soils are also inherently low.

The red-brown earths and red duplex soils can have reasonable physical and chemical properties, but many of those with long cultivation histories have suffered structural degradation and loss of organic matter. Such soils may have hard-setting surface layers, particularly if soil organic matter levels are low.

The duplex soils of the mallee area, known as ‘mallee soils’, are distinguished by their strongly alkaline subsoils. They have a sandy surface layer that ranges from 0.15-1.0 m deep. The pH_{Ca} ¹ varies from 5.5-7.0 in the surface 25 mm with subsoil pH_{Ca} ranging from 7.1-8.5. The mallee soils have well-drained subsoils.

¹ pH in 1:5 soil:0.01 M CaCl_2 (see glossary).

Soil limitations

Inherent low fertility is a limitation common to all duplex soils in the *Western Wheat* region.

Some of the red-brown earths and red and brown duplex soils also have sodic and poorly structured subsoils, which can limit agricultural production. Common features of such soils are low subsoil permeability, high subsoil bulk density and high mechanical resistance to root growth. Waterlogging can be a problem in these soils in high rainfall seasons or if they have a perched watertable.

Poor water infiltration and poor seed germination can also be limitations.



This occurs on the duplex soils with naturally high levels of fine sand and silt particles and low organic matter levels, those that have had their surface layers degraded by conventional cultivation practices or those with high sodium levels in the surface layer (see Sections 6.1 and 6.2).

The surface layers of some of the duplex soils may also be sodic, but non-saline, prone to dispersion and the formation of surface crusts (see Section 6.1).

Soil acidity can be a concern on some of the red-brown earths (see Section 6.3) while high alkalinity can limit crop production on the mallee soils (see Section 6.4).

Native vegetation on duplex soils

Native grass cover usually includes species such as plains grass (*Austrostipa* spp.) and wallaby grass (*Danthonia* spp.). Clearing, cropping and pasture improvement has resulted in other species becoming prominent, including corkscrew grass (*Aristida* sp. or *Austrostipa* sp.), windmill grass (*Chloris truncata*, the biennial form, and *Enterpugon acicularis*, the perennial form), annual grasses such as barley grass (*Hordeum leporinum*) and naturalised clovers and medics.

The main tree types found on duplex soils are black box (*Eucalyptus largiflorens*) and grey box (*Eucalyptus microcarpa*) in the south and east, and boree (*Acacia pendula*) on the plains to the west. Needlewood (*Hakea*

leucoptera) and white cypress pine (*Callitris columellaris*) are found on the levees of old streams.

Other tree species that may be present include bumble box (*Eucalyptus populnea*) and occasionally wilga (*Geijera parviflora*). Yellow box (*Eucalyptus melliodora*) and the occasional rosewood (*Heterodendrum oleifolium*), grey box (*Eucalyptus microcarpa*) and bull oak (*Casuarina luehmannii*), can be found on the associated river ridge depressions. Kurrajong (*Brachychiton populneum*) is also found on well-drained duplex soils, often associated with white cypress pine and bumble box and mallee communities.

1.2.2 Clay soils

There are two types of clay soils found in the *Western Wheat* region:

- Self-mulching clays
- Non self-mulching clays

Self-mulching clays

The self-mulching clays soils occur sporadically throughout the region, usually in low-lying areas and are often associated with gilgai formations. Gilgais comprise areas of 'puffs' and depressions. Self-mulching clay is the dominant soil type of the puff areas, with non self-mulching clay predominant in the depressions. The puff areas are usually 10-25 m in diameter and 0.1-0.25 m high and cover more than 30% of the gilgai.



Soil properties

The self-mulching clays are usually calcareous with lime nodules throughout the profile. The lime nodules can be soft or hard.

Soil colour ranges from grey to very dark brown. And there is little change in texture through the profile, with approximately 50-60% clay throughout.

The self-mulching clays are characterised by extensive cracking as the soil dries, resulting in deep vertical cracks, which allow rapid water infiltration. They have a stable tilth, are not prone to crusting and are relatively resilient to conventional cropping practices.

Soil limitations

The main disadvantage of the self-mulching clay soils is the lack of internal drainage. As a result they dry out slowly, often leading to delays in cultivation or sowing. However they are suitable for most pasture and crop types.

Native vegetation on self-mulching clays

In their natural state the clay plains were often treeless grasslands with occasional areas of shrub woodland. The dominant species in the shrub woodland was boree (*Acacia pendula*), with scattered grey box (*Eucalyptus microcarpa*) and occasional rosewood (*Heterodendrum oleifolium*).

Dominant grass species were wallaby grass (*Danthonia* spp.), spear grass and plains grass (*Austrostipa* spp.)

and windmill grass (*Chloris truncata*, the biennial form, and *Enterpugon acicularis*, the perennial form). Many of the native grass areas have been replaced by introduced pasture species, weeds and/or crop species. Most of the introduced species are annuals, for example barley grass (*Hordeum leporinum*).

Non self-mulching clays

The non self-mulching clays have poor drainage and usually occur in low-lying areas such as flood plains.

Soil properties

The non self-mulching clays tend to be grey and brown soils of heavy texture with a thin surface layer of clay loam or sandy loam over well-drained blocky or poorly-drained massive dark, red-brown, heavy clay.

They are usually sodic (see Section 6.1) and tend to disperse on wetting, resulting in surface crusting and hard-setting subsoils, which restrict water and root penetration. A restricted range of crop species can be grown successfully on these soils.

Soil limitations

The main limitations of the non self-mulching clays to agricultural production are surface crusting, low permeability and poor infiltration resulting in poor internal drainage, susceptibility to waterlogging, poor aeration and poor water holding capacity. It is often difficult to achieve good plant populations on these soils



because these characteristics affect establishment.

Native vegetation on non self-mulching clays

The predominant vegetation on the non self-mulching clays is boree (*Acacia pendula*), with black box (*Eucalyptus largiflorens*) in poorly drained areas.

1.2.3 Massive earths

The massive earths have been formed from wind blown material (aeolian) from central Australia and are distinguished by their lack of variation down the profile. They include the red earths.

These soils are moderately susceptible to sheet erosion by wind or water on the higher country and gulying in the drainage lines and on the lower slopes. They have a seasonally hard-setting surface crust.

Soil properties

The clay content of the massive earths gradually increases with depth. The surface layer has a loamy texture, tending to clay loam, then loamy clay to medium clay at approximately 0.8 m.

The neutral and alkaline red earths are relatively deep. The B horizon is porous. Calcium carbonate levels tend to be high and may be present as soft flecks and nodules in the lower parts of the soil profile. Infiltration rates are moderate unless an impermeable hardpan layer is present.

These soils have reasonable structure as sodium concentrations are not high and do not cause dispersion problems. The clay content of these soils, which increases with depth, ensures reasonable water holding capacity.

Soil limitations

The inherent nutrient status of the massive earths is low. However, a wide range of crops can be grown successfully, providing rainfall and fertiliser inputs are adequate.

Some massive soils have subsoils of high bulk density, which can limit infiltration and reduce crop root growth.

Native vegetation on massive earths

The main tree species growing on this soil type are belah (*Casuarina cristata*), rosewood (*Heterodendrum oleifolium*) and mallee (predominantly *Eucalyptus socialis* and *Eucalyptus dumosa*) on the plains.

1.2.4 Sands

Sands across the region differ mainly in depth of topsoil and the permeability of subsoil. Sandy soils are generally found on river ridges, on dunes and in low lying areas adjacent to dunes.

Soil properties

Sands on the river ridges are at least 0.6 m deep, overlying heavier clay subsoils, which usually have low permeability.



River sands are neutral to alkaline. Their colour is generally brown to red-brown. They have loose topsoil which is greater than 0.15 m in depth and subsoils which are also loose sands to a depth greater than 2 m.

Sandhill soils have a loose sandy topsoil which is greater than 0.15 m deep. They consist of wind blown sand with clay layers at depth.

Soil limitations

All sands are limited by a low water holding capacity and poor nutrient retention owing to a low cation exchange capacity. Some sands, however, have relatively high clay content in sections of the profile, which may increase their water holding capacity and nutrient storage ability.

Sands are usually well drained, although those with a relatively shallow topsoil and a sodic subsoil will have lower infiltration rates. Perched watertables can be a problem in some areas. The presence of bleached layers is an indication of periodic waterlogging.

Soil pH_{Ca} is usually 5.0-6.0, but as sands have a low buffering capacity the sands needs to be monitored for declining pH (see Section 6.3).

The main characteristics limiting agricultural production on sandy soils are poor crop establishment due to wind abrasion, susceptibility to wind and water erosion, low nutrient storage capacity, low buffering capacity and susceptibility to acidification. Deep drainage is

a common feature; the result of a low water holding capacity and high permeability.

Native vegetation on sands

The vegetation on the river sands mainly consists of tall woodland communities. The tree species occurring naturally on these soils are cypress pine (*Callitris columellaris*), bimple box (*Eucalyptus populnea*), with scattered grey box (*Eucalyptus macrocarpa*), yellow box (*Eucalyptus mellidora*), needlewood (*Hakea leucoptera*) and bull oak (*Casuarina luehmannii*), with scattered wilga (*Geijera parviflora*) on the lower areas. Grass cover is sparse, with spear grass and plains grass (*Austrostipa* spp.) the main species.

Dense mallee (*Eucalyptus socialis* and *Eucalyptus dumosa*) communities cover large areas of level to slightly undulating sand plains and can form a mosaic with other communities. As well as mallee, many other small trees and shrubs occur including kurrajong (*Brachychiton populneum*), mallee cypress pine (*Callitris preisei*, subsp. *verrucosa*) and quandong (*Santalum acuminatum*).

In the south-west of the **Western Wheat** region more open mallee communities occur in association with belah/rosewood communities. Here the mallee often supports a shrub understorey dominated by saltbushes (*Atriplex* spp.) and blue bushes (*Santalum lanceolatum*) and herbaceous ground covers.



Farming systems in the 400–450 mm rainfall zone

2.1 Introduction

The dryland farming systems of the 400–450 mm rainfall zone are based on winter cereal production, with the area sown to cereals in most years comprising more than 90% of the total cropping area. Wheat is the main crop grown, with barley production approximately 30% of wheat production.

Cropping became the major enterprise in this rainfall zone as a result of relatively reliable rainfall from 1980 to 2000, low returns from stock during this period and improvements in crop varieties and farming techniques. Wheat is grown on most soil types in the zone, with an average yield of 2.0 t/ha.

Cropping intensity is greatest in the eastern areas of this zone. But despite the trend toward more intensive cropping rotations, pastures remain an important component of farm operations. Livestock, particularly sheep, provide income diversification for many growers and in more recent years relatively high livestock prices have provided good returns to mixed farming operations in the zone.

Alternative crops, such as canola, field peas, lupins and chickpeas have become more widely grown in the last decade (although they still only make up a small percentage of the total cropping area) and have provided a valuable disease break for cereal crops as growers extended their cropping phase. These crops have also improved weed management options, spread farm labour demands and provided income diversification.

Rather than adhering to set rotations, growers often base the decision to sow alternative crops on market forces, commodity diversification, the soil moisture reserves, the timing of the autumn break and paddock history (e.g. density of pasture, weeds present and cereal disease risk).

The well-structured massive soils (red earths) and duplex soils (red-brown earths) with good internal drainage and good water holding capacity consistently produce the highest yields. Alternative pulse and canola crops tend to be grown on these better drained soils.

The main factor, outside the growers' control, that limits crop yield in this zone is the timing and amount of effective rainfall. This impacts on soil



moisture reserves at sowing, sowing times, the total growing season rainfall and length of the growing season. High temperatures and frost during spring when crops are at critical growth stages, specifically anthesis and grain fill, can also have a huge impact on final grain yield and quality.

2.2 Typical rotations in the 400–450 mm rainfall zone

Phase farming, a system in which a cropping phase is followed by a dedicated pasture phase, is the favoured cropping system in this zone and integrates well with livestock enterprises on mixed farms. It is a low risk strategy that utilises a legume-based pasture phase in the rotation, which supplies nitrogen for the subsequent crops and allows varied weed control options. The pasture phase can also provide a disease break for cereal crops if grass weeds are

effectively controlled in the final year of the pasture phase.

Annual species such as subclover and medics and/or lucerne are the main pasture species sown. These are usually established by undersowing the last wheat or barley crop in the cropping phase (see Section 7.2).

Growers in the east of the 400–450 mm zone use a three to five-year pasture phase, but the pasture phase may stretch to five to seven years in the drier, western area. Farms in the east have longer cropping histories and growers usually adopt more intensive cropping programs, with shorter pasture phases and higher stocking rates than growers in the west.

As shown in Table 2.1, wheat or canola is usually the first crop sown after the pasture phase, often following a period of long fallow. Growers use long fallow to control problem weeds, to manage cereal diseases and to initiate seedbed preparation. The long fallow typically

Table 2.1 Characteristics of a typical dryland cropping farm at Narrandera.

Characteristics	Description
Farm Area	1500 - 3000 ha (1500 - 5000 ha in the western part of the zone)
Cropping options	Cereals—wheat (APW, AH or PH quality), barley (malting and feed), oats, triticale (on more acid soil types) Pulses (less towards the west)—lupins, field peas, chickpeas Oilseeds—canola
Cropping phase	2 - 4 years, high proportion of cereals, consecutive crops
Pasture phase	3 - 5 years, subclover and annual rye grass or lucerne
Typical rotation	8 years (4 years pasture, then long fallow wheat or canola, followed by short fallow wheat or barley and then cereal undersown with pasture)



starts with a knock-down herbicide or, occasionally, mechanical cultivation 8 to 10 months before sowing.

The main weeds targeted by long fallowing include annual species such as annual ryegrass (*Lolium rigidum*), annual phalaris (*Phalaris paradoxa*), vulpia (*Vulpia bromoides*, *Vulpia myuros*), barley grass (*Hordeum leporinum*) and capeweed (*Arctotheca calendula*).

While many growers in the east of this zone consecutively crop without long fallowing during the cropping phase the recent run of low rainfall seasons (2002-2005) has seen an increasing number of growers in the west favour long fallow between each crop in a cropping phase, (e.g. two wheat crops in four years).

Glyphosate is the main herbicide used in dryland cropping systems in the 400–450 mm rainfall zone. It is used to initiate the fallow period, but is also heavily relied upon to maintain a weed-free fallow. Other tools for managing fallow weeds are grazing, cultivation and strategic burning.

The use of triazine tolerant and Clearfield® canola technology has enhanced grass and broadleaf weed management. Growers are using these varieties in an integrated weed management system where problem weeds occur, e.g. wild radish (*Raphanus raphanistrum*).

2.2.1 Why are the rotations different in this zone?

Growers in the 400–450 mm zone have greater flexibility than their counterparts further west. They are able to produce economic yields more reliably from a greater range of crops, over a greater range of soil types.

Most growers in this zone operate mixed farming operations and the rotations incorporate legume-based pasture phases. The length of the pasture phase often differs between paddocks and is dictated by various factors such as the density of the pasture, weed pressure, management of nitrogen build-up and livestock and crop commodity prices.

The length of the cropping phase, the crop mix and the crop sequence vary between growers, but can also vary between soil types on the same farm. For example, four consecutive crops may be sown on the better yielding paddocks and two crops in four years on 'problem' paddocks that do not support a vigorous pasture phase.

2.2.2 Advantages and disadvantages of typical rotations

Pasture (4–5 years)/long fallow/wheat/canola or pulse/wheat or barley

This rotation is a relatively intensive cropping program, typical of many of the mixed farming operations in the 400–450 mm rainfall zone. It offers flexibility in crop combinations with the inclusion of alternate



crops enabling growers to extend the cropping phase in response to market forces. The strategic use of these alternative crops also allows growers to manage cereal diseases, use a variety of herbicides to effectively control problem weeds and to reduce the likelihood of herbicide resistance (see the grower case studies on page 22 and page 150).

Although the rainfall patterns suit subclover-based annual pastures, the area sown to lucerne has increased significantly since the early 1990s. Lucerne has advantages over subclovers as it inhibits invasion by summer weeds and complements the demands of the prime lamb market that has developed in recent years. Lucerne provides valuable feed after summer rainfall events and its quick response to rainfall helps fill the autumn feed gap. In areas that are faced with rising watertables lucerne can be used to reduce groundwater recharge. However lucerne can also significantly dry the soil profile to depth and sufficient fallow time is required to refill the profile before commencing the cropping phase.

Soil acidification, particularly in the surface layers, can be a disadvantage of the pasture-based rotation. Consecutive years of productive annual pasture legumes followed by annual crops can result in lower soil pH. Acidification rates vary between soil types, but soils with naturally low pH_{Ca} (below 5.5) should be monitored (see Section 6.3).

Pasture/long fallow/ wheat/long fallow/wheat (undersown)

This rotation is a low input option that usually becomes more popular for some growers, particularly those on the heavier clay soils in this zone, when there is a run of dry seasons. The long fallow allows soil moisture to accumulate and provides growers with reliability of yield in low rainfall years.

Most of the stored moisture comes from winter rainfall. Although cracking clays accumulate moisture from summer storms, most soils lose the majority of the summer rain as runoff or through evaporation. On average one summer in four in this zone has sufficient rainfall to make a significant impact on soil moisture reserves.

Control of cereal diseases in this rotation relies on the maintenance of a host-free fallow period and depends on summer rain to breakdown stubble residue between crops. Stubble burning can also have a role in this rotation in managing weed seed banks and stubble-borne cereal diseases (e.g. yellow leaf spot) (see Chapter 9).

In-fallow weed control with non-selective herbicides in this rotation reduces the reliance on expensive, in-crop herbicides, although some growers choose to use a combination of herbicide and cultivation for weeds control.

The potential loss of income during the fallow period is a major disadvantage of this rotation. The 'opportunity cost' of the fallow will be



greatest in average to above-average rainfall seasons on lighter soils with low water holding capacity and only in high rainfall years on well-structured clay soils with good water holding capacity (see Chapter 6).

There are also potential environmental issues associated with periods of long fallow. Erosion can be a problem, but can be reduced by controlling weeds with herbicides, rather than by cultivation and by retaining stubble. Leaching of mineralised nitrogen and groundwater recharge are also concerns with this rotation, particularly on soils with subsoils of low water holding capacity.

2.3 Crop management in the 400–450 mm rainfall zone

2.3.1 Tillage systems

Farming practices have changed dramatically since the 1980s with cropping becoming a major agricultural enterprise in the 400–450 mm rainfall zone, partly due to machinery innovations, which have aided the development of conservation farming techniques, and improvements in crop varieties.

The lighter textured, duplex soils are most suited to minimum tillage systems. The hard-setting clay soils offer less opportunity, although modified tillage equipment, such as knife points and wide row spacings (>25 cm), has helped growers improve the success of direct drill systems

on these soils in marginal moisture conditions.

The majority of cropping phases begin with an 8–12 month fallow period, aimed at preventing weed seed set and maximising soil moisture reserves for the subsequent crop. The timing of fallow commencement and the choice between cultivation and chemical initiation usually depends on soil type, pasture type, the weed spectrum and the preferred management strategy for potential crop diseases.

There is a trend toward initiating fallowing of lucerne-based pastures during the winter months to maximise accumulation of winter rainfall. Annual legume-based pastures are usually fallowed from late August to early September to prevent the seed set of problem annual weeds such as silver grass (*Vulpia* sp.), barley grass (*Hordeum leporinum*) and capeweed (*Arctotheca calendula*).

The majority of growers (97%) use minimum tillage practices (Finley District Agronomist survey, 2001) and often initiate their long fallow with a knock-down herbicide, usually glyphosate.

The need for follow-up cultivations in long fallow situations to establish a satisfactory seedbed will depend on soil type, the incidence of summer rainfall and subsequent weed growth, and the type of crop being sown. Paddocks coming out of an annual-based pasture are often not cultivated until close to sowing—usually March or April.



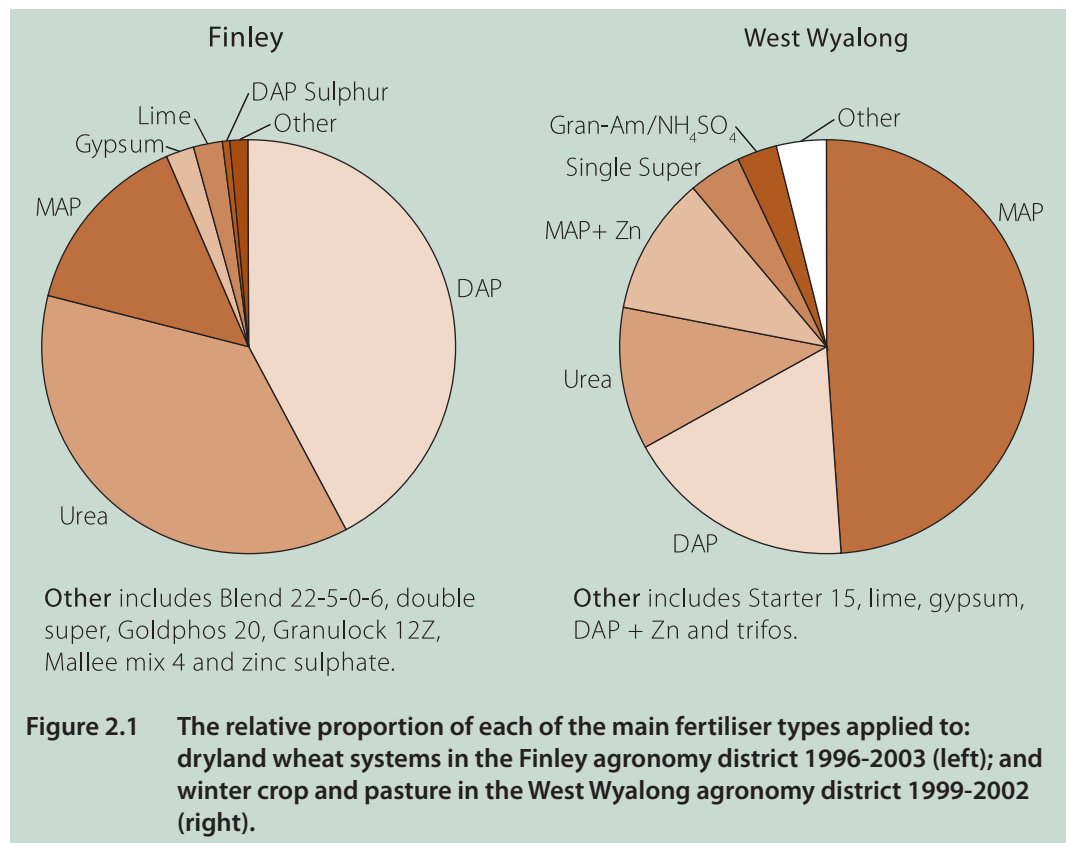
2.3.2 Nutrition and fertilisers

Phosphorus (P) and to a lesser extent nitrogen (N) are the main nutrients limiting yield potential of dryland crops in the 400–450 mm rainfall zone. The three main products growers use are di-ammonium phosphate (DAP), mono-ammonium phosphate (MAP) and urea. These make up over 95% of commercial fertiliser products used in the Finley area and 90% in West Wyalong area (Figure 2.1).

Phosphorus rates are often based on paddock potential (target yield) and aim at supplying at least 6 kg P/t grain removed. The average P rate for wheat crops is 20 kg/ha. Heavily cropped

areas may receive high rates of 25-40 kg P/ha to build up soil P levels. This strategy benefits the pasture phase, particularly if pastures are not top-dressed regularly.

The decision to use nitrogen fertiliser on a wheat crop depends on its place in the rotation, soil moisture reserves and the yield potential of the crop, particularly in regard to disease and weed infestation levels. Pre-drilled urea is not common as growers are wary of promoting vigorous early vegetative growth that will use too much soil moisture. The aim is 500-600 tillers/m² before the first node stage (Zadoks growth stage Z31).



Paddocks with low N status may receive some pre-drilled urea, but most N required at sowing is in the form of DAP. Wheat crops may be top-dressed with N before the first node stage (Z31) if soil moisture levels are adequate or there is a good chance of rain and crops have good yield potential.

Canola has a greater requirement for sulphur than other crops. Sulphur-deficient canola crops can suffer yield penalties of more than 50%. Gypsum applied at rates of at least 200 kg/ha is recommended for canola crops, particularly those grown on lighter textured soils, which are low in organic matter.

Soil acidity is a developing problem in the 400–450 mm rainfall zone. Many years of phase farming with annual legumes has caused acidification of topsoils. Rate of acidification is greatest on light textured soils, but as a general rule soils with a pH_{Ca} levels below 5.5 should be monitored (see Section 6.3).

2.3.3 Sowing rates and plant populations

Crop establishment should target a uniform plant population of 100-150 wheat plants/m² and 500-600 tillers before the first node stage (Z31) in this rainfall zone. Sowing rates vary between paddocks, depending on soil type, usually ranging from 60-80 kg/ha of seed. Seed size, germination levels and sowing conditions should be

considered when deciding sowing rates (see Section 7.1).

The release of dual purpose (grazing and grain) varieties suitable for sowing in the lower rainfall areas has resulted in an increase in the popularity of winter wheat. Sowing rate of winter wheat intended for grazing and grain recovery should be about 25% higher than spring wheat sowing rate, to produce a bulk of early dry matter. Grazing management that maintains low levels of crop dry matter will reduce the depletion of soil moisture reserves by early sown crops. Winter wheats that are allowed to produce a large early vegetative bulk are at risk of depleting moisture reserves that are needed for grain fill.

2.3.4 Stubble management

The majority of growers, particularly those on the lighter soil types, direct drill a proportion of their crops (40% according to a District Agronomist survey of the Finley area, 2001).

Weeds in stubble are controlled by either herbicides or managed with grazing stock or a combination of the two.

The decision to burn or retain stubbles often depends on the stubble load and the stubble handling ability of the sowing equipment. If burning is the chosen option, delaying until March or April will minimise the amount of time the soil is bare and so minimise erosion risk.

The majority of growers in this zone do not have the sowing equipment to handle large stubble loads. Hence they



tend to focus on minimising erosion risk and conserving soil moisture by reduced tillage and only direct drill or retain stubble as the opportunity arises. Most have equipment that can sow into stubble of low yielding crops (grain yields less than 3 t/ha), canola and pulse crops. A small proportion of growers are committed to stubble retention and have either adapted or bought specialist equipment to direct drill into stubble of high yielding crops (5 t/ha +).

Disc ploughs, disc harrows and mulchers are used to manage much heavier stubble loads. Specialist equipment that handles heavy stubble loads while ensuring soil penetration over a range of soil types and provides even sowing depth and good seed soil contact is expensive. It is difficult for many growers to justify the investment in such equipment if they are not convinced that it will ensure successful crop establishment.

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Phase farming with lucerne

Rodney and Ruth Tait, 'Labertouche', Weethalle

Location: 75 km west of West Wyalong and 70 km north east of Griffith.

Rainfall: Average annual is 425 mm; growing season rainfall is 205 mm.

Property size: 1530 ha.

Soil type: The soils on 'Labertouche' are relatively uniform red earths (i.e. massive earths as described in Section 1.2.3). The depth of topsoil can vary from 10 cm to 1 m; pH increases with depth.

The predominant indicator vegetation is red and black mallee, bimble box, grey box and white cypress.

Table 2.2 Soil test results typical of the main cropping soils on 'Labertouche'.

pH _{Ca}	5.5–6.0
Al	Negligible <1%
CEC	12 meq/100 g
EC	0.05 dS/m
P (Colwell)	5 ppm
Organic carbon	1.2%

The Taits usually test their soils at the end of the pasture phase, specifically to monitor phosphorus levels, but also pH.

Phosphorus is the main nutrient targeted in fertiliser inputs, with yield and nutrient removal the guidelines used by the Taits to determine application rates. The lucerne pasture phase is expected to meet the crop nitrogen requirements.

Farm plant

NH8770 tractor, Howard Bagshaw Scaribar and Airseeder (250 mm row spacings), 48-plate Ennor offset, 13 m Smale prickle chain and 19 m Croplands boomspray.

The phase farming system

Rodney and Ruth Tait annually crop about 520 hectares on 'Labertouche': 150 ha of wheat on long fallow, 120–150 ha canola, 120–150 ha feed barley and 120–150 ha of lucerne (sown with no cover crop). The pasture phase is five years of lucerne. They run 850 merino ewes, cutting 7.5 kg/head of 20 micron wool.

The Taits use a phase farming system. Rodney said that their low input livestock enterprise balances the risk of cropping in a marginal area. ➤



Plate 2.1 Rodney Tait sowing lucerne.

Photo: Bob Thompson

The lucerne pasture phase, which is integral to the success of the livestock enterprise, provides nitrogen for the cropping phase.

“Some growers in the area have moved to continuous cropping, citing better returns per hectare. While crop returns have been great in good seasons, in our case it has been livestock underpinning the business in dry seasons,” Rodney said.

Uncertainty over the impact of long cropping rotations on soil acidification and herbicide resistance has also influenced the Tait's decision to stay with phase farming.

The pasture phase

In the last 12 years the Tait's have replaced subclover dominant pasture with lucerne pastures. The move to lucerne pastures has resulted in reduced wind erosion on the sandy loam soils of ‘Labertouche’, but Rodney also credits the move to lucerne for the reduction in hand-feeding and an increase in lambing and weaning percentages.

“The lucerne pasture allows us to join ewes in mid December on a rising plane of nutrition. We weren't able to do this on subclover pasture without supplementary feeding,” he said.

Lucerne is sown with 50 kg/ha of MAP fertiliser and no cover crop.

“The result with a cover crop was either poor establishment or failures, which meant we either had paddocks with high weed burdens for the next five years or we had to re-sow the following season,” said Rodney.

The Tait's achieve lucerne plant densities as high as 80–100 plants/m² in the establishment year, which thin out over time. Recent plant counts for a six year-old stand were 10 plants/m².

Lucerne stands are topdressed after three years and fallowed in the fifth year, depending on the cropping program and stand density.

Rodney says that the herbicide options have been simplified by having pure lucerne pastures and it has been cheaper to keep paddocks clean of problem weeds (using herbicides such as diuron and atrazine).

“Clean pasture has production benefits for both cropping and livestock enterprises,” he said.

The Tait's scan all pregnant ewes for twins to help fine-tune their feed budgeting and individually micron test all maiden ewes to help improve the flock genetics.

The cropping phase

The ‘wool crash’ of 1989 forced the Tait's to re-evaluate their cropping program.

“We increased our cropping area from around 25–35% in an attempt to compensate for the loss of income from wool, and so moved into alternative crops,” said Rodney. ➤



The alternative crops allowed the Taits to tighten their cropping program without suffering yield loss through cereal disease, in particular crown rot and yellow leaf spot.

Rodney said that they sowed small areas of field peas in 1990 and 1991, but found that with yields of 1.0 t/ha they were only breaking even.

There were several issues that made the Taits decide to drop field peas from the cropping program: broadleaf weeds were difficult to control; harvesting was an issue; and the pea stubbles were susceptible to wind erosion.

But it was bacterial blight infestations in field pea crops in 1992 that sealed their decision to look for an alternative pulse crop.

Rodney said that they tried lupins and chickpeas in 1993 as alternatives to field peas.

“Lupins yielded only 0.4 t/ha and at an on-farm price of \$140/t, they weren’t an option. We were also worried about potential stock losses from lupinosis when grazing lupin stubbles,” he said.

However, with yields of 1.0 t/ha, and at \$260/t, chickpeas found a place in the rotation and the cropping program became wheat on fallow, chickpeas, wheat, feed barley and then out to lucerne.

According to Rodney chickpeas were easy to grow and input costs were only marginally more than cereals.

“We had to learn about heliothis management, but the crop presented no harvesting problems, the timing of harvest was not as critical as for other pulses and the money was good,” he said.

The Taits found that although chickpea stubble provided little ground cover over summer, the crop residue did not break up as easily as pea stubble and wind erosion was less of an issue.

Ascochyta blight infestations in the 1998 chickpea crop forced the Taits to revise their cropping program once again. Although an infestation late in the season only caused 10% yield reduction, they decided the risk was too great and have not sown chickpeas since.

Left with no pulse crop option and not wanting to grow wheat on wheat, Rodney said that they decided to give canola a go.

Triazine tolerant canola varieties were sown to combat a spiny emex problem, which was effectively managed by combining triazine herbicides in canola with Glean® in wheat crops. This combination of herbicides also reduced the Taits reliance on Group A chemicals for ryegrass control. The Group A herbicides were able to be used solely for controlling ryegrass in barley crops.

Poor marginal returns from canola on previously cropped or stubble paddocks in a period of dry seasons have prompted another revision of the cropping program on ‘Labertouche’. ➤



Case study...

"I now believe that canola has to be grown on long fallow to produce profitable yields in this marginal area. Realistically we need yields of 2.0 t/ha or greater," said Rodney.

"A number of below average years have depleted capital reserves and caused an increase in borrowing, meaning we once again have to consider the best mix in the phase farming operation," he said.

"Wheat has been our most profitable crop on fallow so we are currently considering a new program of long fallow, wheat, long fallow, wheat and either out to lucerne or another long fallow/wheat cycle. We've been producing 800 t of grain on 450 ha. By adopting the new program we hope to produce 800–1200 t on 300 ha."

Rodney is basing his yield predictions on four to five years of lucerne providing sufficient nitrogen to produce 12 tonnes of grain, which equates to either two years of high-yielding wheat crops (in a four-year cropping phase) or three years of mediocre wheat yields (in a six-year cropping phase).

The Tait's have been guided by results from local NSW DPI trials and the Central West Farming Systems demonstration site at Weethalle, which are showing that long fallow/wheat is a low risk option with profitable returns.

"We have had wheat yielding as high as 5 t/ha on long fallow in average rainfall seasons. By having the entire crop on long fallow we hope to minimise the climatic impact on yield and screenings," said Rodney.

The Tait's anticipate that by reducing cropping area they will not only reduce machinery hours, but they will also benefit from timeliness of sowing, weed control and harvest.

Trial work conducted by the NSW DPI from 1995 to 1998 has shown that wheat sown early yielded between 4 t/ha and 5 t/ha while wheat sown four weeks later yielded only 3 t/ha.

Rodney is confident that timeliness of sowing has a large bearing on wheat yields at 'Labertouche'.

"In 2001 Sunvale sown on Anzac Day yielded 3.2 t/ha, while the variety trials sown in the same paddock in June only yielded 1.2 t/ha," he said.

The tillage system

The Tait's cropping program is based on a reduced tillage system. Fallow commences with herbicide application in June. This is followed by a relatively deep working (10–12.5 cm) with a chisel plough, and, depending on soil type, perhaps a scarifying before sowing in May.

'Labertouche' was included in a Kondinin Group project (The Farm Tillage Demonstration Project) in the mid-1990s, which examined wheat yield responses to different tillage systems. Yields achieved with one cultivation were 1.24 t/ha, while the no-till treatment yielded 0.94 t/ha. ➤

This was a 24% yield reduction and screenings rose from 25 to 50%. Other growers involved in the Kondinin Group project recorded similar results over a three-year period (unpublished data).

“The cultivation operation helps break up the compaction layer produced by grazing stock during the pasture phase,” said Rodney.

Herbicides are usually used to control weeds in stubble, with a late burn being used to reduce the incidence of crown rot and yellow leaf spot, the two main cereal diseases evident on ‘Labertouche’. The stubble burn is followed by a pre-sowing cultivation.

The Tait’s aim to keep tractor hours down and minimise capital plant costs. □



A canola/cereal rotation

Troy, Bowden and John Hamilton, 'Warrawilla', Jerilderie

Location: 20 km north west of Jerilderie, adjacent to the Colombo and Billabong Creeks.

Rainfall: Average rainfall is around 400 mm per annum with an average growing season rainfall of 258 mm.

Property size: 1600 ha dryland and 800 ha irrigated.

Soils: Soil types vary from alluvial soils to heavy grey, brown and red clay soils. Soil test results typical for the main cropping soils on 'Warrawilla' are shown in Table 2.3.

The Hamilton's had the whole farm soil tested when they bought it five years ago and plan to test each paddock once every three years.

They are particularly interested in soil pH and phosphorus levels.

No soils on 'Warrawilla' have been limed to date and there has been very little movement in soil acidity in the five years since the farm was purchased. The Hamilton's consider a pH_{Ca} of 4.6 to be the critical level and would consider liming once pH fell below this if it were to benefit their cropping program. However, the present management has focused on building soil phosphorus.

Table 2.3 Soil test results typical of the main cropping soils on 'Warrawilla'.

pH_{Ca}	4.9–5.1
Al%	0.1%
CEC	20 meq/100 g
EC	0.76 dS/m
P (Colwell)	38–52 ppm
Organic carbon	1.5–1.8%

Key machinery

A Case Concord 4812 air till drill is a critical piece of machinery on 'Warrawilla'. Pulled by a 375 hp (280 kw) tractor, the Concord 4812 has a solidly built four-row tyne configuration, which features a 14.6 m working width and 305 mm row spacing. This provides good clearance and trash flow.

The Hamiltons consider the ground-following tyne with individual press-wheels behind the main frame a key feature of the machine. It allows more control over the sowing depth, especially when sowing into uneven paddock conditions.

The machine is used with steering assist technology and has a trailing seed and fertiliser cart. A combination of 10 cm sweeps and a scatter plate in front ➤



Plate 2.2 The coulter, tyne and press wheel configuration of the Case Concord 4812.

Photo: Matt McRae

of the seed boot creates a 'ribbon sowing' system, spreading the seed over a wider area than normal furrow placement.

"The tyne mounted disc levellers allow us to increase our sowing speed while still having good seed and soil control. The disc levellers stop the soil from moving from one tyne to the next", said Troy Hamilton.

The Concord 4812 has proven to be flexible. The Hamilton's have used it successfully for both cereal and canola crops and consider the infinitely adjustable pneumatic press-wheels and fertiliser placement systems are important features. Fertiliser is placed in the seed row, to help early root development.

"Small-seeded crops like canola can be sown with no problem. The machine leaves a seed bed that gives excellent seed-soil contact," Troy said.

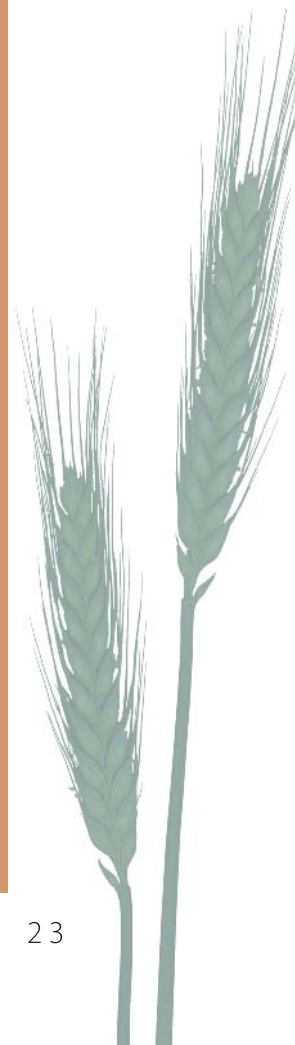
The Hamiltons are often faced with sowing crop into marginal moisture and consider the corrugations in the seed bed left by the Concord 4812 a benefit for channelling run-off (water harvesting). They are also investigating knife-point attachments for sowing into moisture.

The Hamiltons have found that the Concord 4812 has very few limitations but the main one is with trifluralin incorporation. For best results from trifluralin they spray, incorporate with harrows, then sow. On some rare occasions they have been forced to spray then sow and rely on adequate soil disturbance from the air seeder for incorporation. They will do this only on paddocks where weed burdens are low. ➤



Plate 2.3 The press-wheels of the Concord 4812 produce a corrugated surface which assists in water harvesting for the emerging crop.

Photo: Matt McRae



Stubble management

Although the Hamiltons would like to have the ability to retain stubbles, trash management and crop emergence becomes an issue when sowing into stubbles of cereal crops that yield more than 2.5 t/ha. Heavy stubbles are usually burnt to improve the efficiency of sowing and herbicide application. With no livestock they are able to burn at any time during the summer and autumn months.

“We haven’t had problems when sowing into lighter stubbles, but we do generally burn any stubbles from cereal crops that yield more than 2.5 t/ha. We plan to move to a controlled traffic system and hopefully that will improve the precision of our seed placement so we are able to sow into heavier stubbles,” said Troy.

Cropping program

The Hamiltons see the control of cereal diseases as the priority for their cropping rotation. “Without a disease break we’re not going to make much money. Our farming system will not be sustainable if we don’t have a break crop,” Troy said.

“Yellow spot is our biggest target and we’ve moved away from H45 (wheat variety) because of the stripe rust risk,” he said.

Although they have looked at a range of alternative break crops, they consider that canola is the best option to benefit their cereal program.

They have considered faba beans as a break crop option and are interested in their potential as a grain or green manure crop. However, they have found it difficult to calibrate sowing rates on the air seeder for faba beans due to the seed size.

The Hamiltons would prefer to use a precision seeder for such specialist crops but expect that a move to a controlled traffic system in the future will benefit crop establishment and fungicide application in faba beans.

Depending on the markets, chickpeas may be investigated as an opportunity cash crop and as a source of nitrogen for the cereal crops.

The general rotation on ‘Warrawilla’ is canola/wheat/barley/triticale. The preferred wheat varieties are Janz, Diamondbird or Chara. Janz is grown for its reliability across a range of seasons.

Barley is sown after wheat, with the variety Gairdner replacing Schooner in recent years.

Triticale’s good resistance to root and fungal diseases makes it the best option for a third cereal in the rotation. Triticale varieties sown are either Abacus or Muir, although Muir is being phased out because it is hard to thrash.

Canola allows the Hamiltons to stagger their sowing. They begin with canola, follow with wheat, Gairdner barley, preferably all by the first week of May, then Schooner barley and triticale to finish off. ➤

Fertiliser rates of 160 kg/ha DAP on irrigation and 120 kg/ha DAP on the dryland areas are used in the cereal program with the aim of building soil P levels over time. P levels started at about 20 mg/kg Colwell and have steadily increased during recent years.

Canola

The Hamiltons plan to incorporate canola into their cropping rotations as the fourth crop to minimise the risk of cereal disease. Attention is paid to paddock sequence to minimise disease risks from sowing canola too regularly. According to Troy, the one-in-four year canola rotation enables them to maintain a good distance between paddocks.

“We view our rotation in terms of four to five year cycles and look at the profitability of each rotation,” said Troy.

“We plan paddocks so that new plantings are at least 500 m from any canola stubble that may introduce blackleg inoculum,” he said.

The Hamiltons also aim to sow only blackleg resistant to highly resistant varieties in a bid to keep the disease burden low.

Canola nutrition

The Hamiltons usually spread gypsum prior to sowing canola. The gypsum not only provides sulphur needed for the canola crop, it also helps improve the soil structure. The gypsum is spread in April and then worked in with the sowing pass. A canola-specific fertiliser blend (N18:P13:K0:S12) is used at sowing.

Canola plant population and sowing rates

The seeding rate for dryland canola is 4 kg/ha and 2 kg/ha for irrigated crops. The Hamiltons have found that the establishment and plant population achieved is more a consequence of seasonal conditions, rather than the rate sown.

“We’ve found that the critical decider of good plant density is adequate moisture soon after sowing. If we can achieve a good population, yield will be at least 75% of our goal. We aim at 2 t/ha in an average season,” said Troy.

“The aim is to have canola sown by mid May, but if soil moisture reserves are low, the cut off for canola is the 10th May. Without that early break we can’t get the canola up and out of the ground quickly and we’ll sow cereals as a less risky option, as long as weeds and root disease risk in the paddock allows” he said.

Canola is not sown over all the cropping area on ‘Warrawilla’.

“We would like to be able to sow canola in all paddocks but some of the red soil sets hard and establishment of small seeded crops is a problem. We work in stubbles on those soils and fallow for 12 months,” said Troy. ➤



The Hamiltons are using stubble incorporation on the red hard-setting soils to help build the organic matter levels. Once the organic component in this soil is built up and hard setting is not an issue, they will reconsider canola.

Canola varieties

To simplify their management system (herbicide timing and harvesting) the Hamiltons have tended to use one canola variety. Rainbow has been the preferred variety. Yields range from 0.8-2.2 t/ha while oil percentages are usually 40-44%, and are a general reflection of the year.

Although Rainbow has performed well in past years they chose AV-Sapphire and Hyola 43 in 2004 and plan to use AV-Sapphire and a triazine tolerant variety (not yet decided) in 2005.

"Sapphire has a blackleg rating of seven which fits in with our strategy of sowing only resistant to highly resistant lines. Rainbow's poor blackleg resistance is one of the reasons we're replacing it," Troy said.

Harvesting

Choice of harvesting method for canola, either direct heading or windrowing, depends on the yield potential of the crop. The Hamiltons are happy to be guided by the windrowing contractor in making the final decision.

In general any crops over 1 t/ha are windrowed, while the lighter yielding crops and areas that are difficult to windrow are direct headed.

In 2003 the Hamiltons grew a partially irrigated hybrid canola seed crop under contract. Although the final yield was only 1.2 t/ha, at \$1500/t it was a worthwhile exercise.

Troy said, "The crop had two pre-waterings from a centre pivot, but we had enough rain during the growing period, so it didn't need a follow-up irrigation."

"Pollination was a problem with the crop and that kept the yield down. The bees didn't seem to forage more than 50 or 60 metres from the hives. If we grow hybrids again we'd aim to have hives placed every 100 metres along a central road with male and female plants distributed in blocks along the transect," he said.

Pest management

Red-legged earth mite (RLEM) is the main insect pest of canola.

"We always treat seed with Cosmos® (fipronil). Monitoring is the key and depending on the paddock and season, we may also use an omethoate spray early in the crop," said Troy.

The Hamiltons apply post-emergent herbicide as soon as possible and always incorporate omethoate into the tank mix to control RLEM. ➤

General farm hygiene is also important in controlling RLEM. Laneways, tracks, fence-lines and any other potential RLEM harbours are sprayed to prevent them moving into cropped paddocks. The Hamiltons begin their 'clean farm' program when weeds germinate in autumn. Weed control around these areas is also important in keeping the RLEM food sources scarce and limiting potential harbours.

Weed management

The Hamiltons have no major weeds limiting their cropping system. Wild oats (*Avena fatua*), annual ryegrass (*Lolium rigidum*) and annual phalaris (*Phalaris paradoxa/minor*) are the main weeds targeted at the moment, but they expect that wild radish (*Raphanus raphanistrum*) is likely to enter their farm with the next flood event.

"Most of 'Warrawilla' has a relatively short farming history so herbicide resistance is not an issue at present. However we are concerned about ryegrass resistance and our weed management strategies are focused on avoiding this," said Troy.

The Hamiltons also operate a contract harvesting business and focus on machine hygiene making sure machines are thoroughly cleaned down after contract jobs.

Summary

Priorities for a canola/cereal rotation:

- Keep an eye on market potential before planting a crop.
- Assess potential of canola in relation to subsoil moisture.
- Aim to sow by Anzac day (25th April), whether dry or into moisture.
- Sow as shallow as possible.
- Always treat seed with Cosmos®.
- Keep accurate records of all input costs involved.

The Hamiltons consider canola a high input crop, but it has an important role in the profitability of the cereal program. Its benefit to the rotation as a break crop in their cereal program is valued, but it has the added advantage of spreading their labour inputs over sowing and harvest.

Canola is the only practical break crop for the farm. The Hamiltons will stick with canola until there is a better alternative. □





Farming systems in the 350–400 mm rainfall zone

3.1 Introduction

The main dryland enterprises in this rainfall zone are a mix of winter cropping and grazing livestock, with extensive grazing properties predominantly in the west and south of the zone.

Most dryland cropping occurs on the duplex and massive soils, which produce average wheat yields in the order of 1.4-2.0 t/ha. Water holding capacity and internal drainage of the soil impacts on the reliability of crop

yields and can be related to natural vegetation, with ‘kurrajong country’ producing higher and more reliable yields compared to ‘white cypress pine country’ and then ‘mallee country’.

Wheat is the major winter cereal grown, accounting for about 80% of the total area sown to crop in any one year. Traditionally most growers used a phase farming system, with a 4 to 10 year legume-based pasture phase which includes species such as medics, clovers and lucerne. This was then followed by 2 to 4 years of crop.

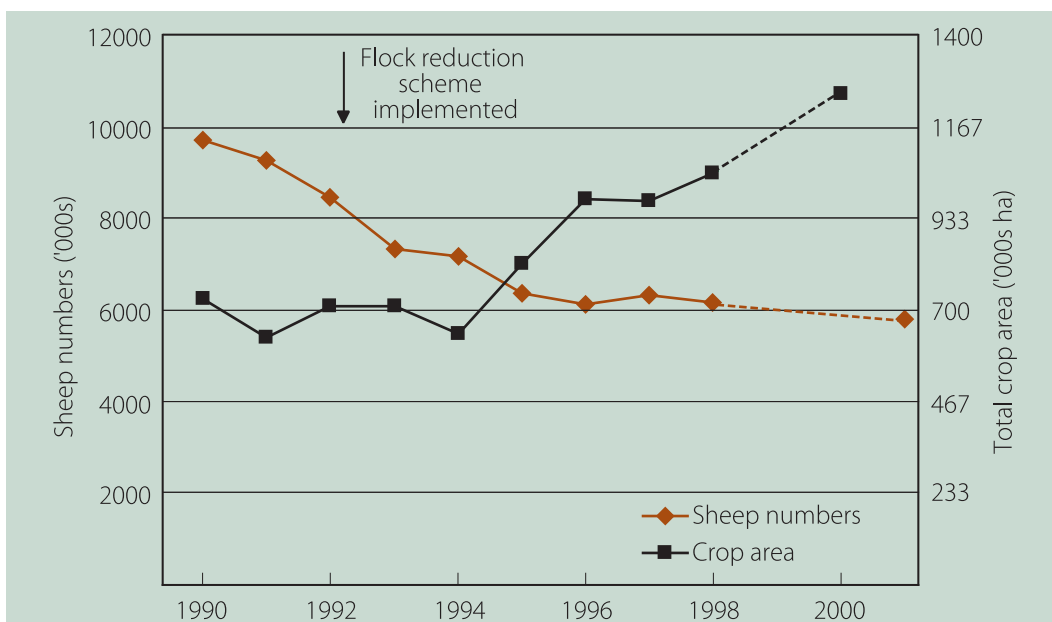


Figure 3.1 The decline in total sheep number (1990 to 2001) and increase in the area sown to winter crops (1990 to 2000) in the low rainfall dryland cropping zone of south western NSW.

Source: Australian Bureau of Statistics



However, the decline in stock numbers since the early to mid-90s (as shown in Figure 3.1) and particularly since the onset of drought conditions since 2002 has seen a reduction in the area sown to pastures and a significant trend towards continuous cropping.

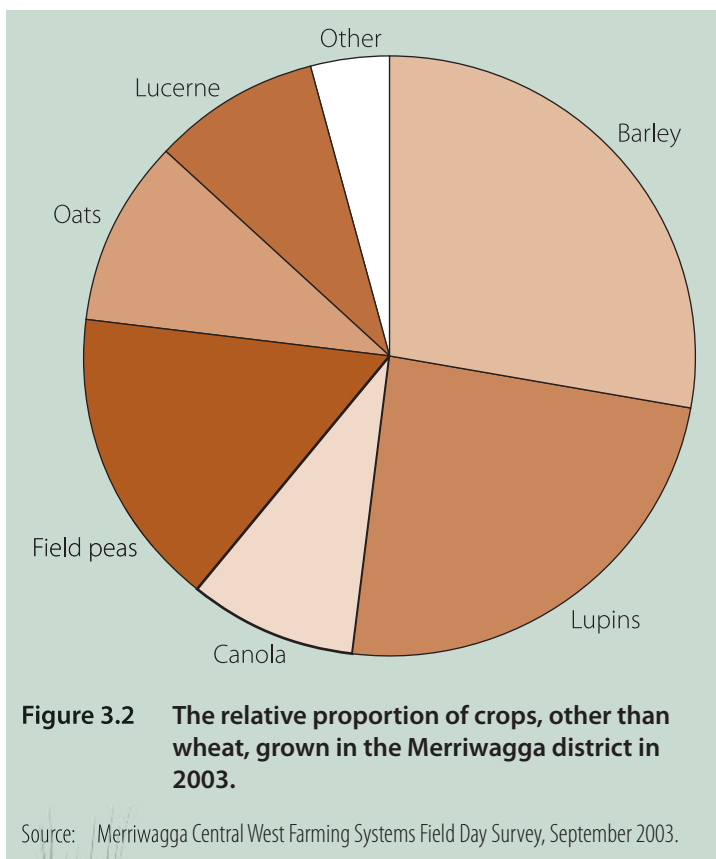
Cropping is now the major source of income for many growers in the 350–400 mm zone.

3.2 Typical rotations in the 350–400 mm rainfall zone

Many growers in this zone use long fallows in the crop rotation to allow moisture accumulation and mineralisation of organic matter during the fallow period. This increases the probability of producing economic yields from the following crop, particularly in dry seasons. Most growers long fallow 10–30% of their cropping country, although this is flexible and depends largely on summer rainfall, the density of pasture, disease risk and the area available for cropping.

The fallow period following a pasture phase usually commences with a knockdown herbicide application in July or August. Strategic timing of subsequent herbicide applications and cultivation controls weeds until sowing the following year. Cultivation is the favoured option when herbicide efficacy is an issue in hot dry conditions or for the control of the hard-to-kill summer weeds, such as field bindweed (*Convolvulus arvensis*), heliotrope (*Heliotropium europaeum*) and silver-leaf nightshade (*Solanum elaeagnifolium*).

As indicated in Table 3.1, wheat is usually the first crop sown after a long fallow, although canola sown on fallow is an option if there is a timely autumn break and/or there are good soil moisture reserves, particularly if cereal disease carry-over is a concern.



The main rotational crops used by growers who have adopted more intensive cropping programs include barley, lupins, canola, field peas and oats. The relative proportion of these crops grown in the Merriwagga district are shown in Figure 3.2.

Table 3.1 Characteristics of a typical dryland cropping farm at Merriwagga, NSW.

Characteristics	Description
Farm Area	2000–5000 ha
Cropping options	Cereals–wheat, barley, oats. Pulses–field peas, lupins, chickpeas. Oilseeds–canola.
Cropping phase	Variable: typically 3–4 years crop, 1 year of fallow.
Pasture phase	Very little pasture is sown.
Typical rotation	Continuous cropping rotations include: wheat/long fallow/wheat/long fallow; wheat/wheat/barley/long fallow; and long fallow/wheat/barley/legume/wheat or canola

A proportion of growers include non-cereal crops in their crop rotations. As well as providing a disease break and hence increasing the yield potential of the following wheat crop, break crops also provide income diversification, allow the use of a broad spectrum of in-crop herbicides (reducing the risk of herbicide resistance developing) and spread labour resources during sowing and harvest. Pulse crops can also increase soil nitrogen levels.

3.2.1 Why are the rotations different in this zone?

Barley and the alternate crops do not reliably achieve gross margins comparable to wheat. Therefore, the main aim of most rotations in the 350–400 mm rainfall zone is to boost the potential yield of wheat crops.

The rotations and cropping systems in this zone have developed in response to factors that have significant impact on wheat crop yield: rainfall, disease levels, weed infestations and, to a lesser extent, soil type.

To be profitable the rotation must be flexible and growers must be able to react to these yield-limiting factors and capitalise on market opportunities.

Management strategies tend to focus on maximising plant available water (PAW) in an attempt to counter the unreliability of the autumn break and rainfall events at critical crop growth stages (e.g. head emergence, anthesis and grain fill for cereals). The development of reduced tillage systems, long fallows, sowing of break crops, and sowing short-season crop varieties are some of the measures used by growers to produce economic yields on limited and unreliable growing season rainfall.

Rhizoctonia bare patch, take-all and yellow leaf spot are the main diseases affecting wheat in this zone. The options to manage these cereal diseases in a continuous cropping rotation are to either ensure an effective long fallow, free of disease-



carrying hosts, or to sow a break crop (see Chapter 9).

Canola, lupins and field peas have been grown with varying success in this zone. The choice of these alternative crops depends mainly on the timing of the autumn break and soil type. Canola and lupins are the options for early sowing, although lupins are not recommended for the mallee soils. Field peas provide flexibility for later sowing and are more suited to the majority of soil types in this zone.

3.2.2 Advantages and disadvantages of typical rotations

Most rotations in this rainfall zone rely on a period of long fallow. The main disadvantage of long fallowing is that fallowed paddocks produce an income only one in two years. The fallow crop must be twice as profitable as a crop in a continuous cropping system.

Given there is a cost in controlling fallow weeds, the economics of long fallowing does not always compare well with continuous cropping systems. Wind erosion of fallowed paddocks is also a concern for many growers.

Wheat-on-wheat

Many growers in this zone grow successive wheat crops, usually for 3 to 4 years. The main advantage of this rotation is that it maximises short term profit because if a paddock is

continually cropped the 'good years' are not missed.

Slow build-up of cereal diseases in the lower rainfall areas is the main reason successive wheat crops can be a viable rotation. However, growers sowing successive wheat crops risk yield penalties from undetected (sub-clinical) levels of root and foliar disease and the development of herbicide resistant weeds. Once established it can then be difficult to eradicate disease and weed infestations without considerable changes to management. The preferred option is to reduce disease and weed levels by long fallowing or by sowing a break crop.

Growers opting for this rotation should be monitoring weed and disease levels to reduce the chances of these yield-limiting factors developing. Tests for disease, such as Predicta B[®] can be a useful guide.

Wheat/barley/long fallow

The wheat/barley/long fallow rotation is favoured in the western part of this rainfall zone where break crops, such as lupins, field peas and canola, don't produce reliable yields.

Wheat is grown after a weed-free long fallow to benefit from soil moisture accumulation and reduced disease risks. Wheat sown on long fallow usually yields 30% more than wheat sown into stubble.

Malting barley is often sown as the second crop to ensure grain protein levels are less than 12%, to meet specifications for malting.



Long fallow/wheat/barley/pulse/wheat or canola

The long fallow/wheat/barley/pulse/wheat or canola rotation is more common in the higher rainfall areas to the east of this zone. Seasonal conditions and soil type play a big role in the choice of pulse that is grown.

The aim of this rotation is to capitalise on the disease and weed management advantages of the break crop.

3.3 Crop management in the 350–400 mm rainfall zone

3.3.1 Tillage systems

Reduced tillage systems have been relatively well adopted in this rainfall zone, with the majority of farmers replacing at least a proportion of their cultivations with a knockdown herbicide application. Growers also consciously minimise cultivations to conserve moisture and avoid erosion by retaining stubbles for as long as possible.

Cultivation is used strategically however, to break hard surface crusts to increase rainfall infiltration, reduce soil-borne diseases and provide a weed control option for hard-to-kill weeds. Strategic cultivation is also a management tool for managing or preventing the development of herbicide resistance.

Direct drill sowing systems suit all the crops grown in this zone but have lost favour with an increase incidence of rhizoctonia bare patch and crown rot in wheat.

3.3.2 Nutrition and fertilisers

Soils in this rainfall zone are generally low in nitrogen (N), phosphorus (P) and sulphur (S). Cereal crops require at least 60–80 kg/ha of a starter fertiliser, such as MAP, for adequate growth. Most fertiliser inputs are to meet the crop's phosphorus requirements; about 10 kg P/ha with each crop.

The decision to use nitrogen fertiliser should take into account the soil moisture reserves and disease and weed status of the crop.

Pre-drilled nitrogen, in the form of urea or sulphate of ammonia, is an option if there is adequate stored soil moisture at sowing. However pre-drilling nitrogen does carry some risks: the crop may respond to the extra nitrogen with vigorous early growth and use the reserved moisture before flowering and grain fill. If there is insufficient rain during these critical times the result will be lower yields and increased screenings compared to crops with no additional nitrogen fertiliser.

Top-dressing with nitrogen (usually urea) is another option, but is rarely practised as growers are concerned about the 'crop burning off'. However, if the crops have good yield potential and rain is expected soon after application, top-dressing low rates of urea (40–50 kg) by the first to second node stage (Zadoks scale 31–32) can increase yield in a responsive crop (i.e. a nitrogen-deficient crop that is free



of disease and where weeds have been controlled) (see Section 8.2).

Sulphur is rarely targeted as a fertiliser for wheat crops, but must be included in fertiliser for canola crops in this zone.

3.3.3 Sowing rates and plant populations

Sowing rates usually range from 30-50 kg/ha for wheat and 25-40 kg/ha for barley, targeting plant populations of 80-100 plants/m². However rates should be varied, depending on seed quality and seed size (see Section 7.1).

Yield potential is increased by increasing sowing rates, but moisture stress and high screening levels become an issue for high sowing rates in low rainfall seasons.

3.3.4 Stubble management

Stubble management in the 350–400 mm rainfall zone varies from burning to stubble incorporation (with wide sweep points, disc harrows or disc ploughs following summer rains), to full stubble retention.

Growers use stubble burning as a cheap weed control option, to minimise disease carryover, improve crop establishment and facilitate sowing. Burning usually begins in March and April when fire permits are available and after the period of high intensity storms.

Although stubble burning is still a common practice, many growers are moving towards conserving stubble

in an attempt to reduce summer wind and water erosion and to build up soil organic matter levels.

Currently less than 30% of wheat stubbles are retained but adoption of specialist machinery by some growers allows them to sow into reasonable stubble loads. However if they have wheat crops of over 3-4 t/ha most growers would opt to either burn or incorporate stubbles.

Stubble incorporation can result in yield penalties if extra nitrogen fertiliser is not added to overcome short-term nitrogen tie-up in the subsequent crop (see Section 8.2.1).



Long fallow/wheat/long fallow/wheat

Lake Cargelligo (grower's name withheld by request)

Location: South west of Lake Cargelligo.

Rainfall: Average annual rainfall of 430 mm; growing season rainfall is about 217 mm (May to October).

Property size: 2000 ha.

Soil type: Variable; ranging from light, gravely ridges through to red loams and with heavy grey clays along the river. Typical test results for the farm soils are presented in Table 3.2.

Table 3.2 Soil test results typical of the red brown earths (the main cropping soils).

pH _{Ca}	5.5
Al%	<1%
CEC	11.46 meq/100 g
EC	0.05 dS/m
P (Colwell)	5–10 ppm

Cropping program

The predominant farming system on this farm is a long fallow/wheat/long fallow/wheat program following a period of legume-based pasture.

Livestock, predominantly sheep, form an integral part of the farming system and provide stability and cash flow for the farming business. With an increasing trend toward sheep meat production, as compared to wool, this grower has chosen to join merino ewes to terminal sire.

Typically, cropping utilises 50–60% of the farm area in any one year, with lucerne-based pasture on 20–30% of the area. Wheat is the main crop sown, although malting barley is also planted. Between 60 and 70% of crops are sown on long fallows, with the remainder being sown on stubbles.

Most wheat crops are planted on long fallow. Soil moisture accumulates during the fallow period. This stored moisture is critical for crop survival and grain fill during the often dry September/October period.

The pasture phase ends with fallow commencement in July or August. The fallow is kept weed-free until wheat is planted in April or May. The ground is again kept free of weeds after harvest, through year two and planted again to wheat in year three, with or without undersown pasture. If pasture is not planted, the ground is fallowed for the next season and then barley or wheat is planted with undersown pasture in year five.

Pastures are predominantly winter-active lucerne, usually mixed with clover (such as Dalkeith and Nungarin subclovers and Hykon rose clover) and Jemalong barrel medics. The pasture phase can range from four to seven years, depending on pasture persistence and paddock history. ➤



Management strategies

The long fallow/wheat/long fallow/wheat system has been used in the Lake Cargelligo region for more than 30 years. This system has increased the land available for cropping with areas once considered high risk producing more reliable and profitable wheat yields. Average wheat yield from this system is 2.0 t/ha.

The system is flexible and the decision to plant or to fallow may not be made until the end of summer. Management may vary between paddocks, depending on soil type, available soil moisture and the probability of getting good, in-crop rainfall.

The legume-based pasture phase and the weed-free long fallow period is used to minimise the incidence of disease in wheat crops and keeps fertiliser and herbicide costs relatively low. The wheat crops' nitrogen requirements are met by the lucerne phase and the long fallow system allows for flexibility of weed control.

The predominant tillage systems used by this grower is reduced tillage. Reduced tillage is the most popular system in the Lake Cargelligo region and is favoured over a no-till system when the soil type requires cultivation to produce a seedbed that ensures good seed/soil contact. Cultivation is also used to improve stubble breakdown.

The fallow period following the pasture phase usually begins with a glyphosate application in July or August. This 'spray fallow' system gives total weed kill and is timed to prevent weed seed set. It has the advantage over mechanical fallowing of extending grazing time on the sprayed areas.

The sprayed area is usually cultivated before November with a chisel plough and may require further cultivation in January or February, depending on summer rainfall, weed growth and soil type. The paddock is then either sprayed or cultivated in March and sown in April or May, with the option of another application of glyphosate as a pre-sowing knockdown.

Weed control on the fallows between wheat crops is mainly dependent on the frequency of rainfall, the amounts received and weed infestation levels. Weeds are controlled either by cultivation or application of a knockdown herbicide, usually glyphosate. The choice depends on the likely effectiveness of the herbicide on the target weeds and the state of the soil.

Chemical control is the preferred weed control option in stubbles as it maintains the stubble cover, reducing the risk of wind erosion. However, if the seedbed is cloddy or has been compacted by grazing livestock, cultivation may be used to create a reasonable tilth. ➤



Advantages

This grower believes the use of a long fallow preceding each crop has increased the reliability of wheat production on this farm. He sees that the system has many advantages:

- The system is well integrated with livestock enterprises.
- Weed seed set is prevented in the fallow period, reducing the in-crop weed burden, thereby reducing herbicide costs.
- A combination of chemical and mechanical weed control strategies minimise the risk of the development of herbicide resistance.
- Long fallow between crops prevents the survival of cereal disease on carry-over stubble or volunteer plants.
- Soil moisture reserves accumulate during the long fallow period, ensuring more reliable wheat yields over a range of seasons in this rainfall zone.

Disadvantages

The grower considers that the only disadvantage in using the long fallow system is the potential loss of production in the fallow year:

- Less frequent cropping may result in decreased income potential. With about 60% of the farm out of crop at anyone time, a large area of land is required to generate the potential income of continuous cropping systems.
- Total production may be less, relative to a continuous cropping system, in years of above-average rainfall.

Other comments

Other comments from this grower are that management options may be restricted by inflexible sowing equipment. The majority of the machinery currently being used in the Lake Cargelligo region cannot produce a satisfactory seedbed over a range of soil types with one pass and does not have adequate trash clearance for sowing into stubble. Therefore, many growers are limited in their ability to retain stubbles and adopt reduced tillage systems.

However, there has been a trend in the region to increased herbicide usage and decreased cultivation. Now growers are looking for equipment that can be used to direct drill into stubble, but that also gives them the option to cultivate to achieve a weed kill if necessary. □



Continuous cropping with pulses in the Rankin Springs area

Michael and Larissa Pfitzner, 'Hill End', Griffith

Location: 35 kilometres north of Griffith.

Rainfall: A district annual average of 439 mm and a farm average since 1967 of 428 mm.

The five-year average for 'Hill End' (2000–2004) was 307 mm (190 mm growing season rainfall).

Property size: 2800 ha, which includes 680 ha of pulses with 430 ha of field peas and lupins and 250 ha of vetch.

Soils: The soils on 'Hill End' are predominantly red sandy loam—the duplex soils described in Section 1.2.1.

Typical results from soil tests of the main cropping soils on 'Hill End' are presented in Table 3.3.

Table 3.3 Soil test results typical of the main cropping soils on 'Hill End'.

pH _{Ca}	5.6
Al%	<5%
CEC	8–13 meq/100 g
EC	<1 dS/M
P (Colwell)	24–40 ppm
Organic carbon	1.2%

Key machinery

The Pfitznrs rate chemical weed control as one of the most cost-effective and important operations on their farm. Hence they consider that the main piece of equipment on the farm to be the Hino 4x4 Gooseneck boom fitted with a 31 m twin-line boom and a tank capacity of 3800 L. The boom uses differential GPS guidance to minimise overspray and eliminate misses.

Michael Pfitzner said that the GPS guidance for boom spray has increased the accuracy of herbicide application by 4–10% and is particularly valuable in larger paddocks where the foam markers don't last from one round to the next.

"This accuracy also translates to very minimal spray misses. Increased seed banks in those missed strips in the past have haunted us for years," he said.

The GPS guidance means there are minimal overlaps with sensitive herbicides and so reduced risk of herbicide damage in crops.

"The GPS also allows us to summer spray at night in the optimum 'delta T' range of low temperature and higher humidity," said Michael.

All cultivation and sowing equipment is pulled by a Case IH STX 450 hp tractor. ➤



Plate 3.1 The Hino 4x4 gooseneck boom spray used at 'Hill End'.

Photo: David Woodside

Cultivation is kept to a minimum and is primarily used to break up hard-setting soils to aid in moisture infiltration, usually after period of grazing by sheep. The Pfitzners cultivate with a Flexicoil 820 bar (16.2 m) on 225 mm row spacings with 196 or 245 mm points. Approximately 1 year in 10 they use two 1-way 30-plate disc ploughs.



Plate 3.2 The airseeder, fitted with presswheels, is used for all sowing at 'Hill End'.

Photo: David Woodside

All crops are sown using a Flexicoil Airdrill 5000 on 225 mm row spacings, with mid-row fertiliser bands. The air cart is a Flexicoil 2640 three-compartment box. Primary Industry super seeder narrow points and press wheels are used for all sowing operations.

All crops on 'Hill End' are harvested with a Case 2388 header. This has an 11 m MacDon draper front attachment. The MacDon Draper 2052 the Pfitzners have also has a cross auger at the back of the platform, which assists in feeding stubborn material into the header, such as field pea vines. Pea lifters are used to harvest field peas.

The header is fitted with a yield monitor and also has yield mapping ability.

The continuous cropping system

The Pfitzners have moved to continuous cropping with a positive response in their gross margins.

Crops grown at 'Hill End' include wheat, barley, canola, field peas, lupins and vetch. Crop sequence is flexible and is determined by a number of factors, including the timing of the autumn break, the time between similar crop types and the weed spectrum and level of infestation.

Typical rotations at 'Hill End' include:

- canola/wheat/barley/legume/wheat
- long fallow/wheat/legume/wheat or canola.

The Pfitzners' farming plant allows for most crops to be sown with minimum ground disturbance. Seedbed preparation and weed control methods vary between paddocks, depending on the paddock and seasonal conditions.

"Most crops are sown into an unprepared seedbed, but we will consider cultivation, stubble mulching or burning when weeds become difficult to control with herbicides or there is too much stubble to handle at sowing," said Michael.

Any stubble from wheat crops yielding over 2.5 t/ha is mulched using Coolamon Harrows fitted with stubble mulching harrows.

"We only run the fire harrows over the paddock when the stubble balls up in front of the machine and blocks it," said Michael. ➤



They have found that the amount of stubble the airdrill will handle depends on a number of factors including, how short the stubble was cut, how well the summer weeds were controlled, how many sheep have run on the stubble and for how long.

“Some years we can get through a power of stubble and not have a problem, yet other years it seems nothing will go through. We’ve found that if there is a bit of moisture about we can get through more stubble. The extra weight seems to make it flow better,” said Michael.

The cropping program

The main aim of the cropping rotation is to maximise wheat yields and to reduce weed and disease problems.

The Pfitzners calculate the profitability of each rotation over a number of years to compare their relative benefits. Wheat or canola crops benefit from the nitrogen that has been fixed by the pulse crop and any soil moisture left after the pulse crop.

“In general wheat following field peas has proved to be the most profitable crop sequence for us,” said Michael.

“The field peas fix nitrogen and use less subsoil moisture than other pulses, leaving moisture reserves for the following crop,” he said.

The choice of pulse crop

The autumn break in the Rankin Springs area has not been reliable in recent years but the Pfitzners consider the flexibility of their rotation an advantage under such conditions.

“Seasonal conditions and paddock characteristics play a big role in deciding which pulse crop to sow,” Michael said.

The late breaks have a big impact on the yields of early sown crops such as canola and lupins because of their limited sowing window.

“Vetch is also affected by late autumn breaks, but field peas give us flexibility for a later sowing,” he said.

Vetch

Vetch (variety Blanchefleur) is usually the first crop sown, preferably in late March. It is then grazed from May, with sheep taken out in November.

The Pfitzners use vetch to clean up weedy paddocks. The paddocks are sprayed before sowing with a residual/knockdown mix such as trifluralin/glyphosate and then ‘brown manured’. (‘Brown manuring’ is the practice of spraying with glyphosate before vetch and weed seed set). ➤



“By spraying out the vetch in October, the soil moisture reserves for the next crop are quite high,” said Michael.

Lupins

Both albus (broadleaf) and angustifolius (narrow leaf) lupins are grown at ‘Hill End’. They are direct drilled into cereal stubble and have a similar role in the crop rotation to field peas.

The Pfitzners consider that lupins are not a viable option from late sowings.

“We will not sow lupins if we don’t get the autumn break by the end of April/early May. The gross margin from wheat after lupins tends to be less consistent than wheat following field peas or vetch, particularly from late sowing,” said Michael.

Field peas

Field peas are usually the last crop sown; often well into May and through June. Varieties grown are all dun types and include Morgan, Parafield and Kaspa.

In an attempt to reduce harvesting difficulties field pea paddocks are rolled after emergence with a set of home-built 18 m rollers to bury stones and break up clods.

“Although field peas aren’t profitable as a single crop, when we look at the two year rotation with wheat, the field pea/wheat rotation gives us our best two-year gross margin,” said Michael.

Most of their field peas are sold to Bartter Enterprises, which use it for their Griffith-based grower chicken operation.



Plate 3.3 Field peas, Parafield (left) and Morgan (right), fit well into the continuous cropping system at Rankin Springs.

Photo: Michael Pfitzner

Summary

“Pulses are an important part of the rotation, particularly as the continuous cropping system tightens. Stock numbers have dropped now that we have less pasture area and we are fallowing less,” said Michael.

The Pfitzners have found that pulse crops benefit the profitability of the whole farm operation, by enabling them to grow better crops at all stages of the rotation and also by providing a break in disease and weed cycles. They have, however, found pulses to be very season dependant.

“One crop, or even one variety (e.g. Parafield field peas) may do well one year but a different crop (e.g. narrow leaf lupins) may do better the next year,” said Michael. ➤

“With this in mind it pays to have a mix of legumes or varieties in any given year to, hopefully, ride at least one winner home,” he said.

Advantages of including pulse crops in the rotation

- Wind erosion is less of an issue when growing pulses compared to the following option.
- Pulse crops broaden the chemical group options for weed control, with both pre- and post-emergent herbicides able to be used as a double knock on problem weeds.
- Herbicides registered for grass control in pulse crops are relatively cheap, The ‘double knock’ approach to grasses can mean that there is no grass weed control needed in the following cereal crop.
- The pulse crop provides an effective break for cereal diseases.
- Pulses have allowed a tighter cropping program, with weed and disease management benefits carrying over for a number of years.
- By sowing a range of pulse crops the Pfitzners are able to stagger their sowing window, with pulses being sown before and after the main cereal varieties.
- Field peas have an earlier maturity than most other crops and desiccation for weed escapes can bring harvest in evenly.

Disadvantages

- Damage by heliothis can limit the marketing options. Crops must be monitored for heliothis.
- Harvest of field peas can seem slow and difficult compared to wheat. The Pfitzners have found that harvesting at the optimum time will minimise soil contamination and harvest losses.
- Field pea paddocks must be ‘clean’ to minimise header damage from rocks and stumps.
- Relatively high pulse sowing rates means large quantities of seed have to be held for sowing.
- Pulses, in general, have poorer water use efficiency than wheat (although this is an advantage for the following wheat crop). □

